

# Compression hosiery in upper body lymphoedema

The construction and classification of  
compression garments

Principles of anatomy and physiology in relation  
to compression of the upper limb and thorax

Evidence for the use of upper body compression  
garments in patients with lymphoedema

Selecting compression hosiery for hand, arm and  
midline trunk lymphoedema

**SUPPORTED BY AN  
EDUCATIONAL GRANT  
FROM BSN MEDICAL**



The views expressed in this publication are those of the authors and do not necessarily reflect those of the publishers or BSN medical.

**THIS DOCUMENT IS ENDORSED BY:**

Australasian Lymphology Association  
(ALA, Australia)

British Lymphology Society (BLS, UK)

Lymphoedema Association of Australia  
(LAA, Australia)

Lymphoedema Support Network  
(LSN, UK)

Lymphology Association of North  
America (LANA)

MLD UK

National Lymphedema Network  
(NLN, USA)

Nederlands Lymfoedeem Netwerk  
(NLN, Netherlands)

Norsk Lymfødforening (NLF  
Norsk, Norway)

Israel Lymphoedema Association  
(ILA, Israel)

Svensk Förening för Lymfologi  
(SFL, Sweden)

**STATEMENT OF RECOGNITION:**

The International Society of Lymphology (ISL) recommends the new *Template for Practice: Compression hosiery in upper body lymphoedema* as a valuable, useful and illustrative educational resource for general practitioners and the public as a thoughtful, detailed compendium of established practices within the United Kingdom

©HealthComm UK Ltd,  
a division of Schofield  
Healthcare Media Ltd, 2009

HEALTHCOMM UK Ltd

All rights reserved. No reproduction, copy or transmission of this publication may be made without written permission, with the exception of BSN medical. No paragraph of this publication may be reproduced, copied or transmitted save with written permission or in accordance with the provisions of the Copyright, Designs & Patents Act 1988 or under the terms of any licence permitting limited copying issued by the Copyright Licensing Agency, 90 Tottenham Court Road, London W1P 0LP.

**TO REFERENCE THIS DOCUMENT  
CITE THE FOLLOWING:**

Template for Practice: *Compression hosiery in upper body lymphoedema*. 2009. HealthComm UK Ltd, Aberdeen

**MANAGING EDITOR**

Nicola Rusling

**SENIOR EDITORIAL ADVISOR**

Christine Moffatt

Honorary Professor, Glasgow University Medical School

**DEPUTY EDITOR**

Binkie Mais

**EDITORIAL ADVISORS**

**Jane Armer**

Professor, Sinclair School of Nursing, Director, Nursing Research, Ellis Fischel Cancer Center, Director, American Lymphedema Framework Project, University of Missouri, Columbia

**Augusta Balzarini**

MD, Oncological Rehabilitation, Palliative care and Rehabilitation, National Cancer Institute, Milan

**Håkan Brorson**

Consultant Plastic Surgeon, Department of Clinical Sciences, Lymphoedema Unit, Plastic and Reconstructive Surgery, Malmö University Hospital, Malmö, Sweden

**Michael Clark**

Senior Research Fellow, Department of Wound Healing, School of Medicine, Cardiff University, Cardiff, UK

**Robert Damstra**

Dermatologist, Department of Dermatology, Phlebology and Lymphology, Nij Smellinghe Hospital, Drachten, The Netherlands

**Sarah Davies**

Physiotherapist, Peter MacCallum Cancer Centre, Victoria, Australia

**Etelka Földi**

Physician-in-Chief, Földi Clinic, special clinic for lymphology, Hinterzarten, Germany

**Nicole Stout Gergich**

Physical Therapist and Lymphedema Specialist, National Naval Medical Center, Breast Care Center, Bethesda, MD, USA

**Kaoru Kitamura**

Vice Director (Department of Breast Surgery), Kyushu Central Hospital, Fukuoka, Japan

**Isabelle Querry**

Professor of Vascular Medicine, Head of the vascular medicine department, Saint Eloi University Hospital of Montpellier, Montpellier University, France

**Saskia Thiadens**

Founder and Executive Director, National Lymphedema Network, Inc, Oakland, California

**Anna Towers**

Director, Palliative Care Division, McGill University, Montreal, Canada

**Horst Weissleder**

Professor of Radiology, Freiburg University, Germany; Honorary President German Society of Lymphology

**Copies of this document are available from:**

[www.wounds-uk.com](http://www.wounds-uk.com)

[www.lymphormation.org](http://www.lymphormation.org)

[www.woundsinternational.com](http://www.woundsinternational.com)

**PUBLISHED BY**

HealthComm UK Ltd, Suite 3.1, 36 Upperkirkgate, Aberdeen AB10 1BA

**PRINTED BY**

WACE Corporate Print Limited, Swindon, Wiltshire, SN3 4FH, UK

# Compression garments in upper body lymphoedema

CJ Moffatt

**Compression hosiery is at the centre of long-term management of lymphoedema and is one of the most important aspects of care that helps patients to take greater control of their condition. Much of the emphasis in the field of compression has been on the lower limb. This Template for Practice is unique in attempting to provide an international resource that provides guidance on the appropriate use of compression garments for the upper body.**

Lymphoedema is a major, international healthcare problem in both developed and developing countries. Although the true size of the problem remains obscure, research across the globe is beginning to show the true extent of the problem. Millions of people are affected at huge personal cost to patients and their families. Professional knowledge and practice is often poor and this level of ignorance leads to incorrect treatment or no treatment being offered, and contributes to the lack of reimbursement of treatment in many parts of the world.

This template follows on from the first document, *Compression hosiery in lymphoedema* (Lymphoedema Framework, 2006a) that recognises the central role that compression garments play in the treatment of lower limb lymphoedema. Together they provide a comprehensive, yet practical guide for practitioners who are managing patients with lymphoedema.

In the first paper, Krimmel describes the basic construction of compression garments and how the different types of knitting and use of yarn affect the type of garment that is produced. This is a critically important issue as it directly influences the choice of compression garment that is given to patients with different clinical presentations. Unlike lower limb hosiery where different national hosiery standards exist, there is only one recently introduced standard, the RAL, that underpins the pressures and production criteria for upper limb garments.

The paper by Carati, Gammon and Piller provides an in-depth review of the anatomy and physiology of the upper body, and outlines how an understanding of arterial, venous and lymphatic flow in the upper body in normal limbs and those at risk of, or with, lymphoedema will greatly improve patient outcomes. The authors highlight the difficulties of measurement beneath compression.

The literature review of the evidence for using

compression garments to treat oedema of the upper body by Johansson shows the paucity of good quality studies in this area over the last 30 years. All of the existing evidence relates to the use of garments on the upper limb, however, it is frequently flawed by poor design, problems of definition and difficulties of standardising assessment methods that would allow comparability between studies. This is an area that requires considerable research investment.

The final paper by Doherty and Williams provides in-depth practical advice on how to use compression garments in practice. The recommendations are largely drawn from the International Best Practice Document in Lymphoedema (Lymphoedema Framework, 2006b) that was developed and endorsed by renowned international experts in the field. This paper highlights the need for careful and continuous assessment of garment efficacy and also gives an overview of the different presentations of lymphoedema in the upper body.

Despite the lack of empirical evidence there is a wealth of expert clinical opinion that supports the central role that compression garments play in lymphoedema management. Of particular importance is the emerging recognition that early treatment and prevention of lymphoedema are critical if the long-term complications resulting from poor management are to be avoided.

By elucidating the rationale for and use of compression garments in the treatment of lymphoedema of the upper body, this document aims to enhance practitioners' and patients' use of compression garments and improve the experience of patients with lymphoedema.

## REFERENCES

- Lymphoedema Framework (2006a) *Template for practice: compression hosiery in lymphoedema*. MEP Ltd, London
- Lymphoedema Framework (2006b) *Best Practice for the Management of Lymphoedema*. International Consensus. London: MEP Ltd

CJ Moffatt, CBE,  
Honorary Professor, Glasgow  
University Medical School,  
Director, International  
Lymphoedema Framework

# The construction and classification of compression garments

G Krimmel

**Flat- and circular-knitting are the two main methods employed in the construction of compression garments for patients with lymphoedema. Both techniques influence the properties of the finished garment in terms of the level of compression it will provide, its thickness, comfort and cosmetic acceptability. It is important that clinicians understand how construction influences the finished garment and how garments are classified, so that they are able to select products that deliver effective compression, fit correctly, are comfortable and encourage long-term use.**

In patients with lymphoedema of the upper body, compression garments are usually prescribed for the long-term management of lymphoedema following a period of intensive therapy, but they can also be used for prophylaxis or as part of initial treatment in patients with mild lymphoedema. In some patients, compression garments may be the only form of compression used, or they form part of a regimen that includes other types of compression, such as multi-layer lymphoedema bandaging. For the chosen compression regimen to be successful, and to aid compliance, it must be comfortable and acceptable to the patient (Lymphoedema Framework, 2006).

There are many styles of compression garment available for the management of swelling of the upper body, including gloves, gauntlets, armsleeves, vests, and masks for facial swelling. The type of garment selected and the level of compression prescribed for patients with lymphoedema is dependent on many factors including the site, extent, shape distortion and severity of the swelling, the patient's ability to manage and tolerate compression, and patient choice (Lymphoedema Framework, 2006).

Thus, in order to use compression garments optimally, it is important that clinicians understand the relevance of the technical aspects of garment construction, so that they are able to select a garment that is effective and which fits accurately and comfortably to encourage patient compliance and long-term use.

## CONSTRUCTION OF COMPRESSION GARMENTS

Compression, defined as the pressure applied to the limb by a garment (Clark and Krimmel, 2006), is dependent upon a complex

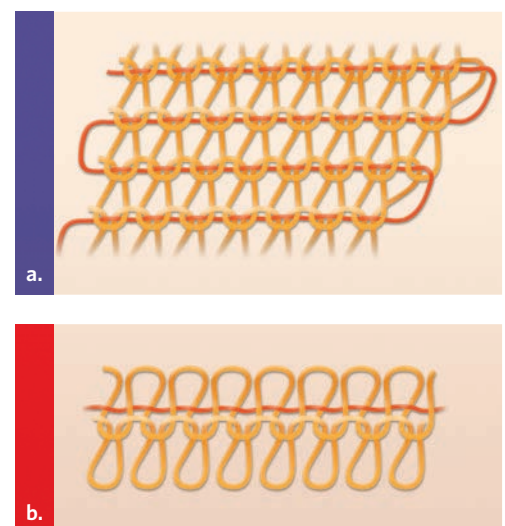
interaction of the physical properties and construction of the compression garment, the size and shape of limb to which it is applied, and the activity of the wearer. As a broad principle, the level of compression is directly proportional to the tension with which the compression device is applied and is inversely related to the size of the limb according to Laplace's Law (Clark and Krimmel, 2006).

The tension exerted by a compression garment is related to the type of yarn used in its construction and the knitting technique selected to produce the fabric.

### Yarn

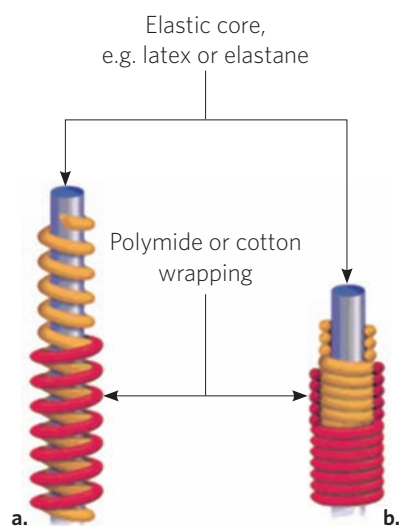
The fabric that is used to make compression garments is produced by knitting two types of yarn together (Figure 1):

- Inlay yarn. This produces the compression
- Body yarn. This delivers the thickness and stiffness of the knitted fabric.



**FIGURE 1.** The arrangement of inlay and body yarn in flat-knit (a) and circular-knit fabric (b).

Both types of yarn are produced by wrapping polyamide or cotton around a stretchable core such as latex or elastane (Lycra) (Figure 2). The wrapping can be adjusted to vary the stretchability and power of the yarn (Figure 2). The stretchability is a measure of how far the yarn can be elongated, and the power is a measure of how easily it stretches. High power yarn is less easy to stretch and is stiffer than its low power counterpart, and thus applies greater compression.



**FIGURE 2.** The fibres that make up body and inlay yarn. The wrapping of the outer fibre around the stretchable core can be adjusted to vary the stretchability and power of the yarn. Loose wrapping (a) means the yarn has more stretch and less power than a yarn in which the fibres are tightly wrapped (b).

The thickness, texture and appearance of the knitted fabric can also be changed by adapting the wrapping of the yarn. Higher levels of compression are mainly achieved by increasing the thickness of the elastic core of the inlay yarn, although adjustments may also be made to the body yarn.

**KNITTING TECHNIQUES**

There are two main knitting techniques used in the production of compression garments for the treatment of lymphoedema:

- Flat-knitting
- Circular-knitting (Table 1).

**Flat-knitting**

As its name suggests, flat-knit technology produces a flat piece of fabric (Figure 3) that is shaped by the addition or removal of needles during the knitting process. The material is then stitched together (resulting in a seam) to produce the final garment.

Recently, however, BSN-Jobst have developed a unique flat-knit technique which enables the production of made-to-measure seamless gloves. The unique technology results in a flat-knit material that is softer than the fabric produced using traditional flat-knit technology. Seamless compression gloves are particularly useful for patients with sensitive skin in whom the presence of a seam may result in skin irritation. They also provide uninterrupted or constant pressure and do not restrict the movement of the hand (Földi and Greve, 2007) (Figure 4).

**Circular-knitting**

Circular knit garments are produced from material that is continuously knitted on a cylinder resulting in a seamless tube that requires comparatively little finishing to produce the end product (Figure 5). The use of this technique results in a garment which is generally thinner and thus more cosmetically acceptable than flat-knit alternatives.

**CUSTOM-MADE AND READY-TO-WEAR GARMENTS**

One particular challenge faced when prescribing garments for the management of upper body lymphoedema is that, in most cases, the size and shape of the oedematous area will not match the size ranges offered by manufacturers of ready-to-wear garments, prompting the need for

**TABLE 1 . Flat-knit and circular-knit characteristics**

	Flat-knit	Circular-knit
How is shape controlled?	By varying the number of needles in operation. The elastic inlay has no pre-tension when it is put into the garment	By varying the tension of the inlay yarn and stitch height; the number of needles in operation cannot be changed resulting in a limited fit range
Number of needles per inch	14-16 (coarse fabric)	24-32 (fine fabric)
Yarn thickness	Coarse, to produce sufficient stiffness and thickness	Fine, to produce a more cosmetically acceptable garment



**FIGURE 3. Flat-knit garment.**



**FIGURE 4. The flat-knit Elvarex® Soft Seamless glove has: (a) seamless flat edges which are not bulky and which do not curl; (b) a unique 3D manufacturing technique that facilitates a good fit between the fingers, aiding oedema control in this area.**



**FIGURE 5. Circular-knit garment.**

custom-made products. This is particularly the case for hard to measure areas such as the breast, where breast shape, weight and density of tissue, torso and shoulder proportions will all have an effect on the fit of the garment. There are ready-to-wear support bras with variations in styles and sizes, but custom-made garments are recommended where there are specific anatomical considerations in patients to obtain a better and comfortable fit.

Both flat- and circular-knit techniques are used to produce custom-made and ready-to-wear garments. However, custom-made garments are most often made using flat-knit technology since it can accommodate a wide range of anatomical distortion. When knitting, the total number of needles can be increased or decreased to produce variations in the width and shape of the fabric used to construct the final garment.

When using circular-knit technology, the number of needles in use during production of a particular garment is fixed, reducing the range of shape distortion that can be accommodated. However, a small degree of shape variation can be produced during knitting by altering the tension of the inlay yarn and varying stitch height. Generally, circular-knit, ready-to-wear garments are only suitable where there is no or minimal limb distortion, as otherwise it may be more difficult to obtain an accurate fit.

In general, flat-knit fabric is coarser than circular-knit because it uses thicker yarn and consequently fewer needles per inch during knitting (Table 1). The thicker yarn produces stiffer and thicker material that is better at bridging skin folds and is less likely to cut into the skin or cause a tourniquet effect. The finer finish of circular-knit garments may make them more cosmetically acceptable, but it also makes the garments more likely to roll at the top and cut into the limb, particularly if worn for extended periods.

#### **EUROPEAN STANDARDS FOR COMPRESSION GARMENTS OF THE UPPER BODY**

National standards cover parameters such as testing methods, yarn specification, compression gradient and durability and are of considerable value in ensuring that compression garments can be selected that are known to produce an appropriate level of compression. They are also usually a prerequisite for reimbursement.

Unlike lower limb hosiery for which British, French and German standards exist (Clark and Krimmel, 2006), currently there is only one standard available for upper body garments. The German standard RAL-GZ 387/2 became effective in January 2008 and applies to compression armsleeves. The German RAL standard covers both ready-to-wear and custom-made garments, but in Germany the latter are preferentially recommended for the treatment of lymphoedema.

The standard uses the HOSY method during testing to measure the compression applied to the upper extremity by the armsleeve and focuses upon *in vitro* measurement of the pressures applied at various points on the limb. The level of compression delivered at the wrist is then classified into one of three classes:

- Class I: 15–21mmHg
- Class II: 23–32mmHg
- Class III: 34–46mmHg.

However, the standard contains little information on the use of compression garments in the treatment of lymphoedema, so should be used in conjunction with clinical guidelines such as the *International Consensus: Best Practice for the Management of Lymphoedema* (2006).

It should also be remembered that there is little clinical evidence to indicate the correct pressures for compression garments of the upper body, especially when managing midline oedema. Recommendations are often borrowed from what we know about hosiery of the lower body, however, anatomical variations make this practice less than ideal and more research is needed in this area.

### GARMENT CARE

Recommendations for the care of compression garments are designed to maintain product performance and prolong garment life, and derive from the materials and method of construction used.

Oil-based skin cream used under compression garments may adversely affect the yarn and thus the garment's performance. Ideally, garments should be hand or machine washed at the temperature recommended by the manufacturer every day or every second day. Conditioner should not be used when laundering as this can cause garment deterioration. As well as cleaning the garment,

washing allows the yarns to realign after being stretched during wear and to maintain the correct compression. Garments should be dried away from direct contact with heat, which may be harmful to the yarn.

The need for replacement garments should be reviewed every three to six months, or when they start to lose elasticity. Very active patients may need replacement garments more frequently.

### CONCLUSION

The techniques used in the construction of compression garments influence the performance characteristics of the final product. Understanding this can help the practitioner to select a compression garment to meet the needs of the individual patient.

National standards were developed to guide manufacturers and to help classify garments according to the compression generated, and several exist for compression hosiery. Despite the existence of only one standard for the use of upper body compression armsleeves, manufacturers offer a wide range of products for the upper body, each with their own classification of the compression they produce, based upon the manufacturer's testing methods.

These differences in class pressure ranges and testing equipment make comparisons between products difficult, and the practitioner should be aware of this. To assist comparison, it would be helpful if garment packaging and studies involving compression garments stated the pressure ranges and the testing methods used to determine the pressures.

However, it is important to remember that the classification of compression garments either by standards or manufacturers provides only an approximate range of the compression delivered. The selection of an appropriate garment should be based on a thorough and holistic assessment of the patient in order to aid compliance and long-term use.

### REFERENCES AND FURTHER READING

- Clark M, Krimmel G (2006) Lymphoedema and the construction and classification of compression hosiery. In: Lymphoedema Framework. *Template for Practice: compression hosiery in lymphoedema*. London: MEP Ltd 2006
- Földi E, Greve J (2007) Technological quantum leap in lymph therapy Jobst® Elvarex® Soft Seamless: Worldwide first flat knit seamless custom-made compression glove. *Eur J Lymphol* **17(5)**: 16–7
- Lymphoedema Framework (2006) *Best Practice for the Management of Lymphoedema*. International consensus. MEP Ltd, London

# Principles of anatomy and physiology in relation to compression of the upper limb and thorax

C Carati, B Gannon, N Piller

**An understanding of arterial, venous and lymphatic flow in the upper body in normal limbs and those at risk of, or with, lymphoedema will greatly improve patient outcomes. However, there is much we do not know in this area, including the effects of compression upon lymphatic flow and drainage. Imaging and measuring capabilities are improving in this respect, but are often expensive and time-consuming. This, coupled with the unknown effects of individual, diurnal and seasonal variances on compression efficacy, means that future research should focus upon ways to monitor the pressure delivered by a garment, and its effects upon the fluids we are trying to control.**

Little evidence exists to support the use of compression garments in the treatment of lymphoedema, particularly in relation to the upper body and limbs. There is much we do not know about the finer details of arterial, venous and lymphatic flow in normal, at risk and lymphoedematous limbs, and how this is affected by the application of compression. However, despite this, the use of compression garments is a widely accepted and important part of treatment (Partsch and Junger, 2006).

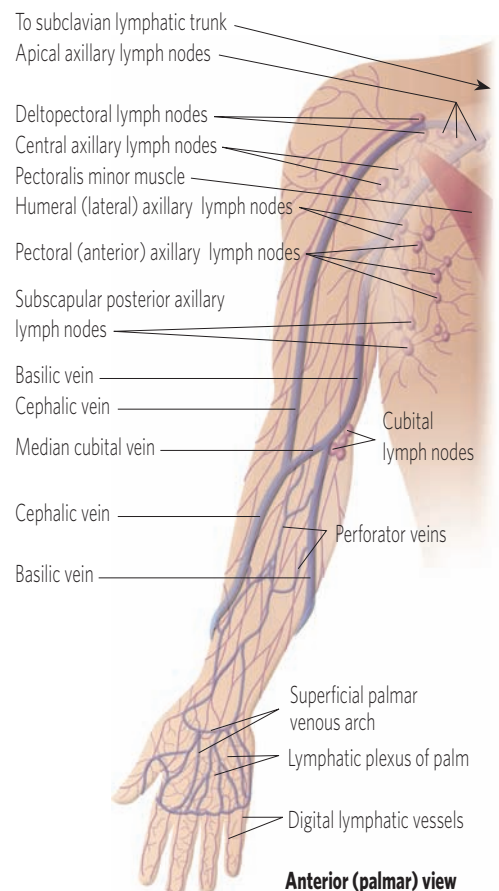
More is known about the possible effects of compression on the pathophysiology of lymphoedema when used on the lower limbs (Partsch and Junger, 2006). While some of these principles can be applied to guide the use of compression on the upper body, it is important that the practitioner is knowledgeable about the anatomy and physiology of the upper limb, axilla and thorax, and of the anatomical and vascular differences that exist between the upper and lower limb, so that the effects of these differences can be considered when using compression garments.

This paper will describe the vascular anatomy of the upper limb and axilla, and will outline current understanding of normal and abnormal lymph drainage. It will also explain the mechanism of action of compression garments and will detail the effects of compression on fluid movement.

## VASCULAR DRAINAGE OF THE UPPER LIMB

It is helpful to have an understanding of the vascular drainage of the upper limb, since the lymphatic drainage follows a similar course (Figure 1). The venous system of the upper limb consists of superficial and deep systems, with numerous 'perforating' veins (so-called because they pierce the deep fascia separating the skin from the muscles and bones) joining the two systems (Moore and Dailey, 2006).

The superficial system arises from the capillary networks of the skin and subcutaneous tissue, which drain into two major vessels. The anterolateral tissue of the upper limb drains into the cephalic vein. This vein originates from the lateral dorsum of the hand and travels via the lateral border of the wrist and forearm, passing through the lateral aspect of the cubital fossa (where it communicates with the basilic vein



**FIGURE 1.** Venous and lymphatic systems of the hand and arm.

C Carati, Associate Professor;  
B Gannon, Associate Professor,  
Department of Anatomy/  
Physiology; N Piller, Professor,  
Director Lymphoedema  
Assessment Clinic,  
Department of Surgery, School  
of Medicine, Flinders University  
and Medical Centre, Bedford Park,  
South Australia

via the median cubital vein), and ascending the arm to pass into the axillary region between the deltoid and pectoralis major muscles. The basilic vein drains the postero-medial aspect of the dorsum of the hand, travels superficially up the antero-medial aspect of the forearm, medially through the cubital fossa and about one-third of the way up the arm, before piercing the deep fascia to then accompany the brachial artery into the axillary region. Both veins connect to the axillary vein, and then the subclavian veins en route to the superior vena cava. Many perforating veins are evident in the anterior aspect of the forearm, coalescing into the median vein of the forearm, which then joins the basilic and/or the cephalic veins (Figure 1).

The lymphatic drainage of the torso does not follow the venous drainage of the torso as closely as in the arm. However, the venous drainage of the torso also enters the axillary, subclavian, or brachiocephalic veins en route to the superior vena cava, and hence may be relevant to the venous drainage of the arm. The anterior wall of the torso and the breast drains mainly into the axillary vein, and to a lesser extent the internal thoracic veins. The ribcage is drained via intercostal and subcostal veins that drain the ribcage posteriorly into the azygous/

hemiazygous venous system, or anteriorly into the internal thoracic veins. The posterior wall of the thorax also drains into the azygous/hemiazygous system, which drains directly into the superior vena cava.

**LYMPHATIC DRAINAGE OF THE UPPER LIMB**

The lymphatic drainage of the upper limb also consists of superficial and deep systems, which follow similar paths to that of the vascular system. There are four major patterns of lymphatic drainage which are based on early cadaver, lymphography and lymphoscintigraphic investigation (Foeldi et al, 2003).

The *superficial lymphatic drainage* vessels arise as a plexus within the skin of the upper limb. Vessels drain from the hand mainly along its palmar surface into larger lymphatic vessels that converge towards the veins draining the forearm, especially the basilic vein (Moore and Dailey, 2006), acquiring new vessels from the skin as they travel up the limb (Figure 1).

The lymphatic vessels draining the *antero-lateral territory* of the arm traverse the upper part of the arm and the anterior aspect of the shoulder, draining into the uppermost (apical) lymph nodes of the axillary lymphatic system (Figure 2). Lymph drainage from the *postero-*

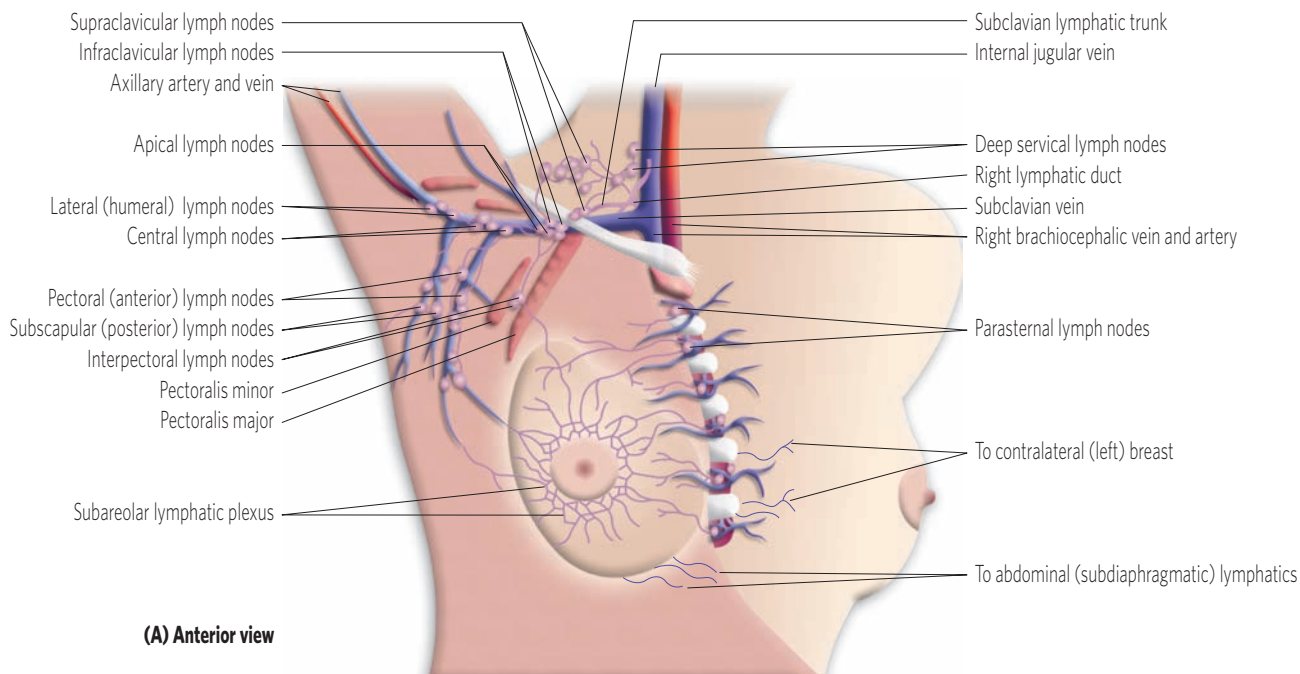


FIGURE 2. The lymph nodes of the axilla.

### BOX 1 Lymphatic drainage of the axilla

It is difficult to get optimum pressure, if any, into the axillary/medial proximal upper arm area using compression garments. This, combined with a likely annulus of often inappropriate pressure on the shoulder and lateral chest provided by the wearer's bra (in the case of a woman), means that there are often very significant issues of fluid accumulation (initially) and fibre (later) in this area.

medial aspect of the forearm passes through nodes in the medial cubital region, proximal to the medial epicondyle of the elbow, and then into lateral (humeral) lymph nodes of the axilla.

The *deep lymphatic drainage* originates from the deeper soft tissue, such as muscles and nerves, joints and the periosteum of the bones. Vessels converge and travel close to the deep veins of the upper limb, occasionally passing through a few lymph nodes, before arriving at the lateral (humeral) axillary lymph nodes (Figure 2) (Moore and Dailey, 2006).

The cutaneous venous drainage of the upper back (thorax) is via dorsal perforating (posterior) cutaneous branches of the posterior intercostal veins and thence to the azygous/hemiazygous system to superior vena cava.

Venous drainage of the skin and dermis of the chest anterior to the mid-axillary line is largely via the thoraco-epigastric vein network, to the axillary vein (via the lateral thoracic vein — the superior part of the thoraco-epigastric venous network). Venous drainage of the female breast is largely via the lateral thoracic vein to the axillary vein, but the more medial superficial aspects of the breast drain to the paired internal thoracic venae comitantes, then to subclavian vein and on to the superior vena cava. Much of the deepest tissue of the breast drains via perforating veins through the deep fascia to the anterior intercostal veins, and then to the internal thoracic veins.

The venous drainage of the skin and dermis of the chest mainly enters the axillary, subclavian, or branchiocephalic veins en route

to the superior vena cava, and hence may be relevant to the venous drainage of the arm.

### LYMPHATIC DRAINAGE OF THE THORAX

The lymphatic drainage of the torso does not follow the venous drainage of the torso as closely as these systems do in the arm. Superficial lymph drainage from the back of the thorax is mainly via a network of superficial lymphatics, which converge to the subscapular (posterior) nodes of the axilla (Figure 2). However, there is the possibility that the more medial back drains via perforating lymphatic connections to the posterior intercostal lymphatics en route to paravertebral nodes (Iyer and Libshitz, 1995).

Lymph drainage of the skin and dermis of the front of the thorax (chest) anterior to the mid-axillary line is largely from individually variable regions (lymphotomes) to particular axillary nodes (i.e. the sentinel node for each region; Suami et al, 2008). The area medial to the nipple in both sexes drains to the parasternal (internal mammary) node chain (Figure 3).

Drainage of the well developed lymphatic network of the female breast, including the dense sub-areola network, is largely via laterally or superiorly directed lymphatics, which pass to pectoral axillary nodes, or to lateral axillary nodes (Suami et al, 2008) (Figure 2). The superficial aspects of the breast medial to the areola, drain medially to par-mammary and para-sternal nodes (Schuenke et al, 2006), then to the right or left lymph duct or thoracic duct to the subclavian vein, and on to the superior vena cava. Sentinel node tracing from non-palpable (deep) breast tumours (Tanis et al, 2005) suggests that much of the deepest tissue of the breast is likely to drain via the deep lymphatics, which perforate through the deep fascia to join the anterior intercostal lymphatics, passing then to the internal mammary lymph trunk and chain of nodes.

### LYMPHATIC DRAINAGE TO THE AXILLA

The lymphatic drainage of the upper limb is intimately related to that of the anterior and posterior regions of the thorax, especially the breast, all of which drain through the axillary region. The axillary region contains five clusters of nodes, arranged in a pyramid pattern dictated by the shape of the axillary region, with three clusters at the base of the axilla, one

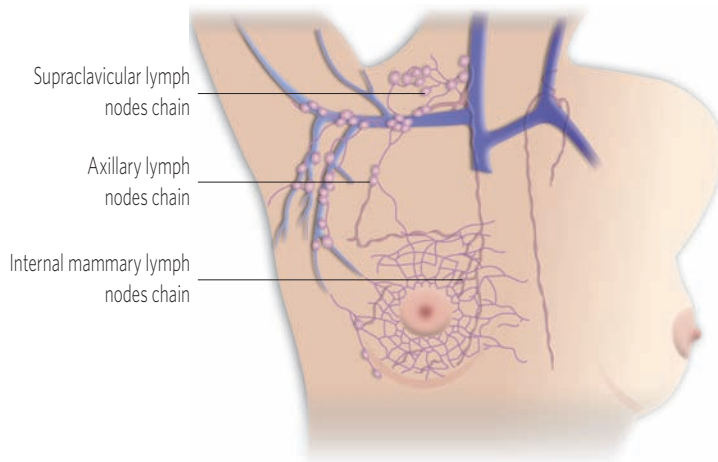


FIGURE 3. Drainage into mammary lymph nodes.

**BOX 2 Lymphatic drainage paths**

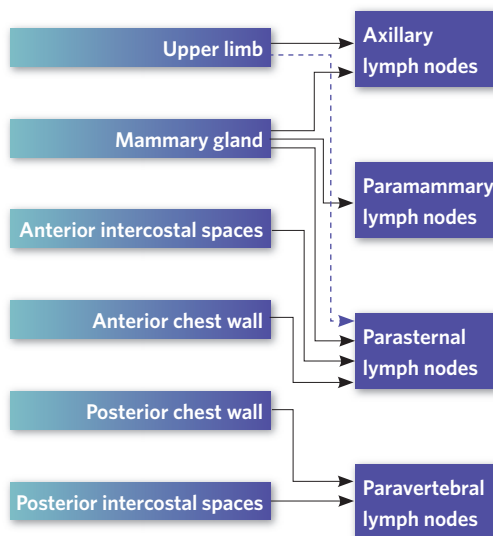
Studies have indicated that lymph drainage of the upper arm travels into the mammary nodes in some individuals with lymphoedema. These drainage patterns also indicate the need to pay attention to the potential effect of clothing (particularly bras) on lymph drainage to the internal mammary, as well as the contralateral axillary nodes.

**BOX 3 Lymphatic cutaneous networks**

There is a greater density of lymphatic vessels in patients with lymphoedema compared to those with normal healthy limbs.

at its apex and one in the middle (Figure 2) (Moore and Dailey, 2006). These nodes are embedded in the axillary fat, external to the axillary sheath that contains the axillary artery and vein. The majority of the lymphatic fluid associated with the antero-lateral lymphatic territory drains into four to six lateral (humeral) nodes, while that of the postero-medial territory drains into the apical nodes. The pectoral and subscapular nodes drain the anterior and posterior thoracic wall, respectively, and along with the humeral nodes drain through the central, then the apical nodes en route to the subclavian lymphatic trunk and ultimately the venous system. The consequence of this arrangement is that lymphatic drainage of the upper limb is directly affected by both the drainage of the upper torso and the state of the central lymphatic system.

As is the case with the groin area, it is difficult to get optimum pressures, or any pressure at all, into the axillary/medial proximal upper arm area and this, combined with a likely annulus of often inappropriate pressure on the shoulder and lateral chest provided by the wearer's bra (in the case of a woman), means that there are often very significant issues of fluid accumulation (initially) and fibre (later) in this area.



**FIGURE 4. Normal drainage pathways of upper limb and thoracic tissues to the lymph nodes. Note drainage from a breast can be to either the ipsilateral nodes (more commonly) or to the contralateral nodes (less commonly).**

**LYMPHATIC DRAINAGE PATHS**

Studies have indicated that lymph drainage of the upper arm travels into the mammary nodes in some individuals with lymphoedema. Kawase et al (2006) reviewed lymphoscintigraphy results from 1,201 clinically node-negative patients with invasive breast cancer who underwent preoperative labial salivary gland (LSG) and axillary sentinel lymph node (SLN) biopsy. They reported a range of lymphatic drainage patterns, and almost 25% of patients had drainage to extra-axillary lymph nodes, especially the internal mammary ones (Figure 3). This has also been confirmed by Ferrandez et al (1996) who after a session of manual lymphatic drainage (MLD) found Tc-labeled tracers moved to the internal mammary nodes in 8% of patients with lymphoedema (n=47), as well as to the contralateral nodes in 20% (Figure 4). What this means for the end results of compression is that not only must we consider the compression level and its gradient in the limb, but also the gradient across the truncal area. These drainage patterns also indicate the need to pay attention to the potential effect of clothing (particularly bras) on lymph drainage to the internal mammary, as well as the contralateral axillary nodes (Figure 3).

**LYMPHATIC CUTANEOUS NETWORKS**

It is known that there is a greater density of lymphatic vessels in patients with lymphoedema compared to those with normal healthy limbs.

Mellor et al (2000) used fluorescence microlymphography to examine the dermal lymphatic capillaries of the forearm in 16 women with oedema following treatment for breast cancer. They reported that the superficial lymphatic density and total length of capillaries was greater in the swollen limb compared to the control arm. Importantly, the distance travelled by the relatively superficial lymph contents before draining to the sub-fascial system was longer in the swollen limb compared to the normal limb. Furthermore, there was no evidence of lymphatic dilation in the swollen limb. These findings suggest that there is a local re-routing of superficial lymph and possibly lymphangiogenesis in the limbs of patients with lymphoedema. Since the work of others has shown blood capillary angiogenesis in swollen limbs, Mellor et al

**BOX 4 Factors affecting lymph drainage**

**There is no resorption of fluid, and the net flux is solely into the tissue from where it is cleared by the lymphatics. Thus, fluid fluxes through the lymphatic system are likely to be larger than previously thought.**

(2000) hypothesised that the increased number (length) of lymphatic capillaries would possibly help to maintain the ratio of drainage capacity to filtration capacity. The impact of external compression on this change is possibly minor, but the longer travel distance of the lymph in the superficial lymph collectors may mean that the establishment and maintenance of a pressure gradient along the limb is very important.

**TISSUE STRUCTURE OF THE ARM**

The upper arm contains deep and epifascial fat layers. The deep fat layer found in the posterior and deltoid region of the arm is thin. In normal limbs the epifascial fat layer is circumferential, but can hypertrophy in the proximal posterior one third of the arm. In lymphoedematous limbs this hypertrophy is marked and not only has an influence on lymph load, but also on lymph drainage, as the additional tissue pressure of the adiposites on the delicate walls of the lymph collectors constrains them from their optimal contraction. Chamosa et al (2005) found that in normal arms, the anterior and distal third of the upper arm tended to have less thick adipose tissue. Occasionally, a specific lipodystrophic zone can be found on the posterior-external area of the normal arm, located between the proximal and medial thirds. Relatively speaking, the skin of the medial aspect of the normal arm is generally thin, devoid of hair follicles, and prone to sag. Overall, the skin is mobile and overlies loose, nonfibrous fat. However, as lymphoedema develops, there are a range of significant epifascial tissue changes which occur (mainly to the amount of fat and fibre, as there is a thickening of the deep fascia and the fascia between the lobules of adiposites). These will have significant effects on the outcome of external compression in terms of its transmittance into the tissues and to the vascular and lymphatic systems within it. Of particular importance is the increase in the thickness of the deep fascia and its impact on the interchange of fluids between the deep and superficial lymphatics. We will not go into these pathophysiological changes here, since they are well documented and in mainstream literature (Foeldi et al, 2003; Weissleder and Schuchhardt, 2008).

Reduced epifascial depth, most often associated with a lesser amount of fat directly

above the deep fascia means that the lymph collectors (which are normally lying above the deep fascia) are more superficial than those which are covered with a greater depth of fat, thus generally requiring a lower compression pressure.

**PHYSIOLOGICAL FACTORS AFFECTING LYMPHATIC DRAINAGE**

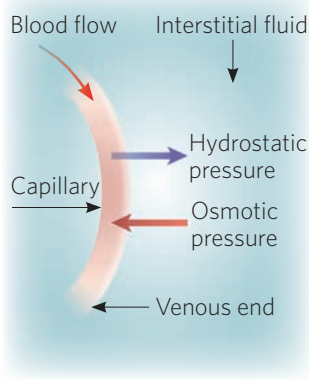
Both normal and abnormal patterns of lymphatic drainage help to demonstrate how fluid flows through tissues, so it is important to understand both previous and current theories of lymph formation and movement.

In the healthy individual, the vascular system runs into the capillaries, which are small vessels that are bathed in interstitial fluid. The capillaries have thin, semi-permeable walls made up of a single layer of endothelial cells that allow the transfer of oxygen and nutrients from the blood into the tissues, and the transfer of waste products such as CO<sub>2</sub> and urea from the tissues into the blood.

Fluid movement across the capillary wall behaves according to the principles first outlined by Starling (1896), whereby the blood's hydrostatic pressure forces fluid from the capillaries down a substantial pressure gradient into the tissues, while the colloid osmotic pressure of the blood 'sucks' fluid back into the capillary 'up' a substantial osmotic gradient (Figure 5). The balance of these forces results in a net fluid flux into the tissue under normal circumstances, which is then drained away by the lymphatic system.

It is important, however, to be aware that the current textbook version of this process has fluid being filtered from the arterial end of the capillary, and resorbed at the venular end (e.g. Marieb et al, 2007), as the hydrostatic pressure decreases along the capillary (due to frictional losses or resistance), and the balance of the so-called Starling forces shift from favouring filtration to favouring resorption along the capillary. This view is now being replaced by the opinion that, at least in most capillaries in normal circumstances, there is no resorption of fluid, and the net flux is solely into the tissue from where it is cleared by the lymphatics (Michel, 1997; Levick, 2004; 2009).

During this fluid movement, most plasma proteins of the blood are retained in the vascular system as they do not cross the capillary membrane in most tissues. The



**FIGURE 5. Diagram of the hydrostatic and oncotic pressures acting across the capillary wall, affecting transendothelial exudation of fluid from plasma to the interstitium.**

emerging consensus is that the 'barrier' to the transcapillary flux of plasma proteins and larger lipophobic solutes lies at the glycocalyx, a complex luminal layer of anionic polysaccharides and glycoproteins secreted by, and attached to, probably all capillary endothelial cells. The glycocalyx acts as a fine fibre filter hindering larger molecule transit by steric exclusion in a size-dependent manner (Squire et al, 2001; Zhang et al, 2006). The physical path for fluid leakage lies beyond the glycocalyx, at infrequent short breaks in junctional membrane strands along inter-endothelial cell junctions, which elsewhere seal junctions tight (Adamson et al, 2004; Curry, 2005). The net result of this arrangement is that fluid resorption at the capillary is unlikely under normal conditions, and requires larger breaks in endothelial integrity, such as those occurring during inflammation. A corollary of this is that fluid fluxes through the lymphatic system are likely to be larger than previously thought, since there is no venular resorption of fluid under normal physiological conditions. For this reason, improved knowledge of the impact of compression on the superficial lymphatic flow is essential.

A further corollary is that increasing interstitial pressure will reduce the pressure gradient forcing fluid out of the capillaries, and will thus reduce fluid fluxes into the tissue. Conversely, increased colloid osmotic pressure of the interstitial fluid would increase fluid fluxes, since the colloid osmotic gradient withholding fluid in the plasma would be reduced in this circumstance (Levick, 2009). Such a situation may arise if there is accumulated interstitial protein due to increased transcapillary protein leakage into the tissue, increased interstitial proteolysis (such as that occurring during inflammation), or reduced drainage of interstitial protein due to poor lymphatic drainage. Each of these factors will be affected by compression of the limb, and can lead to reduced fluid influx into the tissues. The role of compression on the limb, therefore, may well be to prevent fluid accumulation, rather than to encourage lymphatic drainage, as is often suggested.

Blood and lymphatic drainage from the arm is also influenced by movements and contractions of skeletal muscle and intrathoracic pressure, as well as by positional changes.

### **LYMPHATIC AND VASCULAR CHANGES AFTER SURGERY AND RADIOTHERAPY**

The main cause of upper body lymphoedema arises from cancer of varying causes, especially breast cancer, which is often treated by surgery and radiotherapy. It is clear that lymphoedema following surgery and/or radiotherapy starts with an obstruction of the drainage in the axillary area, but the exact pathophysiology of the following sequelae in the lymph vessels (and surrounding tissues) is not well known (Pain et al, 2005). Furthermore, there are some important haemodynamic aspects of the arm following surgery (+/- radiotherapy) which are poorly understood.

#### **Arterial inflow**

There is some evidence that arterial inflow is increased in lymphoedematous arms following treatment for breast cancer (Dennis, 2008). Using a variety of techniques, the blood flow into the lymphoedematous arm has been reported to be increased by 42-68% compared to unaffected arms (Jacobsson, 1967; Svensson et al, 1994a; Martin and Foldi, 1996; Yildirim et al, 2000). Jacobsson (1967) reported this increase was mainly in the skin and subcutaneous tissues. In contrast, Stanton et al (1998) found that the blood flow was the same between affected and unaffected arms, although the per unit volume of blood flow was actually reduced in affected arms since it was of larger volume. The reasons for this change in blood flow in lymphoedematous arms is not clear, although there clearly are structural changes in the affected limb that might cause increased blood flow. On the other hand, an increased arterial inflow may serve to increase fluid filtration into the tissue, and thus increase the risk of developing lymphoedema; such an increase in arterial flow may result from damage to the autonomic innervation to the limb due to surgery and/or radiation (Kuhl and Molls, 1995).

#### **Venous outflow**

Venous outflow may also be compromised in lymphoedematous limbs (Dennis, 2008). Significant venous obstruction was reported in 57% of 81 patients assessed by Svensson et al (1994b) using colour Doppler ultrasound imaging. Szuba et al (2002) reported a lower but still significant 4.6% prevalence of venous

obstruction of lymphoedematous upper limbs. There are several other lines of evidence that indicate that there is an association between venous dysfunction and lymphoedema, especially in the lower limbs (Dennis, 2008), and this should be considered carefully when contemplating compression treatment of the upper limb. Any factors that compromise venous outflow will significantly increase capillary hydrostatic pressures and result in increased fluid filtration into the tissues, leading to larger lymphatic loads.

### **Lymph outflow**

There are few reports on surgery and/or radiotherapy for breast cancer and their effects on lymphatic flow through the arm and torso. Perbeck et al (2006) studied lymph clearance using <sup>99</sup>Tc-nanocolloid clearance in breast tissues 2.5 years after surgery and/or radiotherapy for breast cancer. They reported a 4.0-fold increase in lymph flow after lumpectomy plus radiotherapy, 2.5-fold increase in the contralateral (non-operated) breast and a 1.5-fold increase in the operated non-irradiated breast, indicating long-term changes in basal lymphatic flow of breast tissues. Stanton et al (2008) measured muscle and subcutis lymphatic drainage of the arm after axillary surgery for breast cancer in 36 women, using lymphoscintigraphy. They reported that muscle lymph drainage always exceeded that of subcutis drainage, and subcutis drainage was higher in women who subsequently went on to develop lymphoedema. They concluded that women with higher filtration rates and therefore higher lymph flows through the axilla, were at greater risk of developing lymphoedema after axillary surgery, presumably because they had less lymphatic reserve to deal with additional fluid loads following surgery.

### **MECHANISMS OF ACTION OF COMPRESSION GARMENTS**

In the management of lymphoedema the term 'compression therapy' covers a range of treatment modalities including multilayer inelastic lymphoedema bandaging and compression garments (Partsch and Junger, 2006). Compression garments are used for the prophylaxis, treatment and long-term management of lymphoedema and may work by:

- Increasing interstitial pressure
- Improving tissue fluid drainage
- Stimulating lymphatic contractions
- Breaking down fibrosclerotic tissue.

### **Increasing interstitial pressure**

Externally applied pressure is transmitted into the tissue, although not always in a linear fashion. Pressure up to 200mmHg increased interstitial tissue pressure to within 65–75% of the externally applied pressure in normal pig limbs, and up to 100% when the limb was oedematous and less compliant (Reddy et al, 1981). The pressures generated (and measured) by compression garments are likely to depend on the measurement technique, the nature (knit/elasticity) and fit of the garment, and the compliance of the limb tissue being compressed. Pressures of 8–38mmHg have been measured under garments applied to burns patients using standardised protocols (Mann et al, 1997), but there was wide variation within and between measurement sites; for example, mean pressure over the anterior thigh was significantly less (8mmHg) than that over the posterior thigh (15mmHg), presumably due to radial and circumferential differences (as per the law of Laplace) by the same garment applied at these sites. Custom-made compression garments increased subdermal pressure in burns applications, over a range of 9–90mmHg, but measurements of the pressures under garments over-estimated the pressure transmitted into 'soft' tissues (e.g. muscle) by up to 50%, and under-estimated the pressure transmitted into 'bony' sites by a similar amount (Giele et al, 1997). Thus, measurements taken at the garment-skin interface may not always be representative of pressures transmitted into the tissues, and should be interpreted with care.

Increased interstitial pressure will affect fluid exchange from the blood into the interstitium, so as to prevent interstitial fluid (oedema) accumulation. In addition, interstitial pressures greater than capillary or arterial pressures (>40mmHg) are likely to reduce blood flow, further preventing fluid accumulation. To our knowledge, the contribution of these factors to compression therapy has never been assessed in large trials, although the work of Abu-Own et al (1994) is informative and Partsch and Partsch (2005)

give some indications of the impact of position on pressures required, although these relate to the lower limb.

**Improved tissue fluid drainage**

External compression improves tissue fluid drainage through the lymphatic system up to a point. Clearance of a radioactively labelled colloid in dog hind limbs increased exponentially (to a maximum of three-fold) with increasing externally applied pressure up to 60mmHg. Above 60mmHg, clearance decreased to almost nothing (Miller and Seale, 1981). Similar results were reported in human lower limbs, except that the pressure at which maximum clearance occurred varied with posture, being 30mmHg supine compared with 60mmHg sitting (Chant, 1972). In a more clinical setting, below-knee stockings (ankle pressure 30mmHg) doubled veno-lymphatic drainage of intradermally injected sodium-fluorescein solution in both normal limbs and those with venous insufficiency (Lentner and Wienert, 1996). Most convincingly of all, however, is the general observation that compression therapies can acutely reduce limb (fluid) volume when appropriately used to treat lymphoedema.

The observation that compression garments enhance tissue fluid clearance is at odds with reports that the lymphatic system is a low-pressure system. The lateral pressure in human (and many other) lymphatics reaches 15-40mmHg during movement, but is much lower under resting conditions (1-12mmHg) (Aukland and Reed, 1993). Thus, compression garments, which induce interstitial pressures of, for example, 10-40mmHg on the arm, are likely to be collapsing lymphatic vessels under many circumstances. One can only conclude that compression therapy is unlikely to simply increase drainage through the (often compromised) lymphatic system, but is likely to affect tissue fluid exchange through other, possibly inter-related, mechanisms, such as decreasing fluid influx into the limb.

**Stimulation of lymphatic contraction**

Lymphatic drainage is dependent upon the spontaneous contraction of valved lymph vessels creating a pumping force. The application of a compression garment results in constant pressure on the skin when the limb is at rest (resting pressure). When the

muscles contract, expand and then relax (e.g. during exercise), they transiently press against the resisting garment and so the tissue pressure in the limb increases temporarily. This transiently increased interstitial pressure compresses the adjacent dermal lymphatics and because the collecting and larger lymphatics are valved, these vessels pump passively so that lymph flows up the arm without the lymphatics having to contract. The influence of muscle movement and of different external pressures (and of their transmittance to underlying tissue) depends on the elastic property of the garment material and the compression pressure applied. There is no evidence to suggest that there is increased lymphatic contraction under compression.

**Breakdown of fibrosclerotic tissue**

There are two major strategies to break down fibrotic tissue, but for both the number and breadth of the studies are limited. One strategy is through frictional massage and the other through the use of low level laser therapy. There have been some reasonable studies of the latter, using tonometry as a means of detecting changes in epifascial fibrosis as measured by the resistance of the tissues to compression. When low level handheld or scanning laser is used there is a slow, although general softening of the indurated tissues, presumably aiding in the passage of extracellular fluid and allowing a stronger contraction of the lymphangions since they are less constrained. The softening is most often accompanied by limb size changes and subjective improvement (Piller and Thelander, 1998; Carati et al, 2003).

**OPTIMISING THE EFFECTS OF COMPRESSION GARMENTS**

In order to achieve optimal effectiveness when using compression to treat patients with lymphoedema, it is claimed that ideally garments should be custom made and flat-knitted; however, large scale trials are required to support these claims. Of the upmost importance is accurate measurement of the garment, accounting for changes in the limb volume with position (elevated or in dependent positions), and whether the limb is likely to be active or inactive, which depends on the patient's occupational status. However, little is known regarding the effect of the above

variables on garment pressure gradients and on undergarment pressures. In the interim, however, we can extrapolate our knowledge of how lymphoedematous and oedematous legs respond (at least in the dependent position), as this may help to guide research into the impact of compression on the arm. In addition to these measurement and biological parameters, information about garment characteristics, such as dynamic stiffness index, static stiffness index, multi-component materials, and inelastic bandaging is important (Partsch et al, 2008; Mosti et al, 2008). There are some recent advances in the burns field in the design of pressure garments which exert a specific and known pressure (Macintyre, 2007), but it is the accuracy of the measurement for the garment that is the prime determinant of an excellent, good or adverse outcome for the limb. Newer pressure-sensing materials may help to partially overcome poor measurement, although these must not be used as an excuse for inaccuracy.

### **ANATOMICAL DIFFERENCES BETWEEN ARMS AND LEGS**

When applied to the upper limb the compression bandage or garment used is less likely to be completely in a dependent position in all its parts; the depth of the deep fascia is often less than a similar position on a leg, the depth of the often closely adherent lymph collectors is less (meaning a more marked effect of external pressure application), the lymph collectors are often of smaller diameter, (having less strong flow and reduced intra-lymphatic pressures). Combined, these factors mean that externally applied pressure, such as from compression bandages or garments or clothing, is likely to have a more profound effect. However, this relative superficiality of vessels means it must be realised that too high a pressure may be counterproductive (Modi et al, 2007) and may cause vessels to collapse, which may manifest as swelling in the arm and/or hand.

The shape variation of the arm over its length is often greater than that of a leg, meaning the impact of the various radii of the different parts of the arm result in the application of often significantly different pressures at each circumferential point. This is in concordance with the law of Laplace, the

outcomes of which often necessitate the use of a range of limb padding strategies to ensure some modicum of lengthwise pressure (a gradient) over the length of the limb, rather than just across a given cross-section of the limb.

### **CONCLUSION**

There is much we do not know with respect to accurate details of the arterial flow into and the lymphatic and venous outflow from normal, at risk and lymphoedematous limbs. Specifically, we do not know enough about the effects of compression on venous and lymphatic flow and drainage. In terms of the upper body, the contributory impact of variations in intra-thoracic pressure on proximal arm clearance, a patient's garments and the impact of the varying circumference of the chest with respiratory cycles is relatively unclear and most likely to significantly vary, not only between clients, but also in a client from day to day and hour to hour depending on their activity, body position and the activity level of their limb.

Knowing more about the anatomy, physiology, pathophysiology of the tissues and structures of the upper body will help us gain better outcomes for the client at risk of, and with, lymphoedema. However, it would seem that the best way forward is to acknowledge individuality, diurnal and seasonal variances and to develop better means to monitor the pressure effect of the prescribed garment on the fluids we are trying to control.

Perhaps for the majority of patients this is an easier, more cost-effective option than attempting a range of tests on all patients to determine the anatomy, physiology and pathophysiology of the correct function (or otherwise) of the patient's blood, tissue and lymph systems. Knowing the latter will, however, also help achieve the overall goal of holistic patient care.

### **REFERENCES**

- Abu-Own A, Shami SK, Chittenden SJ, Farrah J, Scurr JH, Smith PD (1994) Microangiopathy of the skin and the effect of leg compression in patients with chronic venous insufficiency. *J Vasc Surg* **19**(6): 1074–83
- Adamson RH, Lenz JF, Zhang X, Adamson GN, Weinbaum S, Curry FE (2004) Oncotic pressure opposing filtration across non-fenestrated rat microvessels. *J Physiol* **557**: 889–907
- Aukland K, Reed R (1993) Interstitial-lymphatic mechanisms in the control of extracellular fluid. *Physiol Rev* **73**: 1–78
- Calbet J, Holmberg H, Rosdahl H, van Hall G, Jensen-Urstad M, Saltin B (2005) Why do arms extract less oxygen than legs during exercise? *Am J Physiol Regul Integr Comp Physiol* **289**(5): 1448–58

- Carati, C, Anderson S, Gannon B, Piller N (2003) Treatment of post mastectomy lymphoedema with low level laser therapy. Results of double blind placebo controlled trial. *Cancer* **98(6)**: 1114-22
- Chamosa M, Murillo J, Vázquez T (2005) Lipectomy of arms and lipograft of shoulders balance the upper body contour. *Aesthetic Plast Surg* **29(6)**: 567-70
- Chant ADB (1972) The effects of posture, exercise and bandage pressure on the clearance of  $^{24}\text{Na}$  from the subcutaneous tissues of the foot. *Br J Surg* **59**: 552-5
- Clark M, Krimmel G (2006) Lymphoedema and the construction and classification of compression hosiery. In: *Lymphoedema Framework. Template for Practice: compression hosiery in lymphoedema*. MEP Ltd, London
- Curry FE (2005) Microvascular solute and water transport. *Microcirculation* **12**: 17-31
- Dennis R (2008) Haemodynamics of lymphoedema. *J Lymphoedema* **3(2)**: 45-9
- Ferrandez JC, Laroche JP, Serin D, Felix-Faure C, Vinot JM (1996) Lymphoscintigraphic aspects of the effects of manual lymphatic drainage. *J Mal Vasc* **21(5)**: 283-9
- Foeldi M, Foeldi E, Kubik S (2003) *Textbook of Lymphology for Physicians and Lymphoedema Therapists. Sufficiency and Insufficiency of the Lymphatic System*. Urban and Fisher, Munich
- Giele HP, Liddiard K, Currie K, Wood FM (1997) Direct measurement of cutaneous pressures generated by pressure garments. *Burns* **23**: 137-41
- Iyer RB, Libshitz HI (1995) Radiographic demonstration of intercostal lymphatics and lymph nodes. *Lymphology* **28(2)**: 89-94
- Jacobsson S (1967) Studies of the blood circulation in lymphoedematous limbs. *Scand J Plast Reconstr Surg Suppl* **3**: 1-81
- Kawase K, Gayed IW, Hunt KK, Kuerer HM, Akins J, Yi M, et al (2006) Use of lymphoscintigraphy defines lymphatic drainage patterns before sentinel lymph node biopsy for breast cancer. *J Am Coll Surg* **203(1)**: 64-72
- Kuhl C, Molls M (1995) Increased arterial blood flow in arm edema caused by radiation induced neuropathy after therapy for breast carcinoma? *Strahlenther Onkol* **171(3)**: 176-7
- Lentner A, Wienert V (1996) Influence of medical compression stockings on venolymphatic drainage in phlebologically healthy test persons and patients with chronic venous insufficiency. *Int J Microcirc Clin Exp* **16(6)**: 320-4
- Levick JR (2004) Revision of the Starling principle: new views of tissue fluid balance. *J Physiol* **557**: 704.
- Levick JR (2009) *An Introduction to Cardiovascular Physiology*. 5th edn. Hodder Arnold, in press
- Macintyre L (2007) Designing pressure garments capable of exerting specific pressures on limbs. *Burns* **33(5)**: 579-86
- Mann R, Yeong EK, Moore M, Colescott D, Engrav LH (1997) Do custom-fitted pressure garments provide adequate pressure. *J Burn Care Rehabil* **18**: 247-9
- Marieb EN, Hoehn K (2007) *Human Anatomy and Physiology*. 7th edn. Pearson Benjamin Cummings, San Francisco
- Martin KP, Foldi I (1996) Are haemodynamic factors important in arm lymphoedema after treatment for breast cancer? *Lymphology* **29(4)**: 155-7
- Mellor RH, Stanton AW, Azarbod P, Sherman MD, Levick JR, Mortimer PS (2000) Enhanced cutaneous lymphatic network in the forearms of women with postmastectomy oedema. *J Vasc Res* **37**: 501-12
- Michel CC (1997) Starling: the formulation of his hypothesis of microvascular fluid exchange and its significance after 100 years. *Exp Physiol* **82**: 1-30
- Miller GE, Seale J (1981) Lymphatic clearance during compressive loading. *Lymphology* **14**: 161-6
- Modi S, Stanton AWB, Svensson WE, et al (2007) Human lymphatic pumping measured in healthy and lymphoedematous arms by lymphatic congestion lymphoscintigraphy. *J Physiol* **583(Pt 1)**: 271-85
- Mosti G, Mattaliano V, Partsch H (2008) Influence of different materials in multicomponent bandages on pressure and stiffness of the final bandage. *Dermatol Surg* **34(5)**: 631-9
- Moore K, Dailey AF (2006) *Clinical Oriented Anatomy*. 5th edn. Lippincott Williams and Wilkins
- Newcomer S, Sauder C, Kuipers N, Laughlin M, Ray C (2008) Effects of posture on shear rates in human brachial and superficial femoral arteries. *Am J Physiol Heart Circ Physiol* **294**: 1833-9
- Pain SJ, Barber RW, Chandra K et al (2005) Short-term effects of axillary lymph node clearance surgery on lymphatic physiology of the arm in breast cancer. *J Appl Physiol* **99**: 2345-2351
- Partsch H, Clark M, Mosti G, Steinlechner E, Schuren J, Abel M, et al (2008) Classification of compression bandages: practical aspects. *Dermatol Surg* **34(5)**: 600-9
- Partsch B, Partsch H (2005) Calf compression pressure required to achieve venous closure from supine to standing positions. *J Vasc Surg* **42(4)**: 734-8
- Partsch H, Junger M (2006) Evidence for the use of compression hosiery in lymphoedema. In: *Lymphoedema Framework. Template for Practice: compression hosiery in lymphoedema*. MEP Ltd, London
- Perbeck L, Celebioglu F, Svensson L, Danielsson R (2006) Lymph circulation in the breast after radiotherapy and breast conservation. *Lymphology* **39(1)**: 33-40
- Piller NB, Thelander A (1998) Treatment of chronic post mastectomy lymphoedema with low level laser therapy. *Lymphology* **31(2)**: 74-86
- Reddy NP, Palmieri V, Cochran G (1981) Subcutaneous interstitial fluid pressure during external loading. *Am J Physiol* **240**: R327-R329
- Schuenke M, Schulte E, Schumacher U (2006) *Atlas of Anatomy. General Anatomy and Musculoskeletal System*. Ross LM, Lamperti ED, eds. Thieme. Stuttgart
- Squire JM, Chew M, Nneji G, Neil C, Barry J Michel C (2001) Quasi-periodic substructure in the microvessel glycocalyx: a possible explanation for molecular filtering. *J Struct Biol* **136**: 239-55
- Stanton AW, Holroyd B, Northfield JW, Levick JR, Mortimer PS (1998) Forearm blood flow measured by venous occlusion plethysmography in healthy subjects and in women with postmastectomy oedema. *Vasc Med* **3(1)**: 3-8
- Stanton AW, Modi S, Bennett Britton TM, Purushotham AD, Peters AM, Levick JR, Mortimer PS (2008) Lymphatic drainage in the muscle and subcutis of the arm after breast cancer treatment. *Breast Cancer Res Treat* 4 Dec [Epub ahead of print]
- Starling EH (1896) On the absorption of fluids from the connective tissue spaces. *J Physiol* **19**: 312-26
- Suami H, O'Neill JK, Pan W-R, Taylor GI (2008) Superficial lymphatic system of the upper torso: preliminary radiographic results in human cadavers. *Plast Reconstruct Surg* **121(4)**: 1231-9
- Svensson WE, Mortimer PS, Tohno E, Cosgrove DO (1994a) Increased arterial inflow demonstrated by Doppler ultrasound in arm swelling following breast cancer treatment. *Eur J Cancer* **30A(5)**: 661-4
- Svensson WE, Mortimer PS, Tohno E, Cosgrove DO (1994b) Colour Doppler demonstrates venous flow abnormalities in breast cancer patients with chronic arm swelling. *Eur J Cancer* **30A(5)**: 657-60
- Szuba A, Razavi M, Rcockson SG (2002) Diagnosis and treatment of concomitant venous obstruction in patients with secondary lymphedema. *J Vasc Interv Radiol* **13(8)**: 799-803
- Tanis PJ, van Rijk MC, Nieweg OE (2005) The posterior lymphatic network of the breast rediscovered. *J Surg Oncol* **91**: 195-8
- Tschakovsky M, Hughson R (2000) Venous emptying mediates a transient vasodilation in the human forearm. *Am J Physiol Heart Circ Physiol* **279(3)**: 1007-14
- Weissleder H, Schuchhardt C (eds) (2008) *Lymphoedema Diagnosis and Therapy*. 4th edn. Viavital Verlag
- Willoughby DA, Di Rosa M (1970) A unifying concept for inflammation. In: *Immunopathology in Inflammation. Excerpta Medica Int Cong Series* **229**: 28-38
- Yildirim E, Soydiñç P, Yildirim N, Berberoglu U, Yüksel E (2000) Role of increased arterial inflow in arm edema after modified radical mastectomy. *J Exp Clin Cancer Res* **19(4)**: 427-30
- Zhang X, Curry FR, Weinbaum S (2006) Mechanism of osmotic flow in a periodic fiber array. *Am J Physiol* **290**: H844-52

# Evidence for the use of upper body compression garments in patients with lymphoedema

K Johansson

**Garments are a widely used form of compression in the management of upper body lymphoedema including prophylaxis, treatment and long-term management. Wearing hosiery may influence patients' feelings of comfort, as well as their psychosocial situation (Johansson et al, 2003). However, there is a paucity of evidence to support this practice, but what does exist in the literature available to date is reviewed in this paper. Randomised controlled studies are scarce, but some evidence has been found for the management of lymphoedema in the upper limb using compression garments but there is a lack of evidence for the thorax and breast. The findings and limitations are outlined, and key points for practice highlighted, based on the literature.**

The importance of wearing compression sleeves in patients with lymphoedema was demonstrated by Brorson et al (1998) who used custom-made compression sleeves for the maintenance of arm volume in patients who had undergone liposuction of the lymphoedematous arm, resulting in complete reduction of the oedema. One year after liposuction, the compression sleeves were removed for one week in six patients. A mean increase in arm volume of 370ml (range 135–775ml) was observed, measured by the water displacement method, but was completely reversed when compression was re-introduced.

Patients with arm lymphoedema were compared in two exercise studies by Johansson et al (2005) and Johansson and Piller (2007). It was observed that lymphoedema in the untreated arm increased faster in volume than lymphoedema that was treated by a compression garment. The patients in the first study (n=31) were treated with a compression sleeve following diagnosis, and after 67±52 months had an arm volume difference of 17±7%. In the second study, the patients (n=18) did not use a compression sleeve. This group had a shorter follow-up from diagnosis (54±49 months), but a larger arm volume difference (25±6%) compared to the group in the first study. In both studies the arm volume was measured by water displacement method.

Vignes et al (2007) found non-compliance to low-stretch bandages or compression sleeves to be a risk factor for increased swelling in the long-term management of breast cancer-related lymphoedema. Five hundred and thirty-five patients were treated with complete decongestive physiotherapy, including manual lymphatic drainage (MLD),

bandaging, exercise and skin care. Results showed a reduction of the lymphoedema from 1054±633ml to 647±351ml, using circumferential measurements to calculate arm volume. After the intensive treatment period, all the patients were fitted with a compression sleeve (86% of patients with 20–36mmHg and 14% with 15–19mmHg). At 12-month follow-up, 356 patients were evaluated and 89% were still wearing their compression sleeve, 70% were performing regular self-bandaging and 66% were receiving MLD (1–3 times per week). The study found that the risk of increased lymphoedema volume (more than 10% compared to the end of the intensive phase) during the follow-up was more than 50% higher for people not using a compression sleeve (adjusted relative risk =1.61[95% CI: 1.25–1.82]; P=0.002) and low-stretch bandaging (1.55[95% CI 1.3–1.76]; P<0.0001). By contrast, the risk of increased lymphoedema volume during the follow-up period was the same for patients using MLD and those who were not.

All of these studies indicated that it is beneficial to wear a compression sleeve in order to maintain a reduction in limb volume following liposuction or intensive therapy. No evidence was found to support the use of compression garments in patients with trunk and breast lymphoedema.

## PROPHYLAXIS

Casley-Smith (1995) observed that secondary arm lymphoedema, if not treated, progresses faster than other types of lymphoedema, such as secondary leg lymphoedema and primary lymphoedema. Ramos et al (1999) showed in 69 breast cancer patients that successful management of arm lymphoedema, with a mean reduction

**BOX 1 Effectiveness of compression garments**

**There is a higher risk of lymphoedema volume increasing in patients with arm lymphoedema when not wearing compression garments. Early intervention and continual use of the garments are also important factors contributing to their efficacy.**

**BOX 2 Improving treatment outcomes**

**The early diagnosis of arm lymphoedema in conjunction with a low initial arm volume at the start of compression intervention improves treatment outcomes.**

**BOX 3 Risks of flying**

**Domestic flights do not increase the risk of developing arm lymphoedema in patients treated for breast cancer, but overseas flights are associated with temporary swelling.**

of oedema volume of 78%, correlated with an initial oedema volume of 250ml or less (using circumferential measurements to calculate arm volume). Patients with initial volumes of 250ml or less had a mean reduction of 78% with CDT, whereas those with initial volumes between 250 and 500ml had a mean reduction of 56%. Delon et al (2008) investigated 133 women treated for breast cancer and found that postoperative swelling after two weeks was the only factor associated with an increase in the incidence of arm lymphoedema. Therefore, early detection and treatment are essential. This was concluded by Box et al (2002) in a randomised intervention study (n=65) including a programme for the treatment group with principles for lymphoedema risk minimisation and early management when the condition was identified.

Stout Gergich et al (2008) concluded that compression garments effectively treat subclinical arm lymphoedema. Arm lymphoedema, defined as an increase of more than 3% in upper limb volume compared with the preoperative volume measured by a perometer, was identified in 43 out of 196 women who participated in a prospective breast cancer morbidity trial. At diagnosis of arm lymphoedema, on an average 6.9 months after preoperative measurements, an increase in limb volume of 83ml ( $\pm 119$ ml) or 6.5% ( $\pm 9.9\%$ ) was observed. The daily wearing of a compression garment (20–30mmHg) was promptly prescribed for an average duration of 4.4 weeks. After the intervention, a volume reduction of 46ml ( $\pm 103$ ml) or 4.1% ( $\pm 8.8\%$ ) was observed. The women were then advised to continue wearing the garment only when completing strenuous exercise or activity, during air travel, with symptoms of heaviness, or if visible swelling appeared. The results were maintained after an average of five months.

In a study of flight-associated lymphoedema by Graham (2002), 287 surveys were completed by relapse-free breast cancer survivors. Fifty percent of the women had flown after receiving treatment for breast cancer. No difference in rate of clinical lymphoedema was observed between women who had flown and those who had not (11.2% *versus* 8.3%). Graham found that there was no difference in the frequency with which the patients with lymphoedema reported temporary swelling according to

whether or not they took precautions, such as use of a compression sleeve (17%). It was concluded that domestic flights were of no risk for patients with arm lymphoedema. However, temporary swelling risk correlated with overseas flights.

No evidence for the prophylactic role of compression garments in breast and trunk lymphoedema were found.

**TREATMENT**

Many studies have shown that compression therapy in general is an effective treatment for lymphoedema. In the case of the upper body, all evidence relates to the treatment of arm lymphoedema following breast cancer treatment. No evidence exists for the efficacy of compression garments in the treatment of thoracic or breast lymphoedema.

The majority of the existing studies used short-stretch bandages for compression, however, some also reported the sole use of compression garments to be important for treatment efficacy.

The study by Swedborg (1980) observed an 11–13% reduction of oedema in 39 breast cancer patients with arm lymphoedema after various combinations of massage and exercise over three treatment episodes, each lasting for four weeks, over an overall period of six months. Patients wore compression sleeves (40mmHg) daily in the four-week interval between treatment periods. During the intervals when the sleeves were worn, no increase of oedema volume was shown, as measured by water displacement method.

Bertelli et al (1991) reported a 17% reduction of oedema, measured by the delta method, in 37 patients who were randomised to wear a compression sleeve for six consecutive hours per day, for two months. Results from this group were compared to a group (n=37) who received additional treatment with electrically stimulated lymphatic drainage. The second group did not demonstrate any further reduction in oedema, showing that positive results can be obtained through the use of compression sleeves alone.

In a study by Johansson et al (1998) standard, ready-to-wear compression sleeves (23–32mmHg) were applied to 24 patients with breast cancer-related arm lymphoedema who had not received any other treatment.

**BOX 4 Wear time of compression garments**

Compression garments can be used to effectively treat arm lymphoedema in both the short and long term, with a volume reduction of up to 60% depending on frequency and duration of wear-time.

**BOX 5 Compression and volume reduction**

Compression garments can be used to stabilise and maintain reductions in arm volume up to six months after initial treatment of arm lymphoedema.

The sleeves were worn for two weeks, in order to stabilise the arm volume before patients were randomised for intervention with MLD or intermittent pneumatic compression (IPC). A significant reduction of  $7\pm 18\%$  (49ml), measured by water displacement method, was observed during the two-week period of treatment in the compression sleeve group.

Another study of two randomised patient groups showed that a three-month treatment regimen which included the use of a custom-made compression sleeve (32–40mmHg), exercises and skin care for one group ( $n=22$ ) reduced lymphoedema volume by 60%, according to circumferential measurements and calculation of arm volume (Andersen et al, 2000). However, only patients with slight or moderate ( $<30\%$ ) lymphoedema were included in this study.

Compression garments can also be used as a long-term treatment of arm lymphoedema. Brorson et al (1998) introduced a procedure known as 'controlled compression therapy' (CCT), where the garment is continuously taken in, both by using a sewing machine and fitting custom-made compression. In their study of patients who had received no previous conservative treatment for lymphoedema, 14 patients were selected for treatment with CCT. After 12 months of treatment, the lymphoedema volume, as measured by water displacement method, was reduced from 1680ml (range 670–3320) to 873ml (range 340–2275ml), with a relative reduction of 47% (range -2–80ml).

**LONG-TERM MANAGEMENT OF UPPER BODY LYMPHOEDEMA**

Some studies with longer follow-up periods have shown that the use of compression garments for the management of upper-limb lymphoedema is also effective in the long term.

In one study, 249 patients with breast cancer-related arm lymphoedema were provided with custom-made compression sleeves that were worn for periods of one week to six months prior to treatment with intermittent pneumatic compression therapy (IPC) (Swedborg, 1984). The sleeve was replaced if it became worn or too large or tight. Results revealed a statistically significant mean relative reduction of 17% in the volume of oedema, measured using the

water displacement method. A further mean relative reduction of 18% was achieved after treatment with IPC over 10 days. After the IPC treatment the sleeve was worn for six months. During this period no significant increase in arm volume was found; thus, no relapse.

In a two-month intervention study by Bertelli et al (1992), 120 patients with breast cancer-related arm lymphoedema were randomised into three treatment groups:

- Compression sleeve worn only for six consecutive hours per day ( $n=37$ )
- Compression sleeve worn only for six consecutive hours per day with the addition of IPC ( $n=46$ )
- Compression sleeve worn only for six consecutive hours per day with the addition of electrically-stimulated lymphatic drainage for two months ( $n=37$ ).

The mean delta value ( $19.74\pm 0.7\text{cm}$ ) was significantly reduced ( $16.8\pm 0.8\text{cm}$ ). Patients wore the compression sleeve alone for a further four months, and results showed that the reduction was maintained ( $17.2\pm 0.8$ ).

Other studies have investigated the effect of wearing compression sleeves in combination with other activities.

In an intervention study by Szuba et al (2000), intensive decongestive lymphatic therapy including MLD, bandaging and exercise was applied to 43 patients with arm lymphoedema. Results showed a mean reduction of excess volume of  $44\pm 62\%$  after a mean duration of therapy of 843 days. At the end of the intensive therapy phase, fitting for a compression garment, most frequently ready-to-wear, was undertaken. After a mean follow-up of  $38\pm 52$  days, the result was maintained by self-massage, self-bandaging, exercise and consistent use of compression garments.

**THE USE OF COMPRESSION GARMENTS DURING ARM EXERCISE**

Several studies have shown that patients undergoing treatment for breast cancer who are overweight may be predisposed to developing arm lymphoedema (Bertelli et al, 1992; Segerström et al, 1992; Johansson et al, 2002). In an intervention study by Bertelli et al (1992), superior lymphoedema reduction (25%) was observed in those women who had a weight gain of less than 3kg following

**BOX 6 Compression garments and exercise**

**Compression garments should be worn immediately after arm exercises, according to usual routine. If a patient prefers to exercise without their garment this will not affect limb volume if it is replaced immediately post-exercise.**

**BOX 7 Patient compliance**

**Obtaining satisfactory long-term results of arm lymphoedema treatment is dependent upon the patient's compliance with their compression garment regimen.**

treatment for breast carcinoma. It is, therefore, important for patients with lymphoedema not to be overweight, and physical exercise is one way to achieve this.

Boris et al (1997) treated 56 patients with breast cancer-related arm lymphoedema with complex lymphoedema therapy (CLT), which included skin care, MLD, bandaging and exercise for 30 days; CLT resulted in an average lymphoedema reduction of 62.6%. Upon completion of CLT, patients were fitted with compression garments for 24-hour wear, combined with a 15–20-minute exercise programme twice daily. After 36 months' follow-up, the average reduction was stabilised at 63.8%.

Using garments during physical activity and exercise has long been recommended (Földi et al, 1985; Casley-Smith and Casley-Smith, 1992). However, a study by Johansson et al (2005) investigated the effect of low intensive resistance exercise with and without compression sleeves in 31 women with breast cancer-related arm lymphoedema. Results showed an initial significant increase of total arm volume measured by water displacement method, but not of oedema volume in both groups, immediately after performing a specifically designed programme consisting of five different arm exercises. Within the 24 hours following the exercise programme, patients wore compression sleeves according to their usual routine. At the 24-hour follow-up, the volume increase had been reversed and both groups showed a tendency towards lymphoedema volume reduction.

**PATIENT COMPLIANCE**

Compliance with wearing compression sleeves once treatment has been introduced is good according to the literature. Treatment compliance was investigated by Bunce et al (1994) in a multimodal physical therapy programme which included self-management. Twenty-five women treated with mastectomy and with lymphoedema were included. At the end of four weeks of intensive treatment with massage, sequential pneumatic compression, compression bandaging and exercise, the women were fitted with a compression sleeve and were educated about its use. Sleeve wearing showed close to total compliance at the one-month follow-up. After six and 12

months compliance had declined, but not significantly, to a level above three on a 1–5 scale.

Results from a longer follow-up period were presented by Boris et al (1997). These showed that 56 patients with arm lymphoedema who had received CLT with an average reduction of 62.6% and who were non-compliant to wearing a compression garment combined with exercise twice daily, maintained a subsequent reduction of 43% of limb volume after 36 months' follow-up. Those with 50% compliance had a 60% reduction, and in patients who were 100% compliant, lymphoedema reduction increased to 79%.

**DISCUSSION**

This paper reviews the literature, available to date for the use of compression garments in patients with upper body lymphoedema. Considering that the included studies stretch out in time for almost 30 years (1980–2009), it is surprising that more high-quality evidence does not exist. Furthermore, some of the key points for practice highlighted in this paper are derived from single, small scale studies indicating that more research is needed in all areas, including prophylaxis, treatment and long-term management of upper body lymphoedema, and on a larger scale.

One reason for this lack of evidence may be associated with the difficulties in assessing lymphoedema. Though some instruments are reliable and recommended by the International Society of Lymphology (Bernas et al, 1996), others used need to be developed and tested. In particular, there is a lack of instruments for the measurement of breast and thoracic lymphoedema, which impacts upon the clinician's ability to robustly evaluate the efficacy of treatments in this area.

Another explanation for the lack of evidence may be that the definition of lymphoedema, in particular at an early stage, has not yet been standardised and therefore this needs to be further investigated and discussed.

A limitation of the findings of the studies presented in this paper is that the pressure delivered by compression garments is very rarely documented. This may be due to lack of standards, although the European Committee for Standardisation (2001) have made recommendations on the range of

pressure within the four different compression classifications. Thus, future research must address issues such as the better monitoring of the pressures delivered under garments.

Stout Gergich et al (2008) concluded that compression garments effectively treat subclinical arm lymphoedema, even if the garments are worn only when completing strenuous exercise or activity, during air travel, with symptoms of heaviness, or if visible swelling appeared. The amount of time for which the patient with early diagnosed lymphoedema can wear the garment without compromising treatment efficacy could be investigated, since reducing daily wear time may improve patient compliance. The comfort and appearance of compression garments can also impact on compliance with therapy, thus garment manufacturers may consider undertaking psychosocial research and use the findings to positively influence their product development.

### CONCLUSION

The literature indicates that the use of compression armsleeves is effective in the management of arm lymphoedema, but the reported findings need to be confirmed by larger scale studies. Research is needed into the role of compression garments in the management of breast and thorax lymphoedema, but may be difficult to undertake until appropriate measuring tools are developed and standardised. Finally, research that results in lower wear-times and garment design that responds to the patient's psychosocial needs will help to improve the outcomes and quality of life for patients with lymphoedema.

### REFERENCES

- Andersen L, Højris I, Erlandsen M, Andersen J (2000) Treatment of breast-cancer-related lymphedema with or without manual lymph drainage. A randomized study. *Acta Oncol* **39**(3): 399-405
- Bernas M, Witte M, Witte C, Belch D, Summers P (1996) Limb volume measurements in lymphedema issues and standards. *Lymphology (Suppl)* **29**: 199-202
- Bertelli G, Venturini M, Forno G, Macchiavello F, Dini D (1991) Conservative treatment of postmastectomy lymphedema: a controlled, randomized trial. *Ann Oncol* **2**: 575-8
- Bertelli G, Venturini M, Forno G, Macchiavello F, Dini D (1992) An analysis of prognostic factors in response to conservative treatment of postmastectomy lymphedema. *Surg Gynecol Obstet* **175**(5): 455-60
- Boris M, Weindorf S, Lasinski B (1997) Persistence of lymphedema reduction after noninvasive complex lymphedema therapy. *Oncology (Hunting)* **11**(1): 99-109
- Box R, Reul H, Bullock S, Furnival C (2002) Physiotherapy after breast cancer surgery: results of a randomised controlled study to minimize lymphoedema. *Breast Cancer Res Treat* **75**(1): 51-64
- Brorson H, Svensson H (1998) Liposuction combined with controlled compression therapy reduces arm lymphedema more effectively than controlled compression therapy alone. *Plast Reconstr Surg* **102**: 1058-67
- Bunce IH, Mirolo BR, Hennessy JM, Ward CW, Luke CJ (1994) Post-mastectomy lymphoedema treatment and measurement. *Med J Aust* **161**: 125-8
- Casley-Smith JR, Casley-Smith JR (1992) Modern treatment of lymphedema. I. Complex physical therapy: the first 200 Australian limbs. *Australas J Dermatol* **33**(2): 61-8
- Casley-Smith JR (1995) Alterations of untreated lymphoedema and its grades over time. *Lymphology* **28**: 174-85
- Collins CD, Mortimer PS, D'Ettorre H, A'Hern RP, Moscovic EC (1995) Computed tomography in the assessment to limb compression in unilateral lymphoedema. *Clin Radiol* **50**(8): 541-4
- Delon M, Evans AW, Cooper S, Walls C, McGillycuddy B, Martlew B (2008) Early post-op swelling and its association with lymphoedema. *J Lymphoedema* **3**(1): 26-30
- European Committee for Standardisation (CEN/TC 205WG2). Medical compression hosiery. European Standard CEN/ENV 12718, 2001.
- Földi E, Földi M, Weissleder H (1985) Conservative treatment of lymphoedema of the limbs. *Angiology* **36**(3): 171-80
- Graham PH (2002) Compression prophylaxis may increase the potential for flight-associated lymphoedema after breast cancer treatment. *Breast* **11**(1): 66-71
- Johansson K, Lie E, Ekdahl C, Lindfeldt J (1998) A randomized study comparing manual lymph drainage with sequential pneumatic compression for treatment of postoperative arm lymphedema. *Lymphology* **31**: 56-64
- Johansson K, Ohlsson K, Albertsson M, Ingvar C, Ekdahl C (2002) Factors associated with the development of arm lymphedema following breast cancer treatment: A match pair case-control study. *Lymphology* **35**: 59-71
- Johansson K, Holmström H, Nilsson I, Albertsson M, Ingvar C, Ekdahl C (2003) Breast cancer patients' experiences of lymphoedema. *Scan J Caring Sci* **17**: 35-42
- Johansson K, Tibe K, Weibull A, Newton R (2005) Low intensity resistance exercise for breast cancer patients with arm lymphoedema with or without compression sleeve. *Lymphology* **38**: 167-80
- Johansson K, Piller N (2007) High intensity resistance exercise for breast cancer with arm lymphedema. *J Lymphoedema* **2**: 15-22
- Ramos SM, O'Donnell LS, Knight G (1999) Edema volume, not timing, is the key to success in lymphedema treatment. *Am J Surg* **178**(4): 311-5
- Segerström K (1992) Factors that influence the incidence of brachial oedema after treatment of breast cancer. *Scand J Plast Reconstr Surg Hand Surg* **26**: 223-7
- Stout Gergich NL, Pfalzer LA, McGarvey C, Springer B, Gerber LH, Soballe P (2008) Preoperative assessment enables the diagnosis and successful treatment of lymphedema. *Cancer* **112**(12): 2809-19
- Swedborg I (1984) Effects of treatment with elastic sleeve and intermittent pneumatic compression in post-mastectomy patients with lymphoedema of the arm. *Scand J Rehabil Med* **16**(1): 35-41
- Swedborg I (1980) Effectiveness of combined methods of physiotherapy for postmastectomy lymphedema. *Scand J Rehabil Med* **12**: 77-85
- Szuba A, Cooke JP, Yousuf S, Rockson SG (2000) Decongestive lymphatic therapy for patients with cancer-related or primary lymphedema. *Am J Med* **109**: 296-300
- Vignes S, Porcher R, Arrault M, Dupuy A (2007) Long-term management of breast cancer-related lymphedema after intensive decongestive physiotherapy. *Breast Cancer Res Treat* **101**: 285-90

# Selecting compression hosiery for hand, arm and midline trunk lymphoedema

D Doherty, A Williams

**A wide variety of factors must be taken into consideration when determining if a patient is suitable for the use of a compression garment, and when selecting the most appropriate product. Compression level, construction type and style, as well as accurate measurement and fit all influence comfort, effectiveness and patient concordance. This paper guides the practitioner through the processes involved in prescribing upper body compression garments for the management of lymphoedema.**

Compression is widely used to control swelling in the upper limb and torso, although there is more evidence for the use of compression in lower limb lymphoedema than upper body swelling. A limited study of interface pressures under compression highlighted the difficulties with identifying effective pressure gradients along the length of armsleeves, and discussed some of the clinical implications (Williams and Williams, 1999). Despite the widespread use of armsleeves and other compression garments such as gloves/gauntlets and bras as first-line treatment in upper body lymphoedema, there is a paucity of research to support this practice; the evidence that does exist is discussed by Johansson on pp. 16-20 of this document.

In the absence of robust evidence, clinical practice is guided by consensus and expert opinion, both of which have been utilised to make the recommendations for practice that are presented in this paper.

## FACTORS INFLUENCING THE USE OF COMPRESSION GARMENTS

Although compression garments can be used prophylactically or to treat early lymphoedema, they are mainly used for long-term management. Therefore, it is important that the correct garment is provided for the patient since fit, style and material influence the appearance and comfort of the garment, and thus patient willingness to persevere with treatment (Doherty et al, 2006). Choosing an appropriate garment involves working with the patient to explore the variety of compression garments available, and selecting the most appropriate product to meet both clinical and lifestyle needs.

A wide variety of factors must be considered when determining if a patient is suitable for compression hosiery:

- Patient's lifestyle, mobility, age, psychosocial status and personal choice
- Dexterity of the patient/carer: they must be able to apply and remove the garment
- Skin condition and skin sensitivity: the skin must be intact and resilient
- Condition of underlying tissues and presence of fibrosis or lipoedema
- Arterial status
- Limb size, shape and distribution of swelling
- Functional status of limb
- Status of underlying disease(s) such as cancer, congestive cardiac failure or other comorbidities
- Stage of lymphoedema and its severity
- Sensory deficit
- Ability to tolerate compression
- The presence of concomitant medical conditions such as peripheral neuropathy.

In addition, there are some contraindications for the use of compression (Box 1).

## READY-TO-WEAR OR CUSTOM-MADE GARMENTS?

Following a full assessment by a trained healthcare practitioner, in which the patient's suitability for a compression garment is confirmed, a decision will need to be made on the style and type of garment required (i.e. ready-to-wear or custom-made, flat- or circular-knit).

Information obtained during assessment can be used to select the most appropriate product for the individual patient and their circumstances.

Ready-to-wear garments have the advantage of being quicker to obtain and fit.

D Doherty, Lymphoedema Framework Project Director and Clinical Nurse Specialist in Lymphoedema; A Williams, Cancer Nursing Research Fellow, Edinburgh Napier University, Edinburgh, Scotland

**BOX 1. Contraindications for compression hosiery**

- Arterial insufficiency
- Venous outflow obstruction/ acute deep vein thrombosis (DVT)
- Uncontrolled congestive cardiac failure
- Lymphorrhoea
- Acute untreated cellulitis
- Acute phlebitis
- Extreme shape distortion, including very deep skin folds

**Caution: supraventricular clavicle obstruction, brachial plexus neuropathy, axillary vein thrombosis**



**FIGURE 1: Compression garments with special adaptations.**

They can be made of thinner fabrics which are more cosmetically acceptable to patients than thicker flat-knit alternatives. However, circular-knit products may not fit perfectly, or provide enough support; they are more likely to roll over at the top, especially if the area covered is fleshy; and can cut into skin folds and tourniquet. Ready-to-wear circular-knit hosiery is suitable for use in patients with mild oedema where there is little deviation from the normal anatomical shape. Ready-to-wear flat-knit garments can be used to accommodate minimal shape distortion or for rebound oedema, where circular-knit garments do not contain the swelling. Generally, custom-made flat-knit garments are used for patients with more severe and complicated lymphoedema, particularly where limb shape is irregular. They better accommodate abnormal shape and tissue distribution, allowing for different levels of compression at different anatomical sites within the same garment. They can also be used when special adaptations are required, such as zips or velcro to ensure exact fit (Figure 1). They are also recommended in the first few months following a period of multilayer lymphoedema bandaging to prevent rebound oedema.

Patients may express a preference for a particular style or thickness of material, depending on their level of activity and garment use. These preferences should be considered when deciding on optimal therapy, while encouraging the most appropriate treatment. Options which may be preferable include layering of garments, or varying the stiffness of the material to encourage greater use.

**CHOOSING THE APPROPRIATE COMPRESSION GARMENT STYLE**

Garments are available in styles to accommodate different clinical presentations of swelling in the upper body. Many arm sleeves have a variety of features which include a bias or slant cut style at the axilla, shoulder attachments, silicone top bands, and separate and combined hand pieces (gauntlets/mittens) (Figure 2). Specialist compression garments are available for midline swelling.

Hosiery should cover the entire area of oedema to avoid swelling in the adjacent quadrant or forcing oedema distally.

**Hand and finger oedema**

Hand and finger oedema (Figure 3) can occur with or without arm swelling. It can be debilitating, making fine finger movement difficult and highlighting the condition to others. The cutaneous affects of docetaxol chemotherapy, which is given to some women with breast cancer, can lead to poorly controlled early lymphoedema of the hand and fingers and fibrosclerotic/scleroderma-like changes in the dorsum of the hand (Farrant et al, 2004).

Ready-to-wear gloves and mittens are available in a variety of sizes, styles and thicknesses, and require careful fitting (Figure 4). Custom-made flat-knit gloves can be tailored to meet specific needs, such as hand or forearm swelling. Using a separate hand piece allows for removal for handwashing and preserves the integrity of the fabric. However, if separate garments are used, care must be taken to avoid too much pressure where the



**FIGURE 2: A selection of compression garments for different clinical presentations.**



FIGURE 3: Hand and finger oedema.



FIGURE 4: Ready-to-wear gloves and mittens.



FIGURE 5: Forearm oedema.

garments overlap at the wrist (Box 2). Patients need to understand that wearing a sleeve without the glove or mitten can increase hand and finger swelling, and so must adapt their activities and use of garments accordingly.

**Forearm oedema**

There are a number of garments for the management of forearm oedema (Box 3). A custom-made flat-knit garment may be required to apply sufficient pressure where rebound oedema occurs or if tissue thickening is present in the forearm (Figure 5). Practitioners measuring for a custom-made garment can pull the tape tightly to adjust the measurements at the mid-forearm, and ensure adequate pressure over areas in which rebound oedema easily occurs. However, care should be taken to avoid unnecessary tightness at the wrist or elbow. Where fibrosclerosis can occur on the lateral aspect of the forearm around the elbow or in the medial forearm, pads can be inserted under the garment in the affected area to apply local pressure and friction to underlying tissues.

It is important to ensure that the sleeve does not cause redness or irritation at the sensitive elbow crease. An advantage of using a custom-made garment is the shaped elbow knitted into the material which can eliminate this problem (Figure 6). However, if the garment is a good fit and irritation still occurs, a silk inner layer can also be used to protect the elbow.



FIGURE 6: Compression sleeve showing shaped elbow knitted into the material.

**BOX 2 Tips when selecting gloves and mittens for hand and finger oedema**

- Gloves and gauntlets/mittens are used for swelling of the hand, fingers and forearm. Flat-knit seamless gloves are now available which increase freedom of movement of the fingers and hand and help to prevent skin damage from pressure at the seams
- Gloves and gauntlets/mittens are also required if use of a sleeve causes hand swelling which was not present before
- Before garment application, check for the presence of interdigital mycosis or excoriation in the web space between the thumb and first finger
- Where finger swelling is present, custom-made finger length garments can be adjusted to cover the area of swelling
- Softer materials, eg. microfibre fabric can be used to allow greater comfort and ease of movement. In some cases there is the flexibility to cut the fingers of the microfibre fabric to customise the fit to the patient
- Tissue thickening on the dorsum of the hand — the use of foam inserts will allow gloves to provide additional pressure and friction to soften thickened tissue

For some patients, custom-made sleeves that just fit the hand and forearm can also be useful if the oedema is localised and a full-length sleeve is not indicated (Figure 7). Where night time oedema control is an issue, bandaging or a garment with lower compression used overnight may be effective. Additionally, use of an inelastic compression device may be beneficial.

**Upper arm oedema**

Swelling in the upper arm may also be accompanied by fat deposition resulting in shape distortion or floppy tissue (Figure 11). In such cases, a compression garment made



FIGURE 7: Custom-made-sleeve to fit the forearm and hand.

**BOX 3 Specific advice for swelling and tissue changes limited to the forearm and/or hand**

- A sleeve without a hand piece can be used where no hand oedema is present (Figure 8)
- An integrated sleeve and hand piece/mitten can be used with hand swelling. A number of patients need gloves or mittens with an arm sleeve. The gauntlet variety (i.e. attached to, and part of the sleeve) is preferable as it reduces the risk of a pressure band at the overlap (Figure 9)
- A separate hand piece and sleeve can be used to offer greater versatility (Figure 10). It is advisable to extend the glove 6cm past the wrist to ensure greater overlap with the sleeve, as a narrow overlap may create a tourniquet
- Although rare, a custom-made gauntlet that covers the forearm can be used



FIGURE 8: Sleeve without a hand piece.

**BOX 4 Specific advice for upper arm oedema**

- Where swelling includes the entire arm or just the upper arm a full sleeve is required (Figure 8)
- A straight or bias slant cut style at the axilla are available (the latter sits better anatomically but choice may depend on patient preference)
- Arm oedema extending to the shoulder may require a sleeve with shoulder coverage. A shoulder cap style of garment with bra or belt attachment is required. Depending on patient preference and if available, a combination of MLD and lymphoedema taping can also be used
- A silicone topband can be useful in ensuring armsleeves stay in position but should not cause undue pressure (which could exacerbate oedema) or damage the skin

of a stiffer material is often required and custom-made flat-knit garments can provide a good fit. Where swelling occurs at the shoulder (root of the limb), manual lymphatic drainage (MLD) may be required (Box 4).

**Trunk and breast oedema**

Upper trunk or breast oedema (Figure 12) is common after cancer treatment, specifically, dissection of axillary nodes in breast cancer or malignant melanoma. Areas of the adjacent trunk quadrant share lymph drainage routes with the arm, and drain into the axillary lymph nodes. Oedema of the



FIGURE 9: Integrated sleeve and hand piece.



FIGURE 10: Separate hand piece and sleeve, offering greater versatility.

axilla, chest wall, breast, back or shoulder can therefore occur, with or without accompanying arm lymphoedema.

Pathological changes underlying the development of arm lymphoedema and trunk or breast oedema may differ. Radiotherapy to the breast or axilla can lead to specific inflammatory changes that damage local lymphatics and cause further oedema, particularly in a pendulous or unsupported breast. Scars and adhesions within the axilla, breast or chest wall can lead to discomfort, which is exacerbated by a poorly-fitting bra or breast prosthesis. Patients are often reluctant to wear a



FIGURE 11: Upper arm oedema.



FIGURE 12: Breast oedema.

compression bra or light compression garment, even though the area is likely to benefit from having adequate support and compression.

Swelling of the breast or upper trunk, axilla and shoulder area creates particular anxieties for the patient, as it is often associated with pain, discomfort and numbness (Bosomptra et al, 2002), leading to fears of cancer recurrence. It can be difficult for the patient and the practitioner to differentiate between oedema, seroma (post-operative accumulation of fluid) and other problems such as post-operative neuropathic pain, radiotherapy reaction or cellulitis (Stevenson et al, 2005). Therefore, careful assessment of the problem and a multidisciplinary approach is required. It will be important to differentiate between a seroma and trunk oedema, as both may exist simultaneously. However, needle aspiration of seroma, or biopsy of fibrotic areas (used to exclude the possibility of cancer recurrence) have the potential to exacerbate local oedema.

Compression garments such as specialist bras or body products can be useful for some people with lymphoedema, alongside other treatments such as MLD and lymphoedema-taping. Patients need support with self-care including self-massage and exercises which will help to decongest the affected areas, as well as the choice of a well-fitting and supportive bra or garment. It is possible that techniques such as tissue release and mobilisation of the fascia can help to restore healthy lymph drainage pathways, although this aspect of treatment requires further research (Mondry et al, 2002).

**Assessment**

Assessment of trunk and breast oedema by a specialist practitioner is recommended. Complications such as recurrent or primary malignancy, cellulitis requiring antibiotic therapy, and presence of an abscess in the underlying breast tissue, for example, should all be excluded before compression is considered. Patients need well-timed and appropriate information to understand the underlying changes and learn what they can do to help reduce the oedema. In many instances, trunk and breast oedema will

**BOX 5 Advice for those with swelling of the trunk or breast oedema**

- Keep the area clean and moisturised (check with radiotherapy department for advice on emollients if appropriate)
- Consult doctor if the area is hot and tender and if infection is suspected
- Wear a well-fitting bra or garment to support the swollen areas and provide gentle compression to the tissues, where comfortable
- Get advice on exercises that will help to decongest the area
- Consider the use of self-massage or MLD
- Find out from a lymphoedema practitioner if lymphoedema taping would be helpful
- Go back for a follow-up check with the lymphoedema practitioner as new or different garments may be required
- Remember that breast and trunk swelling will reduce and sometimes resolve completely, although this can take several months and up to two years; the changed sensations, e.g. numbness, can remain

eventually resolve, particularly if effective treatment and compression can be instigated early.

**Bra and garment fitting**

In women with trunk or breast oedema, a good-fitting bra is essential. A variety are available through companies specialising in breast and lymphoedema care. Sensitivity in measuring and fitting a garment is required, particularly if a woman is in discomfort and is reticent to have compression over the area. It is useful to emphasise that good support is vital to encourage lymph drainage from the breast. If a woman has had breast conservation surgery, her breasts may now be different sizes and shapes, and the oedematous one is likely to be heavier and often pendulous and uncomfortable. Those with a bra cup size of more than C may be at greater risk of oedema (Pezner et al, 1985), and may also benefit from wearing a softer garment or bra at night.

Care is required to achieve a good fit and symmetry, sometimes with the use of prosthetics, or surgical reduction of the untreated breast. Those who have breast reconstruction are also at risk of oedema (Parbhoo, 2006), although the surgeon should be consulted before MLD is used.

Some companies provide specific



**FIGURE 13: Specialist bra.**

garments for trunk and breast oedema, mainly compression vests, or bras (Figure 13) that are made of stiff (but soft) materials and have wide straps. Vests can be used to provide support across the back, incorporating the posterior axillary area and the breast/chest wall. They are available from some companies in white, black and beige and are useful in the early postoperative months. They should be measured for and fitted by an appropriately trained practitioner.

#### **Inserts**

Inserts made of materials such as foam can be used inside the bra to provide friction over fibrotic areas. They can be obtained as ready-made sheets or can be cut and assembled using hypoallergenic foam and adhesive materials.

#### **Oedema of the upper trunk and arm in advanced disease**

Oedema can be a significant problem and difficult to control if locally invasive disease or distant cancer metastases are present. This may be complicated by an open wound due to a fungating tumour around the chest wall, or systemic changes leading to fluid imbalance due to hypoalbumaemia, or use of medications such as dexamethasone. Many women with advanced breast cancer undergo palliative chemotherapy that can exacerbate swelling. However, the direct action of chemotherapeutic drugs in reducing tumour size can lead to significant improvement in oedema.

Fitting compression garments in those with advanced disease requires skill and an awareness of the wider issues around the treatment and palliation of symptoms. Patients may have reduced mobility and be in pain, and thus less likely to tolerate high compression levels. They may find it difficult to apply a garment and, therefore, some creativity and appreciation of individual need and ability is often required from the practitioner. Both circular- and flat-knit garments, usually at low compression, can be used in this patient group depending on individual need.

Support bandaging may be useful before using a compression garment and can be used specifically to reduce finger and hand

oedema, or lymphorrhoea, even if the arm or trunk remains relatively swollen. Those with brachial plexus neuropathy leading to a dependent arm may be more comfortable using long-term support bandaging but can also be fitted with a garment, provided that they can find ways to apply the garment, either independently or with assistance.

#### **MEASURING FOR HOSIERY**

Measurement for compression garments should take place when any intensive therapy is completed and the limb is in the best possible condition. Thus, the oedematous area should be as free from swelling as possible, pitting oedema should be minimal or absent and shape distortion minimised (Lymphoedema Framework, 2006). In most patients, decongestive therapy with manual lymphatic drainage (MLD) and bandaging may be required to achieve this. Subtle swelling, including skin and tissue changes in the limb and trunk should also be identified, since limb swelling may be less well controlled if the trunk area remains congested. Skin and tissue changes such as blisters, lymphorrhoea or subcutaneous thickening may also require alternative management, such as bandaging, before compression garments can be used.

For patients already wearing a compression garment, measurement should be carried out:

- Before garment renewal to confirm correct size is being prescribed
- If the patient is switching from ready-to-wear to custom-made garments or vice versa
- If a different style of garment is required
- If adaptations to the garment are needed, or if a different pressure is required (Lymphoedema Framework, 2006).

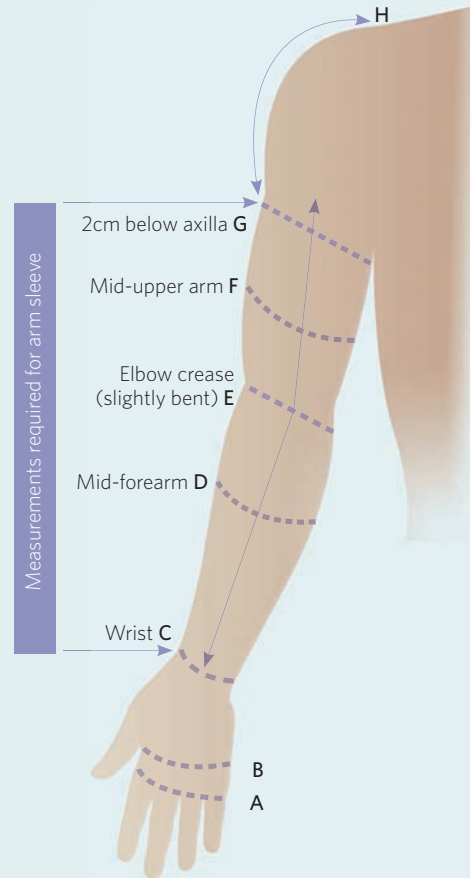
Accurate measurement is essential for correct garment fit and optimal patient comfort. Badly fitting hosiery may not contain the lymphoedema, cause tissue damage, be uncomfortable and poorly tolerated, and dissuade the patient from wearing hosiery long term.

A guide to the measurement of different compression garments for use on patients with upper body lymphoedema is given in Boxes 6–11. However, it should be noted that these are just a guide and careful attention

**BOX 6 Measuring for ready-to-wear compression hosiery**

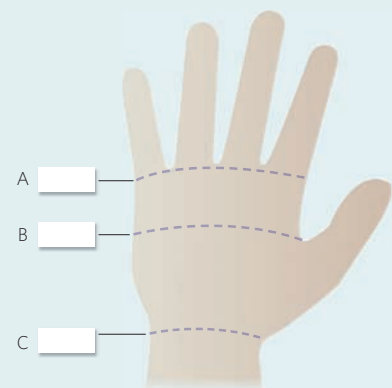
**For forearm or upper arm oedema**

- Begin by relaxing the arm and resting it on a table, bending it slightly to create a small bend in the elbow
- The arm should not be completely straight, or fully bent
- Hold measuring tape around the wrist, going over the little bone (ulnar styloid process) on the outside
- Pull tape to the point of gentle tension; there should be no slack, but do not pull so hard that the tape creates an indentation
- Write down this measurement
- Next, move the measuring tape up the arm so that it goes around the area of the forearm that is directly between the wrist and the elbow crease (mid-forearm, D)
- Use the same amount of gentle tension and record the measurement
- Take measurement at elbow crease
- Finally, bring the measuring tape to the upper part of the arm, halfway between the elbow and the armpit (mid-upper arm, F)
- If there is extra skin here, gather it together as much as possible and hold the tape a bit tighter so that all the skin is encircled evenly
- Take final circumferential measurement 2 finger widths (2cm) below the axilla
- The length measurement is taken along the inside of the arm from the wrist to 2cm (2 finger widths) below the axilla (G) to determine whether a short, standard or longer length garment is required. Measure from G to outside of bra strap, point H, for shoulder cap option
- For an integrated hand piece without fingers, measure the hand at points A and B



**BOX 7 Measuring for ready-to-wear mitten/gauntlet**

- Measurements to be taken with the hand relaxed, palm upwards
- Let the fingers relax, and bring the measuring tape so it is just under the knuckles. Pull gently so the tape has no slack
- Measure on hand at point A
- Measure widest part of the hand, stay slightly away from the web space at point B
- Ask the patient to flex the hand upwards at the wrist and mark this point. Measure at this wrist flexure point C
- Record the measurement



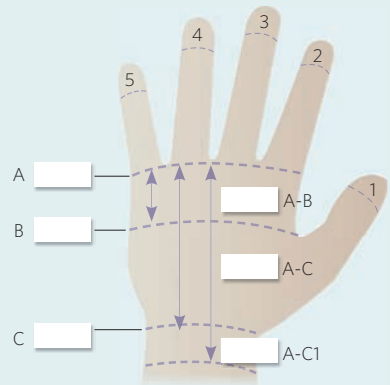
should be paid to the manufacturer's measuring instructions and measuring should be performed by a qualified practitioner.

**RECOMMENDATIONS FOR COMPRESSION GARMENTS IN UPPER LIMB LYMPHOEDEMA**

The optimal therapeutic pressures and stiffness of materials for compression in

**BOX 8 Measuring for ready-to-wear glove**

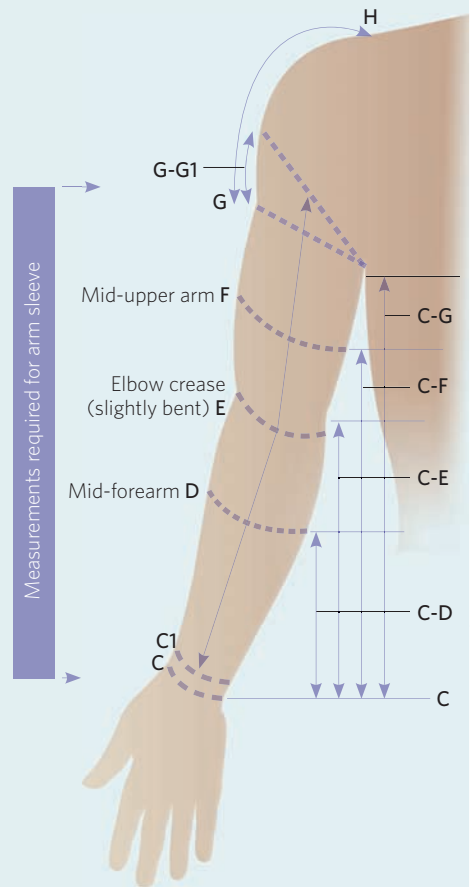
- Measurements to be taken with the hand relaxed, palm upwards
- Let the fingers relax, and bring the measuring tape so it is just under the knuckles. Pull gently so the tape has no slack
- Measure on hand at point A
- Measure widest part of the hand, stay slightly away from the web space at point B
- Ask the patient to flex the hand upwards at the wrist and mark this point. Measure at this wrist flexure point C
- Record the measurement
- Take measurement at C1, approximately 3cm proximal to C
- For hand length take measurements from A- B, A-C, A-C1 to determine size of hand piece
- Take circumferential measurements of the fingers and thumb at the tip and base



**BOX 9 Measuring for custom-made armsleeves**

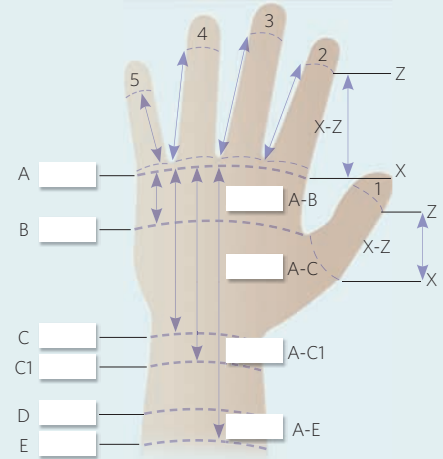
**For forearm or upper arm oedema**

- Begin by relaxing the arm and resting it on a table, bending it slightly to create a small bend in the elbow
- The arm should not be completely straight, or fully bent
- To find C, ask the patient to flex the wrist. Use the level of the second crease from the hand to measure circumference C. C1 is about 5-7cm proximal to C
- Pull tape to the point of gentle tension; there should be no slack, but do not pull so hard that the tape creates an indentation
- Write down this measurement
- Next, move the measuring tape up the arm so that it goes around the area of the forearm that is directly between the wrist and the elbow crease (D, mid-forearm). Measure circumference at D pulling the tape to the point that there is tension against the resistant oedema
- Measure circumference E at the elbow crease with the elbow slightly bent, without any tension applied to the tape. Measure again 1-2cm proximal to E. If this circumference is larger than the E measurement, record this as E
- Bring the measuring tape to the mid-upper part of the arm (F), halfway between the elbow and the armpit. If there is extra skin here, gather it together as much as possible and hold the tape a bit tighter so that all the skin is encircled evenly. Measure the circumference at F pulling the tape to the point that there is gentle tension against the resistant oedema
- Measure G 2cm below the axilla. When measuring circumference G do not apply any tension to the tape
- Measure length G-G1 for bias top
- Measure length from G to outside of the bra strap (H) for shoulder attachment. Also measure width of the bra strap for bra attachment
- The length measurement is taken along the inside of the arm following the entire contour of the arm



**BOX 10 Measuring for custom-made glove/gauntlet**

- Measurements to be taken with the hand relaxed, palm downwards, pressing gently on the table
- Let the fingers relax, and bring the measuring tape so it is just under the knuckles. Pull gently so the tape has very little slack. Avoid any constriction
- Measure on hand at point A, applying gentle tension to the tape
- Measure widest part of the hand, stay slightly away from the web space at point B
- Ask the patient to flex the hand upwards at the wrist and mark this point. Measure at the wrist flexure point C, pulling the tape gently to make skin contact
- Record the measurement
- Take measurement at C1, approximately 5-7cm proximal to C
- For hand length, take measurements with hand relaxed, palm upwards from A-B, A-C, A-C1 to determine size of hand piece
- Take circumferential measurements of the fingers and thumb at the tip and base
- Measure the length of the fingers and thumb from web space. This can be a short or long length as required. For finger length, use the flexi card and read the shorter side for the finger length



- Take a circumferential measurement at the point on the forearm where the glove should finish
- Take a length measurement from point A to point D and/or E (contoured measure)

lymphoedema of the upper limb have not been precisely defined. Usually arm sleeves, compression gloves and truncal garments correspond to mild to moderate compression levels, which are lower than those for the equivalent leg garments. This is mainly due to lower blood pressure and gravity force in the arms and hands plus other anatomical and physiological differences. Moderate compression levels are usually effective and better tolerated in the torso (Lymphoedema Framework, 2006).

The following recommendations aim to give clear guidance based on what is considered to be the effective level of compression for hosiery in primary and secondary lymphoedema in the upper limb.

**Subjective/subclinical lymphoedema (low 14-18 mmHg)**

The prophylactic use of compression garments is increasingly being recommended for use with patients who are at risk of developing upper extremity lymphoedema (Lymphoedema Framework, 2006).

The true potential for using compression to prevent progression and complications in subclinical lymphoedema has not been fully examined; what is known is discussed on p. 17

of this document. Patients with lymphoedema may report a wide variety of complaints such as heaviness or fullness related to the weight of the limb, a tight sensation of the skin, or decreased flexibility of the affected joint. With upper extremity involvement, there may be difficulty fitting the affected area into clothing or wearing previously well-fitting rings, watches, or bracelets. Low compression is frequently used as part of a preventative programme for those at risk of secondary lymphoedema following treatment for cancer. It can help to ameliorate some of the subjective symptoms associated with lymphoedema in the absence of any discernable swelling.

Garments should be worn when doing repetitive activities that can contribute to swelling or exacerbate symptoms. It is also recommended that they are worn during long-haul flights. A study by Graham (2002) found that there was a risk of temporary swelling with overseas flights. Patients may choose to wear the garment during the daytime, for several hours or only during high-risk activities.

**Early/mild lymphoedema (low 15-21 mmHg, RAL, 2008)**

Mild lymphoedema is characterised by pitting

**BOX 11 General points regarding bra fitting**

- Should be done by an appropriately trained fitter
- Straps and side/back sections should be sufficiently wide to provide an even pressure over the tissues without cutting into or causing creases in the skin, particularly in an oedematous area or at the axilla
- The centre front of the bra should lie flat against the chest wall; if not, this may indicate an incorrectly-sized cup
- The size of the cup must be big enough to lift and encase the whole breast, and not allow breast tissue to bulge out at the top or under the armpit as this can lead to bands of fibrosis in the breast tissue. Some versions with a wider band below the breast are preferable for larger breasted women
- Sports bras can be useful as the cup material is generally stiffer, allowing minimal bounce of the breast tissue and reduced movement to the side when moving and exercising
- In some women, a softer bra should be worn at night to provide support, particularly in the early stages

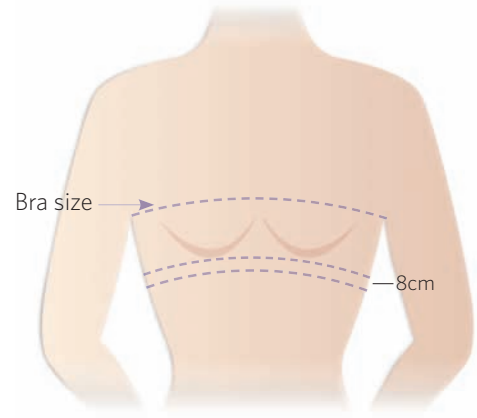
which can subside, or occurs when the excess limb volume is <10-20% compared to the unaffected limb (International Society of Lymphology [ISL], 2003).

Individuals who develop a dependent arm following a cerebrovascular accident or in conditions such as motor neurone disease (MND) can benefit from wearing garments with low levels of compression.

Low levels of compression can also be used in patients with fragile skin and low levels of compression tolerance. This level of compression is recommended for lymphoedema of the extremities where gloves and mittens are used. It also facilitates layering of garments which may be suitable for patients who may be unable to apply a single higher compression garment (Lymphoedema Framework, 2006). Additionally, lower compression garments can be used in the presence of some neurological deficit and, where lipoedema exists, to improve quality of life and palliate symptoms.

#### **Moderate/severe lymphoedema (medium 23-32 mmHg, RAL, 2008)**

This is predominantly non-pitting oedema characterised by tissue thickening with an excess limb volume of 20-40%, or >40% in severe lymphoedema (Lymphoedema Framework, 2006). Deepened skin folds, fatty



deposits and subcutaneous skin changes may also be present.

#### **Complex lymphoedema (high 34-46 mmHg, RAL, 2008)**

The oedema is predominantly non-pitting, with excess adipose tissue, skin thickening, involvement of three joints, with worsening oedema and skin infections (ISL, 2003). Deepened skin folds may also be present. It is rare for high pressures to be used on the upper limbs and should only be prescribed by a specialist practitioner.

#### **FITTING AND EVALUATION**

There are a variety of garments on the market offering a great deal of choice.

**BOX 12 Tips for checking fit**

**On first application, check that the:**

- Ordered garment meets the specification of the prescription
- Garment fully covers the area requiring treatment
- Material of the garment is evenly distributed with no folds, wrinkles or tight bands
- Garment is comfortable and is not too tight or loose
- Attachments or fixations are comfortable and keep the garment in place

**Additionally at follow-up:**

- Assess patient motivation and use of the garment
- Check that the garment:
  - stays in place and that there is no slippage requiring a need for or a change in fixation
  - does not cause skin reactions or localised skin trauma
  - is not folded back at the top, and has not been cut or reshaped

Practitioners should be both aware of and have access to what is available to meet the needs of their patients.

An appropriately trained practitioner should check the fit of the garments and demonstrate and check application and removal. Patients should be reviewed within several days and then two to three weeks after initial fitting with a newly-prescribed garment. Follow-up should occur three to six months thereafter if the garments fit well and the response to compression is satisfactory. More experienced patients may require review on a yearly basis. These patients may be discharged from the lymphoedema service and have their garments prescribed by their GP.

During reassessment practitioners should evaluate the patient/carer's ability to apply good self-care strategies and incorporate the patient's perspective of their progress. It is also important to check with the patient how often they are wearing the garment, if the style suits their lifestyle, and what their perspective is on the garment's effectiveness. This gives the practitioner the opportunity to ascertain if any additional help and support is needed.

Particular attention should be paid to the presence of pain, skin discolouration or any sudden increase in swelling. Practitioners should be alerted to the possibility of infection, thrombosis or ischaemic disease. If lymphoedema is massive/chronic and resistant to treatment, or starts several years after primary surgery without obvious trauma, underlying causes should be investigated. It is particularly important to exclude the recurrence of tumour or the development of lymphangiosarcoma. Referral for specialist assessment is required for appropriate diagnosis.

Generally, hosiery should be comfortable and well fitting (Box 11). It should not roll or mark the skin, or cause pain or numbness. On application, the material should be evenly distributed and not wrinkled, as this can damage the skin. Rubber gloves, providing there is no sensitivity to rubber, can be used to help to grip the material to allow readjustment and avoid overstretching. Overstretching can result in excess material which patients may fold at the wrist or axilla. It can also be a reason for slippage in flat-knit garments. Care

should also be taken to avoid turning back an integral hand piece as this will increase pressure in the area and make swelling worse.

Garments should be applied first thing in the morning when swelling is at a minimum. Fitting the garment soon after bathing or moisturising should be avoided as this can make application more difficult. Excessive use of a skin moisturiser will affect the longevity of the garment and is best applied at night when there is time for it to be absorbed before reapplication of the garment next day. Ideally, hosiery should be worn for as much of the day as possible, and should always be worn during exercise. Two garments are usually given, one to wash and one to wear (Box 13). Where skin allergies are an issue, cotton rich garments are helpful.

Several aids are available for easier application and removal of compression hosiery (Box 14). They require a fair degree of dexterity and the use of particular techniques which need to be demonstrated and checked by the practitioner to ensure correct use.

Hosiery can also be specially adapted. Garments can be made with zips and velcro fastenings to make application and removal easier (Figure 1).

### GARMENT RENEWAL

Initially, only one compression garment is ordered. This is to ensure that it fits properly and controls the swelling. Once this has been established and a good fit has been obtained, a second garment can be ordered. The need for replacement garments will vary depending on frequency of use, how well the garment is cared for and the level of activity. Generally, garments should be replaced every six months or when they start to lose elasticity. An increase or decrease of five or more pounds (2.7 kilograms or more) can also alter the fit of the garment.

### BODY IMAGE AND COMPRESSION GARMENTS

Studies have shown that lymphoedema of the arm can have physical, psychological and social effects on the individual (Johansson et al, 2003). Furthermore, the difficulties that people experience when wearing compression sleeves, e.g. the problems with clothing and the stigmatising effect of wearing a sleeve or gloves, have been

#### BOX 13 Day-to-day care of compression hosiery

- Garments should be washed daily, according to the manufacturer's instructions, to regain their elasticity
- Garments should dry naturally, rather than on a radiator or in a tumble drier
- Never exceed a wear-time of 2-3 days without proper cleaning
- Do not cut any loose threads or snares, as this may cause holes or runs in the garment

#### BOX 14 Application aids

- Ribbed rubber gloves
- Glide applicators
- Applicators to aid removal
- Metal applicators

highlighted (Sneddon et al, 2008). It is therefore important that practitioners explore practical and body image issues with individuals who are fitted with compression garments since they have the potential to considerably influence outcome by enhancing concordance and maximising quality of life (Lymphoedema Framework, 2006).

### CONCLUSION

The main aims of lymphoedema management are controlling limb swelling and minimising complications. Historically, the incidence of lymphoedema has been underestimated and understudied. The number of people who may be affected by upper body lymphoedema is likely to increase as a result of an ageing population and an increasing number of cancer survivors who are at risk of lymphoedema. Additionally, the problem of primary lymphoedema and non-cancer-related causes should not be overlooked.

Lymphoedema is a condition that cannot be cured: the goal is to educate and support patients in its long-term management (Box 15). Compression garments are used once the swelling has reduced and been stabilised. Garments should be comfortable while providing pressure to prevent reaccumulation of swelling in the affected area. There is increasing recognition of the need to provide a range of garments to meet the varied and changing needs of this patient group. Practitioners need to be aware of the available options and be adequately trained to make appropriate choices, together with patients, for the management of lymphoedema of the upper body.

### REFERENCES AND FURTHER READING

- Bosompra K, Ashikaga T, O'Brien PJ, Nelson L, Skelly J (2002) Swelling, numbness, pain, and their relationship to arm function among breast cancer survivors: a disablement process model perspective. *Breast J* **8(6)**: 338-48
- Doherty DC, Morgan PA, Moffatt CJ (2006) Role of hosiery in lower limb lymphoedema. In: *Template for Practice: Compression Hosiery in Lymphoedema*. MEP Ltd, London
- Farrant PBJ, Mortimer PS, Gore M (2004) Scleroderma and the taxanes: is there really a link? *Clin Exp Dermatol* **29**: 360-2
- Graham PH (2002) Compression prophylaxis may increase the potential for flight-associated lymphoedema after breast cancer treatment. *Breast* **11(1)**: 66-71
- International Society of Lymphology (2003) The diagnosis and treatment of peripheral lymphedema. Consensus document of the International Society of Lymphology. *Lymphology* **36(2)**: 84-91
- Johansson K, Holmstrom H, Nilsson I, Ingvar C, Albertsson M, Ekdahl C (2003) Breast cancer patients' experiences

### BOX 15 Information for patients

To use garments effectively, patients need to know:

- How compression hosiery works to control lymphoedema
- How to care for their skin — to apply an emollient at night; to use a cotton liner to protect the garment if emollient is applied just before donning, the skin is at risk of trauma or there is dermatitis
- When to wear hosiery and the importance of wearing hosiery each day, including during exercise\*
- In very hot weather the patient can shower the garment, as the evaporation of the water cools the arm
- How and when to apply the garment, in particular, to remove all wrinkles, to avoid overstretching the garment by pulling too far up the limb, not to fold the garment down at the top, to apply the garment in the morning when the limb is least swollen
- To wash the garment frequently following the manufacturer's instructions and to dry it away from direct heat
- Who to contact if the skin appears chafed, cut or discoloured, or if pain, pins and needles or peripheral swelling develop
- How to monitor swelling and who to inform if there is deterioration

\*During swimming patients may choose to wear an old garment. Current garment should not be used because chlorine will damage the fibres

- of lymphoedema. *Scand J Caring Sci* **17(1)**: 35-42
- Lymphoedema Framework (2006) *Best Practice for the Management of Lymphoedema*. International consensus document. London: MEP Ltd
- Mondry TE, Johnstone PAS (2002) Manual lymphatic drainage for lymphoedema limited to the breast. *J Surg Oncol* **81**: 101-4
- Morgan PA, Franks PJ, Moffatt CJ (2005) Health-related quality of life with lymphoedema: a review of the literature. *Int Wound J* **2(1)**: 47-62
- Michellini S, Campisi C, Failla A, Boccardo F, Moneta G (2006) Staging of lymphoedema: comparing different proposals. *Eur J Lymphol* **16(46)**: 7-10
- Parbhoo S (2006) Lymphoedema in young patients with breast cancer. *Breast* **15(52)**: 561-4
- Pezner RD, Patterson MP, Hill LR, Desai KR, Vora N, Lipsett JA (1985) Breast edema in patients treated conservatively for stage 1 and 11 breast cancer. *Int J Radiat Oncol Biol Phys* **11(10)**: 1765-8
- RAL Deutsches Institut für Gütesicherung und Kennzeichnung e. V (2008) Medical Compression Armsleeves. Quality Assurance RAL-GZ 387/2. Beuth-Verlag GmbH, Berlin
- Sneddon M, Pearson J, Franks P (2008) Lymphoedema: Service Provision and Needs in Scotland. University of Glasgow and Macmillan Cancer Support.
- Stevenson O, Bedlow A, Harries S, Carr R, Charles-Holmes R (2005) Delayed breast cellulitis: a bacterial infection or a skin response to lymphoedema? *Br J Dermatol* **153 Suppl 1**: 48-9
- Williams AF, Williams AE (1999) 'Putting the pressure on': a study of compression sleeves used in breast cancer-related lymphoedema. *J Tissue Viability* **9(3)**: 89-94