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PHYSIOTHERAPY in Medical Conditions







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Foreword
Dharmendra Kumar

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CHAPTER

2

Edema

DEFINITION

Edema is an abnormal accumulation of fluid under the skin or in intercellular spaces or in cavities of the body or in the body tissues. Edema most commonly occurs in the feet and legs, where it is referred to as peripheral edema. The swelling is the result of the accumulation of excess fluid under the skin in the spaces within the tissues. All tissues of the body are made up of cells and connective tissues that hold the cells together. This connective tissue around the cells and blood vessels is known as the interstitium. Most of the body's extracellular fluids that are found outside of the cells are normally stored in two spaces; the blood vessels (as the "liquid" or serum portion of your blood) and the interstitial spaces (not within the cells). In various diseases, excess fluid can accumulate in either one or both of these compartments (Fig. 2.1).

The body's organs have interstitial spaces where fluid can accumulate. An accumulation of fluid in the interstitial air spaces (alveoli) in the lungs occurs in a disorder called pulmonary edema.

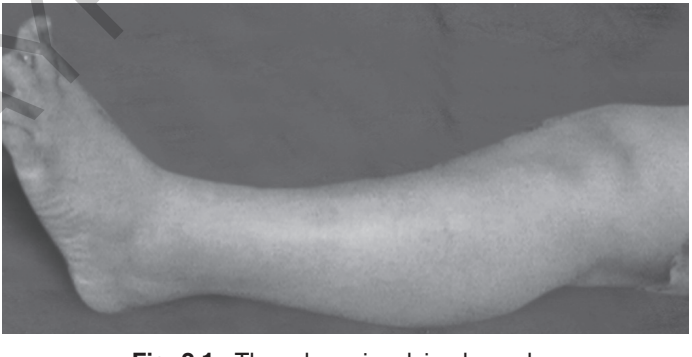

Fig. 2.1: The edema involving lower leg
(*For color version, see Plate 1*)

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In addition, excess fluid sometimes collects in the abdomen (abdominal or peritoneal cavity - called "ascites") or in the chest (lung or pleural cavity - called "pleural effusion"). Anasarca refers to the severe, widespread accumulation of fluid in the all of the tissues and cavities of the body at the same time.

PITTING EDEMA AND NON-PITTING EDEMA

Pitting edema (Fig. 2.2) can be demonstrated by applying pressure to the swollen area by depressing the skin with a finger. If the pressing causes an indentation that persists for some time after the release of the pressure, the edema is referred to as pitting edema. Any form of pressure, such as from the elastic in socks, can induce pitting with this type of edema (Table 2.1).

In non-pitting edema, which usually affects the legs or arms, pressure that is applied to the skin does not result in a persistent indentation. Non-pitting edema can occur in certain disorders of the lymphatic system such as lymphedema, which is a disturbance of the lymphatic circulation that may occur after a mastectomy, lymph node surgery, or congenitally. Another cause of non-pitting edema of the legs is called pretibial myxedema, which is a swelling over the shin that occurs in some patients with hyperthyroidism. Non-pitting edema of the legs is difficult to treat. Diuretic medications are generally not effective, although elevation of the legs periodically during the day and compressive devices may reduce the swelling.



Fig. 2.2: Pitting edema of leg (*For color version, see Plate 1*)

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TABLE 2.1 Grading for the assessment of pitting edema (Seidel et al, 1995)

Grade 1 + edema (Pit depth ≤ 2 mm)	*Grade 2 + edema (Pit depth 2-4 mm)*	*Grade 3 + edema (Pit depth 4-6 mm)*	*Grade 4 + edema (Pit depth 6-8 mm)*
Slight pitting No visible distortion Pit disappears rapidly	More deeper pit No easily detectable distortion Pit disappears 10-15 seconds	Pit noticeably deep Pit lasts more than 1 minute The affected extremity is fuller and swollen	Pit is very deep Pit lasts 2-5 minutes Dependent extremity is grossly distorted due to swelling

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Causes

Edema is caused by either systemic diseases, that is, diseases that affect the various organ systems of the body, or by local conditions involving just the affected extremities. The most common systemic diseases associated with edema involve the heart, liver, and kidneys. In these diseases, edema occurs primarily because of the body's retention of too much salt (sodium chloride). The excess salt causes the body to retain water. This water then leaks into the interstitial tissue spaces, where it appears as edema.

The most common local conditions that cause edema are varicose veins and thrombophlebitis (inflammation of the veins) of the deep veins of the legs. These conditions can cause inadequate pumping of the blood by the veins (venous insufficiency). The resulting increased back-pressure in the veins forces fluid stay in the extremities (especially the ankles and feet). The excess fluid then leaks into the interstitial tissue spaces, causing edema.

Mechanism

Edema can result from (Fig. 2.3) the interaction of about five factors:

- Increased hydrostatic pressure (The pressure exerted by the fluid at equilibrium due to force of gravity) tends to exert higher radially directed pressure on the blood vessel wall thus tends to push fluid out of the vascular tubes.
- Reduced oncotic pressure within blood vessels (Oncotic pressure is the osmotic pressure due to proteins in blood plasma. It tends to retain and attract water in the circulatory system) tends to

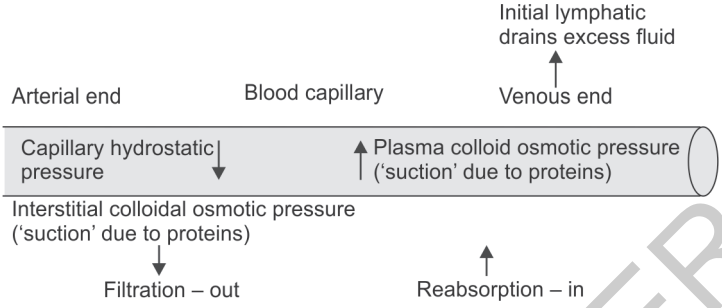

Fig. 2.3: The mechanism of edema production

loose the tendency to keep the water retained with in the vascular channels thus fluid tends to gush out of vessels.

- Increased blood vessel wall permeability occurs due to variety of conditions or early stages of inflammation. The increased vessel wall permeability provides reduced impedance to the outflow of fluid.
- Obstruction of lymphatic impaired fluid clearance it tends to cause accumulation of fluid with in lymphatic channels and also tends to augment the hydrostatic pressure.
- Alteration of the water retaining properties of the tissues may provide reduced space available for fluid accumulation or this may cause reduction of the oncotic pressure.

Rate of outflow of the fluid is primarily dependent on the force balance between hydrostatic pressure and the oncotic pressure (Starling Equation). The capillaries and post capillary venules provide the common interface for the leakage of water due to its semi-permeable nature.

Formation of edema can occur either by an increase in hydrostatic pressure within the blood vessel, a decrease in the oncotic pressure within the blood vessel or an increase in vessel wall permeability. The latter has two effects. It allows water to flow more freely and it reduces the oncotic pressure difference by allowing protein to leave the vessel more easily.

Classification (Based on Region Affected)

Edema may be called as generalized or as localized/tissue specific depending on the area of its involvement.

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- *Generalized edema*: This type of edema involves whole body and multiple organs. It commonly occurs in case of the malfunctioning of the heart, lungs, kidneys or liver. In cardiac failure the peripheral fluid stagnation occurs and this causes increased hydrostatic pressure. In case of kidney or liver pathology the clearance of the metabolites from blood stream fails thus increased in oncotic pressure occurs in the widespread body tissues.
- *Organ-specific edema*: Edema will occur in specific organs as part of inflammation, as in pharyngitis, tendonitis or pancreatitis, for instance. Certain organs develop edema through tissue specific mechanisms.

Cerebral edema is extracellular fluid accumulation in the brain. It may lead to drowsiness, altered sensorium or loss of consciousness. *Pulmonary* edema occurs when hydrostatic pressure in the pulmonary vasculature rises high or obstruction of pulmonary veins (common in left ventricle failure) impairs the removal of blood from lungs. In *lymphedema* abnormal removal of interstitial fluid is caused by failure of the lymphatic system. This may be due to obstruction from pressure from a cancer or enlarged lymph nodes, destruction of lymph vessels by radiotherapy, or infiltration of the lymphatics by infection (such as elephantiasis). Most common cause of the same is the failure of the pumping action of muscles due to immobility, or paralysis. Some medicines like indomethacin (NSAID) reduce plasma rennin activity and aldosterone level thus increases sodium and potassium retention thus it may impair the lymphatic action and may lead to edema (Akbarpour, 1985).

ADVERSE EFFECTS OF EDEMA

- Edema is closely related to disturbances in circulation
- Persistently the fluid is present in the tissue spaces it interferes with nutrition of cells because fresh gases and nutrients are not available and waste products are not removed metabolism and tissue functioning may be seriously impaired the severity of impairment varies with the amount of edema, duration of edema or the nature of edematous fluid.
- The prolonged impairment may lead to atrophy, loss of muscle contractile nature, impaired healing process, impaired immunity mechanisms.

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- If fluid present in the interstitial space for prolonged time fluid tends to organize into fibrous tissues and area gets hardened the organized fibrous content is foreign to body it is acted upon by immune mechanisms cells and blood vessels proliferate in this its size may increase and may obliterate blood vessels causing impaired circulation or disturbance of local nutrition.
- Excessive edema around joint impairs joint ROM (Range of motion)
- Accumulated fluid irritates nerve endings and causes pain.

ASSESSMENT OF EDEMA

Edema is often an early sign of significant fluid retention, which could eventually result in significant cardiac overload and conditions such as heart failure. Although many physicians are aware of the importance of monitoring edema, accuracy and consistency in assessing edema has been a challenge (Kimberly et al, 2009).

A variety of methods (periphery circumference, volume displacement, patient's self report) have been available to assess edema, however each has own set of advantages and disadvantages.

The most widely-used technique is a subjective clinical assessment where an examiner applies pressure with his/her index finger to a single location on the patient's ankle (Raju et al, 2002). This technique captures pit depth and the time needed (see Table 2.1) for the skin to return to its original appearance (recovery time) as a single edema score ranging from 0 to 4 (Seidel et al, 1995).

Water-displacement volumetry (Fig. 2.4) is widely considered to be the quick and common method of edema assessment, can be used for irregular ends of extremity (Thulesius et al, 1973); however, it is time consuming, needs space, difficulty to perform and not possible in case of ICU or wards of hospitals.

Ankle circumference; for consistent ankle circumference (Fig. 2.5) measurements (in cm), each ankle is marked with a marker at approximately 7 cm proximal to the midpoint of the medial malleolus. The circumference of the extremity is measured using a tension-controlled measuring tape, rather than a standard measuring tape, to minimize measurement error due to differences in the amount of tension applied. The measure of circumference is compared over days to see the progress or reduction of the edema.

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Fig. 2.4: Edema water-displacement volumetry
(*For color version, see Plate 2*)

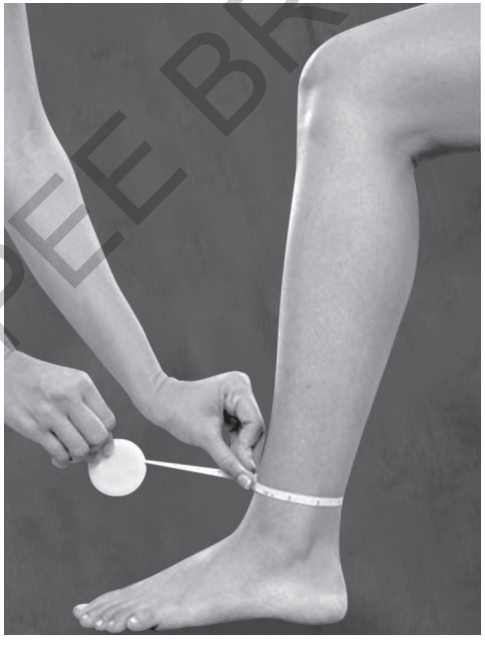

Fig. 2.5: Measurement of ankle edema by measuring tape
(*For color version, see Plate 2*)

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Figure-of-Eight (Kimberly et al, 2009). The figure-of-eight method uses eight landmarks on the ankle and foot to measure ankle circumference in centimeters:

1. Midway between the tibialis anterior tendon and the lateral malleolus
2. Distal to the tuberosity of the navicular
3. Proximal to the base of the 5th metatarsal
4. Tibialis anterior tendon
5. Distal to the distal tip of the medial malleolus
6. Achilles tendon
7. Distal to the distal tip of the lateral malleolus
8. Back to origin.

All these landmarks are marked and the measuring tape is wrapped to link them and the sum total of all the distances between points is used to record the circumference of the periphery.

The *other non-invasive methods of edema assessment* (Stanton and Badger, 2000) include:

1. *Optoelectronic volumetry:* The use of perometer device which measures the interruption of infrared light by limb
2. Tonometry to measure the physical characteristics of edema tissue
3. Harpenden skinfold calipers to measure the truncal edema
4. MRI, CT scan less used to measure the extent of edema in the corss-section of the body deeper layers
5. Ultrasound to evaluate the depth of the edema involvement.

Classification (based on underlying mechanism along with physiotherapy management).

INCREASED VENOUS PRESSURE

General Edema

Chronic venous insufficiency is one of the most common causes of the edema involving distal lower extremities. It is a condition where the veins fail to pump the blood back into the heart for reoxygenation, due to dilated/damaged valves, reduced venous tone or increased tortuosity of veins. The venous pressure is increased in *cardiac failure*. The veins do not get emptied and thus the amount of blood in them increases leading to the raised pressure at the venous end of the capillary which now counteracts the osmotic pressure of the plasma proteins, thus impeding the reabsorption of tissue fluid.

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Management

Treatment involves the appropriate management of cardiac failure, or venous insufficiency including the use of drugs such as digoxin and diuretics.

LOCAL EDEMA

Gravity

An important factor in determining the site of edema. Even in healthy people edema of the feet and legs can occur if the limbs remain dependent for too long, as on a long flight.

Management

Change of posture can be of great importance in controlling edema. Example is the prevention of edema of the lungs in a patient with left ventricular failure by sleeping propped-up in bed against pillows.

Inactivity

The venous return, especially from the legs under normal condition depends on compression of the veins by muscular activity in conjunction with competent valves in the veins which prevent reverse flow. If the muscles are inactive the venous return is poor, the venous capillary pressure is raised and so edema occurs. An extreme example is paralytic edema and the edema due to poor muscle tone.

Management

- *Poor muscle tone*: Physiotherapist can help to restore the strength and tone of the muscles by teaching graded exercises.
- *Laxity of the fascia*: Limb is elevated and a firm (but not tight) elastic bandage may be used.
- *Paralytic edema*: Passive measures to promote venous return will be required. These include:
  - Elevation of the affected limb
  - Passive movement of joints
  - Artificial exercise of the paralysed muscles by interrupted direct current (now rare)
  - Light massage which is sometimes effective in dispersing the fluid into regions not affected by the paralysis. Care must be

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taken neither to increase the paralytic vasodilation nor to bruise or stretch the atonic muscle fibres.

Varicose Veins

These greatly impair venous return from the legs. The dilatation of the veins causes valves to become incompetent so that even with muscular activity the venous return is poor.

Management

Venous return can be improved by raising the legs or by providing support, e.g. with an elastic stocking. Surgical treatment of varicose veins is often effective.

PHYSICAL THERAPY MANAGEMENT OF EDEMA

The management of edema greatly underlies on the cause of the edema, thus accurate diagnosis to reveal its cause must be done.

Acute Inflammation

During this phase the movement or stress will aggravate the problem rest is needed. The cryotherapy is helpful as it reduces the metabolic activity and thus reduce the blood flow to the region.

Patient may need bed rest or at least the rest of the affected part by help of splint.

Once the symptoms of acute inflammation phase start getting over, the movement or activity in controlled environment is important to avoid the organization in the fibrous tissues.

The circulation of the affected part has to be maintained to allow healing procedures to function optimally and also to avoid fluid stagnation and organization in to fibrous lumps.

To improve the circulation:

- Active exercise
- Rhythmic contraction of muscle
- Isometrics of the affected extremity.

Reduced Plasma Proteins

The plasma proteins may be reduced by inadequate intake as in starvation, or excessive loss as in Protein-losing nephritis.

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Management

Management includes raising the level of plasma proteins, particularly, albumin by intravenous infusion and treatment of the cause.

Increased Capillary Permeability

The sluggish circulation associated with raised venous pressure tends to cause anoxia of the endothelial cells. The resulting increased capillary permeability is thus a factor in circulatory edema. Damage to the capillary endothelium is also a factor in the edema occurring in nephritis, e.g. periorbital edema. Allergy, e.g. wasp sting may also damage the endothelium of capillaries and produce local edema which can be a hazard to life if the sting involves the tongue. The edema of nettle-rash is similar and may be controlled by antihistamine drugs, histamine being one of the main substances causing damage to the capillary endothelium in allergic states.

Rums are an important cause or increased capillary permeability. The resulting edema fluid has a high protein content so that it clots and organises readily. This may result in permanent disfiguration if appropriate steps are not taken to promote its reabsorption. The underlying principles and practical measures have already been described but unfortunately their application may be impeded by the extent of injury caused by the burns.

Management

An over-riding consideration is the maintenance of blood pressure by the infusion of plasma or plasma substitute to replace the fluid and protein lost from the circulation into the tissue spaces as edema fluid.

Obstruction to Lymphatic Drainage

Raised venous pressure, which obstruct both veins and lymphatics, there may also be selective lymphatic obstruction. This occurs after repeated attacks of lymphadenitis and lymphangitis following radical surgery, e.g. for carcinoma of the breast and as a long-term effect of filarial infection (elephantiasis). The edema produced by lymphatic obstruction is usually of the non-pitting variety due to fibrosis.

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Management

Unless treated early it rarely responds to physiotherapy.

- Physiotherapy modalities for edema
  - Cryotherapy in acute edema the application of cryotherapy under pressure is helpful to reduce the edema. This can be easily done by the cryo-cuff (Fig. 2.6).
- Manual lymphatic drainage (massage)
  - Direct intervention by a therapist (Kathrin et al, 2000). The effleurage method is most promising and the direction of the massage stroke must be directed towards the lymph nodes so as to facilitate the lymphatic drainage and venous return.
  - Self-massage by the patient
  - Sometimes the self-massage may be done in aquatic environment to combine the effect of aqua therapy, and active efforts to achieve lymphedema reduction (Dorit et al, 2007)
- Compression
  - Nonelastic or low-stretch bandages or custom-fitted garments
  - Intermittent, sequential pneumatic compression pump
  - Elastic bandages and inelastic bandages also provide a good mean to reduce the swelling and edema. Previous researches have proved a lesser efficacy of the elastic bandages while



Fig. 2.6: Application of cryo-cuff for acute edema around ankle
(*For color version, see Plate 3*)

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PHYSIOTHERAPY in Medical Conditions

Physiotherapy in Medical Conditions is designed for the physiotherapy students who wish to acquire knowledge of physiotherapy in different medical conditions. The book contains appropriately well-explained details of the medical topics that include inflammation, edema, arthritis, skin diseases, deficiency diseases, psychiatric disorders and respiratory, cardiovascular, and neurological conditions. The book would be helpful for the physiotherapists and other professionals working in the area of rehabilitation management.

Salient Features

- Covers the basic as well as advanced details warranted for the clinical understanding, theoretical aspects, and practical knowledge
- Thoroughly updated by the subject experts
- Includes references to augment the authenticity of the facts related to various clinical conditions and their management
- Contains nine topics, including various subtopics
- Illustrated throughout with photographs that support the explanations of the therapeutic application
- Presents the text in simple language that makes the learning process easy and reader-friendly.



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