

# Compression therapy for leg oedema in patients with heart failure

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## Abstract

The presence of chronic heart failure (CHF) results in a significant risk of leg oedema. Medical compression (MC) treatment is one of the basic methods of leg oedema elimination in patients with chronic venous disease and lymphedema, but it is not routinely considered in subjects with CHF-related swelling. In the study, an overview of the current knowledge related to the benefits and risk of using MC in the supportive treatment of leg oedema in CHF patients is presented. The available studies dedicated the comprehensive management of leg swelling using MC in CHF patients published in the English language literature till December 2019 were evaluated in term of the treatment efficacy and safety. In studies performed on CHF populations, manual lymphatic drainage, MC stocking, multilayer bandaged, as well as intermittent pneumatic compression or electric calf stimulations were used. The current evidence is based on non-randomized studies, small study cohorts, as well as very heterogeneous populations. The use of the intermittent pneumatic compression in CHF patients significantly increases the right auricular pressure and mean pulmonary artery pressures as well as decreases systemic vascular resistance in most patients without the clinical worsening. The transient and rapid increase in the human atrial natriuretic peptide, after an application of the MC stocking in New York Heart Association (NYHA) class II patients was observed without clinical exacerbation. An application of the multilayer bandages in NYHA classes III and IV patients lead a significant increase in the right arterial pressure and lead to transient deterioration of the right and the left ventricular functions. In the manual lymphatic drainage study, aside from expected leg circumference reduction, no clinical worsening was observed. In a pilot study performed in a small cohort of CHF patients, electrical calf stimulation use resulted in a reduction in the lean mass of the legs without cardiac function worsening. The use of local leg compression can be considered stable CHF patients without decompensated heart function for both CHF-related oedema treatment and for treatment of the concomitant diseases leading to leg swelling occurrence. The use of MC in more severe classes of CHF (NYHA III and IV) should be the subject of future clinical studies to select the safest and most efficient compression method as well as to select the patients who benefit most from this kind of treatment.

**Keywords** Heart failure; Leg swelling; Medical compression; Lymphedema

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## Introduction

Compression treatment, including medical compression stocking (MCS), is one of the commonly used treatment methods in patients with various types of leg oedema, including primary and secondary chronic venous disease and lymphedema<sup>1–3</sup> Also among the current MCS indications are leg swelling prevention in both chronic venous disease patients and healthy individuals at risk of leg swelling (e.g. occupational leg swelling).<sup>1</sup> The other groups of indications

are focused on venous thromboembolism prophylaxis and treatment and venous leg ulcer therapy.<sup>1</sup>

Leg oedema is a relatively common occurrence in the adult population; in addition to the clinical situations mentioned previously, a variety of other conditions can result in lower extremity swelling, including hypoproteinemia, obesity, renal failure, and chronic heart failure (CHF). In most of these clinical conditions, the presence of leg swelling is usually secondary to the primary disease [e.g. heart failure (HF)], which suggests focusing the treatment on the

primary pathology and using, if possible, the other measures (including compression) as supportive treatment only.

One of the increasingly common current problems in the community is the presence of CHF; these patients often experience very advanced leg swelling and swelling-related complaints.<sup>4,5</sup> The growing number of patients with CHF, which is the result of the increasing cardiovascular disease prevalence and the growing population age, suggests considering the presence of HF in the differential diagnosis for all cases of bilateral leg oedema. According to the 2016 ESC HF treatment guidelines, evidence-based treatment of peripheral oedema in patients with CHF is, in most cases, limited to pharmacotherapy, including diuretics.<sup>4</sup> Moreover, despite the wide spectrum of therapies that has been recommended in this guideline document, no information regarding the possibility of using medical compression in the multidisciplinary treatment of CHF-related leg oedema can be found.<sup>4</sup> In the most recent MCS guideline document proposed by an international expert group and published in the journal *Phlebology* in 2018, the role of compression in HF-related oedema treatment was also not specified.<sup>1</sup>

In this review, the importance and clinical meaning of leg swelling in **CHF** patients as well as the possibilities of its treatment based on the implementation of physical methods are discussed.

## Leg oedema in chronic heart failure patients

Peripheral oedema in patients with **CHF** can be related to left-sided and/or right-sided heart insufficiency, to autoregulation mechanisms in the cardiovascular system, as well as concomitant fluid retention and/or to the medication used to treat it.<sup>6–8</sup> Considering the age of the affected population as well as their potential comorbidities, the coexistence of leg oedema related to chronic venous disease and lymphatic system pathology can also be expected in many CHF patients. Additional factors related to possible peripheral oedema occurrence and progression in this group of patient are limited mobility, possible malnutrition, and hypoalbuminemia leading to a decrease in oncotic pressure.<sup>9</sup> In patients with right-sided HF, blood stasis and venous and lymphatic hypertension result in swelling and fluid collection below the heart level (including in the lower limbs and sacral region or pleural cavity). In left-sided HF, a decrease in cardiac output, in addition to the possible subsequent influence on right-side heart function impairment, also activates compensatory (nervous and hormonal) mechanisms that result in peripheral oedema related to the activation of the renin-angiotensin system, antidiuretic hormone release, and retention of sodium and water.<sup>6,7</sup>

The commonly used New York Heart Association Classification (NYHA classification) consists of four classes of HF, but in its functional description, no references to lower leg oedema or its importance can be found.<sup>10,11</sup>

The commonly used HF classification (NYHA classification) presents 4 classes of HF, but in this functional classification description, no references to lower leg oedema or its importance can be found.<sup>10,11</sup> Despite the common use of the NYHA classification, the proposed staging discriminates HF patients across the wide spectrum of clinical signs and symptoms related to soft tissue swelling in this population. In the 2016 ESC guideline document, ankle oedema is mentioned among the typical and specific symptoms of HF, such as breathlessness, orthopnoea, reduced exercise tolerance, and fatigue.<sup>4</sup> The presence of more advanced swelling, including advanced peripheral oedema as well as sacral or scrotal swelling, is included in the discussion of less specific signs related to HF occurrence.<sup>4</sup>

The growing number of patients with potentially heart-affecting diseases, including arterial hypertension, diabetes, and heart ischaemic disease, as well as the ageing of the population, has resulted in a growing number of patients with advanced stages of CHF. In terms of this community health-related situation, the prevention and recognition of the early HF stages seem to be justified and required. According to the literature and daily clinical practice observations, lower leg complaints related to vascular problems concern almost half of the adult population.<sup>12</sup> In the Bonn Vein Study, chronic venous disease-related complaints were reported in 56% of the examined population and in the Polish study, the prevalence of lower limb chronic venous disease was 45% in the female population and 37% in the male population.<sup>13,14</sup> Contrary to the large epidemiological studies performed on chronic venous disease patients, the prevalence of CHF-related oedema in the community is unknown. In addition to chronic venous disease, bilateral leg swelling can also occur in other pathological conditions, including occupational leg oedema, lymphedema, obesity, or hypoalbuminemia. The relatively high prevalence of at least some of the aforementioned clinical states can mask the presence of HF-related oedema. In this aspect, the use of bilateral leg swelling as the single diagnostic HF-related parameter seems to be of very low sensitivity and specificity. On the other hand, implementation of leg swelling assessments in the screening diagnostics algorithm based on the general patient assessment can also be a valid and important approach for recognition of the early stages of CHF. Kedler *et al.*, in a study based on physical examinations additional testing in the diagnostics of HF in the primary health care setting, reported a high prevalence of bilateral ankle oedema in newly diagnosed patients with HF compared with the population without heart insufficiency (40.6% vs. 22%).<sup>15</sup> Todd *et al.*, in a study dedicated to screening for undetected cardiac dysfunction in a cohort of 102 unselected patients with bilateral swelling

classified preliminarily as lymphedema, evaluated B-type natriuretic peptide (BNP) levels as well as potential heart abnormalities in asymptomatic cardiac patients.<sup>16</sup> Elevated BNP concentrations were observed in 7% of lymphedema subjects, and in all these patients, heart pathology was confirmed by echocardiography.<sup>16</sup> Kataoka *et al.* studied the prevalence of leg oedema in asymptomatic patients at risk of symptomatic HF development.<sup>17</sup> The authors used the criteria from the 2001 Chronic Heart Failure Guidelines, which specified stage A HF as patients with a high risk for congestive HF development but without structural heart disease or heart-related symptoms.<sup>18</sup> Leg oedema was observed in 12.0% of 274 subjects at risk of HF; in most of the cases (88%), the oedema was localized as ankle or foot oedema. Compared with the patients without leg swelling, the lower limb oedema patients were older, more likely to have pulmonary crackles (52% vs. 31%), and more often had varicose veins (55% vs. 15%).<sup>17</sup> Ammar *et al.* estimated the prevalence of stage A HF in the community as 22%.<sup>19</sup> This high prevalence of subjects at risk of HF development supports further research dedicated to early recognition of HF development in initially asymptomatic patients. Unfortunately, as mentioned previously, the occurrence of leg swelling as the only patient sign has limited sensitivity in HF recognition and, in most cases, has to be supported with either the occurrence of other symptoms or signs or additional imaging or laboratory tests. Mueller *et al.*, in their study performed in the emergency department setting, observed the prevalence of lower limb oedema more often in patients with cardiovascular causes of dyspnoea than in the patients with non-cardiovascular dyspnoea cases (47% vs. 23%).<sup>20</sup> Considering the current knowledge as well as the prevalence of leg swelling in the community, the routine assessment of BNP or other HF markers in all patients with lower leg oedema seems to not yet be justified. Further research is needed to define the proper and simple clinical algorithm allowing the diagnosis of the early stages of CHF. However, the presence of bilateral leg swelling should justify further efforts to exclude HF by physical examination and, if required, by further specialist workup.

## Local leg swelling consequences in heart failure patients

Various severities and levels of advancement of lower limb swelling can be observed in patients with CHF. In the most advanced cases, massive peripheral oedema of the lower limbs and/or sacral region has been observed. Except for the typical symptoms of CHF, such as shortness of breath and physical capacity limitations, the local symptoms of the lower limbs can significantly influence the patient's general condition and quality of life.<sup>21</sup> The presence of leg heaviness,

pain, advanced leg oedema, and mobility limitations can be accompanied by local skin injury and transcutaneous fluid migration. In cases of more advanced and permanent swelling, the process of skin liquid transudation, epithelial maceration, and soft tissue oedema can lead to the development of large skin and subcutaneous tissue defects and chronic leg ulcer occurrence. In long-term follow-up, the persistence of permanent swelling of the lower limbs results in trophic changes with skin discoloration, inflammation, and induration. Augley *et al.* prospectively analysed a group of 100 patients with lower limb stasis ulcers. The diagnosis of stasis ulcer was based on clinical criteria (venous insufficiency, cutaneous signs, and/or severe leg oedema), and the results were compared with a group of 200 control subjects. Multivariate analysis showed that stasis ulcers were strongly associated with the presence of venous insufficiency and HF.<sup>22</sup> HF was also significantly associated with the bilateral localization of leg ulcers.<sup>22</sup> On the other hand, in the cross-sectional study by Kelly and Gethrin performed in a population of venous leg ulcer patients, the prevalence of symptomatic CHF was 18%.<sup>23</sup>

In cases where soft tissue defects are already present (e.g. a chronic wound of the foot or in the leg segment below the knee), the presence of HF with significant fluid accumulation in the lowest parts of the body can significantly affect the healing process, leading to delayed healing or worsening of the local condition. According to a study performed on 107 consecutive patients with foot ulcers and diabetes, the only independent predictive factor responsible for failure of healing, delayed healing at 12 weeks, or a reduced healing rate was the presence of congestive HF.<sup>24</sup> In the study performed by Xu *et al.* on a group of 330 consecutive patients with diabetic foot ulcers, HF was present in 64.3%. Simultaneously, the prevalence of HF increased with increased Wagner classification grade from 1 to 5 (grade 1–42% of the patients had HF and grade 5–87% of the patients had HF). The presence of HF also correlated with a greater risk of worse prognosis.<sup>25</sup>

The worsening of local leg oedema should also be considered an important parameter when documenting a decline in heart function. However, its use as the only variable in heart status monitoring is questioned. Kataoka, in a study based on 83 ambulatory HF patients with established mild to moderate HF, assessed bilateral leg oedema and fluid weight gain to determine the value of monitoring this parameter monitoring in the follow-up of already diagnosed HF patients.<sup>26</sup> In the study, the following potential HF-related parameters were evaluated: weight gain, leg oedema, ultrasound pleural effusion, and pulmonary crackles. Compared with the only the presence of leg oedema, the patients with leg oedema events and additional HF signs had more clinically symptomatic worsening of their HF (7% vs. 55%) with a simultaneously higher incidence of elevated serum BNP. It should also be mentioned that the study patients that had oedema in both legs accompanied by weight gain more often

experienced worsening HF. Among the patients with leg oedema events and additional HF-related abnormalities, weight gain was noticed in 84% of cases.<sup>26</sup> Similar to the primary HF diagnostics, despite the low sensitivity of the presence of bilateral swelling, the use of this parameter in combination with the assessment of other variables should not be limited to the clinical evaluation of symptomatic HF prognosis and progression.

## Lower limb compression in heart failure-related oedema treatment: evidence-based data on safety and efficacy

Despite the common use of compression therapy in the treatment of leg swelling, especially for leg swelling of venous and lymphatic origin, guidelines regarding its potential use in HF-related oedema therapy have not been specified. Moreover, as suggested in at least some guidelines dedicated to leg ulcer treatment, medical compression treatment is contraindicated in patients with severe and decompensated HF.<sup>27</sup>

Among the biggest problems related to the available evidence in this field is the lack of properly performed studies as well as a very heterogeneous population of HF patients with various degrees of clinical severity and varied heart pathology. Sudden movement of a large amount of blood from lower extremity veins, as happens when using compression, can, at least theoretically, lead to worsening of cardiovascular condition and pulmonary oedema.<sup>28</sup> Few case reports confirming this possibility are found in the available literature; however, this situation should not be extrapolated to the whole range of HF patients.<sup>29</sup> The ESC HF guideline document specifies the risk factors that can trigger acute decompensation of chronic cardiac failure, such as surgery or stress, but neither medical compression therapy nor manual drainage are mentioned among the suggested triggering factors.<sup>4</sup> As documented in the available studies, compression treatment can potentially be used in selected HF patients.<sup>30–35</sup>

One of the first studies concerning the use and effect of compression therapy in HF patients was reported by Dereppe *et al.*<sup>30</sup> In this study, a very heterogeneous group of 11 patients (six patients in the acute phase of myocardial infarction and only five with CHF) was included. A Swan-Ganz catheter-based evaluation of the consequences of lower leg pneumatic compression was used. After compression application, statistically significant increases in right auricular pressure, mean pulmonary artery pressure, and pulmonary wedge pressure were observed; all returned to their initial values 30 min after stopping the intermittent compression cycles. Unfortunately,

due to the very small number of CHF patients in this study, the clinical significance assessment of the pulmonary artery pressure increase in this subpopulation was not possible.<sup>30</sup> Galm *et al.*, in a study performed in NYHA class II HF patients, compared three groups of patients treated with knee length compression stockings.<sup>30</sup> In this study, the mean blood pressure, heart rate, and plasma level of human atrial natriuretic peptide (hANP) were measured within a period of 3 h in healthy volunteers, chronic venous insufficiency patients, and chronic venous insufficiency patients with concomitant class II HF according to the NYHA classification. A significant but transient increase in the hANP after compression was observed only in the group with venous insufficiency and concomitant HF. The rise in the hANP was noticed after a mean time of 10 min after compression application with fast normalization to baseline values. None of the patients manifested clinical worsening of their cardiovascular condition. In chronic venous insufficiency patients without HF, no hANP concentration changes were noticed, but after compression use, transient mean arterial blood pressure elevation was observed. According to the study results, the authors suggested that in non-end-stage HF patients, cardiac stress related to the use of below the knee compression was only transient, and there was fast adaptation to haemodynamic changes.<sup>31</sup> In NYHA class II HF patients (which were evaluated in this trial) with chronic venous insufficiency, sudden movement of a large amount of blood from the lower limbs (from the deep vein system as well as enlarged varicose veins) led to a temporary increase in hANP levels, which was not observed in chronic patients with only venous insufficiency.<sup>31</sup>

In another study focused on surgical varicose vein patients, the long-term effect of surgical varicose vein removal on brain natriuretic peptide levels was observed. Surprisingly, in the group of 150 patients qualified for surgical varicose vein removal, the presence of a preoperative increase in brain natriuretic peptide over >100 pg/mL was observed in 7.3%. After varicose vein removal, a decrease in brain natriuretic peptide was noticed in all patients, including the group of patients with elevated baseline BNP; in this study, BNP assessment was performed preoperatively as well as 1 and 3 months after the procedure.<sup>32</sup>

The influence of blood movement from the lower limbs on heart function was also studied in other studies of HF patients. In the study conducted by Bain *et al.*, 15 patients with moderately severe and severe chronic congestive HF were studied to assess the central haemodynamic changes after short-term increases in lower body positive pressure.<sup>33</sup> In the haemodynamic assessment of all patients, Swan Ganz catheterization and arterial cannulation were used. The patients were treated in the supine position by means of medical anti-shock trousers with pressures of 25 and 55 mmHg. The application of pneumatic compression caused an increase in both mean right atrial pressure and mean pulmonary artery pressure, but there were no significant changes in

pulmonary vascular resistance, the cardiac index, the left ventricular stroke work index, the right ventricular stroke work index, or cardiac power output. According to the study results, a short-term increase in cardiac return, despite the right-side heart pressure increase, did not significantly change left-side heart function.<sup>33</sup>

Regarding the potential harmful effect of fluid transfer from lower limb vessels to the central circulation, research focusing on the most severe stage of HF is especially important. Wilputte *et al.* tested the use of multilayered bandage dressings on the lower limbs of NYHA classes III and IV HF patients.<sup>34</sup> A Swan-Ganz catheter was used for the assessment of cardiovascular variables, and the effect of both bandage compression and muscle contraction was investigated. As documented in this study, simultaneous multilayer bandage compression and muscle contraction induced a significant increase in the right arterial pressure and led to transient deterioration of the right and left ventricular functions with an increase in preload and afterload. Despite the return of the investigated parameters to baseline without long-term heart clinical impairment, the authors of the study suggested that continuous use of multilayered bandages in severe HF patients should be limited.<sup>34</sup>

It seems that, in addition to HF class and severity, the type of compression/drainage procedures matters, and their role in potential heart function impairment should be taken into consideration. Among the most frequently used compression garment in the treatment of the venous and lymphatic diseases, the MCS should be mentioned.<sup>1,2</sup> MCS is usually available in four classes of compression, from the weakest class 1, which corresponds to the compression pressure of 18–21 mmHg at the ankle level to the class 4 representing very strong compression, corresponding to 50 mm Hg or more.<sup>1</sup> The required length of the compression garment depends on the indications, leg anatomy, and patient's tolerance to the compression.<sup>1–3</sup> In patients with foot, ankle-level, and distal calf swelling, a knee length compression can be used. In the cases of the swelling concerning also upper calf, knee level, or thigh level, the use of thigh length compression is reasonable. In the patients without significant leg swelling or in prophylactic indications, class 1 compression MCS or prophylactic graduated compression stockings is usually used. In more advanced chronic venous or lymphatic diseases, including advanced leg swelling, the higher class of compression (e.g. class II) can be applied; however, patient's tolerance as well as possible adverse effects should be taken into consideration.<sup>1,2</sup> The risk of adverse effects increases with the compression class—MCS in classes III and IV is usually used in advanced lymphedema, post-thrombotic syndrome, or venous leg ulcer limbs.

Recently, an interesting alternative to the traditional elastic MCS compression has been proposed. It is non-elastic, patient-oriented compression based on the special knee length or thigh length garment adjusted to the leg by the

patient, with the special wraps that are potentially easier to apply as well as can be adjusted to the leg circumference and size changes during application and day course. Another alternative to the commercially available compression is the use of elastic or non-elastic bandages. In walking patients, to achieve the high level of the compression as well as an optimal support to the calf muscle pump, the use of a low expandable, short stretch bandages seems to be reasonable.<sup>35</sup> Among other physical methods used for lower leg oedema treatment, a decrease in usage of manual lymphatic drainage should also be mentioned. Active leg compression can also be achieved by the pneumatic sequential compression devices including foot pump compression, knee-length, or thigh-length intermittent pneumatic compression.<sup>2</sup>

The influence of sequential compression devices on HF patient status has been evaluated in some studies. Nose *et al.* used intermittent pneumatic compression in a venous thromboprophylaxis trial that included 19 patients with aggravated HF (all patients  $\geq$  stage III according to NYHA).<sup>36</sup> In all patients, an increased flow velocity in lower limb veins was reported when using the intermittent pneumatic compression (IPC) devices. None of the patients presented worsening of their cardiovascular condition, but in this study, patients were treated with foot or foot and calf-length intermittent compression sleeves only. In another study performed in CHF patients to investigate efficient venous thromboembolism prophylaxis, the effect of intermittent pneumatic cuff compression on central haemodynamic parameters was studied.<sup>36</sup> This study also used only foot compression devices. Twenty patients with HF and at least two of three criteria were included: pulmonary artery wedge pressure greater than or equal to 15 mmHg, pulmonary artery congestion or oedema on chest X-ray performed within the last 24 h, and/or documentation of organic heart disease in the medical records. Haemodynamic changes were evaluated by pulmonary artery catheterization. Clinical exacerbation of HF was not observed in any of the patients, and despite the theoretical risk of increased venous return to the heart, the application of intermittent pneumatic foot compression did not significantly alter the central haemodynamic parameters in the CHF patients in this study group.<sup>36</sup>

As documented in another study concerning CHF patients, an intermittent compression device with a thigh-length pneumatic cuff can also be applied in properly selected individuals.<sup>37</sup> The influence of thigh-length sequential compression was tested in the study performed by Moady *et al.* that included 19 patients with systolic left ventricular dysfunction and functional classes NYHA II and III CHF (mean left ventricular ejection fraction was 29%, range 10–40%).<sup>37</sup> Haemodynamic and echocardiographic parameters were measured before, during, and after intermittent compression activation (two cycles of compression per minute were used). The use of pneumatic sleeves caused an increase in pulmonary venous return, leading to a decrease in systemic vascular

resistance and an increase in cardiac output and stroke volume. In this study, no significant increases in heart rate or symptoms of clinical worsening were observed.<sup>37</sup> Discussing and explaining the study results and benefits of IPC in these clinical situations, the authors suggest at least two adaptive mechanisms of the cardiovascular system in response to increased heart preload and afterload caused by intermittent pneumatic compression; both are related to the subsequent systemic vascular resistance decrease. The first mechanism proposed is an increase in secretion of nitric oxide from the vascular endothelium, causing vasodilatation and subsequently systemic vascular resistance decrease.<sup>38–40</sup> The second mechanism could be the sympathetic autoregulation decrease that occurs when using IPC; these observations were made according to the results from a laparoscopic surgery study with IPC implementation.<sup>37</sup> Considering the characteristics of the group of patients investigated in the study and the observed positive IPC effect on the left ventricle functional parameters in patients with left systolic ventricular dysfunction, the authors suggested very careful use of this technique in subjects with high right atrial pressures or severe right ventricular systolic dysfunction.<sup>37</sup> As suggested, in these particular situations, an increasing venous return cannot translate to improvement in LV stroke volume and cardiac output (despite a decrease in systemic vascular resistance).<sup>37</sup>

Among other possible options to potentially influence local leg swelling in patients with HF, manual lymphatic drainage and electrical stimulation should be mentioned. The efficacy and safety of manual compression drainage procedures were investigated by Leduc *et al.* in a group of NYHA classes III and IV patients.<sup>41</sup> In the study group of nine HF patients, manual lymphatic drainage was applied for a total of 15 min using 'Leduc's technique', and haemodynamic parameters were measured with duplex ultrasound of the left and right side of the heart. Aside from the expected leg circumference reduction, no clinical worsening of heart function was observed. Additionally, in the study population, the mean heart rate decreased, and no significant changes in the studied parameters were observed, including left and right diastolic pressures or pulmonary artery pressure. According to these study results, the authors suggested the possibility of using manual lymphatic drainage in patients with HF and lower leg oedema.<sup>41</sup> Taking into account the small number of patients, the results of this particular study should be confirmed in the larger group, especially in individuals with severe HF.

Another interesting option influencing blood outflow from the lower limbs is the use of electrical calf stimulation devices.<sup>42</sup> There is no need for direct compression with this procedure; the use of the patient's own muscle contraction forces and the low invasiveness of the procedure suggest the possibility of using it in CHF patients. In a pilot study performed in a small cohort of CHF patients, electrical calf

stimulation was used (average 1 h per day) and resulted in a reduction in the lean mass of the legs without cardiac function worsening.<sup>43</sup> As documented in previous studies conducted in other patient populations, an improvement in venous outflow and flow velocity as well as a decrease in leg swelling and fluid accumulation can be expected in legs undergoing electrical calf stimulation.<sup>44,45</sup>

In addition to the traditional, lower leg swelling-related indications, the use of compression therapy in HF patients was also the subject of a trial focusing on postural hypotension related to HF. Under normal physiological conditions, the postural reduction in venous return reduces cardiac output, but mean arterial pressure is maintained by vasoconstriction and increased heart rate. In HF patients, decreased cardiac output and reduced peripheral tissue perfusion lead to activation of the sympathetic system as well as to an abnormal postural response.<sup>46</sup> This abnormal response is based on maintained or even enhanced cardiac output and blood pressure as well as on the lack of a reflex increase in heart rate and total peripheral resistance. In some patients, even these mechanisms can be insufficient, ultimately leading to postural orthostatic hypotension (OH).<sup>47</sup> Broznwear *et al.* investigated the influence of the currently used multidrug therapies on the cardiovascular autonomic response to postural stress in HF patients.<sup>48</sup> Postural OH was recognized in 16 out of 33 HF patients, independent of NYHA functional class. The authors concluded that, in HF patients, the autonomic vasomotor response to postural stress is abnormal and more pronounced with increasing disease severity. An interesting proposal regarding the use of compression in patients with HF-related OH was suggested by Gorelik *et al.*<sup>49</sup> In their study of 108 individuals aged over 60 years who were hospitalized for decompensated HF, sitting-induced postural hypotension was recognized in 49% of cases.<sup>49</sup> In this study protocol, compression bandages were applied along both legs, before sitting, on the next day after admission in patients manifesting postural hypotension. In 21 of 49 patients, the compression bandages prevented postural hypotension and decreased the degree of postural blood pressure fall. No clinical worsening or HF worsening was observed in this group.<sup>49</sup> In an overview concerning HF and OH, Gorelik *et al.* suggest that the prevalence of OH in HF patients ranges from 8% among community-living individuals to 83% in elderly hospitalized patients.<sup>50</sup> Due to the relatively frequent adverse effects occurrence, related to possible proposed OH pharmacotherapy with fludrocortisone and midodrine in HF patients, these authors also emphasized the role of the non-pharmacological interventions in this particular patient cohort.<sup>50</sup> Also the group of Papismadov *et al.* documented statistically significant lower rate of the postural hypotension in hospitalized elderly patients who underwent compression leg bandaging and mobilization.<sup>51</sup>

## Comprehensive management of leg swelling using medical compression in heart failure patients

According to currently available evidence, no level A recommendations regarding the use of compression therapy in CHF patients can be specified. Considering the heterogeneous patient population in terms of local leg swelling-related complaints as well as heart disease severity and pathogenesis, an individual approach must be considered in all cases of lower limb swelling related to CHF. Of course, it has to be emphasized that the use of compression treatment should not replace pharmacological treatment with diuretics and other medications; instead, it should be part of a multispecialty approach to the disease and treatment of its complications in selected cases.

The number of patients with HF and other concomitant diseases, including chronic venous and lymphatic pathology, results in a number of visits to other specialty centres by HF patients with leg swelling. The standard approach to leg swelling in patients with confirmed or concomitant HF usually requires modification of pharmacotherapy based on patient dehydration and fluid retention reduction. In the majority of CHF patients with NYHA classes I and II HF, the use of medical compression as a supportive treatment for lower limb oedema seems to be reasonable and safe if it is well tolerated locally by patients. Of course, in this situation, according to prior research and real-world clinical practice, compliance with compression therapy differs between the patient groups and indications.

Another problem that impacts compression tolerance is the possibility of local and systemic adverse effect occurrence after compression implementation. Too strong compression, especially in the places of angulations or skin irregularities, can lead to the skin injury and soft tissue necrosis as well as can cause significant pain complains. The application of the high-grade compression in the patients with peripheral, arterial ischaemic disease can potentially result in the blood flow impairment and ischaemia worsening.<sup>1</sup> In some of the patients, the low level of compression tolerance can manifest by dyspnoea. This particular complain should be especially monitored in the HF patients as the potential presentation of the HF-related worsening. Precise information and rules regarding the supervised application of compression therapy for both efficacy and safety, as well as to inform patients about the possible side effects and warnings, should also be part of the compression prescription process if used in patients with leg swelling related to CHF. As mentioned before, various compression options can be proposed, starting with MCSs in the form of knee-length and thigh-length commercially available garments. Like in other indications, the shape of the leg and extent of the swelling should always be taken into consideration. An important difference regarding the

use of compression in this group (especially when used together with pharmacological, dehydration-oriented treatment) is the high probability of rapid leg circumference changes in the course of the therapy. In patients with sudden and significant leg swelling reduction, a reduced size compression garment should be considered after leg circumference decrease to maintain the compression efficacy (which can require repeated measurement of the legs as well as compression stocking exchange). When using medical stockings, due to foot swelling observed in the majority of HF or gravity-influenced diseases, compression garments with a foot segment should be suggested. Other options in the initial phase of compression use are the implementation of short stretch bandages or patient-oriented compression based on the application of a non-elastic wrap system. In both of these options, the size of the compression garment can be modified and adjusted according to the current leg size. Another interesting option, the use of electrical calf stimulation can also be proposed, especially in patients with contraindications to standard compression (i.e. PAOD patients). From a practical point of view, the application of a pneumatic sequential compression device is usually taken into consideration as a temporary solution as it has limited efficacy as continuous treatment after an intermittent compression course if used without other compression garments. Additionally, this treatment should be closely supervised in terms of safety and efficacy.

As mentioned before, relatively little is known about the safety of the long-term medical compression use in patients with more advanced stages of HF, including the group of patients with decompensated or end-stage heart insufficiency. In most of these cases, the standard compression therapy approach seems to be contraindicated, and further research should be provided to select patients who benefit mostly from this kind of supportive therapy. The projected studies focusing on NYHA classes III and IV HF patients should include both efficacy and safety evaluations and various heart conditions and pathology (i.e. right and/or left ventricular dysfunction), as well as various compression protocols, should be addressed. According to the current knowledge, the use of compression as a sole initial treatment in this patient group should be omitted. Despite some papers published with research performed on a group of NYHA classes III and IV information on which type of compression can be successfully and safely used in these patients is lacking.

## Conclusions

In patients with leg oedema, the presence of CHF as the factor causing or worsening local leg swelling should always be considered. In all patients with bilateral leg swelling, the presence of possible HF always has to be evaluated. The use of

local leg compression can be considered in stable CHF patients without decompensated heart function (NYHA I and II) for both CHF-related oedema treatment and for treatment of the concomitant diseases leading to leg swelling occurrence. The use of medical compression in more severe classes of CHF (NYHA III and IV) should be the subject of future clinical studies to select the safest and most efficient

compression method as well as to select the patients who benefit most from this kind of treatment. The current knowledge does not support the routine use of lower limb compression in swelling related to end-stage heart disease and decompensated HF; further studies should be conducted to establish the role of medical compression as part of the multidisciplinary care of this complex clinical condition.

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