Upper Extremity Edema Control: Rationale of the Techniques

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Edema of the upper extremity is a condition frequently encountered by those interested in hand rehabilitation. It frequently accompanies other problems associated with functional restrictions of the upper extremities. Its control and prevention are a part of the total rehabilitation of these extremities. Persistent edema becomes painful, disfiguring, and disabling. Fibrosis develops in the edematous tissue leading to contractures. The susceptibility for infection increases and the functional ability of the limb decreases. Treatment is based upon an understanding of the pathophysiology of edema. Edema occurs when there is an imbalance of effective pressures across the capillary membrane or when there is an obstruction to venous and lymphatic flow. The conservative treatment program consists of elevation, massage, use of external compression devices, exercises, and instructions to avoid contributing factors. This paper will discuss the physiologic rationale for the effectiveness of these treatment methods.

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Edema is the presence of abnormally large quantities of fluid in the intercellular spaces. It is a frequent result of injuries, operations, and burns (1-3). An extremity in a dependent position and inactive because of weakness, paralysis, or pain is likely to develop edema. Obstruction to the lymphatic and venous flow from an extremity leads to edema.

Persistent edema becomes painful, disfiguring, and disabling. The tendency for collagen tissue to be laid down in this protein-rich fluid increases, thus leading to fibrosis (4), and eventually contractures and deformities. The susceptibility to infection increases, especially in lymphedema (5). All these factors can lead to an overall decrease in function of the extremity.

Physiology of Body Fluid Regulation

The physiology of body fluid regulation needs to be reviewed in order to fully understand the rationale of treatment measures. This paper provides a summary of the pertinent points. More detailed descriptions of body fluid mechanics are available in standard textbooks on medical physiology (6, 7).

The fluid in the body is distributed in the intracellular and extracellular compartments. Extracellular fluid is mainly comprised of the fluid between cells (intercellular fluid) and the fluid in the vascular compartment (the blood plasma). There is a constant exchange of fluid between the intracellular and the extracellular spaces, and also between the intercellular spaces and blood plasma. The exchange of fluid between the intercellular spaces (tissue spaces) and the blood plasma occurs across the capillary membrane. The fluid
exchange depends upon the properties of the capillary walls and the balance of pressures acting across the capillary membrane (6).

The permeability of the capillary is dependent on its integrity and the effective forces acting across it. Of the factors that determine the fluid movement across the capillary membrane, the three important ones pertaining to our discussion are:

**The Capillary Filtration Pressure.**
This is the blood pressure within the capillaries that tends to move the fluid from the capillary outward into the tissues. The pressure is greater at the arterial end of the capillary than it is at the venous end. Because of this difference, fluid "filters" out at the arterial end, and most of it is reabsorbed at the venous end.

**The Tissue Hydrostatic Pressure.**
The pressure exerted by the tissue fluids, the interstitial fluid pressure, promotes the movement of fluid from the tissue into the capillaries.

**The Hydrostatic Pressure.**
The pressure within the peripheral blood vessels may be altered independently of that of the central or systemic arteries by the hydrostatic effects of changes in the position of the limb.

When the hand is in a dependent position, that is, in a position lower than the level of the heart, the intravascular pressure is increased. This, in turn, increases the capillary filtration pressure. In addition, the venous return from the limb is also reduced in this dependent position, due to the effects of the hydrostatic pressure, resulting in a secondary increase in the capillary filtration pressure (8).

The lymphatic system plays an important role in maintenance of tissue fluid balance. The superficial lymphatic plexus is an enormous meshwork of capillaries that offer no resistance to the flow of fluids (6). The fluid can move in either direction, its course determined by such factors as motion, gravity, and massage. The superficial plexus empties into the deep vessels, which in turn empty into the venous system. The deeper vessels have valves, allowing the lymph to flow centripetally, that is, distal to proximal (toward the heart). Passive transmission of pressure from muscular contractions helps in propulsion of the lymph toward the heart. Elevation of tissue hydrostatic pressure increases the flow of intercellu-
lar fluid into lymphatics, and thus increases lymphatic flow (6). Local pressure as with massage and passive and active movement of the limb increases the lymphatic flow (7, 9).

Thus, it is evident that several factors are responsible in the regulation of the amount of intercellular fluid. The overall effect of these during normal conditions tends to favor the fluid leaving the capillary at the arterial end to enter into the tissues. However, nine-tenths of the filtered fluid reenters the capillary at the venous end (6). The lymphatic system returns to the blood stream the fluid that cannot return to the capillaries, and thus plays an important role in the regulation of the amount of intercellular fluid.

Pathophysiology of Edema
An increase in the capillary permeability, an imbalance in the effective pressures across the capillary membrane, or an obstruction of lymphatic flow leads to edema.

The capillary permeability is increased with external injury, operative trauma, and burns (1, 2, 7). The capillary filtration pressure is elevated by arterial dilatation produced by factors such as local heating, generalized heating, and muscular activity. It is also increased by impaired venous return produced by mechanical obstruction or inactivity of the limb (8). The dependent position of the limb leads to increase in the capillary filtration pressure due to increase in hydrostatic pressure. The central flow of venous blood and lymph is also resisted in this position. The tissue hydrostatic pressure is reduced when tissue loses resilience after an increase in volume of intercellular fluid. This further facilitates the movement of fluid into the intercellular spaces. Lymphatic obstruction due to infection, surgery, or any other cause leads to edema. Edema of the upper extremity continues to be one of the most disturbing sequelae following radical mastectomy (5, 10).

Treatment Techniques and Their Physiologic Rationale
The conservative treatment program is aimed at reduction of edema and prevention of the disabling sequelae. In patients with a persistent underlying cause of edema, as in venous and lymphatic obstruction or muscular inactivity, a program is devised to prevent and control further edema. Attempts to facilitate venous and lymphatic drainage are supplemented by techniques to increase and maintain the tissue hydrostatic pressure. Numerous treatment programs and devices have been advocated and described for reducing edema and rehabilitation of the hand (11). This paper will not discuss the details of treatment techniques, but will present a brief description of the following commonly used techniques and discuss the physiologic rationale for their effectiveness.

Elevation
Elevation of the extremity is a simple and the most effective procedure for prevention and reduction of edema. It should be encouraged as much as possible and practical. It is necessary to have the hand higher than the level of the heart (10). Usually, this is accomplished by propping the hand on pillows or using an overhead suspension. Gardner describes the construction and use of a canvas sling that is a safe, comfortable, effective, and inexpensive method of elevating the upper extremity (12). Brown and Clark describe the construction and use of an adapted discarded crutch for helping in elevation (13).

Elevation decreases the hydrostatic pressure in the blood vessels. This results in decrease in the capillary filtration pressure at the arterial end. It also facilitates the venous and lymphatic outflow from the limb (8, 10).

Manual Massage
Firm kneading massage followed by stroking massage in a centripetal direction is recommended. Massage can be accomplished with the extremity elevated for better results. The duration and technique depend on the therapist involved.

Manual massage breaks intramuscular adhesions and mobilizes tissue fluid. Lymphatic flow is significantly increased (9, 10).

External Compression Devices
Rhythmic compression of the extremity is provided with a pneumatic compression device. The extremity is inserted into a cuff, which is inflated intermittently at a pressure and duration that are adjustable. These external compression devices have been found to be effective in reduction of edema (4, 5, 10). A small size blood pressure cuff can be used to provide external compression to the hand alone. Greenberg and Braun describe the use of air bag splints for reducing edema as a part of a treatment program for the injured hand (3).

External compression accelerates the lymphatic and venous flow by its massaging effects and also by increasing the tissue hydrostatic pressure (8, 10).

External Elastic Support
This can be provided by means of elastic bandages or sleeves. Custom-fitted elasticized sleeves are preferred since they provide properly graded support with ease of application. The elastic support is easily measured for the individual patient and helps in preventing recurrent edema (6, 10). The support is worn at all times as
is practical and is used to maintain the successful results and prevent recurrent edema.

The external elastic support helps in maintaining and reinforcing tissue hydrostatic pressure. This facilitates venous and lymphatic flow (8, 10).

**Exercises**

Either passive or active exercises can be used as appropriate. Passive exercises maintain range of motion of the joints in the extremity as well. Active exercises are encouraged as much as possible, and should be incorporated as part of the activities of daily living. Functional activities of the extremities are encouraged whenever possible. Exercises in an elevated position are advocated (13). The exercises should be modified and adjusted for each individual patient by the therapist after evaluation and consultation with the physician.

Exercises cause an increase in both the venous and lymphatic outflow from the limb (6). Passive exercises also cause increase in the lymphatic flow (9).

**Aggravating Factors to Avoid**

Patients with edema should be provided with instructions for maintaining elevation, use of external elastic support, and exercises on a home program. In addition, they are instructed to avoid factors that would aggravate edema. These include the avoidance of excessive use of the extremity, local heat to the extremity, dependent position of the limb, and constricting clothing.

Excessive use of the extremity causes an increase in capillary filtration pressure. The use of local heat to the extremity, such as whirlpool baths, should be avoided unless a strong indication exists. The dependent position of the limb, arterial dilatation, and usual lack of voluntary activity during whirlpool treatment leads to increased edema. Magness and co-workers (14) determined the volume of the upper extremities increased with increasing temperatures in whirlpool baths. This increase was greater among patients with upper extremity disorders than among normal subjects (14). Dependent position of the limb and constricting clothing are to be avoided, as they impede venous and lymphatic drainage (10).

**Summary**

The occupational therapist is frequently faced with the problem of management of upper extremity edema. Knowledge of the physiology of body regulation and the pathophysiology of edema is essential in order to understand the rationale of the conservative treatment techniques. The physiologic rationale for the effectiveness of the commonly used treatment techniques that include elevation, manual massage external compression devices, elastic supports, exercises, and instructions in avoidance of aggravating factors is discussed. The treatment program is aimed at reducing existing edema and controlling formation of additional edema.

Empirical observation of success in the treatment of edema by these means confirms the pathophysiologic rationale.

**Acknowledgments**

This updated review was based on a presentation at the 55th Annual Conference of the American Occupational Therapy Association, Milwaukee, Wisconsin, October 1975.

The pneumatic compression device and the elastic support are products of the Jobst Institute, Toledo, Ohio.

**REFERENCES**