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INTERMITTENT PNEUMATIC COMPRESSION THERAPY: A SYSTEMATIC REVIEW

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ABSTRACT

Intermittent Pneumatic Compression (IPC) therapy is an effective modality to reduce the volume of the lymphedematous limbs alone or in conjunction with other modalities of therapy such as decongestive therapy. However, there is no consensus on the frequency or treatment parameters for IPC devices. We undertook a systematic review of contemporary peer-reviewed literature (2004-2011) to evaluate the evidence for use of IPC in the treatment of lymphedema. In select patients, IPC use may provide an acceptable home-based treatment modality in addition to wearing compression garments.

Keywords: intermittent pneumatic compression, lymphedema, pneumatic compression

Lymphedema is a condition resulting from lymphatic system disruption. Accordingly, protein-rich fluid accumulates in soft tissues of the affected body parts, such as arms, hands, trunk, head, or neck (1,2). There are two types of lymphedema, namely, primary and secondary lymphedema (3). Primary lymphedema can occur due to the dysplasia of the lymphatic system since birth or may occur later in life. Secondary lymphedema is more common in the U.S. and caused by the disruption of the lymphatic system resulting from extrinsic cause such as cancer or its treatment (i.e., removal of axillary lymph nodes or radiation therapy) (1,4). It is estimated that one-third to two-fifths of breast cancer survivors are conservatively estimated to develop lymphedema (5-7). Therefore, risk reduction and management of lymphedema is essential for these patients.

Pneumatic compression devices have been utilized in the medical management of swelling since the early 1950's (8,9). The initial IPC devices were pumps with a single-chamber pressure cuff that applied a uniform level of compression to the entirety of the limb. Segmented compression devices were developed in the 1970s and eventually evolved technologically to allow pressure gradients, with the pressure in the distal chambers being higher than in the proximal chambers and enabling a sequential mechanism of distal to proximal application of pressure.

In recent years, advanced pneumatic compression devices have evolved even further in their sophistication and allow for digital programming to mimic manual lymphatic drainage techniques and promote fluid clearance from the proximal trunk and extremity. The advanced IPC devices have appliances that can treat the torso as well as the limbs.

IPC devices can be broadly categorized as outlined in *Table 1* (10). As pump technology has progressed, it has been accompanied by a body of research

TABLE 1
Characteristics of IPC Devices

IPC Device	Unique Characteristics
Single Chamber	• Single cuff that expands and contracts applying pressure against the limb. • No manual control over pressure distribution. • No pressure gradient exists. • Not optimal for lymphedema management at this time.
Multi-Chamber segmented without manual control	• Commonly have 3-4 chambers which inflate sequentially from distal to proximal until all are inflated and then all deflate together. • May have limited pressure programming options and are not typically independently adjustable. • May be constructed so that each chamber has the same pressure and pressure gradient is achieved by virtue of the limb contours. • These pumps can treat one or two legs or arms.
Multi-Chamber segmented, calibrated	• Gradient of pressure exists; higher pressure in the distal chambers and lower pressures in the proximal chambers • Exhibit at least three zones of pressure; some pumps allow adjustment of each chamber. • Typically manually programmable, enabling adjustment of the level and location of compression. • May have from 4 to up to 36 chambers.
Advanced compression systems	• Enable digital programming. • May simulate, through adjacent pneumatic truncal applications, the action of clearing the proximal trunk and extremity. • The truncal and proximal chambers enable clearing of the lymphatic pathways. • Only 1 to 2.5 chambers at a time are active as compression progresses in a distal-to-proximal direction, simulating the action of manual lymphatic drainage.

Source: Adapted from Medical coverage policies: Lymphedema pumps. 2005; https://www.bcbsri.com/BCBSRIWeb/pdf/medical_policies/LymphedemaPumps.pdf

supporting medical applications of these devices both alone and in conjunction with other compression treatment modalities for optimal reduction and control of lymphedema. Research findings, however, are somewhat lacking in terms of the reported physiological effects of pumps and support for the optimal application parameters for pump use. Further, reports vary regarding volumetric improvements in swelling and symptom relief associated with lymphedema treatment using IPC devices.

This manuscript presents the results of a systematic review investigating the evidence for pneumatic compression use with lymphedema and provides recommendations for clinical applicability of these data.

METHODS

A systematic review of the literature was performed to examine contemporary peer-reviewed literature (2004-2011) evaluating the use of intermittent pneumatic compression therapy in the treatment of lymphedema. The current review is part of a larger project of the American Lymphedema Framework Project (ALFP) in partnership with the International Lymphedema Framework (ILF) to provide evidence for the Second Edition of the Best Practices Document, a project which provides clinical practice guidelines on all aspects of lymphedema diagnosis and management.

A systematic review of the literature was performed in two phases (*Fig. 1*).The initial phase was performed by a reference research librarian who searched 11 medical indices (PubMed, Medline, CINAHL, Cochrane Library databases (Systematic Reviews and Controlled Trials Register), PapersFirst, Proceedings First, Worldcat, PEDro, National Guidelines Clearing House, ACP Journal Club, and Dare) for articles using terms to capture all literature related to lymphedema (lymphedema, lymphoedema, elephantiasis, swelling, edema, and oedema). Article archives of the authors and reference lists from related articles were also examined through 2010. Further, additional literature in 2011 was considered for inclusion. A total of 5,927 articles were retrieved by the reference librarian search. Of 5,927 articles, 4,624 articles were excluded because they were not related to lymphedema (screen 1). This left 1,303 articles to be reviewed by three editors for inclusion criteria (research study, lymphedema- related, 10 cases) and exclusion (gray literature) criteria. A total of 644 articles were excluded, thus leaving 659 articles for consideration for the topic reviews, including IPC (screen 2). The search results were then imported into Endnote (Build 3210) to remove duplicates. In this phase, key words for IPC were applied [pneumatic compression device, intermittent compression therapy (ICT)], IPC, compression pressure). A total of 13 articles were selected and reviewed by the author team (screen 3). Inclusion criteria for the final review included valid study design or literature review (randomized controlled trial, controlled trial, and literature review); primary or secondary study outcome was lymphedema; and IPC was the intervention. A total of 13 studies met inclusion criteria (screen 4). The studies are outlined in *Table 2*.

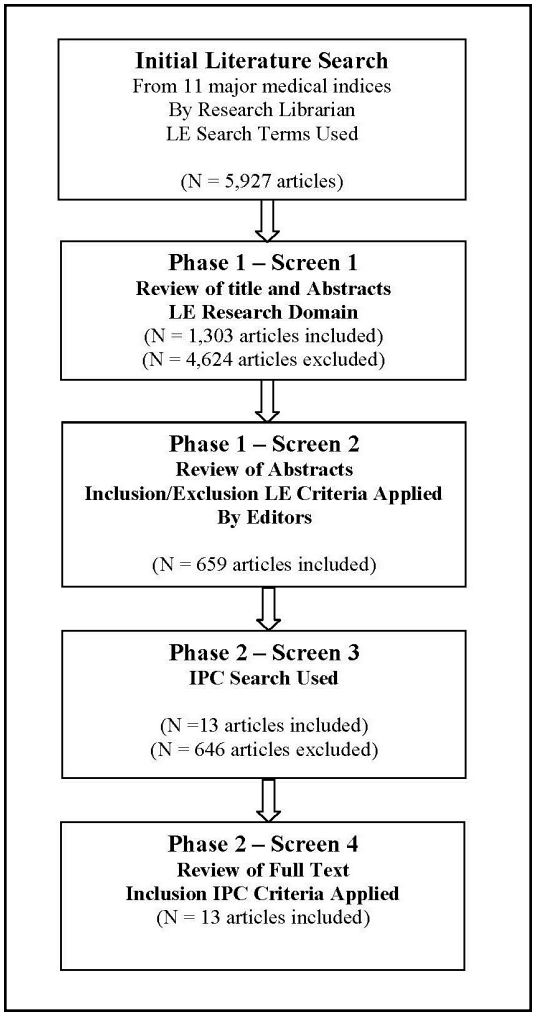

Fig. 1. Literature review process for IPC and lymphedema systematic review

Of the articles reviewed, two were systematic reviews, one was a literature

review, two were randomized control trials, six were controlled trials, and two were case studies. Each article was summarized by one author and reviewed by another author to ensure appropriate and accurate representation of the material. Information was abstracted on study design, sample, measures, intervention, pump features, pressure, frequency, outcomes, adverse events, strengths, and weakness. The Bandolier Strength of Evidence Guidelines from The Oxford Medical Journal was used to rank the reviewed articles (11). *Table 3* outlines the Bandolier model.

FINDINGS

Two level I systematic reviews were published regarding IPC therapy both focused on IPC outcomes associated with breast cancer-related lymphedema. Rinehart-Ayres et al (12) published a 2010 systematic review on the use of IPC for treating breast cancer-related lymphedema (BCRL). Of 26 full-text articles, only eight studies were designed as research studies and adhered to Sackett's levels of evidence. The conclusion was that there was no evidence to suggest that the use of IPC in the treatment of upper extremity lymphedema provides greater reduction in lymphedema than education about arm care and hygiene, and there was no evidence to support one type of IPC device over another. There was no consensus offered on the number of treatments, treatment regimen, or pump pressure settings. Moseley et al (13) published a 2007 systematic review on the use of conservative therapies to treat breast cancer-related lymphedema. They identified IPC devices as one of the modalities most likely to provide greater volumetric reductions in the treatment of BCRL.

The remaining articles reported a broad representation of outcomes, and the studies reported here all investigated unique outcomes variables. The general themes in outcome reporting center around: physiological changes associated with IPC device use, parameters for optimal pressure levels, and volumetric changes with IPC use.

Physiological Changes

Olszewski et al (14) studied tissue fluid pressure and flow under the skin in the subcutaneous tissue of the lower extremity with obstructive stage II to IV lymphedema. The limbs were studied both at rest and during distal-to-proximal manual compression and pneumatic compression under various pressures and sleeve inflation timing. Pneumatic compression generated tissue fluid pressures on the average 20% lower than the pressure in the inflated sleeve chambers. The variance in pressure gradient between the skin and subcutis may be attributed to skin rigidity (fibrosis), low hydraulic conductivity of the subcutis, and dissipation of the applied force in the subcutis to the proximal non-compressed regions. Pneumatic sequential compression produced unidirectional flow toward the groin without backflow.

Adams et al (15) employed an investigational near-infrared fluorescence technique to evaluate the physiological response to IPC therapy in three control subjects and six subjects with unilateral breast cancer-related lymphedema. Lymphatic propulsion rate, apparent lymph velocity, and lymphatic vessel recruitment were measured before, during, and after 2.5 hours of advanced IPC therapy. Lymphatic function improved in all control subjects and all asymptomatic arms in BCRL subjects. Lymphatic function improved in only 4 of 6 BCRL affected arms suggesting that pneumatic compression alone may not be sufficient to improve lymph uptake when system dysfunction is present.

Pressure Level

According to Mayrovitz (16), the compression pressure settings routinely used are well in excess of pressures measured within the normal skin lymphatic vessels, which are in the range of ± 4 mmHg to 8

TABLE 2
Articles Abstracted and Reviewed

Citation	Study Design	Reported Findings	Level of Evidence
Moseley, AL et al. 2007	Systematic review • 43 articles reporting outcomes of studies using common conservative BCRL therapies	IPC devices identified devices as one of the modalities most likely to provide greater volumetric reductions in the treatment of BCRL.	I
Rinehart-Ayres, M et al. 2010	Systematic review • 23 articles reporting the use of IPC for treatment of BCRL	No evidence to suggest that the use of IPC in the treatment of UE lymphedema is better than education about arm and hygiene. No evidence to support one type of pump or treatment regimen over another.	I

Pilch, U et al. 2009	RCT
	• N = 57 women with BCRL (90s-90s single chamber sleeve vs. 90s90s 3-chamber sleeve vs. 45s-15s single chamber vs. 45s-15s 3-chamber)
	• Dependent variables: limb volume measured by water displacement
	• Parameters: Daily treatment for 5 weeks (25 treatments)
	  • Single chamber vs. 3-chamber (30-50 mmHg)
	  ◦ 90 second compression and 90 second decompression
	  ◦ 45 second compression and 15 second decompression
		Significant reduction of edema volume was observed in all therapeutic subgroups, regardless of cycle times and number of chambers.
		No Adverse Events reported
			II

Szolnoky, G et al. 2009	RCT • N = 27 (MLD vs. MLD + IPC) • Dependent variables: limb volume calculated by circumferential measures taken every 4 cm	No significant difference between groups regarding volume reduction. Both groups reported a decrease in symptoms. No Adverse Events reported	II

	• Parameters: LymphaMat sequential pump with 12 overlapping segments (50 mmHg) treatment over 2 weeks • 13 subjects: 60 minutes MLD • 14 subjects: 30 minutes MLD and 30 minutes IPC		
Partsch, H et al. 2008	Literature review • 59 articles on compression therapy – garments, bandages & pumps – in the management of venous and lymphatic diseases.	Little is known about dosimetry in compression, for how long and the optimal compression level(s). 10-30 mmHg stockings effective in managing telangiectases after sclerotherapy, etc. High level compression with bandages (30-40 mmHg) are effective healing leg ulcers, etc.	II
Vanscheidt, W et al. 2009	Clinical trial, pre-test/post-test design, between group comparison using an experimental pump • (N = 28) sustained pneumatic compression (SPC) vs. intermittent pneumatic compression (IPC) • Dependent variables: volume as measured by water displacement • SPC additionally measured leg circumference • IPC additionally measured changes in toe systolic pressure and transcutaneous O2 pressure • Parameters: • SPC: 6 treatments for 6 hrs each: ◦ 20, 30, 40mmHg at the gaiter graduated ◦ 20, 30, 40 mmHg at the gaiter non-graduated • IPC: 6 treatments for 6 hrs each: ◦ 40, 50, 60 mmHg at the gaiter graduated	There was a significant relationship between increased SPC/IPC pressures and reduced leg edema. • Limb volume was most effectively reduced with the highest pressures of 40 mmHg (136 ml) non-graduated SPC and 60 mmHg (87 ml) graduated IPC. However, some patients reported discomfort at these pressures. • Limb volume was reduced >100 ml with 30-40 IPC and by 69 ml with 50 mmHg graduated IPC. These pressures were reported to be comfortable. No Adverse Events reported	III

Continued

Table 2 (continued)

Citation	Study Design	Reported Findings	Level of Evidence

Olszewski WL et al. 2010	Non-randomized controlled, pre-test/ post-test
	• N = 30; 25 with obstructive unilateral leg lymphedema and 5 normal controls
	• Dependent variables:
	  • Tissue fluid pressure measured by wick-in-needle technique
	  • Limb volume measured by strain gauge plethysmography
	  • Lymphatic fluid uptake measured by lymphoscintigraphy
	• Parameters: Distal to proximal manual massage and sequential pneumatic compression with 8 chamber pump. Pressures 50 to 125 mmHg
		The pressures generated in tissue fluid by IPC were lower than the actual pressure in the inflated chamber The gradient depended most likely on skin rigidity (fibrosis) and dissipation of the applied force in the subcutaneous tissue to the proximal non-compressed regions.
		Tissue fluid flow occurred during manual compression only during pressing of the tissues and stopped after cessation of manual compression
		No Adverse Events reported
			III

Adams, K, et al. 2010	Non-randomized, controlled, pre-test/ post-test • N = 9 (6 unilateral BCRL and 3 controls) • Dependent variables: Lymphatic propulsion rate, apparent lymph velocity and lymphatic vessel recruitment as measured by NIR-fluorescent imaging • Parameters: Flexitouch automated, calibrated device	Evidence of lymphatic function improvement, defined as proximal movement of the dye, was noted in 4 of 6 BCRL-affected arms and in 3 control arms No Adverse Events reported	III
Ridner, SH et al. 2008	Quasi-experimental, pre- and post-test design. 155 community-swelling individuals, 93 with cancer related LE and 62 with non cancer-related LE. Participants used a program-mable pneumatic device 1 hr twice a day for one month and then 1 hr per day. Post-therapy survey conducted after one month.	Patients without cancer were more adherent to the protocol. Both groups reported improvement in physical and emotional status. The use of professional MLD, self-MLD and bandaging declined. No Adverse Events reports	III

Ridner, S et al. 2010	Non-randomized, quasi-experimental, pre-test / post-test design. • N = 12 women with BCRL and trunk swelling • Dependent variables: Symptom report, circumferential trunk measures, skin changes • Parameters: • Flexitouch System: Ten 1-hr per day treatments over 10 consecutive days. Re-assessed after treatment 5 and 10.	BC patients with truncal LE may benefit using an advanced PD with truncal RX as part of their self-care program. • Symptom report: Relief reported and sustained after 5 treatment sessions. • No significant circumferential measurement changes between groups No Adverse Events reported	III
Mayrovitz, HN et al. 2007	Descriptive study • N = 10 healthy adults (33-48 years) • Dependent variables: Interface pressure as measured by 256 pressure sensors • Parameters: 45 mmHg for the LymphaPress (LP) device vs. Flexitouch (FT) device; at least 2 cycles for each device. Device assessment separated by at least 48 hrs.	The FT pressure pattern displayed a rapid rise & fall progressing from the wrist to the elbow segment evaluated. The LP pressure rose slower and was sustained at a higher level during the inflation cycle. LP pressures were significantly greater than the FT pressures. Adverse events: none reported.	V
Hammond, T 2009	Case study (N=1) BC related lymphedema • 4 week of intensive therapy with Flexitouch device followed by home therapy with same device for a 3 year follow-up period. • Reported on volume outcomes and cost associated with treatment	• Patient achieved effective volume reduction. Transition from outpatient care to home management was successful and gains were maintained with Flexitouch system. • Cost of outpatient-based treatment was 4X greater than the cost of home-based treatment with the Flexitouch Transition to home helps to alleviate costs associated with intensive outpatient therapy. No Adverse Events reported	V
Hammond, T et al. 2010	Case study N=5 BC related lymphedema. In- clinic visits taught exercise, skin care, dietary, short-stretch bandaging, compression garment and use of the Flexitouch device, followed by in-home use over 2 months	Volume outcomes were similar among patients. Trunk circumferences decreased Results suggest that limb and trunk lymphedema can be effectively treated in the home with an advanced programmable pneumatic device with truncal coverage. No Adverse Events reported	V

TABLE 3
Bandolier Ranking System

Weight of Evidence category	Description
I	Strong evidence from at least one published systematic review of multiple well-designed randomized controlled trials.
II	Strong evidence from at least one published properly-designed randomized controlled trial of appropriate size and in an appropriate clinical setting.
III	Evidence from published well-designed trials without randomization, single group, pre-post, cohort, time series or matched case-controlled studies.
IV	Evidence from well-designed non-experimental studies from more than one center or research group.
V	Opinions of respected authorities, based on clinical evidence, descriptive studies or reports of experts consensus committees.

Source: http://www.medicine.ox.ac.uk/bandolier/band6/b6-5.html

mmHg depending on measurement method and site. The pressure used must be sufficient to overcome the resistive forces within the tissue being treated, and in lymphatic obstruction, the subcutaneous tissue pressure can be significantly elevated with pressures in edematous lymphatics and tissues ranging from 15 to 18 mmHg (17). A peak inflation pressure of 25 to 50 mmHg might be sufficient for most patients in the absence of significant fibrosis.

Partsch et al (18) published a consensus of the literature on the indications for compression therapy in venous and lymphatic diseases. The levels of compression shown to be effective in different experiments are broad, and range between 5-10 mmHg and >120 mmHg. There also is a need to differentiate between sustained and intermittent pressure. Data from studies of skin microcirculation show that ischemic skin damage may occur from high levels of compression applied for long periods. A sustained pressure of 60-70 mmHg may be considered as the maximum upper limit. Strong levels of evidence support the use of IPC for thrombosis prevention after surgery, in the treatment of post-thrombotic syndrome, and in lymphedema.

Szolnoky et al (19) stated that pumps must be used at relatively low pressure to avoid collapse of the superficial lymphatics and as part of a comprehensive CDT program. In this study, MLD alone or in conjunction with IPC at 50 mmHg as part of a CDT protocol resulted in notable reductions in arm lymphedema and subjective complaints.

Treatment Times and Frequency

Ridner et al (20) analyzed self-reported data generated as part of a manufacturer's market survey on home-based IPC treatment with a programmable device. Patients were instructed to use the pump one hour twice a day for the first month, followed by one hour per day thereafter as a maintenance treatment. Among participants with non-cancer related lymphedema, approximately 56% reported following the prescribed maintenance protocol, with 7% reporting use more than once a day and 37% less than once per day. Of those patients with cancer-related

lymphedema, 32% followed the prescribed protocol, 21% reported they used the device more than twice per day, and a total of 47% of these participants reported they used the pump less than the prescribed protocol. In the non-cancer group, 7% did not use the pump at all. In the cancer group, 4% reported no use. No statistically significant association was found between reported use pattern and age, gender, lymphedema severity, or time since diagnosis. Those who used the pump as prescribed reported higher satisfaction.

Subjective Reported Changes

Ridner et al (20) studied home-based lymphedema treatment retrospectively and reported on changes in clinical utilization behaviors. Ninety-five percent of participants reported a self-perceived positive limb volume outcome. Forty-two percent reported self-perceived limb volume decreases as much as 20%, and an additional 20% reported decreases of less than 20%. They found a statistically significant drop in the use of clinician-administered MLD, from a rate of 60% MLD-usage before using a programmable IPC device to a 13% MLD-usage rate at follow-up. There was also a decrease in the application of compression bandages and in the teaching of self-MLD.

In a non-randomized, quasi-experimental, pre-test/post-test designed study of 12 breast cancer patients with truncal lymphedema treated with a programmable IPC device, Ridner et al (21) found there was statistically significant improvement in the symptoms of heaviness and tightness in the swollen truncal areas after five treatments. There was no significant reduction in truncal girth.

Hammond (22) described a single case study of a woman with breast cancer-related lymphedema who experienced no further episodes of cellulitis and hospitalizations over a 3-year time period after the initiation of IPC. Additionally, she reported less intensive and less frequent medical follow up. Hammond (23) also reported a five patient case study on the use of a programmable IPC device to treat truncal and arm breast cancer-related lymphedema. After receiving 2 months of in-clinic decongestive therapy, including in-home self-treatment with the IPC device, the patients showed reductions in trunk and arm swelling, fibrotic tissue softening, pain reduction, and improved range of motion and flexibility. The patients reported enhanced in-home compliance with their self-treatment program.

Volumetric Changes

Pilch et al (24) compared the use of single and three-compartment sleeves, and found that IPC reduced the extent of edema, with no significant differences between the type of IPC device applied. They hypothesize that, unlike MLD where lymphatic pressure is applied centripetally from proximal to distal parts of the extremity, the IPC wave in sequential compression is directed centripetally, but starts in the distal parts of the extremity. If any mechanical block hampers lymph outflow, the pressure wave shift to the proximal extremity parts may even hamper lymph drainage, if it is not preceded by emptying of the proximal lymphatic vessels. Pilch et al (24) state that another reason for the significant reduction in lymphedema, independent of the compression sequence, might involve the physiological mechanism of IPC. IPC acts as a "muscle pump" which facilitates the flow of lymph in lymphedema. During compression, the lymph vessels collapse and their content is shifted toward proximal parts of the extremity while the release of compression during a decompression interval allows refilling of lymph vessels with lymph.

DISCUSSION

Overall, the use of IPC devices for lymphedema treatment is well-founded in the literature. This review presents Level II and III evidence to support physiological

changes associated with IPC use in patients with lymphedema. These studies, individually, targeted two primary outcomes: 1) inter-vessel fluid pressure changes and the association with applied IPC pressures; and 2) the uptake of radiotracer dye into the lymphatic system. Each of these endpoints speaks to the effectiveness of the IPC device in changing the physiological milieu of the lymphatic system through compression application, a mechanism necessary to promote fluid uptake and alleviate limb swelling. These studies are consistent with past findings of improved tissue fluid translocation (25,26). However, there is evidence to suggest tissue fluid transport is not associated with transport of macromolecules (i.e., protein) from the interstitial tissue (27). This may raise questions as to the effectiveness of IPC as a stand-alone modality that promotes sustainable limb volume congestion (26,27). The results here support the necessity of a multi-modality approach when fluid uptake is desired in an altered state of lymphatic function (15).

Level I - III evidence supports compression pressures in the range between 30 and 60 mmHg. There is agreement that IPC pressure is dissipated when applied to tissue. Forces such as tissue resistance and blood pressures should be considered when applying IPC and suggest that a direct relationship exists between the level of pressure needed to impact fluid uptake and the level of resistance the tissue affords. Advanced stages of lymphedema are characterized by interstitial fibrosis which results in greater tissue resistance therefore compression levels should be set with consideration for the relatively delicate nature of the superficial lymphatics in an effort to not cause ischemic damage.

There is no standard consensus for the frequency of IPC treatments. This review portrays the results of one study that offers Level III evidence as to IPC frequency and duration. While an optimal strategy for IPC use likely varies based on the tissue and blood flow characteristics, the study presented here demonstrates that patient preference plays a significant role in determining the frequency of IPC use. While specific IPC parameters should be outlined for patients (28), considerable variance in reported IPC use is expected. Attention to patient adherence, identification of barriers to IPC treatment and willingness to tailor treatment prescription should be investigated as mechanisms to ensure optimal IPC use. IPC use undoubtedly contributes to volumetric reduction of lymphedema. However, the sustainability of volume reduction when using IPC alone is called into question through this review.

Adverse Events

None of the abstracted lymphedema studies reported significant adverse events during or after the IPC treatments. In the Vanscheidt et al (29) study of compression therapy for chronic venous edema, two patients reported discomfort at 60 mmHg when being treated with intermittent pneumatic compression but not at 40 or 50 mmHg. One patient treated with sustained pneumatic compression had skin irritation and three subjects reported discomfort at least once. It can be concluded that under these controlled circumstances, IPC devices have little detrimental effect on patient safety.

Cost Considerations

IPC devices range in price from several hundred to several thousand dollars. This review highlights evidence that suggests potential for time-saving in the clinical setting with IPC device use. This may indirectly decrease overall resource utilization and costs; however, no economic comparison has been conducted to evaluate the direct and indirect costs associated with IPC use. One single case study suggested significant cost savings with decreased incidence of infection and reduced hospitalizations when an IPC device was used to control lymphedema.

However, further investigation is warranted to explore the cost benefit of IPC use.

Clinical Relevance and Impact on Best Practice

Previous studies report that CDT is an accepted and effective combination of techniques which decongests the soft tissue swelling associated with lymphedema (1,3, 30-32). While the use of IPC devices has not been traditionally espoused as an accepted component of the gold standard of CDT, this review suggests there is a viable place for IPC devices to be utilized as an adjunct in effective management of lymphedema. Further, several clinical studies have used IPC in the context of their trials and have demonstrated good utility and outcomes with IPC devices (30,31).

The results of this systematic review indicated that IPC devices are well-tolerated in low to moderate pressure ranges, and the device enables compression application in the patient's home. IPC is also a safe and effective intervention for many suffering with chronic lymphedema who have little to no access to medical care in the health care system of proximity. Considering the aging population of the United States, it is wise to recognize interventions that have good clinical utility and are easily and safely applied by patients or their immediate care-givers in an independent, home-structured environment. This application calls for further studies among the aged and disabled in a culturally-sensitive environment.

This review demonstrates variability in IPC-related clinical outcomes based on individual patient presentation. No clear single Best-Practice guideline for IPC emerges as preferential. It is clear, however, that an individualized, multi-modal approach is optimal to treat lymphedema and evidence shows that IPC devices may play a formative role in this approach. Clinical recommendations for pneumatic pressures can be guided by the literature offered here, but no universal consensus is noted, pending further rigorous studies. These points of non-consensus have lead to international scientific bodies taking initiative to explore the current state of the science through convened symposia and conferences. The International Compression Club (ICC) has published consensus documents highlighting the obvious dearth in the current literature surrounding the use of compression therapy to treat lymphedema (15). The ICC documents offer suggestions for Best Practice based on a synthesis of the current literature and suggest clinical trials that are needed to alleviate gaps in the current literature. These recommendations are supported by this 2004-2011 review.

A limitation of this systematic review is that it was limited to the English language literature or available translated non-English literature published from 2004 to 2011 in peer-reviewed sources. Despite our best efforts, it is possible that potentially eligible studies might have been missed.

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