CURRENT ROLE OF PNEUMATIC COMPRESSION THERAPY IN LYMPHEDEMA CARE: A SCOPING REVIEW OF PERSISTENT DEBATES AND NEW APPLICATIONS

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ABSTRACT

Access to trained lymphedema care providers remains limited making patient-driven management solutions essential. One such option, sequential intermittent pneumatic compression (IPC), has gained traction as a supportive tool for lymphedema management. While newer IPC devices and innovative applications are being introduced to the market, questions regarding the safety and efficacy of this technology persist. This underscores the importance of reviewing current literature to understand IPC's evolving role in lymphedema care and to identify existing knowledge gaps. A scoping review of literature was conducted across various databases using PRISMA-ScR guidelines. The eligibility criteria included articles published in English language from database's inception to June 2023, discussing IPC's safety, and/or efficacy, and/or optimal modes and settings for lymphedema management. Review articles and case reports and original studies with unclear outcome measures were excluded. The review identified 49 eligible studies from an initial pool of 614 articles, consisting of 12 randomized controlled trials, 25 cohort studies, and 12 experimental studies. Most studies (44) focused on limb lymphedema, while five examined non-limb regions. Sample sizes varied widely, ranging from 10 to 718 participants, reflecting differences in studies' power. Minor adverse events

were reported in six studies, including transient skin irritation, paresthesia, and rare cases of genital edema. Efficacy data indicated that IPC, whether used with or without manual lymphatic drainage (MLD), improved limb volume, quality of life, and reduced infection rates, although results varied according to treatment protocols and limb type. The addition of IPC improved compliance of decongestive therapy and increased patient satisfaction. IPC sessions ranged from 45 to 120 minutes per day, conducted 3 to 7 days per week, with pressures set at 60 to 120 mmHg for lower limbs and 25 to 60 mmHg for upper limbs. Higher pressures were associated with more significant limb volume reduction in the lower limbs. A cost analysis indicated that IPC could potentially lead to healthcare savings by reducing infections and hospital admissions. IPC application also showed promising results in head and neck lymphedema, though results for trunk lymphedema were equivocal. Future research should aim to refine IPC protocols in different regions of the body and ascertain its long-term benefits.

Keywords: Intermittent Pneumatic Compression, Lymphedema, Best Practices, Safety, Review

Lymphedema is characterized by chronic accumulation of lymphatic fluid, fat, and fibrosis which presents a complex therapeutic

challenge. Complete decongestive therapy (CDT), encompassing manual lymphatic drainage (MLD), compression, exercise, and skin care, remains the cornerstone of conservative management. Although there have been significant advancements in lymphatic surgery, elevating the goals of modern lymphedema management, access to these specialized surgical interventions, as well as to trained lymphedema therapists remains limited. This dual constraint necessitates patient-driven self-management. Intermittent pneumatic compression (IPC) pump has emerged as a viable at-home supplement to traditional lymphedema treatments, empowering patients with greater control over their condition (1). The market offers a variety of IPC devices, each differing in sleeve and pump design, configuration, programmability, chamber count, inflation/deflation cycles, maximum pressure, and pressure gradient. The advent of new compression modes, such as those mimicking MLD, further complicates the landscape. Recently, IPC usage has expanded to include other body areas, such as the head and neck, highlighting the need for comprehensive review. Recent innovations have further expanded IPC capabilities, including applications for non-limb areas such as the head and neck and introduction of new compression modes. While previous reviews have explored IPC effectiveness, they haven't addressed the recent advancements. Also, experimental studies using imaging to optimize compression settings have not been reviewed (2-5). This literature review aims to fill these gaps by synthesizing current evidence on IPC usage in lymphedema management and identifying areas requiring further research.

METHODS

Search Strategy and Information Sources

We conducted a scoping literature review following PRISMA-ScR guidelines utilizing Ovid MEDLINE, PubMed, EMBASE, and the Cochrane Library databases covering the period from their inception to June 2023 (6). The search was limited to articles published in

English language. Keywords and MeSH terms included "intermittent pneumatic compression", OR "compression therapy", OR "compression pumps", OR "sequential compression" AND "lymphedema" OR "lymphatic flow". Cross references of the selected articles were screened for any relevant articles and included in the search results.

Eligibility Criteria

Inclusion criteria included studies evaluating safety and/or efficacy and/or optimal machine settings of IPC in lymphedema patients. Eligible studies encompassed both pediatric and adult patients with lymphedema affecting the extremities, trunk, or head/neck. Primary outcomes of interest were imaging findings, changes in limb volume or circumference, patient-reported outcomes, quality of life assessments, and adverse events. Case reports, literature reviews, and studies with unclear outcome measures were excluded. Also, studies focusing on non-lymphedema patients, or animal studies, were eliminated.

Study Selection and Data Extraction

Four independent reviewers conducted a screening process of titles, abstracts, and full texts using a web-based tool, Covidence (Melbourne, Australia). Studies that met the eligibility criteria were identified individually and any discrepancies were resolved through consensus. Data extraction was carried out using a standardized form generated in Covidence, capturing information on study design, study aim, cohort characteristics, sample size, lymphedema etiology, affected regions, outcome measures, treatment protocols, IPC device specifications, duration of study, and key findings.

Synthesis of Results

We categorized the outcomes into following domains – safety, efficacy, optimal device settings, and cost effectiveness. The efficacy results were subcategorized based on evaluation methodology, the treated region,

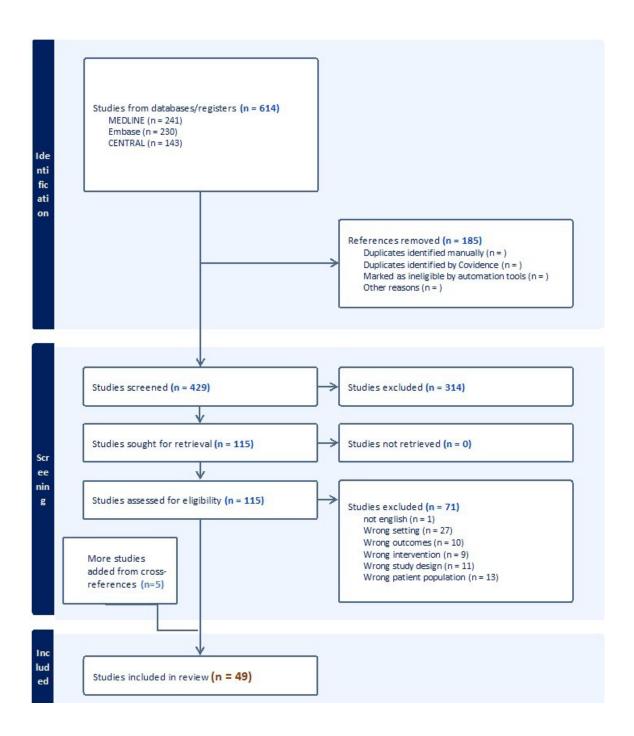


Fig. 1. PRISMA diagram detailing study flow from initial manuscripts to final 49 utilized for the scoping review.

and any special situations. Evidence for sustainability of effects, variations based on the affected limb, and efficacy of new compression modes were also reviewed.

RESULTS

Study Characteristics

The search yielded 614 articles, of which 49 studies satisfied eligibility criteria (Fig. 1). Table 1 (larger version in supplementary materials) presents the characteristics of the included studies. These encompassed 12 randomized controlled trials, 18 observational studies, 7 case series and 12 experimental studies. Forty-four articles focused on lymphedema in the limbs, while five studies explored non-limb regions, including the head, neck, and trunk. The sample sizes in the studies varied significantly, ranging from 10 to 718 patients, reflecting the diversity in the power of the studies. The findings of the studies are presented below.

Safety

IPC is contraindicated in patients with underlying peripheral arterial disease, active deep venous thrombosis, active infections, and/or evidence of cancer recurrence (2). There is lack of consensus on the safety of IPC in patients with cardiac failure where the severity of cardiac dysfunction should be considered to weigh the risks and benefits. Vigilant monitoring is essential to circumvent potential cardiac decompensation in patients with severe disease as a result of augmented venous return (7).

We screened all selected studies for report on adverse events associated with IPC use in patients with lymphedema. Only six studies provided information on adverse events in their study population (1,8-12). In these studies, minimal effects like transient skin irritation, paresthesia, mild pain (25% patients), muscle cramps, and limb erythema were noted. Patient discomfort attributable to IPC was ameliorated by modulation of the applied pressures (9). Rare events included headache, nausea, and dizziness (10). One

particular study highlighted a significant disparity in genital edema incidence, registering a 43% occurrence with IPC intervention as opposed to a 3% occurrence without IPC (12). The duration for which the genital edema lasted was not delineated in the study. No other study reported increase in genitalia swelling although mild groin and knee swelling was reported in another study which was transient and could be mitigated by additional groin compression (13). In aggregate, the studies under review did not report any major complications ensuing from IPC treatment.

Efficacy

Total 37 studies examined the efficacy of IPC using various strategies. The efficacy of IPC in limb lymphedema was assessed in comparison to manual lymphatic drainage (MLD), as an adjunct to MLD, or as a standalone treatment (no MLD). All studies examining the absolute benefit of IPC as a standalone therapy allowed patients to continue using compression garments by default, hence was not in effect a solitary management tool. The most common outcome measure used for determining efficacy was limb circumference or volume change. Patient-reported outcomes, such as change in symptoms, range of motion, quality of life, reduction in cellulitis episodes, and hospital admission rates was utilized by several studies (Table 1). Six experimental studies used imaging techniques including ICG lymphography or lymphoscintigraphy to objectively study the immediate effects of pneumatic compression on lymphatic flow after a single treatment session (14-18). The only prospective clinical study that utilized imaging was conducted in head and neck lymphedema cohort, using ICG lymphography before and after two-weeks of IPC therapy (19).

IPC

Eight studies evaluated IPC as a standalone therapy (without MLD but with compression garments) for primarily lower limb (7 studies, primary and acquired disease) or

	Adverse ovents						Transient increase in grand knee swelling, although and think reduced	Four adverse events was recorded for these subje		Genital swelling			discomfort and lymphan								No adverse effects on s elasticity and joint rang					
/sis	Outrome measures	Quality of life scores and	The primary endpoints:	Absolute limb volume, BMI,	Episode sof celluitis,	Rates of hospital resits, outpatient hospital visits,		Reduction in limb volume (LV), clinician and ratient-			imb circumference before circumference, shoulder	Limb circumference before	i -	arm volume, level of	take of infection, number of	Linb volune, symptoms questionnaire	Percentage reduction of excess volume (PREV), symptoms of rein.	Limb circumference	ROM of UE jts	The volume reduction of the upper limb measured by	olume- water displacement		Changes in lineb volume (LV), tirene flud, lissue tone, and patient-reported outcomes (CRCs).—2 only volume and BIS were reliable	Bilateral leg volume (with circumference) and quality	inductorities assument controllers assument to the following and selection and selection the IPC device.	Rates of lymphoedema- related cellulitis, manual the rapy use, outpatient
naly 1a,	Study Design	Prospective		Prospective A	Prospective cohort study	Retrospective cohort study	prospective cohort study	Prospective]			RCT	NRCT	RCT	RCT	NRCT	RCT	RCT	RCT	RCT		RCT V	NRCT	Prospective cohort study	RCT	NRCT; L Prospective cohortsmdy	Retrospective cohort study
or A dem	Device	N/A	Flexitouch	Metrum	Cryotlex N/A	N/A	N/A	NA	N/A	N/A	N/A N/A	N/A	N/A	N/A	N/A	Lympha-mat	Pulse press	N/A	N/A	NA	N/A	N/A	NIA	LymphAssis t	NIA	NA
d fo	PC Pressure	100 mmHg	N/A	40 or 50	MMHg N/A	N/A	80 to 120 mmHg	80 to 110 mmHg	80 to 120 mmHg		60 mmHg 50-80 mm	Hg 25 mmHg	50 to 80 mmHg	40-60 mm	N/A	50 mm Hg	0.40 mmHg	40 mmHg	60 mmHg	40 mmHg	40 to 50 mmHg	60 or 120 mmHg	55 mm Hg distal to 30 mm Hg proximal	40 mmHg	MLD. mimicking mode: 40-60 mnHg; conventional mode: 80- 100 mnHg	NA
use ymr es)	Compressio n Cycles	N/A	N/A	18 sper	chamber N/A	N/A		N/A	N/A		N/A Sequential	+	N/A		Sequential	100	m			N/A	Sequential	Sequential	MA	N/A	38 38 38 38 1.18 me, thon me, thon thon	N/A
ups Ib L udie	Frequency	deily	5 days per	week twice daily	5 to 7 days	N/A		N/A	daily		N/A 3 days per		5 days per week	5 days per	+	5 days/Wk	5 days per week	6 days per	5 days per week	5 days per week	N/A	N/A	Group A: Once per day, Group B: Twice per day, Group C: Twice per	twice daily	ay	N/A
Gro Lim	Max Follow up	N/A	52 weeks					4 to 9 weeks	single in hospital treatment		3 months	_	2 months			2 months				12w			5 days	+		12 months
d into 4 Groups u ns, Non-Limb Lyn Pressure Studies)	Duration per Day	Il.	45m	lh	45m	N/A	45 mins	NA	WS.	<i>y</i>	2h 30 mins	45m	30m	2 hrs	NIA	60 mins MLD vs 30 mins MLD + 30 mins IPC	60 mins MLD vs 60 mins MLD + 30 mins IPC	45 mins	NA	1h	30 to 60 minutes	45m	Group A: I hour Group B: I hour four twice per day, so 2 hours (but twice per day, so 4 hours (but twice per day, so 4 hours (but).	N/A		N/A
£1 ped tions on P	Total Duration of	8w	52w	52w	57w	N/A	2 to 3 years	N/A	2 days		9w Sw	m9	4w	2w	78w	2m	4m	3w	3w	12w	26 - 52 weeks	4w	5 days or 12 days	2w	N/A	12 months
TABLE 1 n Groupe Situatio	Region	E	E	UE, LE	E	N/A	TE	31	1	37	UE	UE	UE; LE	UE	E	UE	an ne	UE	UE	UE	nE	LE	97	TE	TE.	unspecified
TA n G I Sii npre	Etiology	secondary	secondary,	secondary	secondary,	secondary	se condary, primary	secondary, primary	se condary, primary	secondary, primary	secondary	secondary	secondary, primary	secondary	secondary,	secondary	secondary	secondary	secondary	secondary	secondary	Phlebolymph edema	secondary	secondary, primary	secondary	secondary, primary
TABLE 1 ation Groupe ecial Situatio Compression	Samp le size	12	74	117	801	1065	81	196	43	128	67	30	182	28	69	27(13 CDT, 14 CDT+IPC)	76 (38 CDT, 38 CDT +IPC)	31	25	112	23	81	21	40	99	1731
TABLE 1 Manuscript Information Grouped into 4 Groups used for Analysis nb Lymphedema, Special Situations, Non-Limb Lymphedema, and Relevant Compression Pressure Studies)	Salient point	FC improves all patients' functional and	symptom scores, except sexual function. The Flexibouch APCD showed a agnificant	into guth reduction as early as 1.2 weeks PC improves clinical outcomes, quality of	He, and function for UE and LE secondary IPC improves symptoms of LE framehode me	Lymphedema is common among cancer survivors, and IPC is valuable in treating	The first one hour IC showed: decrease in ircumference of lower parts of the calf and thich arth increase below knee and in the	The APCD treatment was associated with significant reductions in LV and showed	Introduction of a new mode for IPC which allows unidirectional forward lymph flow and is well-tolerated in chronic cases of the	IPC can increase proximal swelling, no mention on the duration for which the	IPC may have limited clinical value IPC treatment can be substituted for MLD	in CDT due to its easier accessibility and Manual lymphatic drainage and	Compression candages may perform IPC and bandages is not inferior to IPC + menual lymphatic drainage + bandages	IPC is as efficacious as MLD in BCRL	Compliance improved with IPC	Excellent discussion about fears of using IPC and the different pressures.		no additional benefit of adding IPC to CDT	no additional benefit of adding IPC to CDT for BCRL	CDT alone ; educing limb v			No benefit of > 1 kr gre day IPC in short FU	The improvement in limb volume and quality of life for patients with LE	The FP Green has estimate those designed to make the manual jumplants of designed to minth the manual jumplants of designed to minth the minting of the gendry all jumplants chaning of the gendry all jumplants channing of the minting cost as IPC devices with a MID munching program can be benefitted in maintaining in the obtain end a chalacterial in the cOL for pattern with a special program can be benefitted in the coll for pattern with a special program can be benefitted in the coll for pattern with a special consistent of the pattern with a special pattern with a spe	The study compared the clinical and health utilization outcomes between two types of PCDs (MP-PCD and P-PCD) in patients
iled Manuscr (Limb Lymph and	Summary of Outcomes	IPC participants showed a	significant improvement in mean global IPC treatment significantly improved	LY MUCUL scores, paysned component of IPC resulted in a 28% decrease in absolut	Imb volume, decreased body mass index The studyshowed a significant decrease i	The use of IPC was associated with a significant decrease in rates of	nospitatizators, outgement forspiral visite, The limb circumference decreased or did not further increase, elasticity of tissues increased or was maintained No.	In patients treated with APCD, 90% experienced a significant reduction in lindo	IPC at high pressure was effective in reducing affected lower limb edema by a mean of 75% in lymphedema ratients,	Of the 128 patients with lower limb lymphedema, 75 received no pump	After 9 weeks of treatment, mean delta No significant difference bw the two gps in	Both treatment modelities, namely IPC +	group): manual lymphatic drainage +	Intermittent Pneumatic Compression + Arm volume, mobility, strength and	yarpoints improve ment not sig direction. IPC significantly reduces infection rate. bornish educations and planned these	noplant annasons, and paper a mercy. Ann volume and symptoms significantly improved in both gas at therapy end, at 1 month and at 2 months. Volume reduction	IPC seems to edd no benefit when combined with CDT for Jamphedems, but, maybe functional in reducing the		rved in	The studyshowed that both the use of CDT alone and in combination with IPC	The addition of IPC to standard the rapy led to a significant increase in mean volume	IPC at 120 mmHg led to the greatest reduction of edema compared to lower	have been a served and a served a	The study found that the LymphAssist group exhibited no significant volume	The use of statements affortune description counties affortune affortune manustrature. The appropriate of the counties affortune affortu	Dynamic pressure programmable devices demonstrated better lymphedema-related health outcomes compared to
Detailed (Lin	Title	Seve re lymphoedema in	Synaecological cancers Assessment of quality of life	Superior Clinical, Quality of	Pneumatic Compression	Lymphedema mevalence and treatment benefits in	The Effectiveness of Intermittent Pneumatic	Fne umatic compression device treatment of lower		The risk of genital edema after external pump	Pre unatic compression vs The efficacy of intermittent	et	Physical therapies in the decongestive treatment of	lymphedema: A A randomized study	Adding Pre-unatio	IPC acts synergicitically with MLD in complex deconvestive thistotherape	Role of intermittent pre-unatic compression in the treatment of breast	Efficacy of manual	Intermittent preumatic	Comparing two treatment methods for post	Decongestive lymphatic therapy for patients with		J. J.	Intermittent Preumatic Compression for the	Prematic Compression Prematic Compression Choracy The Import in Choracy The Import in in Petrie Transie for Cymerobigic Cancer Cymerobigic Cancer	A comparison of programmable and nontrogrammable
	Author, Vear	A Freyne 2022	Maldonado	2021 Desai 2019	Blumberg	Brayton 2014	Zaleska 2014	Muluk 2013	Modaghegh 2010	Bomis 1998	Gozza 1996 Sanal-Toprak	2019 Gurdal 2012	Fomer- Cordero	2021 Johansson	052	Szolonsky 2022	Tastaban 2020	Uzkeser	Uzkeser 2013	Haghighat 2010	Szuba 2002	Taradaj 2015	Keeley 2023	Dum 2022	Kim 2022	Karaca- Mandic 2017
	Research focus	MPHEDEM. Efficacy	Efficacy	Efficacy	Safety,	Efficacy, Cost	Safety, Efficacy, Settings	Efficacy, Safety		Safety	Efficacy	Efficacy	Efficacy	Efficacy	Efficacy	Efficacy	Efficacy	Efficacy	Efficacy	Efficacy	Safety, Efficacy	Pressures	Frequency of use	Compression	uo.	Programmab ility 1
	Aim Aim	A) LIMB L			ملد		MID	امط	. بامار،	، ام			IPC vs MLD			A.0		IPC+MLD								

Devise Companie 2 Fib 2012 Section 2 Fib 2012 Constitution and devices studies studies Constitution and studies	Trunk Ridner 2012 congression preceding arm congression	No. of Pilch 2009 chambers and cycle time	Comparing 2 Mayrovitz devices 2007	No. of Bergan 1998 chambers	Imaging for Zaleska 2019 Efficacy, Best setings	Efficacy, Bok 2018 Best settings	Imaging for Aldrich 2017 Efficacy	Imaging for Kitayama Efficacy 2017	Best settings Zaleska 2013	Efficacy, Okzewski MOA 2011	Imaging for Okzewski Efficacy 2011	Imaging for Adams 2010 Efficacy	Efficacy in Manjula	Chairmin 2000
A nandomized controlled that comparing two types of parentes to compare study for breast cancer-nals and Jeruphe dente breasternt in the home	A randomized clinical trial comparing advanced pre-unatic truncal, chest, and arm frestment to arm treatment only in self-care of	Influence of compression cycle time and number of sleeve chambers on upper extensive lymphedema	Interface pressures produced bytwo different types of lymptedema therapy devices	A comparison of compression pumps in the treatment of lymphede ma	The Effectiveness of Internation Congression Lympachan of Lower Limbs Methods of Evaluation and Results	Evaluation of Stiffness in Postmastectomy Lymphe dema Using	Effect of pneumatic compression therapy on lymph movement in	Real-Time Direct Evidence of the Superficial Lymphatic Drainage Effect of Internation t Pre-unatic	Pressures and timing of intermittent pre-umatic compression devices for	r 8	Path tissu	温湿	Evaluation of sequential	in the constitute of the constitute of the
The APCD-Restle gloup aboved a gaparinant 39% abuton in schman againfant 39% abuton in schman and schman and abuton and a schman and a 55% reduction in mean a consequent to 15% reduction in mean 15% increase for the ReCD group, antically a schman and a APCD group, and a APCD group, and a APCD group, and a schman and	When comparing experimental true-alches/sam advanced gaeumatic compression through to arm-only pneumatic compression (control), there is obtained to contract the control of the control o	IPC is an effective method of volume reduction in women with postmaster tomy arm lymphedena regardless of cycle times and number of sleeve chambers. Two	Significant differences in pressure funings, personal and	One and three cleamber gaments were less effective than 10 chamber gament in reducing swelling	Adjustment of compression posture tos to frage ut filtres partial final accumulation volumes, and final movement deling voltamic conductivity of fissues) at vozious line levels is represented for effective therapy. The yrecommended differential compression pressures and prolonged timings at vosious limb levels prolonged timings at vosious limb levels prolonged timings at vosious limb levels	After a single session of IPC, using a pressure of 35 mmHg resulted in the largest improvement in proximal upper arm	The studyde monstrated improved lyaph movement during and after IPC in all affected less of the subsects tested, with	Different inflation/deflation modes and two different pressures evaluated (45 and 90 mmHg) using quantitative ICGL and software-assisted video analysis; ICG	The study points to the necessity of applying high pressures (120 mm Hg) at ankle with 20 % proximal pressure gradient	The skin's rigidity (fibrosis) and the discipation of applied compression force to proximal noncompressed limb regions menthed in a high transame randiant through	ate the d static	Improvement defined as proximal movement of dys after therapy. Lymphatic function improved in all control subjects	12 patients with grade II filarial	bearing adams had 206% underston in
Andwood INC season and the Stift of the Stif			F = 0 0	multi chamb more effect		IPC reduces eiffhess and subcutaneous issue thickness of UE in patients with BCRL	IPC improves lymphatic function either by mobilizing fluid through lymph vesse is or through interstrial channels.	Preop sevenitygrading done with LSG and fhose with demail backflow in leg and foot were excluded (only mild case sincluded).	The pneumatic devices were set at three different inflation times 5, 20, or 50 sec in each chambers of the eight chambers, and	This pre-unit	The pnet	IPC was effective in stimulating the lymphatic function locally and systemically.		_
% %	42	23	01	a	R	45	4	25 (8 control, 17 affected limbs)	18	21	51	3 controls, 6 with BCRL	88	
secondary	secondary	secondary	NA	secondary, UE	secondary, primary	secondary	secondary, primary	secondary	secondary, primary	N/A	secondary	secondary 1	secondary	
UE 12w	UE 30 days	UE 5w	UE Single session for each device (at least 48 hours between each device assessment)	UE, LE N/A	1.Br	UE single session	LE single session	LE single session	LE single session	LE single session	LE single session	UE single æssion	LE 4w	
ৰ	ys Ih in UE + frunk gp, 36 mins in UE onlygp	114	Single session for each device device view as s s s seech session for each	2 hrs		ssion MA	ssion 1h	ssion single session	noise	sion single session	ssion N/A	ssion single session. An hour-long IPC (30 mins trunk and proximal arm basins		
			N/A	N/A						N/A	N/A		6 months	
N/A	7 days por week	5 days per week for 5 weeks	Single session for each device		MATERIAL STATES	NiA	NIA	single session		single session	NA	single session		
18 sper (chamber (ctd) (chamber (ctd) sequentially inflated very all in fabred very per chamber (chamber chamber inflated ctamber inflated ctamber inflated ctamber inflated at inflated at itme)	NIA	N/A	Sequential 4	Sequential or Sequential c	Sees inflation, 5 see deflation for each for chamber, total 40 sec g period for 1 cycle.	N/A	N/A	00000		sequential, distal most chamber was	NA			
30 mmHg (standard) or n 9.0± 4.2 mmHg and 13.7±4.8 mmHg (Advanced)	9.0± 42-13.7± 4.9 mm Hg	30 to 50 mmHg	45mmHg for the Lymphs Press and the "standard" setting for Flexitouch	50 mmHg in one or 3 chambers, 80 to 30 mmHg gradient in ten chambered	The steeve inflation pressure at foot level was 120 marHg, gradually decreasing in the groin by 20%.	25, 35, and 45mmHg	45 distal to 30 mmHg proximal	45 mmHg and 90 mm Hg		50 to 120 B	50 to 125 mmHg	NA		
N/A	NIA	N/A.	Lympha Fress, Fress, Flexitouch		N/A H	N/A E	N/A.	N/A	N/A.	Biocompress Fi	N/A B	Hexitouch B	10	-
MCT %	RCT	RCT	Study page study page 100 0 0 0 1 page 100 0 0 0 1 page 100 0 0 1 page 100 0 0 1 page 100 0 1 pa		Experimental study, single pm session	Experimental study, single session	Experimental IC study, single in session	Experimental IC study, single session co	Experimental study, single session	Experimental Costudy, single a session	Experimental LS study, single session de	Experimental IC study, single sis session		-
Limb volume (vrift) volume fevenia volume fevenia volume me tec) at Week U Mostune me tec) at Week U	LSIDS-A score, arm circumference, trunk circumference, (FASQ score, bioimpedence	Limb volume	Interface pressures applied to left foream (used 256-19esum seron anny) over 0.1 second intervals for at least 2 cycles of each device	Linb volume (water displacement)	issue stiffness, fluid pressure, flow volume, LSG, ICGL	UE subcutaneous tissue fuickness, circumference, and stiffness	ICGL before (15 mins after injection), during and after IPC using commession	ICGL. Janph velocity, real time with transparent compression sleeve, during IPC	anssari moqns	Continuous Tissue pressure, and girth (plethysmograph attached to starin gauges amailed at different limb	8 2	ICGL same and contralateral side , Lymphatic propulsion rate, apparent lymph	volume (with water	Acres 1
Seven patients had adverse events, none in the standard group.											One patient experienced muscle cramps and a second reported increased limb			

			No advante evente we re reported.						
pun in excelorad superiors		Symptoms (including praesthesis, pain, paraesthesis, pain, heaviness), function (cervical notion, speech), swelling mennal and external	expanding (meaning (meaning management) and subject a panel improvements	ICGL before and 2 weeks after +/. during IPC/MLD	Patient-reported comfort,	feelings post-treatment, and likelihood of home use.	Patient reported symptoms, and trunk circumference	ICGL before and after, also measured tissue pressure using four different	Limb volume and circumference before and after treatment
		RCT	Prospective of coloronal coloronal study where subjects were maged using NIRFIL before and after the initial treatment treatment and then eight and then degain after 2 weeks of dully the ament the ament the familiar of the subject	NRCT conference		Prospective 1	_	Experimental study, single session	Prospective cohort study
series area constitution of the constitution o		N/A	Flexitouch	NA	N/A		Flexitouch	N/A	N/A
mm Hg mm Hg greep, 80 protop, cose protop, cose Protop, cose Hg		NIA	MA	N/A	N/A		N/A	50 to 120 mm Hg gradient	
Tentran hac		N/A	MA	N/A	N/A		N/A		N/A
9	-	prescribed by the days per days per week, but most pis used once a day	7 days per week	dailyfor 2 weeks	once		7 days per week		N/A
		ця	2 weeks.		N/A				
		23 to 45 minutes	33 H	N/A	32m		lh		N/A
of his confinuously pre shin and subon many for the propertion, of the propertion of the properties of		8w	2 weeks.	2 weeks.	Single	session	10 days	single session	N/A
		H&N	H&N	H&N, limbs	H&N		Trunk	UE, LE	UE, LE
E, UE, UE	5	secondary	secondary	secondary	secondary		secondary		secondary
7		43	01	66	4		12	N/A	36 arm patients and 42 leg
неди развит мен то пи пот вече и		eignificantly enhanced potient perception regarding their shilly to control their lymphedeme, jobe theillyn during patent distress.	by the we of the submitted florescence by pripate in meging (VIRFL) to cotally one of the impact of the pretunate ones as the impact of the pretunate and the shighty to deserve although the properties of hypphotic update and dranage, as we'll as changes in teases of demand societies, we will as changes in teases of demand societies, in adjects after the treatment.	The only study that used imaging after a sustained us of IPC	The treatment was found to be safe, easy to	use, and well-tolerated, showing edema reduction after just a single initial treatment	100% compliance with IPC, Flexibuch used, study period was short	Determined sleeve pressure required for moving fluid proximal 40 mm Hg in the issues which can be generated with was	estinate of required compression pression
Ask in the pip (was of the call and		aft afti-	The rehyeverhald (DCL demnal locations as in I) guistants before and after IPC completion, Inching a reduction in beaching with order and reduction in condition and consistent angreed facel composite moreoved facel composite measurements exact and self-eryorded by outcomes mult I I onlogic te with no adverse events reported.	tag.		comfortable, effective, and well-tolerated, with one treatment showing statistically re-	_	Realtine movement of edema fluid observed using various compression modelities. Threshold pressures necessary	44 +4 h
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Communest with with Surgery Surgery	C) NON LIMBS LYMPHEDEMA	Safety, Efficacy	Safety, Efficacy	Imaging for Efficacy	Safety	Efficacy, Best Settings		Efficacy, best settings	Other

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upper limb (1 study, acquired disease) lymphedema on a sample size ranging from 12 to 1065 patients (1,10,13,20-24). The treatment sessions varied from 45 minutes to 1 hour/day for 5-7 days a week and patients continued to use compression garments in between sessions. Peak IPC pressures used were 80 to 120 mm Hg in lower limbs and 60 mm Hg in the upper limb. In one study, 74 patients experienced significant reductions in ankle and calf circumference, a decrease in cellulitis rates from 32% to 12%, and enhanced quality of life scores after 12 weeks of daily 1-hour IPC sessions, with the benefits sustained at 1 year (20). After at least 3 months of IPC treatment all patients experienced symptoms improvement and 54% experiencing substantial quality of life enhancements and significant reductions in limb girth and infection episodes (21).

Prolonged use of IPC (more than 8 weeks) was associated with improved quality of life, limb volume reduction, and enhanced limb function in two other studies (1,21). Improved tissue elasticity besides significant reductions in limb circumference was observed in 18 patients with lower limb lymphedema over a three-year period (13). Improved skin fibrosis and reduced limb pain and was reported in majority of the participants with lower extremity lymphedema in another study, although only a third of the patients showed >10% volume reduction (10).

The only study that exclusively studied utility of IPC without MLD in upper limbs randomized the postmastectomy arm lymphedema patients into study and control groups but used shorter treatment period. After two cycles of 2 hours per day of 2 weeks treatment, the mean volume change was significantly more in the IPC group (p=0.009) compared to the control (p=0.3), although no difference in the number of patients who achieved > 20% reduction was observed (22-25).

These studies collectively indicate that IPC when used over several weeks can be effective as a standalone therapy for managing lower extremity lymphedema. However, the undisclosed variation in the duration and strength of the compression garments is a potential confounder. While volume reduction

was frequently noted as significant, only a few studies reported precise percentage reductions. Additionally, the lack of a control group in most of the above studies limits the interpretation of results. Due to paucity of studies, effectiveness of IPC alone for managing arms lymphedema cannot be determined.

IPC vs MLD

In the comparative analysis between IPC and MLD, four studies examined treatments for upper (3 studies) or both upper and lower limbs (1 study) (26-29). The duration of IPC treatments ranged from 30 minutes to 2 hours for 3-5 days a week, using compression pressures of 25 mm Hg to 80 mm Hg. These investigations reported that IPC and MLD resulted in similar decreases in limb volume as well as improvement in pain levels, range of motion, and patient-reported symptoms over the study period of 2-6 weeks in 28 to 182 subjects (27). Volume reduction was more pronounced in the lower limbs as compared to arms using either therapy. Self-lymphatic drainage was permitted along with IPC in one study making the findings less reliable (27). Overall, the results of rest of the included studies indicated that both treatment approaches yielded comparable outcomes in terms of volume reduction and symptomatic relief, although the time and cost consumption for MLD was higher and compliance was lower (28).

IPC and MLD vs. MLD

Seven prospective studies examined IPC as an adjunct to MLD, of which six studies focused on arms lymphedema and only one studied lower limbs. In the context of lower extremity lymphedema, two studies indicated that combining high-pressure IPC (120 mm Hg) with MLD led to greater reductions in limb volume compared to MLD alone (30,31). Furthermore, incorporation of IPC into CDT was associated with improved compliance and significantly lower rates of infection (16.9% vs 29.2%), hospital admissions (13.6% vs 29.2%), and fewer physical therapy sessions over 18 months among 62 patients (30). In contrast,

six studies investigating upper extremity lymphedema produced variable results (31-36). Two studies found that combining MLD + IPC at 40-60 mmHg pressure for 30-60 minutes daily for 2 to 52 weeks, resulted in superior volume reduction and/or limb function improvement compared to MLD without IPC (32,33). However, the remaining four studies did not observe significant benefits which could be related to lower pressure levels (30-40 mmHg), shorter treatment durations (30 minutes), or limited sample size in these studies (31,34-36).

IPC as an adjunct to Surgical Treatment

One study investigated the perioperative application of IPC to improve outcomes of lymphatic surgery (37). The study involved 15 patients undergoing lymphaticovenular anastomosis, during which the use of IPC enhanced the visualization of lymphatic vessels intraoperatively. The IPC was continued postoperatively to promote flow through the anastomoses. When used prior to excisional lymphatic surgeries, authors observed a decrease in wound complications and a reduction in postoperative pain. These findings suggest the potential of utilizing IPC for improving lymphatic surgery outcomes and further research may be steered in this direction.

Application in Head and Neck

Four studies evaluated use of IPC for management of head and neck lymphedema (19.38-40). Mayrovitz et al reported high levels of patient satisfaction and notable reductions in facial and neck lymphedema following a single session of IPC lasting 32 minutes (38). Gutierrez et al documented a decrease in dermal backflow as shown by indocyanine green lymphography in 6 out of 8 patients, following two weeks of daily treatment sessions of the same duration (39,41). Ridner et al and Rasmussen et al further corroborated these outcomes, with patients reporting swelling reduction, improved symptoms and enhanced quality of life following 2 to 3 months of daily IPC application (19,40).

Application in Trunk and Chest

Only one study was found that specifically evaluated role of IPC in managing trunk lymphedema. All 12 patients reported improved symptoms but there was no significant reduction in the trunk volume after 10 days of 1-hour daily IPC treatment (42).

Factors Influencing the Effectiveness of IPC Treatment

In a cohort of 56 patients, Forner-Cordero et al found that similar to other decongestive therapies, lower limb lymphedema and less advanced disease showed more notable improvements with IPC as compared to upper limbs and advanced lymphedema (28). Conversely, in a larger cohort of 208 patients, Muluk et al did not find an inverse relationship between disease severity and volume reduction (10). This conflicting evidence regarding the correlation between disease severity and response to IPC mirrors findings reported for CDT (43,44). High BMI, which has been linked to poorer responses to CDT, has yet to be thoroughly evaluated for its impact on IPC outcomes.

Durability of Treatment Results

Sixteen studies investigated the longevity of results post IPC treatment, with follow-up periods extending up to one year. It was generally noted that volume reductions achieved with IPC require ongoing use of compression garments. The outcomes tend to diminish once IPC is discontinued (11,45). For example, Johansson et al reported a 31% reduction in lower limb volume at the conclusion of the IPC treatment period, which declined to a 25% reduction after one month of stopping the treatment (26). These findings are similar to other decongestive therapies and underscore the importance of continued self-care with IPC for maintaining lymphedema reduction (11,26,32,46).

Machine Settings

Pressure Setting for Lower Extremity

In their investigation to determine adequate compression, Olszewski et al and Zaleska et al conducted tissue pressure measurements during IPC treatments (13,47-52). Effective therapeutic subcutaneous pressures greater than 40 mmHg and improved proximal fluid movement on lymphoscintigraphy were achieved with IPC machine pressures of 80–120 mmHg for durations exceeding 60 seconds (11,16). The authors concluded that higher interface pressure is necessary as the severity of lymphedema increases due to greater tissue stiffness (48,50). Furthermore, using a combination of ICG lymphography and tissue pressure measurements, Zaleska et al found that IPC pressures below 80 mmHg were insufficient for lymph clearance in advanced stages of the disease. Supporting these findings, Taradaj et al demonstrated in a clinical study that limb volume reduction in patients treated with IPC at 60 mmHg did not statistically differ from the no-IPC group but was significantly less than in the group treated with higher pressure (120 mmHg) (31).

Pressure Setting for Upper Extremity

Bok et al conducted a comparison of IPC pressures of 25, 35, and 45 mmHg in a cohort of 40 patients (53). Utilizing ultrasound and acoustic radiation force impulse imaging, they assessed change in tissue thickness and stiffness with IPC. The findings indicated that the 35-mmHg pressure setting was optimal, as it provided significant volume reduction while maintaining a balance between patient comfort and treatment efficacy.

Compression Cycle

Most current IPC machines are designed so that the distal chamber remains inflated while the other chambers sequentially inflate and deflate during the compression cycle (50). Zaleska found that to generate effective tissue pressures for lymphatic outflow, high-pressure cuffs should remain inflated for more than 50 seconds (50). Additionally, Pilch et al studied

the effects of different inflation/deflation cycles (60/60 seconds versus 90/30 seconds) in a cohort of 81 patients and found no significant differences in outcomes between the two settings (54). One study evaluated the benefit of MLD mimicking truncal compression prior to limb compression as compared limb pneumatic compression alone and did not find significant difference in the outcomes (55).

Treatment Duration

The treatment periods used in the published studies have ranged from 30 mins to 2 hours per day for 3 to 7 days per week. Keeley et al randomized 21 patients to receive 1 hour of IPC once daily, twice daily, or 2 hours twice daily over a span of 5 days (56). The study concluded that extending IPC beyond 1 hour daily does not yield additional reduction in limb volume or tissue extracellular fluid percentage.

Cost Effectiveness

The economic impact of IPC was explored in six studies. Lerman et al benchmarked IPC against other compression therapies in a group of 138 patients, identifying significant cost savings over 18 months attributed to fewer complications and hospital stays (57). IPC users experienced a reduction of 66% in emergency department visits and 69% in hospitalizations. Desai et al reported substantial savings, amounting to \$3,200 per patient annually (23). Meanwhile, Karaca-Mandic et al presented IPC as a cost-effective solution when considering quality-adjusted life years, with an incremental cost-effectiveness of \$1,400 (58). The amount of cost-benefit of IPC devices varied depending on device pricing and the extent of insurance coverage.

DISCUSSION

The evolution of Intermittent Pneumatic Compression (IPC) technology provides a therapeutic opportunity for personalized, patient-centered care. As lymphedema remains a chronic, often debilitating condition, the diversification of IPC devices – with their varied pressure settings, sleeve designs, and compression modes – reflects a broader trend of tailoring treatment to individual patient needs. Our review illuminates the complex landscape of IPC, where the multitude of device configurations and operational parameters mirrors the heterogeneity of lymphedema presentations and patient experiences. Despite the availability of numerous studies, lack of standardized protocols and conflicting evidence continues to obscure the optimal application of IPC, necessitating further research to unify these disparate threads into a coherent clinical strategy.

It is important to note that although many studies compared outcomes of IPC with reference to MLD, the efficacy of MLD as part of CDT itself has remained questionable (59). Central to the value of IPC is its capacity to empower patients, offering a semblance of control over their condition. This autonomy is especially critical given the limitations in access to specialized lymphedema services and trained therapists. The convenience and adaptability of IPC facilitate consistent selfmanagement, potentially enhancing adherence to therapeutic regimens and improving long-term outcomes.

The efficacy of IPC, however, is not universally consistent across different patient populations and lymphedema manifestations. Our review suggests a greater benefit in lower extremity lymphedema, possibly due to greater struggle for patients to mobilize the lymphedema fluid against gravity in this region. The nuanced interplay between IPC treatment parameters and patient-specific factors - such as disease severity, and body mass index - highlights the importance of individualized treatment protocols. The optimal IPC settings, notably pressure and duration, should be tailored based on comprehensive assessments including imaging studies and tissue pressure measurements, to maximize therapeutic efficacy and patient comfort. An interesting trend shows that recommended pressure settings have decreased over time, with European studies typically using higher pressures than U.S.

studies – possibly because of difference in the disease severity. The presence of lipodystrophy and fibrosis would require higher pressure settings for efficacy, which although would increase patient discomfort and reduce compliance. While there are several studies evaluating pressure settings for leg lymphedema (which generally recommend high pressure), there is limited research on optimal pressure settings for arm lymphedema.

From a mechanistic perspective, IPC acts on both lymphatic and interstitial fluid dynamics, yet the relative contributions of these pathways remain poorly understood (15.48). Imaging studies during IPC sessions have shown enhanced lymphatic propulsion, suggesting a direct effect on the lymphatic system. However, the long-term implications of these acute changes, particularly regarding the sustainability of lymphatic function improvement, are yet to be fully explored. This gap underscores the need for longitudinal research to elucidate the mechanisms underlying IPC's therapeutic benefits and to define its role within the broader spectrum of lymphedema management strategies.

The application of IPC extends beyond routine outpatient care, showing potential in perioperative settings to enhance surgical outcomes in lymphedema treatment. Preliminary evidence indicates that IPC can improve lymphatic vessel visualization during surgery. reduce postoperative complications, and facilitate quicker recovery. Additionally, emerging studies highlight the utility of IPC in managing truncal and head/neck lymphedema, areas that have historically received less attention in lymphedema research. These findings point to a promising avenue for expanding IPC's clinical utility, warranting more comprehensive investigations to validate these initial observations and refine treatment protocols.

CONCLUSION

IPC emerges as a safe and economical option for management of extremities' lymphedema, aligning well with patient-led care approaches. Future research should aim to refine IPC protocols and ascertain its long-

term benefits and its integration into contemporary lymphedema treatment regimes.

CONFLICT OF INTEREST AND DISCLOSURE

All authors declare that no competing financial interests exist in products or devices mentioned in the manuscript.

AUTHOR CONTRIBUTIONS

Sonia Pandey coordinated the study and composed the original manuscript. Berk Ozmen, Suat Morkuzu, Ying Xiong, Elise Kemp assisted with the articles screening and manuscript drafting. Wei F. Chen conceptualized the project and edited the manuscript.

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TABLE 1

Detailed Manuscript Information Grouped into 4 Groups used for Analysis (Limb Lymphedema, Special Situations, Non-Limb Lymphedema, and Relevant Compression Pressure Studies)

	focus	Author, Year	Title	Summary of Outcomes	Sa lient point	Sample size	Etiology	Region	Total Duration of	Duration per Day	Max Follow up	Frequency	Compressio n Cycles	IPC Pressure	Device name	Study Design	Outcome measures	Adverse events
A). LIMB LYN	MPHEDEM	A							I Use		l permd							
	Efficacy	Freyne 2022	Severe lymphoedema in gynaecological cancers:	Following IPC participants showed a significant improvement in mean global	IPC improves all patients' functional and symptom scores, except sexual function	12	secondary	LE	8w	1h	N/A	daily	N/A	100 mmHg	N/A	Prospective cohort study	Quality of life scores and history of hospital	
3	Efficacy	Maldonado 2021	Assessment of quality of life changes in patients with	IPC treatment significantly improved LYMOOL scores, physical component of	The Flexitouch APCD showed a significant limb girth reduction as early as 12 weeks	74	secondary, primary	LE	52w	45 m	52 weeks	5 days per week	N/A	N/A	Flexitouch	Prospective cohort study	The primary endpoints: OOL change at 12 weeks,	
	Efficacy,	Desai 2019	Superior Clinical, Quality of	IPC resulted in a 28% decrease in absolute	IPC improves clinical outcomes, quality of	117	secondary	UE, LE	52w	1h		twice daily	18 sper	40 or 50	Me trum	Prospective	Absolute limb volume, BMI,	
-	Cost Safety,	Blumberg	Life, Functional, and Health Pneumatic Compression	limb volume, decreased body mass index The studyshowed a significant decrease in	life, and function for UE and LE secondary IPC improves symptoms of LE	100	secondary.	LE	57w	45 m		S to 7 down	chamber N/A	mmHg N/A	Cryoflex N/A	cohort study	SF-36 quality of life, and leg Episodes of cellulitis,	
	Efficacy	2016	Improves Quality of Life in	ankle and calf limb girth, as well as the	lvmphedema	100	primary	LE	37W	45 m		5 to 7 days per week	INIA	IN/A	N/A	Prospective cohort study	number of ulcers, venous	
	Efficacy,	Brayton 2014	Lymphedema prevalence	The use of IPC was associated with a	Lymphedema is common among cancer	1065	secondary	N/A	A/M	N/A		N/A	N/A	N/A	N/A	Retrospective	Rates of hospitalizations,	
IPC without	Cost		and treatment benefits in cancer: impact of a	significant decrease in rates of hospitalizations, outpatient hospital visits,	survivors, and IPC is valuable in treating lymphedema					g	,					cohort study	outpatient hospital visits, cellulitis diagnoses, and	
	Safety;	Zaleska 2014	The Effectiveness of	The limb circumference decreased or did		18	secondary,	LE	2 to 3 years	45 mins				80 to 120	N/A	prospective	limb circumference, tissue	Transient increase in groin
	Efficacy, Settings		Intermittent Pneumatic Compression	not further increase, elasticity of tissues increased or was maintained. No	circumference of lower parts of the calf and thigh with increase below knee and in the		primary							mmHg		cohort study	Tonometry	and knee swelling, although calf and thigh reduced. No
	Efficacy,	Muluk 2013	Pneumatic compression	In patients treated with APCD, 90%	The APCD treatment was associated with	196	secondary,	LE	N/A	N/A	4 to 9	N/A	N/A	80 to 110	N/A	Prospective	Reduction in limb volume	Four adverse events were
<u> </u>	Safety	M 1 1 1 1	device treatment of lower	experienced a significant reduction in limb	significant reductions in LV and showed	40	primary	I.F.	0.1	01	weeks	1.2	37/4	mmHg	37/4	cohort study	(LV), clinician and patient-	recorded for these subjects.
1	Efficacy	Modaghegh 2010	A newlydesigned IPC device for management of	IPC at high pressure was effective in reducing affected lower limb edema by a	Introduction of a new mode for IPC which allows unidirectional forward lymph flow	43	secondary, primary	LE	2 days	8h	single in hospital	daily	N/A	80 to 120 mmHg	N/A	Experimental study, single	Limb circ umference	
_		1600000	lymphoe dema	mean of 75% in lymphedema patients,	and is well-tolerated in chronic cases of the					-	treatment					session	35	
	Safety	Bomis 1998	The risk of genital edema after external pump	Of the 128 patients with lower limb lymphedema, 75 received no pump	IPC can increase proximal swelling, no mention on the duration for which the	128	secondary, primary	LE							N/A			Genital swelling
-	Efficacy	Gozza 1996	Pne umatic compression vs	After 9 weeks of treatment, mean delta	IPC may have limited clinical value	67	secondary	UE	9w	2h		N/A	N/A	60 mmHg	N/A	RCT	Limb circumference before	
	Efficacy	Sanal-Toprak	The efficacy of intermittent	No significant difference bw the two gps in	IPC treatment can be substituted for MLD	46	secondary	UE	5w	30 mins	3 months	3 days per	Sequential	50-80 mm	N/A	RCT	circumference, shoulder	
-	Efficacy	2019 Gurdal 2012	pneumatic compression as a Comparison of intermittent	the extent of improvement in Both treatment modalities, namely IPC +	in CDT due to its easier accessibility and Manual lymphatic drainage and	30	secondary	UE	6w	45 m	-	week 3 days per	N/A	Hg 25 mmHg	N/A	NRCT	pain and ROM Limb circumference before	
	curracy	Gurdal 2012	Companson of intermittent pneumatic compression with	Self Lymphatic Drainage (SLD) and	IVlanual lymphatic drainage and compression bandages may perform	3U	secondary	UE	υW	4JM		3 days per week	IVA	22 mmrig	A/N	MRCI	and at the 1st, 3rd, and 6th	
IPC vs MLD	Efficacy	Forner-	Physical the rapies in the	Group A (control	IPC and bandages is not inferior to IPC +	182	se condary,	UE;LE	4w	30 m	2 months	5 days per	N/A	50 to 80	N/A	RCT	Limb volume before and	discomfort and lymphangitis
		Cordero 2021	decongestive treatment of lymphedema: A	group): manual lymphatic drainage + Intermittent Pneumatic Compression +	manual lymphatic drainage + bandages		primary					week		mmHg			after treatment	
	Efficacy	Johansson	A randomized study	Arm volume, mobility, strength and	IPC is as efficacious as MLD in BCRL	28	secondary	UE	2w	2 hrs		5 days per		40-60 mm	N/A	RCT	arm volume, level of	i i
	7.07	1998	comparing manual lymph	symptoms improvement not sig different in		40				270		week		Hg	****	1 FP OF	mobility and strength	
3	Efficacy	Soran 2022	Adding Pneumatic Compression Therapy in	IPC significantly reduces infection rates, hospital admissions, and physical therapy	Compliance improved with IPC	69	secondary, primary	LE	78w	N/A		N/A	Sequential	N/A	N/A	NRCT	Rate of infection, number of hospital admissions, and	
· ·	Efficacy	Szolonsky	IPC acts synergictically with	Arm volume and symptoms significantly	Excellent discussion about fears of using	27(13	secondary	UE	2w	60 mins MLD vs 30 mins	2 months	5 days/Wk		50 mm Hg	Lympha-mat	RCT	Limb volume, symptoms	i i
	CONTRACTOR OF STREET	2022	MLD in complex	improved in both gps at therapy end, at 1	IPC and the different pressures.	CDT, 14	CONTROL OF SECRETAR		3000	MLD + 30 mins IPC	Allerandensia	10.1100.000.000		AND THE REAL PROPERTY OF THE PARTY OF THE PA		75-514	que stionnaire	
-	Efficacy	Tastaban	decongestive phsiotherapy Role of intermittent	month and at 2 months. Volume reduction IPC seems to add no benefit when		CDT + IPC) 76 (38 CDT.	secondary	UE	4w	60 mins MLD vs 60 mins	 	5 days per		30-40 mmHg	Pulse press	RCT	Percentage reduction of	
		2020	pne umatic compression in	combined with CDT for lymphedema, but,		38 CDT	15411111111111111111111111111111111111	8.5	76	MLD + 30 mins IPC		week		2014000000		20882	excess volume (PREV),	
IPC + MLD	Efficacy	Uzkeser	the treatment of breast Efficacy of manual	may be functional in reducing the All tested parameters of limb volume,	no additional benefit of adding IPC to CDT	+IPC) 31	secondary	UE	3w	45 mins		6 days per		40 mmHg	N/A	RCT	symptoms of pain, Limb circ umference	
	Efficacy	2015	lymphatic drainage and	circumeference and dermal thickness	for BCRL	31	secondary	UE	-5W	4) mins		week		40 mming	IVA	RC I	measure ments, volume	
	Efficacy	Uzkeser 2013	Intermittent pneumatic	Significant improvements were observed in the function (ADL) and ROM of the	no additional benefit of adding IPC to CDT for BCRL	25	secondary	UE	3w	N/A		5 days per week		60 mmHg	N/A	RCT	ROM of UE jts	
 -	Efficacy	Haghighat	compression pump in upper Comparing two treatment	The studyshowed that both the use of	CDT alone provided better results in	112	secondary	UE	12w	1h	12w	5 days per	N/A	40 mmHg	N/A	RCT	The volume reduction of the	
_	050	2010	methods for post	CDT alone and in combination with IPC	reducing limb volume than when combined		- 51					week		100			upper limb measured by	
	Safety, Efficacy	Szuba 2002	Decongestive lymphatic the rapy for patients with	The addition of IPC to standard the rapy led to a significant increase in mean volume		23	secondary	UE	26 - 52 weeks	30 to 60 minutes		N/A	Sequential	40 to 50 mmHg	N/A	RCT	V olume- water displacement	No adverse effects on skin elasticity and joint range of
	Pressures	Taradaj 2015	Comparison of efficacy of	IPC at 120 mmHg led to the greatest		81	Phlebolymph	LE	4w	45 m		N/A	Sequential	60 or 120	N/A	NRCT	7	causiony and pain range or
_		** 1 0000	the intermittent pneumatic	reduction of edema compared to lower	V	0.4	edema	10	63. 40	2			37/4	mmHg	37/1	n :		
Fr	requency of use	Keeley 2023	A Prospective Preliminary Study Examining the	Limb volume measurements demonstrated no potential benefit of increasing IPC	No benefit of > 1 hr per day IPC in short FU	21	primary> secondary	LE	5 days or 12 days	Group A: 1 hour. Group B: 1 hour (but twice	5 days	Group A: Once per	N/A	55 mm Hg distal to 30	N/A	Prospective cohort study	Changes in limb volume (LV), tissue fluid, tissue	
			Physiological Impact of	duration more than 1 hour per day during 5	1.7		,			per day, so 2 hours total).		day.		mm Hg			tone, and patient-reported	
			Pneumatic Compression Dosing in the Treatment of	days of treatment						Group C: 2 hours (but twice per day, so 4 hours total).		Group B: Twice per		proximal			outcomes (PROs)> only volume and BIS were	
			Lower Extremity							per day, so 4 nodes iolar).		day.					reliable	
			Lymphe dema									Group C:						
												Twice per day.						
C	Compression	Dunn 2022	Intermittent Pneumatic	The study found that the LymphAssist	The improvement in limb volume and	40	secondary,	LE	5w	N/A		twice daily	N/A	40 mmHg	LymphAssis	RCT	Bilateral leg volume (with	
G	modes compression	Kim 2022	Compression for the Home-Based Intermittent	group exhibited no significant volume The use of a home-based IPC device	quality of life for patients with LE The IPC device has a distinct mode	30	primary secondary	LE	N/A	1h	4 weeks.	twice a day	MLD-	MLD.	t N/A	NRCT:	circumference) and quality Limb-volume measurement,	
	modes	Kun 2022	Pneumatic Compression	alongside a routine self-maintenance	designed to imitate the manual lymphatic	390	secondary	LL	11//12	TH.	4 Weeks.	for 4 weeks	mimicking	mimicking	11/11	Prospective	quality of life (QOL),	
	101000000		Therapy: The Impact in	program of short-stretch bandages in stage	drainage (MLD) technique, aiming to							N. W. S. J. S.	mode: 3 s	mode: 40-60		cohort study	satisfaction, and safety of	
			Chronic Leg Lymphedema in Patients Treated for	3 chronic leg lymphedema patients resulted in a lower limb-volume difference ratio and	gently aid lymphatic draining of the proximal extremities. This study shows that								inflation, 1 s holding time	mmHg; conventional			the IPC device.	
			Gynecologic Cancer	higher quality of life compared to using a	using such an IPC device with an MLD-	E.							7 s deflation	mode: 80-				
			AND AND STATE OF A SHAPE STATE OF A SHAP	home-based IPC device alone.	mimicking program can be beneficial in								and resting	100 mmHg				
					maintaining limb volume and enhancing the QOL for patients with stage 3 chronic								time; conventional					
					leg lymphedema during their maintenance								mode: 6 s	Î				
					phase.								inflation, 1 s holding time,					
													7 s deflation					
													time for each					
D	rogrammab	Karaca-	A comparison of	Dynamic pressure programmable devices	The study compared the clinical and health	1731	secondary.	unspecified	12 months	N/A	12 months	N/A	chamber N/A	N/A	N/A	Retrospective	Rates of lymphoedema-	
1.,	ility	Mandic 2017	programmable and	demonstrated better lymphedema-related	utilization outcomes between two types of	1.01	primary,	a.aponied	- 2 monute	ATTAA	1.2 mondo	47744			1,744	cohort study	related cellulitis, manual	
			non program mable	health outcomes compared to	PCDs (NP-PCD and P-PCD) in patients	ı	500 500		ı	I	1	1	I .	ı	1	1 450	the rapy use, outpatient	1

Device	Comparing 2	Fife 2012	A randomized controlled	The APCD-treated group showed a	Advanced IPC as an adjuvant treatment	36	secondary	UE	12w	1h		N/A	18 sper	30 mmHg	N/A	RCT	Limb volume (with	Seven patients had adve
ttings and	devices	THE ZOLZ	trial comparing two types of	significant 29% reduction in ede ma	may be better than standard IPC devices for		secondary	0.5	120	***		Altak	chamber (std)	(standard) or	1044	1001	circumference) and tissue	events, more in the stand
modes -	Percentility of		pneumatic compression for	compared to a 16% increase in the IPC	treating BCRL. Seven pts had adverse								sequentially	n 9.0±			water measurement (with	group.
linical			breast cancer-related	group, with a 5.8% reduction in mean	events, more in the Std gp.								inflated	4.2 mmHg			Moisture meter) at Week 0	
tud ies			lymphedema treatment in	TDC values for the APCD group and a									ending with	and 13.7±4.8			and 12	
			the home	1.9% increase for the IPC group, indicating that adjuvant treatment with an APCD									all inflated vs 1 to 3 secs	mmHg (Advanced)				
				provides better outcomes than with an IPC,									per chamber	(Marancea)				
				and both groups demonstrated very good									(onlyone					
				device compliance.									inflated at a					
													time)					
	Trunk	Ridner 2012	A randomized clinical trial	When comparing experimental		42	secondary	UE	30 days	1h in UE + trunk gp, 36		7 days per	N/A	9.0 ±	N/A	RCT	LSIDS-A score, arm	
	compression		comparing advanced	truncal/chest/arm advanced pneumatic				5.3350		mins in UE only gp		week		4.2-13.7 ±			circumference, trunk	
	preceding arm		pne umatic truncal, chest, and arm treatment to arm	compression therapy to arm-only pneumatic compression (control), there										4.9 mm Hg			circumference, (FASQ score, bioimpedence	
	compression		treatment only in self-care of	were no statistically significant changes in													score, otorm pedence	
	No. of	Pilch 2009	Influence of compression	IPC is an effective method of volume		57	secondary	UE	5w	1h		5 days per	N/A	30 to 50	N/A	RCT	Limb volume	
	chambers		cycle time and number of	reduction in women with postmastectomy			96					week for 5		mmHg				
	and cycle		sleeve chambers on upper	arm lymphedema regardless of cycle times								wee ks				l		
	time Comparing 2	Mayrovitz	extremity lymphedema Interface pressures produced	and number of sleeve chambers. Two Significant differences in pressure timings,	There were significant differences between	10	N/A	UE	Single	Single session for each	N/A	Single	Sequential	45mmHg for	Lympha	Experimenta	Interface pressures applied	
	devices	2007	by two different types of	patterns, and magnitude were found after	the Flexitouch and Lympha Press devices.	10	11/11	0.5	session for	device	11/11	session for	bequentur	the Lympha	Press,	study	to left forearm (used 256-	10
			lymphedema therapy	comparing the Lympha Press and	During inflation cycles, the pressures				each device			each device		Press and the	Flexitouch		pressure sensor array) over	8
			devices	Flexitouch devices. In terms of timing, the	exerted by the Lympha Press were higher				(at least 48					"standard"			0.1 second intervals for at	
				duration of pressure pulses in the	and were sustained for longer periods of				hours					setting for			least 2 cycles of each device	
				Flexitouch device were significantly shorter than that of the Lympha Press. Due to this	time. However, the Flexitouch differed drastically by displaying quick rise and fall				be tween each device					Flexitouch				
				quick application of pressure, the	progressions.				assessment)									
	No. of	Bergan 1998	A comparison of	One and three chamber garments were less	multi chamber sequential compression	35	se condary,	UE, LE	N/A	2 hrs	N/A	`	Sequential or	50 mmHg in			Limb volume (water	ľ
	chambers		compression pumps in the treatment of lymphedema	effective than 10 chamber garment in reducing swelling	more effective than fewer chambers		primary						non sequential	one or 3 chambers, 80			displacement)	
			treatment of tymphedema	reddenig sweming									sequential	to 30 mmHg				
														gradient in				
														ten				
	Imaging for	Zaleska 2019	The Effectiveness of	Adjustment of compression parameters to		52	se condary,	LE	1 hr		-	-	5 secs	chambered. The sleeve	N/A	Experimenta:	tissue stiffness, fluid	1
	Efficac v.	LARDIN LOTS	Intermittent Pneumatic	tissue stiffness, fluid accumulation		24	primary						inflation, 5	inflation		study, single		g
	Best settings		Compression in	volumes, and fluid movement ability									sec de flation	pressure at		session	ICGL	1
			Lymphedema of Lower	(hydraulic conductivity of tissues) at									for each	foot level was				
			Limbs:Methods of Evaluation and Results	various limb levels is indispensable for effective therapy. The yrecommended									chamber, total 40 sec	120 mmHg, gradually de-				
			Evaluation and resums	differential compression pressures and									period for 1	creasing in				
				prolonged timings at various limb levels									cycle.	the groin by				
													9000000	20%.				
	Efficac y,	Bok 2018	Evaluation of Stiffness in	After a single session of IPC, using a	IPC reduces stiffness and subcutaneous	45	secondary	UE	single session	N/A		N/A	N/A	25, 35, and	N/A	Experimenta:	UE subcutaneous tissue	
	Best settings	Correction and	Postmastectomy	pressure of 35 mmHg resulted in the	tissue thickness of UE in patients with	327	3573337752	5.8		100,000		334450	000000	45mmHg	10010000	study, single		
	tereserence entre 2 v		Lymphedema Using	largest improvement in proximal upper arm	BCRL									320000000000000		session	and stiffness	
	Imaging for Efficacy	Aldrich 2017	Effect of pneumatic	The study demonstrated improved lymph	IPC improves lymphatic function either by	4	se condary,	LE	single session	1h		N/A	N/A	45 distal to 30 mmHg	N/A	Experimenta.	I ICGL before (15 mins after injection), during and after	r
	Emcacy		compression therapy on lymph movement in	movement during and after IPC in all affected legs of the subjects tested, with	mobilizing fluid through lymph vessels or through interstitial channels.		primary							proximal		study, single session	IPC using compression	
erimenta Studies	Imaging for	Kitayama	Real-Time Direct Evidence	Different inflation/deflation modes and two	Preop severity grading done with LSG and	25(8	secondary	LE	single session	single session		single session		45 mmHg	N/A	Experimenta	ICGL-lymph velocity, real	1
Stuurs	Efficacy	2017	of the Superficial Lymphatic	different pressures evaluated (45 and 90	those with dermal backflow in leg and foot		V165.608.0008.23	1000	100 (T) (M) (C) (C) (C)	5706445340600				and 90 mm	1,000,000	study, single	time with transparent	
		111-1-1111	Drainage Effect of Intermittent Pneumatic	mmHg) using quantitative ICGL and software-assisted video analysis. ICG	were excluded (only mild cases included).	affected								Hg		session	compression sleeve, during IPC	
	Best settings	Zalecka 2013	Pressures and timing of	The study points to the necessity of	The pneumatic devices were set at three	limbs) 18	se condary,	LE	single session						N/A	Experimenta:	subcut pressure	
	Dest se tango	LARDAM ZOTO	intermittent pne umatic	applying high pressures (120 mm Hg) at	different inflation times 5, 20, or 50 sec in	10	primary		andre account						1,,,,,	study, single		
			compression devices for	ankle with 20 % proximal pressure gradient	each chamber of the eight chambers, and		0 0						ideae			session		
	Efficacy,	Olszewski	Tissue fluid pressure and	The skin's rigidity (fibrosis) and the	Tissue fluid pressures generated by a	15	N/A	LE	single session	single session	N/A	single session	sequential,	50 to 120	Biocompress	Experimenta.	Continuous Tissue pressure	,
	MOA	2011	flow during pneumatic compression in lymphedema	dissipation of applied compression force to proximal noncompressed limb regions	pneumatic device were found lower than in the compression chambers. The obtained	l							distal most chamber was	mmHg	ion	study, single session	and girth (plethysmograph attached to starin gauges	8.9
			of lower limbs	resulted in a high pressure gradient through	results point to the necessity of applying								not deflated			Session	applied at different limb	
	Imaging for	Olszewski	Pathways of lymph and	The study utilized LSG to demonstrate the	The study finds that while intermittent	15	secondary	LE	single session	N/A	N/A	N/A	N/A	50 to 125	N/A	Experimenta:	LSG- The primary outcome	s One patient experienc
	Efficacy	2011	tissue fluid flow during	move ment of subcutaneous fluid and static	pneumatic compression can effectively	l	120		187					mmHg		study, single		muscle cramps and a se
	Imaging for	Adams 2010	intermittent pneumatic Direct evidence of lymphatic	lymph propelled towards the groin after Improvement defined as proximal	push mobile tissue fluid towards the groin, IPC was effective in stimulating the	3 controls, 6	secondary	UE	ainalo mari	single session. An hour-long		single session		NA	Flexitouch	session Experimenta	destinations of fluid moved ICGL same and contralaters	reported increased lin
	Imaging for Efficacy	Auams 2010	function improvement after	improvement de fined as proximal movement of dye after therapy. Lymphatic	lymphatic function locally and systemically.	with BCRL	secondary	UE	engle session	IPC (30 mins trunk and		emilie session		IVA	Plexitouch	study, single		
	> 2000000000000000000000000000000000000		advanced pneumatic	function improved in all control subjects						proximal arm basins						session	rate, apparent lymph	1
SPECIAL	SITUATION Efficacy in	VS Manjula	Evaluation of sequential	12 patients with grade II filarial		28	secondary	LE	1 4w		6 months					1	volume (with water	ŕ
	filariasis	Manjula 2002	Evaluation of sequential intermittent pneumatic	12 patients with grade II filarial lymphoedema had >26% reduction in		28	secondary	LE	4W		o montas						volume (with water displacement)	
	Efficacy in	Hassall 2001	A Retrospective Studyof the	In this retrospective study of 16 children	pressure required decreased over time in	16	secondary,	UE;LE	N/A	N/A	N/A	N/A	N/A	N/A	Lymphapres	Retrospoetive	Volume and circumference	d .
	children		Effects of Lymphapress	with lymphedema of the upper or lower	the same pt	-0.0	primary		v=163000	-0000E2	-mmi0854	5000000			s	cohort study		
	53863-54W		Pump on Lymphede ma In A	extremities, the Lymphapress pump													before and after treatment	

Combined with Lymphatic Surgery	Zelikovski 1983	The sequential preumatic compression device in surgery for lymphede ma in the limbs	IPC used before, during and a fler suggery. Aids intraop lymphatics visualization for LVA and maintains enastronosis pale ney, reduce wound complications and pain in excisional suggeries.	Higher pressure used for the more severe case 1, preoperatively.	3	secondary LE, UE	1 UE, 2 LE	Case I (LE)- 36 hrs continuously pre skin and subcut resection, 3 day postop 6 hrs/Day, Case 2 (LE)- intop for dilating groin lymphatics for LV A, postop for 12 hrs, Case 3 (UE) intraop for propelling blue dye, skin and subcut resection and LV A done.				Se que ntial	case 1-130 mm Hg preop, 80 mm Hg postop, case 2-80 mm Hg	Lymphpress	case series	wound complications and pain in excisional surgeries.	
Safety,	Ridner 2021	Advanced pneumatic	Patients who received advanced pneumatic	significantly enhanced patient perception	43	secondary	H&N	8w	23 to 45 minutes	1	prescribed	N/A	A\M	N/A	RCT	Symptoms (including	
Efficacy		compression for treatment of lymphedema of the head and neck: a randomized wait list controlled trial	compression device (AIPC) care for lymphedema showed significant improvements in their perceived ability to control lymphedema, patient-reported outcomes, visible external swelling, and reported pain compared to those who	regarding their ability to control their lymphedema, polentially reducing patient distress.		y		22000			twice daily, 7 days per week, but most pts used once a day		355			paraesthesia, pain, heaviness), function (cervical motion, speech), swelling internal and external	
Safe ty, Effic acy	Gutierrez 2019	Head and Neck Lymphede ma: Treatment Response to Single and Multiple Sessions of Advanced Pneumatic Compression Therapy	The studys valuated ICGL dermal backflow are in 10 patients before and after IPC completion, finding a reduction in backflow in 6 out of 3 subjects, and demonstrated improved facial composite measure ments cores and as lf-re-ported outcomes in all 10 subjects with no adverse events reported.	The use of near-infrared fluorescence lymphatic imaging (NIRRLI) to visually assess the impact of the preturable compression therapyon Janphatic drainage and the ability to observe enhanced lymphatic uptake and drainage, as well as changes in areas of dermal backflow, in subjects after the treatment.	10	secondary	H&N	2 weeks.	32m	2 weeks.	7 days per week	N/A	NIA	Flexitouch	Prospective cohort- Observational study where subjects were imaged using NIRFLI before and after the initial treatment, and then again after 2 weeks of daily treatment.	external swelling (measured using facial composite scores), and subject-re-ported improvements.	No adverse events : re ported
Imaging for Efficacy	Rasmussen 2019	Imaging the Lymphatic Response to Manual Lymphatic Drainage and	Both MLD and IPC showed improvement in lymph velocity, and enhanced lymphatic uptake in both control and symptomatic	The only study that used imaging after a sustained us of IPC	69	secondary	H&N, limbs	2 weeks.	N/A		daily for 2 weeks	N/A	A\N	A\M	NRCT- conference abstract	ICGL before and 2 weeks after +/- during IPC/MLD	
Safety, Efficacy, Best Settings	Mayrovitz 2018	Usability of advanced pneumatic compression to treat cancer-related head and	The majority of patients found APCD to be comfortable, effective, and well-tolerated, with one treatment showing statistically	The treatment was found to be safe, easy to use, and well-tolerated, showing edema reduction after just a single initial treatment	44	secondary	H&N	Single session	32m	N/A	once	N/A	N/A	N/A	NRCT; Prospective cohort study	Patient-reported comfort, feelings post-treatment, and likelihood of home use,	
Safety, Efficacy	Ridner 2010	Advanced pne umatic therapy in self-care of	Significant reduction in overall symptoms but the reduction in trunk circumference	100% compliance with IPC, Flexitouch used, study period was short	12	secondary	Trunk	10 days	1h		7 days per week	N/A	AVA	Flexitouch	Prospective cohort study	Patient reported symptoms, and trunk circumference	
RTIVE STUDI	ES ON COM	IPRESSION PRESSURE	but the feduction in trunk circumference	used, study period was short		10 V	E .	M			Week			fet.	conortstudy	and trunk circumference	5
Efficacy, best settings	Zaleska 2017	Indocyanine green near- infrared lymphangiography for evaluation of	Realtime movement of edema fluid observed using various compression modalities. Threshold pressures necessary	Determined sleeve pressure required for moving fluid proximal 40 mm Hg in the tissues which can be generated with was	N/A		UE, LE	single session					50 to 120 mm Hg gradient	AVA	Experimental study, single session	ICGL before and after, also measured tissue pressure using four different	
Other	Partsch 2011	Dose finding for an optimal compression pressure to reduce chronic edema of the extremities	The study examines the change in limb volume and circumference after 2 hours of using compression garments with different pressures, revealing that the upper limit for	Indirect estimate of required compression pressure	36 arm patients and 42 leg patients	secondary	UE;LE	N/A	N/A		N/A	N/A	gamati	N/A	Prospective cohort study	Limb volume and circumference before and after treatment	

ADL, activities of daily living. AE, adverse events; APCD, advanced pneumatic compression device; ASES, American Shoulder and Elbow Surgeons; BCRL, breast cancer-related lymphedema, CB, compression bandages; CDT, complex decongestive therapy, CL, contralateral; ; FU, follow up, gps, groups; h/hr, hour, H&N, head and neck, iCG, indocyanine green near-infrared lymphorgraphy, IPC, intermittent pneumatic compression, jis, joints, LE, lower extremity, LLCS, key lymphedema complex ity score; LYMp(OL, Lymphedema, CB, lymphore infiguraphy, IPC, intermittent pneumatic compression device; NRCT, non-randomized control residence in maging; NP-PCD, pneumatic compression device; PREV, pneumatic compression device; PREV, pneumatic compression device; PREV, pneumatic compression, PCD, pneuma