1 Anatomy and Physiology of the Circulation of the Blood

Blood

Blood can be regarded as a liquid tissue. It circulates in the body, driven by a pump, the heart. Our blood accounts for 7%–8% of our body weight, which in a person of 70 kg (154 lb) body weight amounts to about 4.5–6 L of blood. Blood is made up of **blood plasma** and **blood cells** (erythrocytes, leukocytes, and thrombocytes) (**Fig. 1.1**).

Red blood cells (erythrocytes) develop like all other blood cells from pluripotent stem cells in the bone marrow (**Fig. 1.2**). Erythrocytes contain hemoglobin, which transports oxygen. They are not motile (i.e., they cannot move on their own), but are carried along in the bloodstream.

White blood cells (leukocytes) include granulocytes (neutrophilic, basophilic, eosinophilic), lymphocytes, plasma cells, and monocytes.

Thrombocytes are blood platelets, which play an important part in blood coagulation.

Blood plasma contains dissolved organic and inorganic molecules. Albumins make up the majority of **plasma proteins**. They are metabolized in the liver and have a role as transporters, e.g., of hormones. Like all plasma proteins, albumins are water soluble and are thus responsible for the colloid osmotic pressure. The immunoglobulins (also called antibodies) are the molecular front of the body's defense system. They are released into the blood by certain lymphocytes, called plasma cells.

Both blood and lymph contain **fibrinogen**, which has a role in coagulation. Examples of organic substances found in blood are lipids, lipid–protein compounds (lipoproteins), hormones, vitamins, amino acids, and bile pigments. ("Organic substances" is the name given collectively to all molecules containing the carbon atom C, except for CO [carbon monoxide] and CO_2 [carbon dioxide]). Examples of inorganic substances are phosphate, iodine (I), iron (Fe), potassium (K), and sodium (Na).

The main task of blood is as a transporter. Oxygen is carried from the lungs directly to all tissues via the red blood corpuscles (erythrocytes), and carbon dioxide is carried back from the tissues to the lungs. The only structures excluded from this direct exchange are joint cartilage, a small section of the bone–tendon connection, and parts of the intervertebral disk. In addition, as a liquid medium, the bloodstream transports nutrients from the intestines to the tissues and metabolic waste to the organs of excretion.

Red Blood Cells (Erythrocytes)

Erythrocytes, which are non-nucleated, make up 99% of the corpuscular components of the blood. Their function is to transport oxygen, which bonds to hemoglobin, the ferrous blood pigment in the cell.

Erythrocytes are formed in the bone marrow and have a life cycle of 120 days. They are broken down in the spleen. At maturity they are 6–7 µm in size, which means that they are larger than the diameter of the capillaries. Because they cannot move on their own, they have to be very pliable so that they can be pushed through the capillaries (**Fig. 1.3**).

White Blood Cells (Leukocytes)

Leukocytes are not a uniform group of cells: their three main groups comprise such differing cells as lymphocytes, granulocytes, and monocytes.

Granulocytes, which are nonspecific defense cells, make up 60% of leukocytes. They are divided into three groups (**Fig. 1.4**):

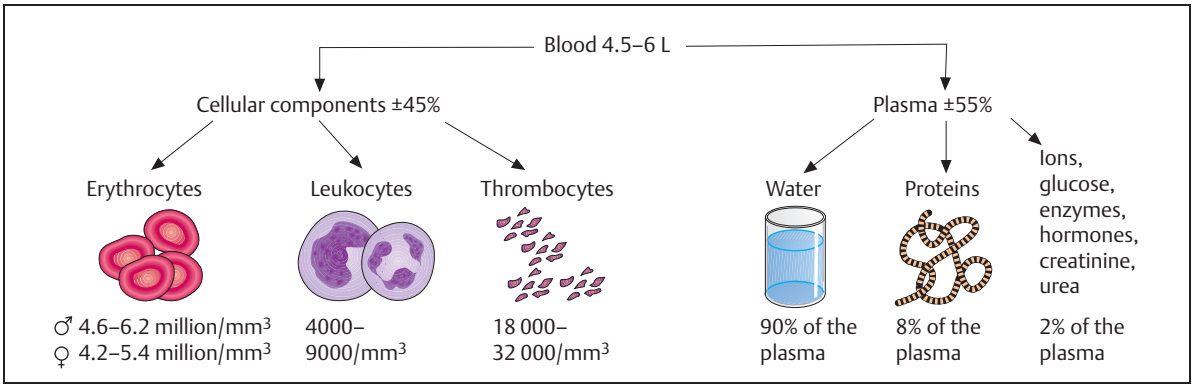

Fig. 1.1 Solid and liquid blood components.

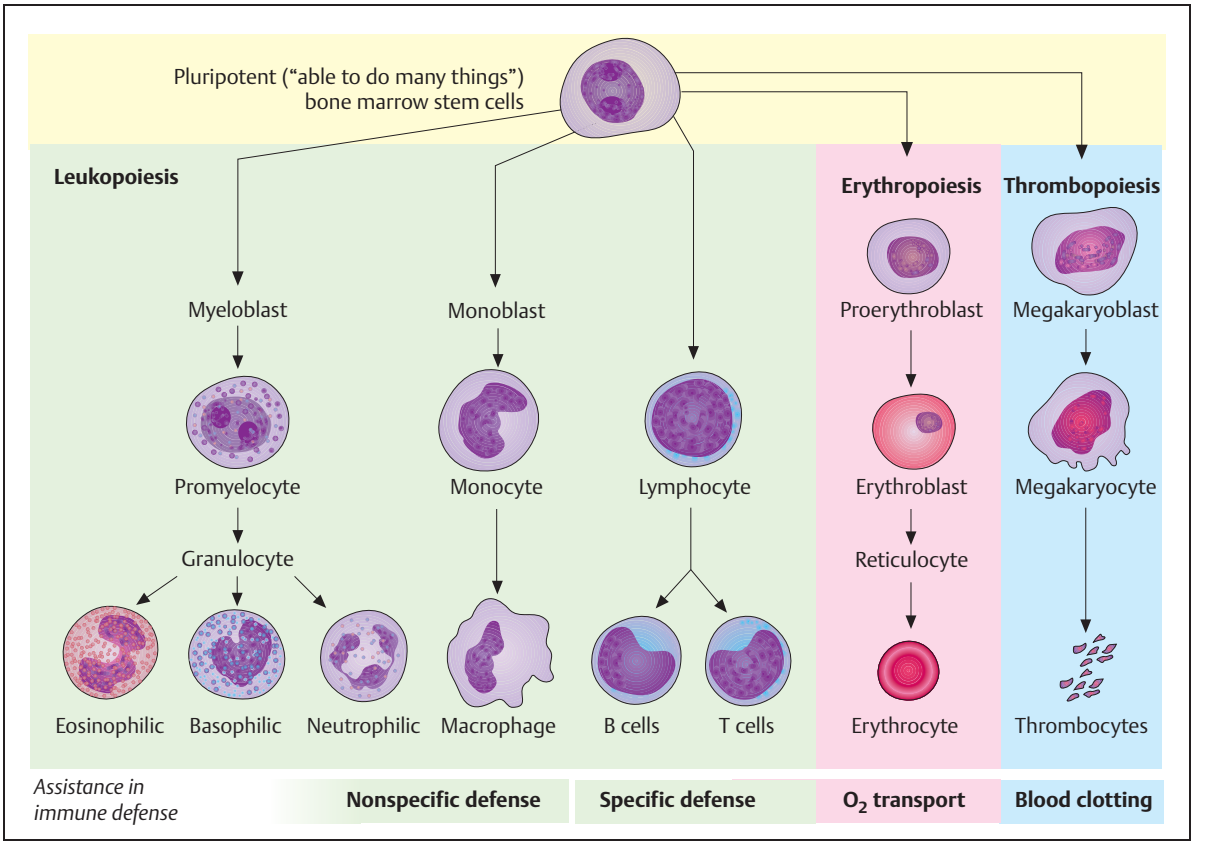

Fig. 1.2 Family tree of blood cells. **Q 46**

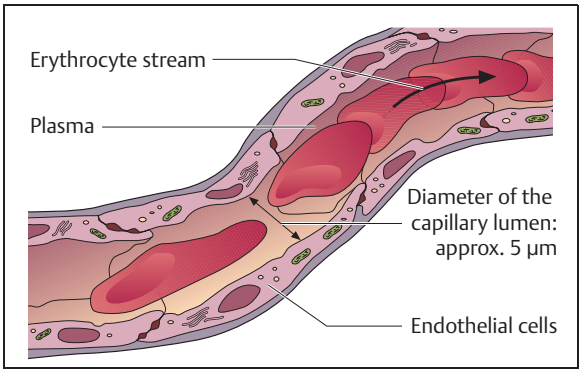

Fig. 1.3 Deformation of red blood cells as they pass through capillaries.

- Neutrophilic granulocytes (95 %)
- Eosinophilic granulocytes (3 %)
- Basophilic granulocytes (2 %)

With a diameter of 10–17 µm, they are considerably larger than the erythrocytes. Granulocytes remain in the blood only for a short period of time, moving on from there to the tissues, especially the mucous membranes, where they fulfill their defense function by destroying bacteria through phagocytosis.

Approximately 30 % of white blood cells are **lymphocytes**. They are 7–12 µm in diameter, so between erythrocytes and granulocytes in size. Only 4 % of lymphocytes circulate in the blood. Most of them are to be found in the lymphatic organs: spleen, thymus, lymphatic intestinal tissue, and lymph nodes.

Lymphocytes are subdivided into two groups: **T lymphocytes**, which are formed in the *t*hymus, and **B lymphocytes**, formed in the bone marrow. These two groups have reciprocal effects. Certain T cells, the T helper cells, can stimulate B lymphocytes after an antigen has sensitized the latter. These B lymphocytes develop into plasma cells, which specialize in producing antibodies. T suppressor cells inhibit the immune response of B lymphocytes and other T cells. Specialized B lymphocytes represent the body's antigen memory. **Q 39**

Lymphocytes come in contact with an antigen in the lymph node. This contact sensitizes them and causes them to reproduce. They leave the lymph node through the efferent lymph vessels, enter the blood, enter the tissues, and then return to the lymph nodes. Lymphocytes spend most of their lifespan in lymph nodes or other lymphatic tissue and only hours (up to 24) in the blood. **Q 11**

Monocytes remain in the blood for a few days and travel from there to the tissues, where they reside as **macrophages** for months or even years. For this reason they

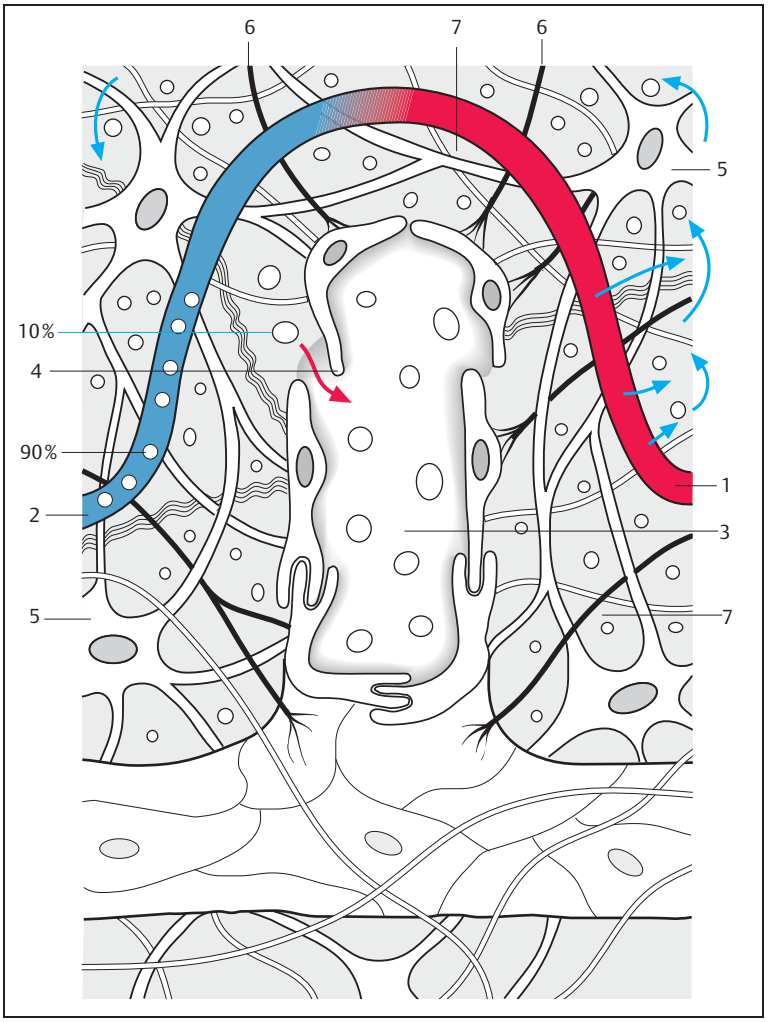

Fig. 2.1 Longitudinal section along a glove-finger-shaped initial lymph vessel with a blind origin in the tissue. **1**, arterial limb of capillary; **2**, venous limb of capillary; **3**, initial lymph vessel; **4**, swinging tip of an endothelial cell of the initial lymph vessel allowing influx of interstitial fluid (arrow to the left and right of 4); **5**, fibrocyte; **6**, anchor filaments; **7**, intercellular space.

ing vessel. It may have some muscle cells and empties into the precollectors. **Q 2**

Precollectors

Initial lymph vessels turn without noticeable transition into precollectors, which pass the collected lymph on to the next vessels (the collectors). In the skin (and also in the mucous membranes) they run vertically into the deep tissues.

The precollectors show similarities to both the smaller and the larger lymph vessels. They have rudimentary valves which determine the direction of flow and also prevent reflux. There are some isolated muscle fibers and openings in the walls that allow them to absorb fluid from the connective tissue. **Q 3**

Precollectors have a transitional character. On the one hand they are transport vessels and form the link between the initial lymph vessels and the collectors. In addition, though, like the initial lymph vessels they are able to absorb a small amount of lymph-obligatory substances from the interstitium and are therefore also regarded as collecting vessels. The larger vessels to some extent exert a suction effect on the content of the precollectors, which speeds up the transport. As mentioned above, this suction can continue to have an effect all the way into the initial lymph vessels. **Q 4**

Lymph Collectors

The lymph collectors are the next size up of the lymph vessels. Along their course from the periphery to the venous angle, lymph nodes are interposed. The walls of the lymph collectors exhibit the classic three-layered structure of the entire vessel system: intima, media, and adventitia.

The **intima** consists of endothelial cells with flaps every 2.5–15 mm. The section between two paired flaps (valves) is called a lymph vessel segment or, to use Mislin's term, **lymphangion**. The valves control the direction of flow.

The **media** is mainly made up of smooth muscle cells, with a multilayered structure consisting of a medial circular layer and a longitudinal layer. This is a spiral-like plexus that may include several angions. It also contains some thin collagen fibers. The muscles are only found in the middle section between the valves: the valves themselves are without muscles. This gives an impression of constriction at the valves, leading to a "string of pearls" appearance on contrast imaging.

The **adventitia** is the support layer and is linked to the connective tissue. **Q 5**

When the lymphflow increases, the internal pressure rises, the wall of the vessel stretches and its tension increases. This is the triggering stimulus that causes the muscle cells of the lymphangion to contract. The contraction drives the lymph proximally while the distal valves close (**Fig. 2.2**).

The lymph flow is also maintained by so-called "auxiliary pumps." The following factors exert external pressure on the vessels:

- Manual lymph drainage
- Contraction of skeletal muscles
- Pulsation of large arteries
- Increased intestinal peristalsis during manual lymph drainage
- Pressure changes in the thorax during respiration that cause intensified contraction of the large lymph trunks and produce a suction effect in the venous angle. **Q 12**

Lymphangions also have their own pulsation, which is independent of internal pressure, with a frequency at rest of one to eight pulsations per minute.

One of the most important auxiliary pumps is manual lymph drainage. The collectors lie in the subcutis, and during Dr. Vodder's Manual Lymph Drainage they are stretched both lengthways and crossways. Stretching the lymphangions increases the pulsation rate, accelerating the flow of the lymph (Mislin, 1973).

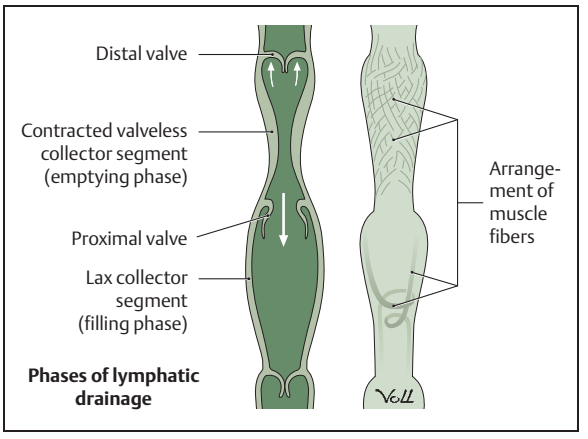

Fig. 2.2 Lymphangion, showing the action phases of lymphatic drainage.

Sympatolysis is an additional effect of manual lymph drainage, as described by Hutzschenreuter (1994). It causes dilatation of the lymph collector, which increases the contraction of the lymphangion.

Hence, both a large amount of lymph and manual lymph drainage result in an acceleration of lymph flow. Manual lymph drainage does so through a particular technique that increases the pulsation frequency of the lymphangions.

When the lymph-obligatory load has been absorbed into the vessels from the connective tissue, and lymphangion motoricity has been increased by manual lymph drainage, the suction produced by the lymphangions reaches as far as the initial lymph vessels, which then suck in more lymph-obligatory substances. Transport and removal of these are in turn accelerated by the increased lymphangion pulsation rate.

- *The **initial lymph vessel** is a collecting vessel. It absorbs the lymph-obligatory load into the vessel system.*
- *The **precollector** is both a transport and a collecting vessel: It can both absorb lymph-obligatory load (though only in small amounts) and transport lymph from the initial lymph vessels to the collectors.*
- *The **collector** is called a transport vessel. It maintains the lymph flow.* **Q 6**

Lymph Nodes

Lymph nodes are filtering stations located along the lymph collector paths. There are about 600–700 lymph nodes in the human body, about 160 of them in the neck region alone. They are mostly bean-shaped, with a diameter of 2–25 mm, and are surrounded by a connective-tissue capsule (**Fig. 2.3**). However, they can vary considerably in size, shape, and number. Every region of the body has its own group of **regional lymph nodes**. They consist of an internal trabecular framework, embedded in lymphatic tissue. Each lymph node has several afferent vessels that enter through the convex side of the capsule and empty into the sinus (marginal, intermediary, and cortical sinus) of the node. One or two lymph vessels and one vein (efferent vessels) exit the capsule and one artery enters it at the hilum. Some lymph vessels may pass the lymph node by. This can be important, in cancer, for example, because it means that metastasis of more centrally located lymph nodes can occur without the regional nodes being involved.

The responsibilities of lymph nodes are manifold. They may be described as biological filters, filtering out everything harmful to the body and rendering it harmless—viruses, bacteria, fungi, and so on. The lymph is cleaned. In the lymph node sinus, antigens (bacteria) are broken down just as they are in the liver.

In addition, lymph nodes concentrate (thicken) the lymph, by about 50%; that is, they remove water from the lymph. This is done by colloid osmotic suction in the

9 Massage Techniques

The Nature of the Massage

The technique of manual lymph drainage (MLD) developed by Dr. Vodder is a large-surface massage technique that cannot be classified among any of the other existing, well-known massage techniques. A study of manual lymph drainage will show that the technique is complex and the movements involved require special training. They cannot be learned from a book.

All massage techniques have one thing in common: skin contact is used to stimulate receptors, leading to a particular reaction. Which receptors are stimulated and what effect is achieved is determined by the nature of the skin contact.

To achieve the intended effects with Dr. Vodder's Manual Lymph Drainage, it must be carried out exactly as taught in its original form at the Dr. Vodder Schools in Austria and North America.

Manual lymph drainage consists of four stroke techniques as described below. They can be applied in any combination during treatment. As the descriptions make clear, Dr. Vodder's Manual Lymph Drainage is made up of a combination of round or oval, small or large, large-area circular motions that move the skin without sliding over it.

Stationary Circle

"Stationary circles" are primarily applied to the neck and the face.

- Phalangeal and metacarpophalangeal (MCP) joints are extended; the wrist is rigid and does not move. The circular movement is created through motion of the elbow and shoulder.
- Stationary circles are performed with both hands and in the same direction.
- In the starting position (SP), the fingers or whole hands are placed on the skin in the zero phase. Zero phase means that there is enough tension in the therapist's hands to extend the phalangeal and MCP joints but the touch remains very light. We call the touch on the skin: "… as light as a fly … a wasp would be too heavy!"
- After the initial contact (SP) with the flat fingers or hand, the skin is moved with a push-pressure motion toward the tips of the fingers and the circle is finished in the direction of lymph flow. The push-pressure movement increases until it reaches the maximum push-pressure force.
- While finishing the circle, the skin leads the fingers back to the SP, and the push-pressure decreases until the SP is reached (zero phase).

Scoop Technique

The scoop technique is used on the extremities. This movement is performed with one hand, or with two hands alternating. The scoop technique is learned on the forearm.

- The therapist's hand is placed flat on the palmar side, phalangeal and MCP joints extended, and the thumb is juxtaposed in opposition to the fingers, similar to a lumbrical grip.
- In this SP, the therapist does not apply pressure, because while in this position the hand is in the zero phase with maximal skin contact.
- The ideal push-pressure phase is initiated, *still without pressure*, by ulnar abduction of the therapist's wrist, "wrist forward."
- The palm is partially lifted off the forearm; only the ulnar side of the hand remains in contact. We say: "Bring the wrist forward, perhaps ever so slightly the elbow as well …"
- During the following increasing push-pressure phase, with a movement that resembles palmar flexion, we stretch the skin transversely (transverse push) until the majority of the palm is in contact with the skin again.
- Once the palm is in contact with the forearm again, it spirals in the direction of the index finger, performing dorsal extension and longitudinal push. In this phase the therapist swings his/her extended fingers from distal to proximal, not sliding over the skin. The stretch (push) is released without lifting the wrist and the skin allowed to return under the hand. At this point, the movement is repeated.

Pump Technique

The pump technique is used on the extremities. The movement is performed with one hand or two hands, alternating or together.

- The therapist's hand is placed flat in dorsal extension on the front of the thigh. The thumb is again in opposition to the fingers. Contact is made without pressure (zero phase) but with the entire hand surface. During the SP, the muscles of the hand are not engaged and no pressure is exerted onto the skin.
- The ideal push-pressure phase is initiated, *still without pressure*, by palmar flexion of the therapist's wrist. This palmar flexion continues so that the ulnar side of the palm remains in contact with the leg. *Tip:* Make sure that the radius moves forward, not the ulna. In this position, the increasing transverse push takes place with the MCP joint of the thumb on one side and the MCP joints of the fingers on the other until the greatest pos-

sible area of contact between the palm and the thigh is reached. The direction of the push is toward the table.
- Maintaining the transverse push, the wrist is lowered until the thenar and hypothenar eminences touch the thigh and with a push-pressure movement the skin of the front of the thigh is moved proximally (longitudinal push).
- The transverse and longitudinal push phases are performed in one smooth motion.
- This is followed by the phase of decreasing push-pressure down to zero, the hand remaining in the greatest possible contact with the skin. During this movement the skin of the patient returns beneath the hand of the therapist.

Rotary Technique

The rotary technique is used on flat body surfaces such as the back. The rotary technique is always performed with two hands together or alternating.
- The therapist places both hands flat on the back, parallel to the spine. The finger joints and MCP joints are extended. The thumb is abducted in a 90° angle to the index finger. The hand lies flat and relaxed on the skin in the zero phase.
- From this SP the hand moves the skin forward (toward the fingertips) with increasing push-pressure motion and outward (toward the little fingers) in a slightly oval circle. The oval circle is the "rotation" of the rotary technique. This rotation is achieved through slight ulnar abduction and decreases until the zero phase is reached.
- During the zero phase, the hand lies on the skin without exerting pressure and the thumb moves in across the skin toward the index finger.
- Now the palm of the hand is lifted off the skin of the back, but the thumb and tips of the extended fingers maintain contact with the skin of the back. The fingertips slide cranially along the spine without exerting pressure. The thumb remains a fixed point and remains where it was when the wrist was raised. The span of the hand (distance between index finger and thumb) is increasing. Thus the hand moves cranially.
- Once the angle between index finger and thumb has reached approximately 90° the hand is placed flat on the back again, the thumb moving slightly medially without exerting pressure.
- The hand has now returned to the SP as described above and the push phase starts again.

The fingers are always an extension of the palm of the hand. The work is done not with the palmar aspect of the fingers but with the palm of the hand. This rule applies to the pump technique, scoop technique, and rotary technique.

Thumb Circles

Thumb circles can be used on all parts of the body except the face and neck. Thumb circles are usually applied with two hands together or alternating. For practice purposes, thumb circles are done on the back of the hand.
- The thumb lies on the back of the hand in the direction of drainage. It is in the zero phase (SP). One thumb is moved 90° laterally.
- With increasing transverse push the skin of the back of the hand is moved and at the same time spiraled inward proximally. This proximal inward spiraling is the longitudinal push of the thumb circle. The thumb circle is a 90° movement performed by the wrist alone.
- During the zero phase, the skin of the back of the hand slides very slightly distally under the thumb.
- Now the wrist moves the thumb back to the SP without exerting pressure, and the movement starts again, this time using the other hand and thumb.

Duration and Intensity of the Massage

There is no general rule for the **length of treatment**. In many cases it is stipulated by the patient's health insurance or prescribed by official guidelines (Germany).

The **intensity of treatment** is determined on the basis of the clinical features of the individual case. This requires experience, sensitivity, and intuition on the part of the therapist.

Experience has taught us that the more precisely the strokes are performed, the better the desired effects. The application of pressure can vary greatly and depends on the condition of the tissue. As a general rule it may be said that the softer the tissue, the lighter the massage pressure should be.

Lymphedemas are usually treated with greater pressure.

Creating the Environment for Optimal Treatment

For the best possible treatment, certain requirements are made of the therapist and the environment:
- Avoid conversations during treatment. The patient is intended to experience your hands. This allows the effects of manual lymph drainage on the autonomic nervous system to become more noticeable.
- Avoid interruptions during treatment if possible.
- The decision whether to accompany the treatment with music should be left to the patient.
- The room should be well insulated against, or located away from, external noise (telephone, street noise, etc.).

Knee (Fig. 10.14)

Cauliflower: Pump-push. The fingers and thumb grip like flat pliers (lumbrical), without pinching. The push is a thumb circle with the proximal hand. Hands alternate, 3 ×.
Popliteal space: The fingers of both hands are quite flat. The fingertips do not touch. Continuous spirals are applied across the back of the knee, counting to 5, from distal to proximal, 3 × (not shown).
Patella: The thumbs are placed on the border of the patella, 5 continuous thumb circles are performed progressing proximally along the border, 3 × (not shown).
Pump technique: With the inferior hand over the knee, the superior hand supports underneath, counting to 5, 3 × (not shown).
Pes anserinus: Work the pes anserinus (goosefoot) with alternating thumb circles, counting to 6, 3 ×.

Notes:

Fig. 10.14a Pump and push on the "cauliflower" during treatment of the knee, position 1.

Fig. 10.14b Position 2

Fig. 10.14c Alternating thumb circles on the pes anserinus.

Lower Leg (Fig. 10.15)

■ *The therapist stands next to the lower leg.*

Pump–scoop on the lower leg: Place the foot flat on the table, the knee flexed. The hand on the shin bone pumps, the hand on the calf scoops, counting to 6 or 8. Both thumbs rest on the lateral side of the lower leg, 3 ×.

■ *The therapist stands at the foot.*

Alternating scoop technique on the calf, counting to 6 or 8. One thumb is placed on the medial aspect of the lower leg, the other thumb is placed on the lateral aspect of the lower leg, 3 × (not shown).

Fig. 10.15a SP for the alternating pumps and scoops during treatment of the right leg; medial view.

Fig. 10.15b Lateral view

Foot (Fig. 10.16)

Achilles tendon: The leg returns to the extended position. Work with 5 continuous spirals with 4 fingers of each hand proximally. Similar to the technique for the back of the knee, 3 ×.
Thumb circles alternating, in several lines over the ankle joint, 3 × each (not shown).
Thumb circles alternating, in several lines over the dorsum of the foot, 3 × each (not shown).
Lymph sea: Parallel simultaneous thumb circles on the lymph sea; 5 ×, 3 × (not shown).
Pressing of the transverse arch, 3 × (not shown).

Fig. 10.16 Continuous circles on the Achilles tendon in parallel with two hands.

Final Effleurage

1 × (not shown).

Notes:

Treatment of the Nape of the Neck

The therapist stands at the patient's left side.
The patient is prone.

Effleurage

Rotary technique from the middle of the thoracic vertebrae to the cervical vertebrae, 1 × (not shown).

Profundus to Terminus

Stationary circles from the profundus down the neck to the terminus, 5 circles per position, 3 × (not shown).

Occiput to Terminus (Fig. 10.17)

Stationary circles from the occiput down the neck to the terminus, 5 circles per position, 3 ×.

Notes:

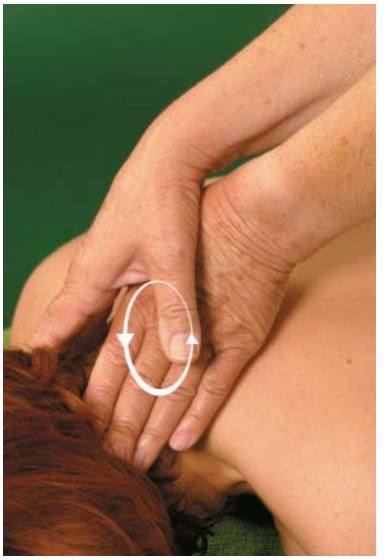

Fig. 10.17a Stationary circles on the occiput.

Fig. 10.17b ... down the middle of the neck.

Fig. 10.17c ... to the terminus.

Back of the Head (Fig. 10.18)

■ *The therapist stands at the patient's head.*

Stationary circles along the nuchal line, 5 × per position, 3 positions, push toward the body, circle toward the little finger, 3 × (not shown).
Stationary circles in 2 lines on the back of the head, 3 positions per line, then the next line, 3 repetitions per line (not shown).
Stationary circles, on the lateral aspect of the back of the head caudally to the terminus, connecting the end points of each of the previous lines. Depending on the anatomy of the patient (length of the neck, size of the head), 5–6 positions are treated, in terminus supinate hands, 3 ×.

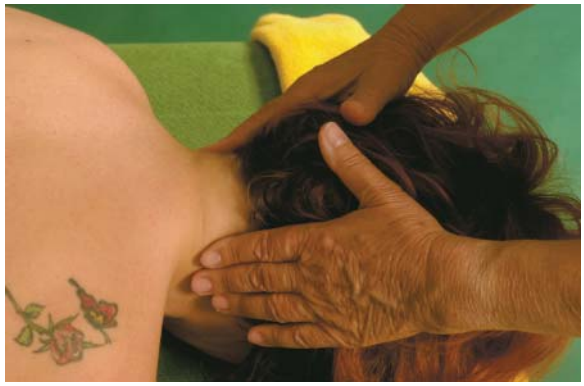

Fig. 10.18 Lateral stationary circles during neck treatment. Position midway down the neck.

Shoulders

Pump technique from lateral to medial, over the deltoid muscle, counting to 5 (when finished, the thumbs rest in the termini), 3 × (not shown).

"Rabbit" Technique (Fig. 10.19)

■ *The therapist stands at the patient's left side.*

Pump technique with the cranial hand, alternating with pushing toward the terminus, using the thumb and the fingers of the caudal hand, counting to 6, 3 ×.

Fig. 10.19a "Rabbit" technique: SP, caudal hand.

Fig. 10.19b "Rabbit" technique: caudal hand, push phase.

Notes: