5 Immediate Care of Acute Orthopedic Injuries

CHAPTER OUTLINE

OPENING SCENE

During a first-aid class, the instructor told Sammy that ice is applied almost universally after sprains, strains, cuts, and bruises. This agreed with what Sammy had observed in an athletic training clinic, and it got him thinking. He realized he had many questions regarding ice: Does it matter when you apply ice after an injury? Does it matter what kind of ice you use? Is it okay to apply an ice pack directly to the skin, or should there be a towel between the skin and the ice bag? How long should ice be applied? Is ice used to reduce swelling or pain or both? Is immediate care just about ice? What about compression, elevation, and rest? During a break, Sammy asked his questions but was disappointed with many of the instructor's answers. "How could such a basic, simple modality be so confusing?" he wondered.

RICES: The Prescription for Immediate Care

In Chapter 4 we discussed the inflammatory response, a series of physiological and pathological changes that occur after an injury. Some of these changes are necessary prerequisites to healing; without them, healing would not occur (see Chapter 6). But some of the changes can lead to further injury and complications that extend the recovery period. Immediate care techniques are designed to limit the unwanted changes, while allowing the necessary changes to occur and thereby facilitate healing and repair.

When applied properly, rest, ice, compression, elevation, and stabilization—known as **RICES**—limit secondary injury, swelling, muscle spasm, pain, and neural inhibition (Fig. 5.1). These efforts result in quicker healing of the injury and thus reduced disability time. Although there seems to be no doubt about using RICES, there is confusion about the pathophysiological response to, and specific protocols for, using, these modalities.

FIGURE 5.1. The immediate care of all acute injuries includes RICES: rest, ice, compression, elevation, and stabilization.

MODALITY MYTH

IMMEDIATE CARE

The following are modality myths about the immediate care of orthopedic injuries:

- Acute care and immediate care are the same.
- Ice decreases swelling.
- The goal of immediate care is to decrease inflammation.
- The purpose of ice is to decrease hemorrhaging.
- Inflammation and swelling are the same.
- Ice should be applied for 20 min during immediate care.
- All injuries should be treated for the same amount of time.

Each of these will be discussed in this chapter.

IMMEDIATE CARE VS. ACUTE CARE

Injuries are usually classified as acute or chronic. **Acute injuries** are of sudden onset, are caused by high-intensity forces, and are of short duration—for example, sprains, strains, and contusions. There are two types of **chronic injuries:** those caused by low-intensity forces of long duration, as in tendinitis and bursitis, and those that are recurring acute injuries, such as a chronic sprained ankle.

The care of acute (and recurring acute) injuries is often divided into three stages: acute (0–4 days), subacute (5–14 days), and postacute (after 14 days). Although this classification is used extensively, there are three problems with it:

- It does not incorporate the concepts of immediate care and emergency care.

- Acute care spans too wide a range of treatments. Treatment given 10 min after the injury is much different from treatment given 3 days after the injury. Acute care therefore must be subdivided.
- Injuries heal at different rates, depending on the type and severity of the injury and the individual patient. Care must be dictated by patient progress, not by specific time frames.

Stages of Acute Injury Care

We suggest the following classification of acute injury care. The general time frames should be considered as points of reference only to help in discussing specific techniques. Actual patient care should be based on patient needs and progress, not on these general time frames.

1. **Acute care**: 0–4 days
   - **Emergency care:** such as cardiopulmonary resuscitation (CPR) or transportation to a hospital, if needed
   - **Immediate care**: 0–12 hr
   - **Transition care:** 12 hr to 4 days
2. **Subacute care:** 4–14 days. An injury in this stage is moving beyond acute but is still "somewhat" or "bordering on" acute.
3. **Postacute care:** after 14 days

ICE, RICE, OR RICES?

The acronym ICE was developed to communicate the combined use of ice, compression, and elevation for treating acute injuries. Most clinicians use RICE because part of the standard practice is for the patient to refrain from activity or to *rest* the injured part. PRICE is used by some because it emphasizes the need to *protect* the injury from further damage. We prefer to use RICES because *stabilizing*, or splinting, the injury lessens pain and neural inhibition in addition to protecting the injury.

RICES is applied to protect the injury from further damage and to decrease or minimize the development of:

- Swelling
- Pain
- Muscle spasm
- Neural inhibition
- Secondary injury

And thus:

- Total injury

What about inflammation? *No!* Review Chapter 4.

Each of the listed elements is important. The majority of professional and public attention, however, has been on controlling swelling through cold application. This is somewhat shortsighted, as we will reveal throughout this chapter.

EVIDENCE FOR THE EFFECTIVENESS OF RICES

Most sports medicine clinicians feel that RICES used immediately postinjury (begun within the first 10–20 min) will control swelling and other negative **sequelae**, or aftereffects, of acute musculoskeletal injuries. Not all agree with this opinion, however. Those who disagree generally cite research in which cold was applied incorrectly.[1,2] Their conclusions should have been that *improperly applied* cold is ineffective, not that cold is ineffective. Others disagree because there is not enough clinical evidence.[3,4]

The few clinical studies on RICES support the effectiveness of the treatment.[5,6] The studies involve hospital patients, so treatment was not initiated as early as typically occurs in athletics. Had treatment been initiated earlier, the results probably would have been even more impressive.

One reason for the lack of clinical studies is that athletic trainers are so convinced of the efficacy of RICES that they cannot in good conscience withhold treatment from athletes who would be assigned to a control group. Athletic trainers have seen the consequences of enough cases of athletes who were not treated properly (because the injury occurred away from campus) to know RICES is necessary. In addition, studies based on patients treated in hospitals and physician's offices do not help because RICES is not applied quickly enough after the injury to be considered immediate care.

TYPES OF INJURIES FOR USING RICES

All acute musculoskeletal injuries should be treated with RICES. In all cases of tissue damage, there is the potential of secondary injury. Failure to treat with RICES will result in greater soft tissue damage and thus delay the final resolution of the injury.

Some authorities advocate RICES for sprains and dislocations, but only ice packs for strains.[7] There is no logic to this recommendation. All acute orthopedic injuries should be treated with RICES.[8]

The Theoretical Basis for RICES

Each element of RICES contributes to the effectiveness of the treatment. None of the elements should be left out. Understanding how the body responds to each element will help you maximize the use of RICES.

REST LIMITS INJURY AGGRAVATION

Rest during immediate care means moving the injured limb as little as possible. The goal is to not aggravate damaged tissue, which could cause further injury[9] and pain, thereby contributing to the pain–spasm–pain cycle. Some define rest during immediate care as "relative rest," meaning decreased activity rather than inactivity.[10] This philosophy is the result of an inadequate definition of immediate care—that is, the idea that immediate care lasts 4–5 days. According to the stages of acute injury care outlined earlier, during immediate care patients should be as inactive as possible. During transition care, patients transition to relative rest, which means protecting the injury but using the rest of the body to prevent deconditioning.

The problem of pain after an injury is not only about the discomfort but about the body's response to the pain. Pain causes the body to shut things down in an attempt to protect itself. It does so by a process called **neural inhibition**, a decrease or absence of normal neuromuscular functions such as strength and range of motion and thus an inhibition of most activity. Often these neural inhibitions continue long after the injury itself has healed,[1] thereby preventing the patient from a full return to normal activity. Resting immediately after an injury (keeping activity below the level where it causes pain) reduces the complications of neural inhibition.

APPLICATION TIP

AVOID PAIN LIKE THE PLAGUE. Two rules of thumb for rehabilitation are "If it hurts, don't do it" and "Work up to the level of pain, but don't go beyond it." The concept of "No pain, no gain" is OK during conditioning exercises but totally wrong during rehabilitation. Pain causes neural inhibition, which prolongs rehabilitation (see Chapter 8). It's not a question of how tough a patient is but how smart he is. Tell the patient to work around the pain, not force his way through it.

The primary rationale for a patient using crutches after a lower-extremity injury is to remove pain. Limping results from pain. Even though a patient may think she can hobble along, doing so invokes pain, which invokes neuromuscular inhibition. The patient should always use crutches until she can walk with a normal gait.

Too little activity may be as detrimental as too much activity. Too little activity results in:

- Delayed healing
- Adhesions
- Muscular atrophy
- Loss of conditioning
- Skills becoming rusty
- Loss of confidence

You must keep your patients as active as possible without causing further problems. Usually this means exercising noninvolved body parts to the maximum and exercising the involved body part to a level just under that which causes pain.

CRITICAL THINKING 5.1 *Why is a three-point gait (walking on both legs, but using the crutches to support the injured leg) more effective than a swing gait (no pressure on the injured leg, it just swings) for a patient who is using crutches 3 days after a moderate ankle sprain?*

ICE LIMITS SECONDARY INJURY

Many think controlling swelling is a major goal of immediate care. Controlling swelling is important, but it is only part of immediate care. Limiting secondary injury and neural inhibition are more important than controlling swelling.

As explained in Chapter 4, swelling is an increase in tissue volume owing to extra fluid and cellular material in the tissue. It results from direct hemorrhaging into traumatized tissues and edema formation. Edema forms when fluid accumulates in the extracellular spaces because of a disruption in the normal fluid exchange between the vascular system and the extracellular spaces; more fluid moves out of the circulatory system than moves back into it. Thus fluid accumulates in the tissues. Cold applications are commonly used to treat swelling.

There are two major theories for why **cryotherapy**, the therapeutic use of cold, should be used for the immediate care of orthopedic injuries: the decreased blood flow theory (or the circulatory theory) and the decreased secondary injury theory.

The Decreased Blood Flow Theory

The traditional theory for immediate care is that cold decreases blood flow.[7,11] The logic of the theory is as follows:

- Cold causes vasoconstriction, which
- Decreases blood flow, and therefore
- Decreases hemorrhaging, and therefore
- Swelling is reduced

Cold does cause vasoconstriction and decreased vascular permeability,[12] compression decreases underlying blood flow,[13,14] and elevation reduces blood pressure.[15] However:

- Cold is rarely applied sooner than 5–10 min after injury. It takes 5–10 min to perform even a cursory evaluation of the injury, transport the patient off the court or field, remove equipment, and then apply RICES.

Often a more comprehensive evaluation of the injury is performed on the sidelines, so the time is extended even longer.
- Once the cold is finally applied, it takes 5–30 min (depending on the depth of the injury) to get significant cooling in the target tissue.
- For most injuries, clotting occurs within minutes after the injury.[16] Thus hemorrhaging ceases long before the blood vessels at the injury site are constricted.
- Therefore the beneficial effects of cold on swelling cannot be attributed to decreased circulation.

Despite the illogical basis of the decreased blood flow theory, many still believe it.[7]

The Decreased Secondary Injury Theory

An alternative theory, proposed in 1976[17] and refined in 1995[18] and 2002,[19] is that cryotherapy has little effect on hemorrhaging; rather it limits the amount of secondary injury and edema.[17] The logic of this theory is twofold. First:

- Without cryotherapy, cells within the injured tissue that escaped ultrastructural damage from the trauma (primary injury) and many cells on the periphery of the primary injury suffer secondary metabolic injury because of inadequate blood flow and oxygen.
- Cryotherapy, however, decreases the metabolic needs of these cells so they require less oxygen. They are put into a state of temporary hibernation.
- These cells are therefore more resistant to the ischemic state caused by the compromised circulation.
- The result is less secondary metabolic injury, so
  - Less total injury
  - Less free protein generated by phagocytosis
  - Less edema

Second:

- Damaged cells release chemicals that attack the tissue and uninjured cells in the vicinity, thus causing secondary enzymatic injury.[18]
- Decreased secondary metabolic injury means there are fewer damaged cells to release these chemicals.

The decreased secondary injury theory is modeled in Figure 5.2. Cryotherapy has no effect on primary traumatic injury nor on the hemorrhaging that occurs before clotting. Nothing can be done about primary injury and hemorrhaging once they have occurred. Early applications of cryotherapy decrease the amount of secondary injury, but they do not totally eliminate it.

The major goal of cryotherapy during immediate care is, therefore, to prevent or minimize secondary injury. With less secondary injury, the total injury is decreased so there is less damaged tissue to repair. The repair process is much shorter because with less tissue debris to remove, healing begins more quickly. With less total damage, repair runs its course faster.

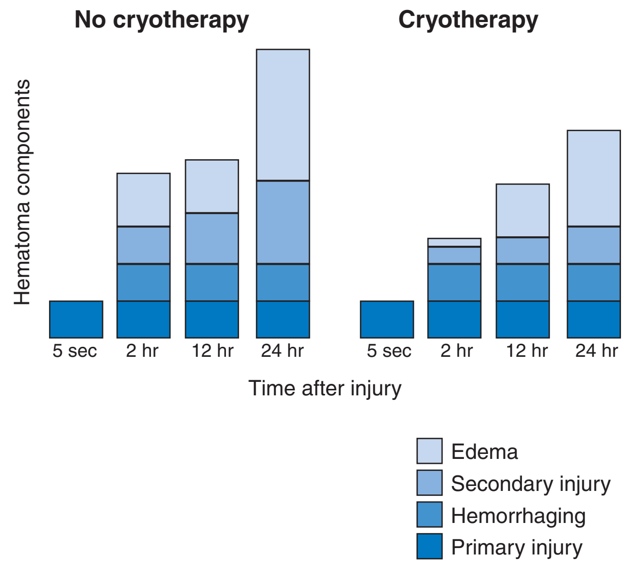

FIGURE 5.2. A model of the effects of immediate cryotherapy on the components of acute orthopedic injury: primary injury, secondary injury, hemorrhaging, and edema. (Adapted with permission from Knight.[17])

Cryotherapy and Metabolism

Cryotherapy limits secondary metabolic injury by decreasing tissue metabolism and bringing oxygen demand back into balance with the reduced supply (Fig. 5.3). Damage to blood vessels and the hemodynamic changes of the inflammatory response result in decreased oxygen supply. Cooling reduces cellular energy needs, thereby decreasing the tissue's need for oxygen.[20–23] This same mechanism is used to preserve organs for tissue transplantation; an organ can be removed at one site, packed in a cooler of ice, transported great distances, and safely implanted into another body.[24,25]

There is a direct relationship between tissue temperature and metabolism (Fig. 5.4).[20–22] The greater the cooling, the greater the decrease in metabolism.* And the sooner the cold is applied, the more effective it is. Cryotherapy must be applied within minutes after the injury for maximal results.

Heat applications during this period have just the opposite effect. Heat causes an increase in metabolism and therefore increases the oxygen consumption of the tissue. This causes greater secondary metabolic injury and thus more total injury.

*See Chapter 6 in Knight[18] for more detail.

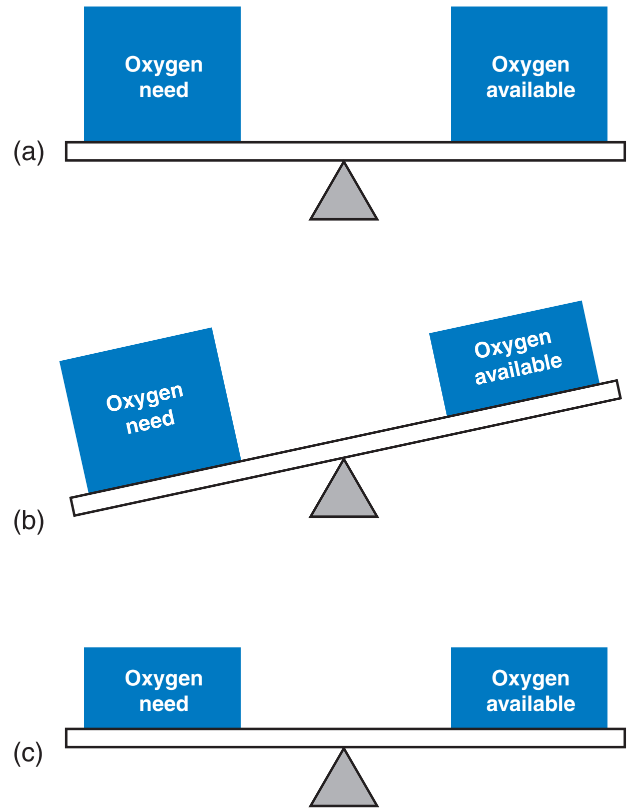

FIGURE 5.3. **(a)** Before injury the oxygen supply and demand were balanced. **(b)** After injury, circulation is decreased and therefore supplies inadequate oxygen to meet the demands. **(c)** Reducing the demand by cooling the tissue reestablishes the balance.

Cryotherapy and Swelling: Decreased Edema, Not Hemorrhage

Cryotherapy reduces edema but has little effect on hemorrhaging. With orthopedic injuries, however, most swelling occurs from edema not hemorrhaging, the exceptions being the immediate "goose egg" and hemarthrosis. A goose egg occurs when a moderate to large vessel near a loose-skinned surface is ruptured. Hemorrhaging occurs immediately into the loose skin, creating a mound of blood. **Hemarthrosis**, the presence of blood in a joint, occurs when the injury involves a joint capsule. Synovial fluid within the capsule prevents total clotting, and blood continues to ooze into the joint.

When Does Edema Occur? When Should Ice Be Applied?

Most edema occurs hours after the injury. The inflammatory process breaks down tissue debris into free protein, which increases tissue oncotic pressure (TOP) and increases capillary filtration pressure (see Chapter 4). Over time, this shift in capillary filtration pressure increases tissue fluid. It is not uncommon for a patient to go to bed a few hours after an acute injury with little swelling and wake up the next morning with significant swelling (edema).

However, it would be misguided to think that the proper time for applying ice is hours after the injury when edema begins forming. The sooner ice is applied—minutes after the injury—the more effective it is.

How Does Ice Decrease Edema?

Cryotherapy cannot decrease TOP, but it can limit the amount of increase by limiting the amount of tissue debris (Table 5.1). This is done in two ways: by decreasing metabolism and by decreasing permeability. Decreased metabolism results in decreased secondary metabolic injury and thus less tissue debris. With less tissue debris, there is less free protein and, therefore, a lower tissue oncotic pressure.

Increased permeability of the blood vessel wall is a necessary part of the normal inflammatory response. In addition to allowing leukocytes to pass through the vessel wall and into the extracellular spaces, permeability lets great amounts of protein-rich fluid escape. This additional protein contributes to increased TOP and increased edema.

Thus cryotherapy, when used immediately after the injury, limits not only the extent of the injury but also the amount of edema that develops as a consequence of the injury. But once secondary injury has occurred, cryotherapy will have no effect on edema or swelling.

COMPRESSION CONTROLS EDEMA

Compression increases pressure outside the capillaries, which, although not a Starling force, decreases capillary filtration pressure and thus helps control edema formation (see Table 5.1). External force pressure—compression—is most beneficial once edema begins occurring and will be effective as long as edema is present. Because it is unknown when edema begins developing, compression should be applied within minutes after the injury and be continued until edema is resolved.

Compression has no effect on normal fluid exchange. An analogy with a balloon will help explain this concept.[18] When the balloon is filled with water, it expands. If the opening of the balloon is not held tightly, the elasticity in the balloon will force the water out. If, however, the balloon is first filled with rocks, the water will occupy spaces between the rocks (Fig. 5.5). As long as just enough water is added to fill the spaces between the rocks, it will not be forced from the balloon—the rocks overcome the balloon's elasticity. Squeezing the balloon (or putting an elastic bandage around it) will similarly have no effect on the water. As more water is added, however,

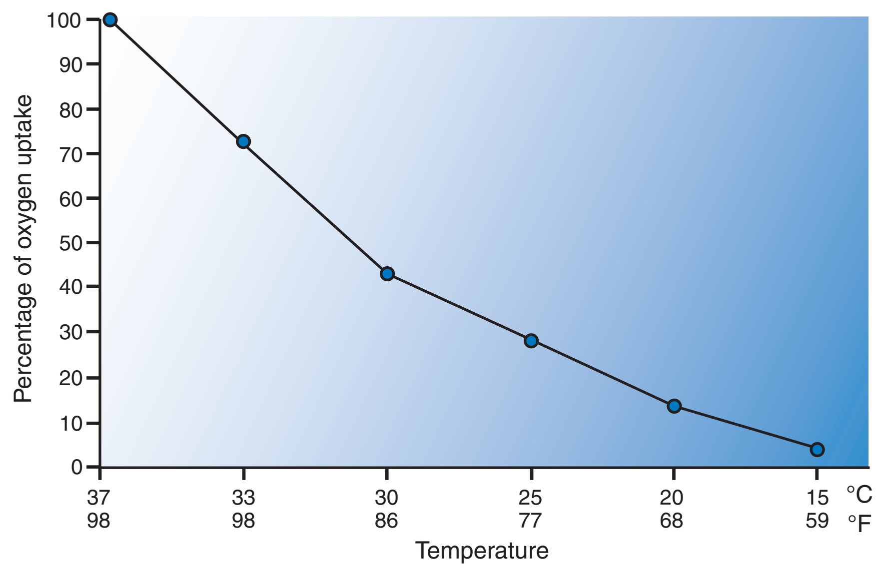

FIGURE 5.4. The relationship between tissue temperature and oxygen consumption. The cooler the tissue, the lower its metabolism. (Adapted with permission from Blair.[21])

and the balloon expands (swells) beyond the rocks, pressure is exerted on the water by the elasticity of the balloon. An elastic bandage around this "swollen" balloon would increase the external force. Also, if the elastic bandage were placed around the balloon before the extra water is added, it would be much harder (i.e., take more force) to add the extra water. The same is true with the human body. An elastic bandage around a normal ankle will have no effect on fluid exchange, but it will tend to retard and/or cause reabsorption of swelling.

While constant compression is essential during immediate care when the goal is to prevent edema, intermittent compression is most effective when the goal is to remove edema (Table 5.2). Intermittent compression stimulates the lymphatic system, which is the route through which tissue debris is removed from the tissue. (Intermittent compression is discussed in more detail later in the chapter.)

Compression also enhances the cooling effect of ice packs, probably by compressing superficial blood vessels and thereby reducing the amount of heat they deliver to the tissue (Fig. 5.6).[14]

ELEVATION CONTROLS EDEMA

Elevation decreases capillary hydrostatic pressure (CHP) and therefore decreases the major factor (in a noninjured state) in forcing fluid out of the capillaries (see Table 5.1). Elevation also decreases tissue hydrostatic pressure (THP), but this has little consequence because THP is small and thus has a minimal effect on fluid filtration.

As discussed in Chapter 4, hydrostatic pressure is caused by the weight of water.[26] The more water above a particular point, the greater the hydrostatic pressure at that point. Capillary hydrostatic pressure is greater when a body part is in a dependent position than when it is elevated because there is more water above.[15,27]

TABLE 5.1 ***The Effect of RICES on Capillary Filtration Pressure Components After Acute Injury***

CAPILLARY FILTRATION PRESSURE COMPONENT	NORMAL AVERAGE PRESSURE (MM HG)*	CHANGE IN PRESSURE FROM			
		Injury	Ice	Compression	Elevation
Capillary hydrostatic	+23				↑
Tissue oncotic	+10	↑	Less ↑		
Tissue hydrostatic	−1 to 4	↑			
Capillary oncotic	−25				
External	0			↓	
Net (overall)†	−4 to 7	↑	↑	↑	↑

**If pressure is positive, fluid moves into the tissue. If pressure is negative, fluid moves out of the tissue.*

†The net change in pressure owing to the application of ice, compression, and elevation illustrates the additive effect as each one is incorporated into the treatment.

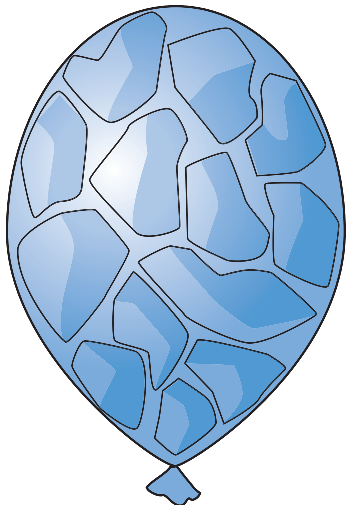

FIGURE 5.5. Rocks in a balloon illustrate how compression on uninjured tissue has no effect on tissue volume. The rocks give the balloon structure (as bones and muscles do for tissue) and therefore prevent it from collapsing under external compression.

STABILIZATION LIMITS NEURAL INHIBITION

The goal of **stabilization** is to support the injured limb so that surrounding muscles can relax. This reduces both pain and neural inhibition. Stabilization should not be confused with compression or rest; its purpose is quite different. It is true that stabilization may provide compression and may force the injured body part to rest, but these are only secondary effects.

Muscle guarding is an unwanted response to injury. The body attempts to protect the traumatized tissue from further injury by causing muscles to spasm and thus splint the joints surrounding the injury. But muscle spasm also causes pain, which causes more muscle spasm, which causes more pain, and so on. Thus a pain–spasm–pain cycle is perpetuated. Early stabilization lets the muscles relax, thereby easing the cycle. There are numerous braces and splints that can be used for stabilization (Fig. 5.7).

CRITICAL THINKING 5.2 *Early in the chapter, we stated that focusing the majority of attention concerning RICES on controlling swelling through cryotherapy is somewhat shortsighted. Give a reason for agreeing with this statement and a reason for disagreeing with it.*

The Physics and Physiology of Cryotherapy

When ice is applied to the body it cools the structure it is applied to. Although it sounds pure and simple, there are many factors that determine the amount of cooling. First, we must define *cold*. **Cold** is not a physical substance; it is merely the absence of **heat**, which is the kinetic energy of atoms and molecules. The state of being cold is relative. Consider, for example, that in the northern tier of the United States in October, after a hot summer, when the temperature gets down to 40°F (4.4°C), you feel cold and want to put on a jacket. In March, however, after a cold winter, when the temperature gets up to 40°F (4.4°C), you feel warm and want to take off your jacket.

THE PHYSIOLOGY OF HEAT TRANSFER

During cooling, heat is transferred from the body tissues to the cold modality through a process known as conduction. **Conduction** is the exchange of energy (heat) between two substances that are in contact with each other. Heat moves from the body of higher energy to the body of lower energy, causing the warmer body to cool and the cooler body to warm until they reach equilibrium.[28]

Rate of Conduction

The rate of heat conduction, and therefore the rate of tissue temperature decrease, depends on the interaction of many factors (a list follows). These same principles apply to superficial heating modalities (discussed in Chapter 11) when heat is added to the body:

- *The temperature differential between the body and the cold modality.*[29,30] Heat will conduct more quickly from 95°F (35°C) tissue into a 50°F (10°C) cold pack than it will into a 77°F (25°C) cold pack.
- *The regeneration of body heat and/or modality cooling.*[30] As the tissue gives up heat to the modality, some lost tissue heat is replaced by heat from circulating blood and conduction from surrounding tissues. Simultaneously, the heat given up to the cold modality either is held by the modality, which therefore increases its temperature, or is removed from the modality (e.g., as with a cryomatic

TABLE 5.2 ***Swelling Management with Cold and Compression***

MODALITY	CONTROL/LIMIT SWELLING	REMOVE SWELLING
Cold, intermittent (39–50 min)	X	
Compression, continuous	X	
Compression, intermittent		X

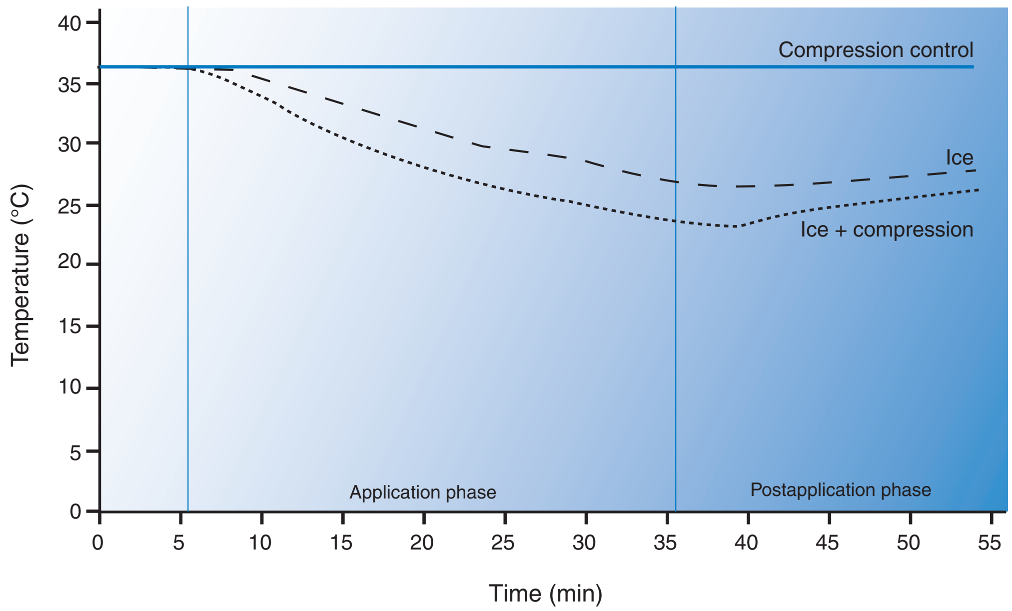

FIGURE 5.6. Compression exerted by an elastic wrap over a crushed ice pack causes a greater tissue temperature reduction than application of the ice pack alone.

unit), which maintains its lowered temperature. Both reheating the body and recooling the modality affect the temperature differential.

- *The heat storage capacity of the cold modality* (explained in the next section). Various modalities can accept differing amounts of heat before they begin warming. Thus a modality that can accept greater amounts of heat will maintain a greater temperature differential between the modality and the tissue. If two cold packs are identical except for their size, the larger one will have a greater heat storage capacity.
- *The size of the cold modality*. The larger the cold pack, the more heat it can accept.
- *The amount of tissue in contact with the cold pack*. The greater the contact area, the more heat will be extracted from the body and thus more cooling. This is why immersing the forearm in 50°F (10°C) water will cool it to the same degree as a 32°F (0°C) cold pack (Fig. 5.8).

A

B

FIGURE 5.7. Stabilization is essential during immediate care. **(a)** Muscles around the injury normally go into spasm to splint the injury, resulting in great pain, even when compression or a sling is used. **(b)** Stabilization allows the muscles to relax, thus breaking the pain–spasm–pain cycle.

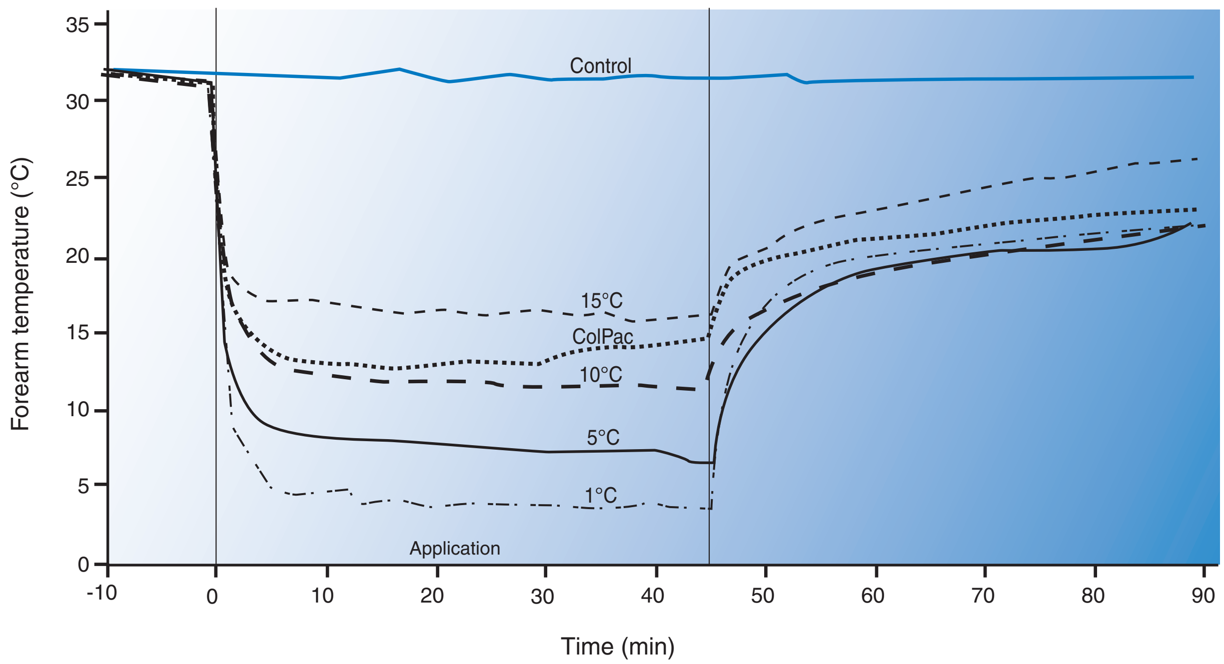

FIGURE 5.8. The influence of the amount of contact between the body and the cold modality on cooling. Note the similarity in tissue temperature during the application of a 32°F (0°C) cold pack and immersion in 50°F (10°C) water. (Adapted with permission from Knight et al.[31])

If other things are equal, a large cold pack will cool a body part more than a smaller one because it covers a larger area of the body and therefore extracts heat from a larger area.

- *The length of application.*[30] The longer the application of the cold modality, the more time for energy to be exchanged and thus more heat removal from the body.
- *Individual variability*. People react differently to cold applications.

An analysis of each of these factors in every type of cold application is beyond the scope of this book. You can evaluate the relative contribution of each factor to the cold modalities of your choice.

Heat Capacity of Modalities

The amount of heat that the same sizes and shapes of various cold modalities can accept depends on their specific heat, their latent heat of fusion, and whether they undergo a phase change.[28] **Specific heat** is the amount of heat energy required to raise 1 kg of a substance 1°C.[32] Therefore, the greater a substance's specific heat, the more heat energy it can withdraw. Water has a very large specific heat, greater than most substances, so it is excellent for cold packs.

Phase change refers to the change from one state (solid or liquid or gas) to another without a change in chemical composition or temperature.[28] Of particular interest here is the phase change from ice to water. The **latent heat of fusion** is the amount of energy needed to convert a substance from its solid state to its liquid state—that is, to undergo a phase change. It takes tremendous amounts of heat energy to change ice at 32°F (0°C) to water at 32°F (0°C).

For example, a 1 kg ice pack would extract 85 kcal of heat from the body if left until the ice melted and warmed to 41°F (5°C). A gel pack of the same mass would extract only 22 kcal by the time it warmed to the same temperature, about 25% as much (Fig. 5.9; Box 5.1 lists specific calculations). This is one of the advantages of crushed ice over gel packs for cooling the body. Crushed ice packs freeze solid and therefore can absorb more heat than gel packs, which do not freeze solid.

TEMPERATURE CHANGES RESULTING FROM CRYOTHERAPY

The beneficial effects of cryotherapy are related to tissue temperature changes. The magnitude and rate of these changes, and of rewarming after application, vary according to the depth of the tissue and the rate of conduction.

Surface Temperature

Cold applications cause an immediate and rapid decline in the temperature of the surface to which the cold is applied, as heat is conducted from the body to the cold modality (see Fig. 5.8). The rate of cooling steadily slows until the surface temperature eventually plateaus a few degrees above the temperature of the modality.[33–37] After application, there is an immediate sharp temperature increase, like the initial decrease but of lesser magnitude,

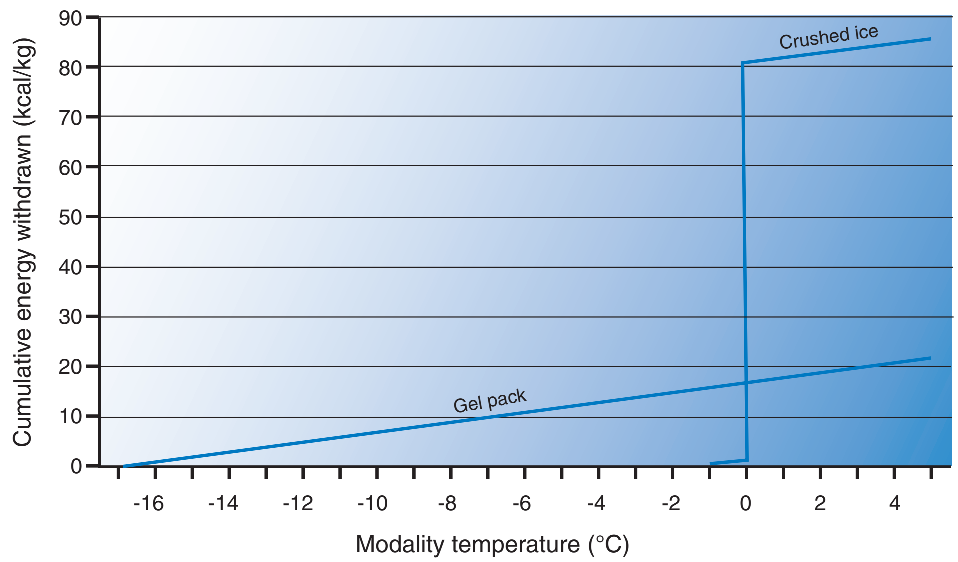

FIGURE 5.9. Crushed ice packs are more effective than gel packs because they undergo a phase change, which results in more heat being withdrawn from the body.

followed by a gradual and prolonged return toward preapplication temperature.

The type of cold modality affects the magnitude of the difference between the modality temperature and the plateaued tissue temperature and whether the tissue temperature begins to rise before the modality is removed. For instance, compare the temperature curves for the ColPac to the 34°F (1°C) and 50°F (10°C) water baths in Figure 5.8. Although the ColPac was initially colder than the 34°F (1°C) water bath, it does not have the capacity to cool the forearm as much as the 34°F (1°C) water bath. In fact, it appears much like the 50°F (10°C) water bath during the first 15 min or so of application. After 15 min, the arm temperature treated with ColPacs began to increase, while the arm temperature in the 50°F (10°C) water bath continued to decrease slightly.

The degree of cooling, but not the rate of cooling, is affected by previous activity (Fig. 5.10).[37,38] Stationary bike riding at a moderate intensity (enough to increase the heart rate to 60–80% of the subject's heart rate range) resulted in an increase of 3.6°F (2°C) in the ankle[37,38] and thigh[37] before, during, and after ice pack application.

Cooling during repeated applications is not consistent. The degree of cooling during a second application depends on the length of the first application, the time between treatments,[37] and the activity of the patient between the two applications.[37,39] The following are principles based on our research on the intermittent application of cold:[37,39]

- Mild activity, such as walking on crutches and showering, causes more rapid rewarming. Therefore, cold should be reapplied immediately after these activities.
- Protocols with cooling to rewarming ratios of 1:2 (i.e., 30:60 min) and less resulted in lower temperatures during the second application–rewarming cycle. If additional reapplication has an additional cooling effect, this may result in tissue damage.

A compression wrap over an ice pack causes a greater decrease in temperature during application and less of an increase after the application of an ice pack in both surface and deep temperatures (see Fig. 5.6).[14]

Tissue Temperature

The response of deep tissue to surface cooling depends on the depth and type of the tissue.[40,41] The reaction of subcutaneous (just below the skin) tissues is the same as that of the skin but decreased in magnitude;[42–44] temperature initially decreases sharply, followed by a more gradual decrease, until it eventually plateaus (Fig. 5.11). Like skin temperature, subcutaneous tissue temperature immediately begins to increase after the application.

Deeper tissue temperatures, on the other hand, do not begin decreasing until minutes after the cold application (see Figs. 5.6 and 5.11).[40,41,45] They then decrease more gradually and to a lesser magnitude than subcutaneous temperature.[40,46,47] Both the delayed response and decreased magnitude of temperature changes in the deeper tissue are the result of the time it takes for heat to exchange between various layers of molecules in the tissue (see Chapter 13).

After cold application, deep tissue temperature continues to decrease (see Figs. 5.6 and 5.11).[41,45,46] The length of the decrease depends on the depth of the tissue[40]—for example, after 5 min of ice massage to the calf, tempera-

BOX 5.1 LATENT HEAT OF FUSION: COOLING CAPACITY OF AN ICE PACK AND A GEL PACK

The example given here illustrates the difference in heat energy extracted from tissue during applications of a crushed ice pack and a cold pack (a fourfold difference in this example). For purposes of the illustration, assume the following:

- Both packs weigh 1 kg.
- Both packs are applied to the same surface.
- Both packs are applied until they withdraw enough heat to warm to 41°F (5°C).
- The crushed ice came from a free-standing ice machine, which stored it at 30°F (−1°C).
- The gel pack was stored in a freezer unit at 1°F (−17°C).

Constants required for the equations:[32]

- Heat of fusion of ice (L) = 80 cal/g
- Heating ice (Q) = 0.5 cal/g
- Heating water (Q) = 1 cal/g

Computing the energy associated with the heat withdrawn from the respective modalities requires a single step for the gel pack and three steps for the ice pack (degrees Celsius is the standard convention for these calculations):

Gel Pack

1. Heat water 22°C (from −17°C to 5°C)

   Q = 1 kg × 1 cal per g water/°C × 22°C = 22,000 cal or 22 kcal

Ice Pack

1. Heat ice 1°C (from −1°C to 0°C)

   Q = 1 kg ice × 0.5 cal per g water/°C × 1°C = 500 cal or 0.5 kcal

2. Heat of fusion (ice to water at 0°C).

   Q = 1 kg ice × 80 cal/g = 80,000 cal or 80 kcal

3. Heat water 5°C (from 0°C to 5°C)

   Q = 1 kg ice × 1 cal per g water/°C × 5°C = 5,000 cal or = kcal

   Total = 0.5 + 80 + 5 = 85.5 kcal

Thus the energy differential is 85.5 kcal for the ice pack and 22 kcal for the gel pack: 85.5 ÷ 22 = 3.886. This means that the total energy available for cooling is 3.9 times greater with an ice pack than with a gel pack of equal size and shape.

tures decreased for an additional 2.5 min at 1.0 cm deep, 10 min at 2.0 cm deep, 30 min at 3.0 cm deep, and 50 min at 4.0 cm deep.[40]

The magnitude of the temperature change in deep tissues (at all levels) depends on the magnitude of cold application (the amount of heat removed from the body). This relationship can be seen in the data of Waylonis,[40] who reported that skin temperature was basically the same after 5 min and 10 min of ice massage, but the temperature at 4.0 cm decreased more than twice as much after the 10 min ice massage. This difference in deep tissue temperature reflects a greater conduction owing to the longer application of ice. Some researchers have misinterpreted the effects of ice massage by considering tissue temperature change during application rather than after application.[48]

Adipose tissue insulates deeper tissues and thus decreases the effect of cooling on them.[49,50] Changes in deep tissue temperature correlate with the amount of adipose tissue over the biceps brachii muscle[48] and the thigh muscles[51] when cold is applied to the skin over these muscles and to the percentage of fat of the entire body when application and measurement involve the lower leg.[52]

Intra-Articular Temperature

Intra-articular temperature, or temperature within a joint, resembles that in other tissues—the temperature seems to be a function of the magnitude of heat lost. For instance:

- Cold immersion results in a greater temperature decrease than crushed ice packs (~38°F [21°C] vs. 7.2°F [4°C] in 15 min) and ethyl chloride spray (4.5°F [2.5°C] in 15–30 min).[53]
- Intra-articular temperatures decrease more than adjacent muscle: 4.5°F (2.5°C) vs. 3.6°F (2.0°C), 1.9 cm intramuscularly with 15–30 min ethyl chloride spray[45] and 33°F (18.4°C), 31°F (17.4°C), and 30°F (16.4°C) in the knee joint, adjacent muscle, and adjacent subcutaneous tissue, respectively, as a result of cold packs (43–50°F [6–10°C]) applied for 1 hr.[54]
- Like other deep tissues, the minimum temperature is reached after the ice pack is removed.[53,55]
- The longer the application, the greater the decrease in temperature.[53] For instance, ice packs applied for 5, 15, and 30 min resulted in decreases of 0.6°F (2°C), 7.2°F (4°C), and 11.9°F (6.5°C), respectively.
- Rewarming after cold applications is delayed for hours;[55–57] 215 min after a 30 min application of a frozen gel pack (−23°C) applied over a thin towel to the knees of 10 young healthy bulls.[56] And 150 min after a 30 min crushed ice pack application to 42 human knees, the intra-articular knee temperature was still depressed 8°F (4.5°C).[55]

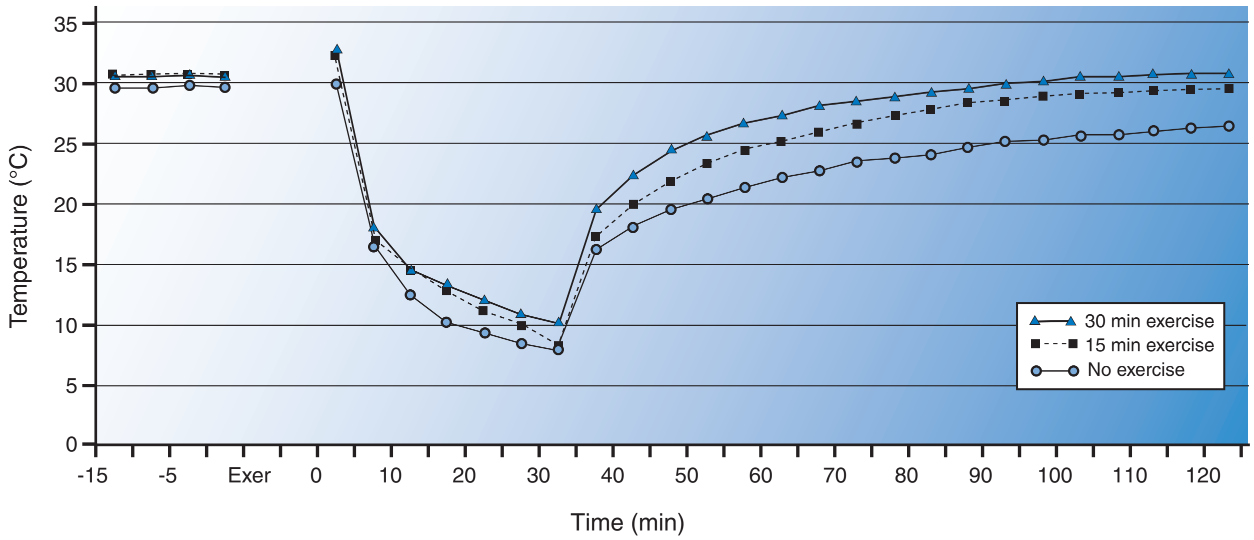

FIGURE 5.10. Exercise before cold pack application moderates the temperature decrease during and after application. (Reprinted with permission from Mancuso and Knight.[38])

Rewarming After Cryotherapy

Rewarming after cryotherapy is a function of three factors:

- The activity level before cryotherapy
- The amount of heat removed from the body during application (i.e., magnitude and duration of cold exposure)
- The amount of heat available to rewarm the area, which is a function of circulation, environmental temperature, and activity

The fingers rewarm much more quickly than the ankle,[34,36] forearm,[36] calf,[46] and interarticular knee.[55,56] Fingers rewarm in 15–20 min, whereas the other body parts take >3 hr (Fig. 5.12). Presumably this is owing to the increased circulation in the fingers.

Deep tissue rewarming is not as straightforward as is surface temperature rewarming. It varies according to the depth of the tissue. Tissues that are more superficial (up to ~2 cm deep) begin rewarming immediately after the cold is removed.[40,52] Deeper tissues continue to decrease.[40,46,58] The longer the cold is applied and the deeper the tissue, the slower the rewarming after application.

Activity during rewarming increases the rate of rewarming.[37] Even mild activity, like walking on crutches and standing in a shower for 20 min, significantly increases the rate of rewarming.

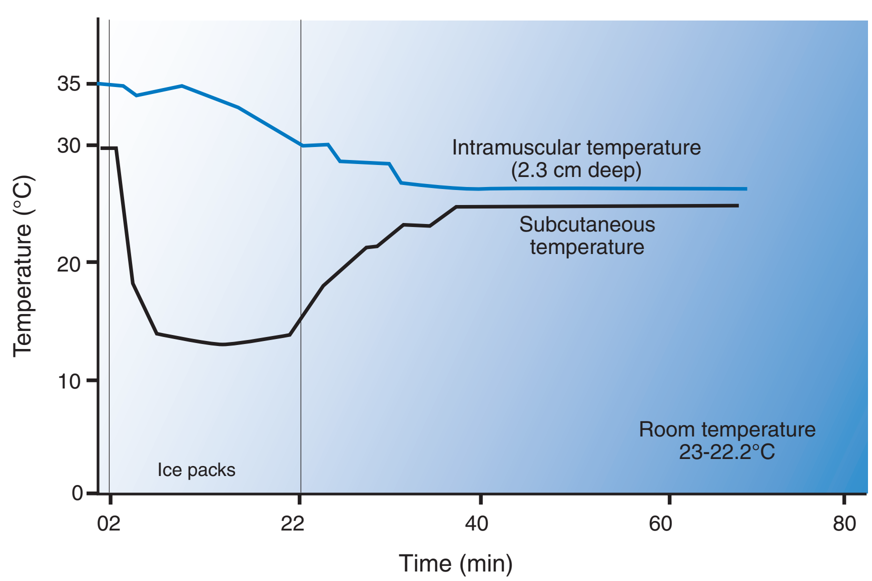

FIGURE 5.11. Subcutaneous temperature responds much like surface tissue temperature (compare with Fig. 5.8). Deep temperature, on the other hand, decreases much more slowly, continues to decrease after application, and returns to preapplication levels much more slowly. (Adapted with permission from Hartviksen.[58] Reproduced with permission from the BMJ Publishing Group)

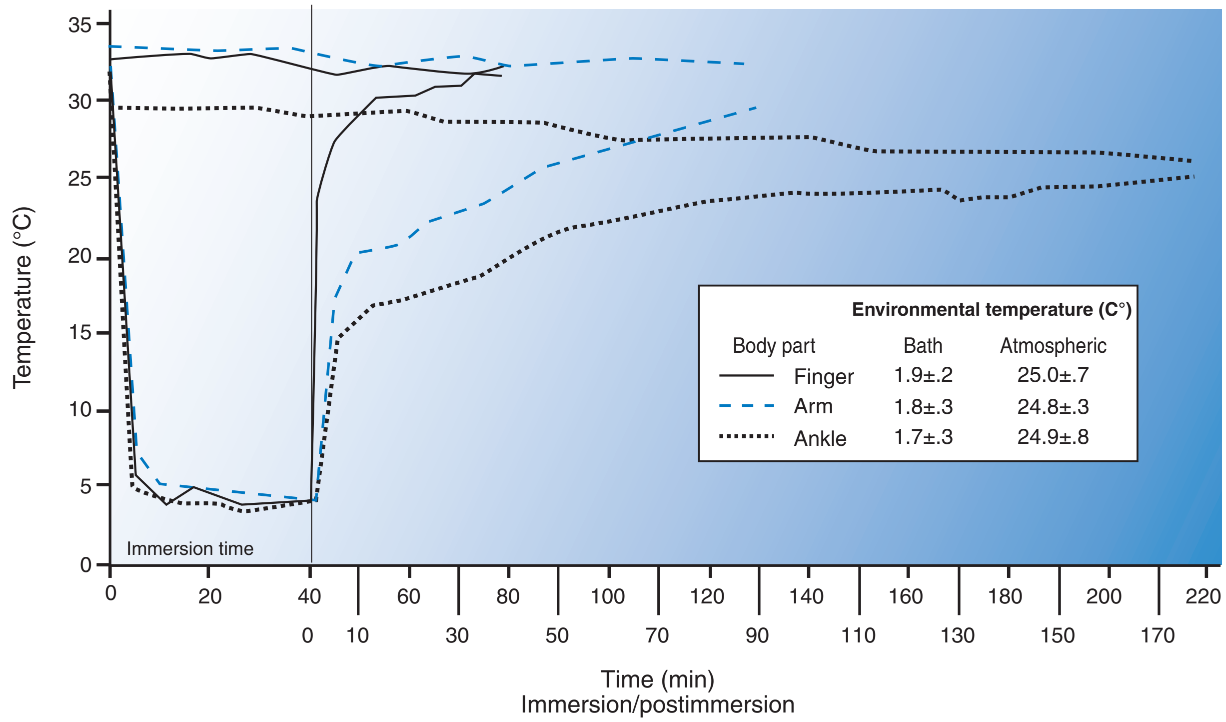

FIGURE 5.12. Fingers rewarm quickly after the removal of a cold pack. Most other body parts take hours to rewarm, here demonstrated by arm and ankle temperatures. (Reprinted with permission from Knight and Elam.[36])

Rewarming after a second application is generally the same as after the first application, as long as the ratio of application time to interval between applications is >2:1 and the application times and the activity level during rewarming are the same.[37]

Cryotherapy Application Principles

Does it matter how you apply cold? Absolutely! The cold modality chosen and how it is applied result in great differences in tissue cooling. Understanding the factors that affect tissue cooling will help you make proper decisions.

Various protocols have been suggested for applying cold during immediate care. In one review of the recommended length, frequency of application, and duration of therapy of >30 published protocols, there were only two instances in which two recommendations were the same.[59] The following discussion will help solve some of the confusion.

FACTORS THAT AFFECT TISSUE COOLING

Numerous factors influence tissue cooling during cold pack application. Some of these were discussed above, including the following:

- The temperature differential between the body and the cold modality
- The regeneration of body heat and/or modality cooling
- The heat storage capacity of the cold modality
- The size of the cold modality (the larger the cold pack, the more cooling)
- The amount of tissue in contact with the cold pack (the greater the area of contact with the cold modality, the more cooling)
- The length of application (the longer the application, the more cooling and the slower the rewarming)
- Individual variability
- Heat capacity of modalities

Other factors that influence tissue cooling and guidelines for application are types of cold packs, application directly to the skin rather than over a towel or elastic wrap, length of application, rate of intermittent application, and the duration of therapy (number of treatments).

TYPES OF COLD PACKS

The four main types of **cold packs** are crushed ice packs, gel packs, artificial ice packs, and crushable chemical packs (Fig. 5.13).

Crushed Ice Pack

A **crushed ice pack** is crushed ice, typically from an ice machine, in a plastic or cloth bag. Ice packs are typically 30°F (−1°C) to 32°F (0°C) when applied to the body. They are the most effective type of cold modality because they undergo a phase change and therefore extract great

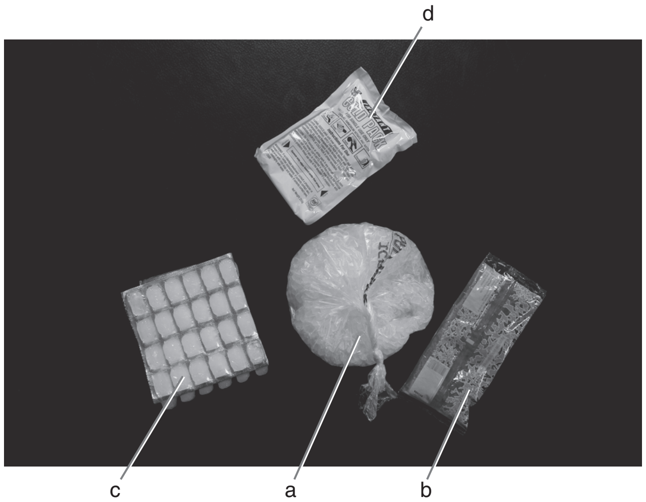

FIGURE 5.13. The four most common types of cold packs: (*a*) crushed ice pack, (*b*) gel pack (cold pack), (*c*) artificial ice pack (with sheets of ice visible on top), and (*d*) crushable chemical pack.

amounts of heat from the body (see Fig. 5.9). Yet they are not so cold that they cause frostbite, unless applied for hours.

Crushed ice packs are also excellent for on-the-field use. They can be prepared before a practice or event, placed in an insulated cooler, and used hours later. Without a phase change, other types of cold packs are not nearly as effective.

Crushed ice packs are not effective for home use. They cool to about 1°F (−17°C) in a home freezer; if applied directly to the skin they will cause tissue damage. They also become solid when frozen in a home freezer, so they do not conform to irregular body surfaces.

You can make an ice pack by placing 1.5–2.5 lb (0.7–1.2 kg) of crushed or cubed ice in a plastic bag. Suck out as much air as possible from the bag, and tie the end in a knot (Fig. 5.14).

Gel Pack

A **gel pack** is a reusable type of cold pack. It consists of water mixed with an antifreeze, such as alcohol, and a gel substance, in a vinyl pouch. The alcohol keeps the water from freezing solid, and the gel gives it body so the water does not slosh around in the pack. They are cooled in a freezer to about 1°F (−17°C).

Gel packs are not as effective as crushed ice, and they are much more dangerous. The water does not freeze, so they do not go through a phase change when applied. Thus they do not withdraw as much heat from the body. But because they are cooled to ~1°F (~17°C), they might cause frostbite if applied directly to the skin (Fig. 5.15). Applying a barrier to protect the skin from the extreme temperature further decreases their cooling effectiveness.

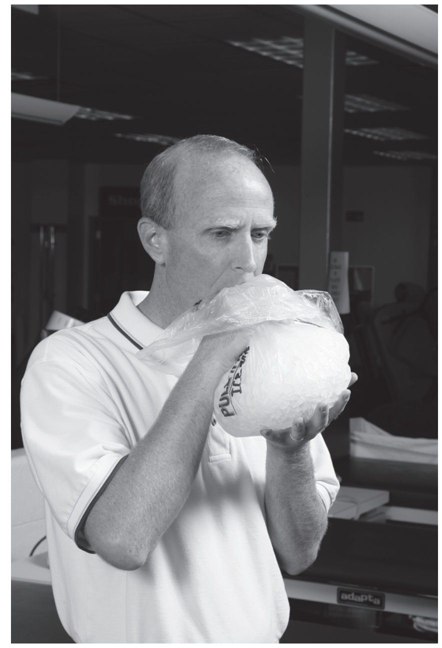

FIGURE 5.14. Remove as much air as possible from a crushed ice pack by sucking it out. Twist the end of the bag before removing it from your face, and then quickly tie the end in a knot.

Artificial Ice Pack

An **artificial ice pack** is a pouch made of vinyl sheets 1 × 1.5 in. (3 × 4 cm). The pouch is filled with water and enclosed in a nylon covering (see Fig. 5.13). The vinyl is meant to keep fruit and vegetables cool during interstate shipping and is cut from large sheets. Artificial ice packs are frozen in a freezer at ~1°F (~17°C), but the nylon covering insulates them so the application temperature is close to 32°F (0°C). Artificial ice packs are not as flexible

FIGURE 5.15. Frozen gel packs can cause severe skin damage if applied directly to the skin. This individual took a frozen gel pack from our laboratory without permission and applied it directly to his skin (thigh) for 90 min to treat radiating pain. Blisters began forming that evening and continued to grow until 2 days later, when this photograph was taken. The skin healed without scarring but was still mildly sensitive to touch 20 months later.

as gel packs, but they are much more flexible than refrozen crushed ice packs. Because of their nylon covering, artificial ice packs are not as effective in cooling tissue as is crushed ice, but they are more effective in cooling than a gel pack because they undergo a phase change. They are preferred for home use because they can be safely applied after cooling in a kitchen freezer, are flexible, and go through a phase change as they warm.

Crushable Chemical Pack

A **crushable chemical pack** consists of a thin-walled vinyl pouch of a liquid packaged within a stronger, larger vinyl pouch of dry crystals. When squeezed with sufficient force, the smaller pouch is broken, leaking its fluid into the larger, outer pouch. The fluid and crystals combine in a chemical reaction that cools the fluid. Crushable chemical packs are not recommended because they neither get the body cold enough nor last long enough to be used in place of crushed ice.[60] There also is a danger of chemical burns if the contents of such a pack leak onto the skin. Crushable chemical cold packs should be used only as a last resort.

APPLICATION DIRECTLY TO THE SKIN

In general, crushed ice packs are applied directly to the patient's skin (Fig. 5.16).[61,62] A towel or elastic wrap between the ice pack and the body insulates against the full effect of the cold, thereby making the treatment less effective.[60,63–65] If used for <60 min, most cold packs do not cause frostbite. Frozen gel packs are an exception, however, and should not be applied directly on the skin. Their temperature may be many degrees below zero and could cause frostbite.

APPLICATION TIP

KNOW WHEN NOT TO APPLY COLD PACKS DIRECTLY TO THE SKIN. Some types of cold packs are too cold to be applied directly to the skin because they will damage the skin. These include frozen gel packs and crushed ice packs using ice frozen in a refrigerator or freezer. Most crushed ice packs are made from ice from an ice machine, which stores the ice just below freezing (30°F or −1°C). But ice from a freezer and gel packs are in the range of −2°F to −5°F (−16°C to −19°C). This is much too cold for the skin and often results in tissue damage.

Placing a towel or elastic wrap between the skin and the cold pack, as many recommend,[7,66] insulates the skin against the cold, decreasing the effectiveness of the cold pack (Fig. 5.17).[60,61–65] Using wet [7,67] or frozen[68] elastic wraps between the skin and the cold pack is preferable to using dry ones, but not as beneficial as application directly to the skin.[61–65]

Most first-aid texts recommend against applying ice packs directly to the skin.[7,69] This is beginning to change,

A  B

FIGURE 5.16. **(a)** Apply cold packs directly to the skin. **(b)** A towel or wrap between the cold pack and the skin will decrease the effectiveness of cooling.

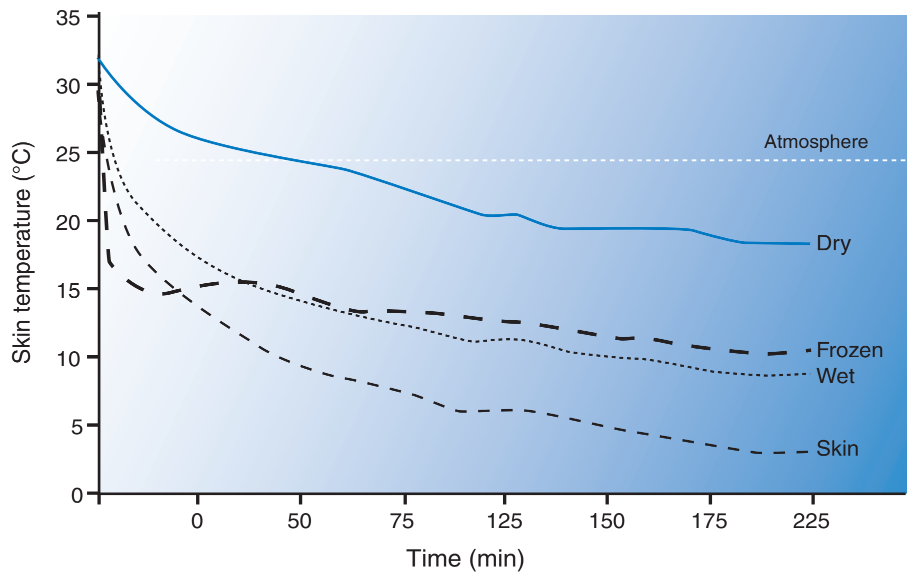

FIGURE 5.17. Applying a crushed ice pack over two layers of a dry, wet, or frozen elastic wrap insulates the body from the cold pack. The most effective cooling occurs when the cold pack is applied directly to the skin. (Reprinted with permission from Urban.[64])

however.[70] The newest text from the American Academy of Orthopaedic Surgeons and the American Academy of Emergency Physicians recommends applying crushed ice packs directly to the skin.[70]

Mirkin[62] claimed that ice packs directly on the skin were safe because living tissue will not freeze until its temperature drops below 25°F (−4.3°C); because an ice pack is 32°F (0°C), it is incapable of causing frostbite. Although his estimate of the freezing temperature of skin was probably low by 3–5°F (2–3°C),[18] he was correct in stating that ice packs can be applied safely to the skin as long as they are not left on >60 min. Long-term application can lead to tissue damage.[71]

We can find no reference to frostbite occurring as a result of a short-term (<60 min) cold application in the literature, nor have we observed frostbite in >30 years of clinical experience applying ice packs directly to the skin of patients for up to 45 min at a time[18] (see also Chapter 14).

LENGTH OF APPLICATION

Ice packs should be applied intermittently. Continuous application is both unnecessary and potentially dangerous. Frostbite can occur with continuous application,[71] and most areas of the body rewarm quite slowly after ice pack application.[35,36,72] The beneficial effects of cold application, therefore, remain after the cold packs are removed. Tissue temperature remains low after removing the cold modality, so tissue metabolism remains depressed. The body part can be kept cool by applying an ice pack for 30–45 min every 2 hr (every hour if the patient is active between applications, such as showering or walking on crutches).

MODALITY MYTH

USING INVALID LENGTHS OF INTERMITTENT COLD APPLICATION

Many clinicians apply ice packs for inappropriate lengths of time, believing their applications are effective. Many applications are less than optimal. Application times for ice packs vary from 6 min to continuously for 24–48 hr.[59] A period of 6 min is much too short to be of any value, and 24 hr is dangerous. The wide variety of application lengths may result from an inadequate theoretical basis for using cryotherapy during immediate procedures.

Most clinicians recommend intermittent applications, even though their reasons for doing so vary.

- Some believe cold-induced vasodilation (CIVD) will increase blood flow to the area if they apply cold for longer than 10–12 min.[73–76] Chu and Lutt[77] felt that initial cold applications should last at least 20 min so the body part could pass through a 3–5 min period of vasodilation and be in a second period of vasoconstriction. CIVD does not occur (see Chapter 13), so this logic is incorrect.
- Some fear frostbite[71,73,78] or nerve palsy[79] if they apply cold for too long, which most define as 15–30 min. The concept is true, but the time frame is much too short. Applications of up to 60 min (for fleshy tissues) are safe.
- Boland[61] believed the application of ice packs for longer than 20–30 min was too painful and should not be done. Ice packs applied for this length are not overly

painful. Ice immersion can be painful, but immersion is not recommended for immediate care.

There is no direct research on how the length of application affects the amount of tissue damage or subsequent resolution of the injury. The rate of rewarming after application, however, indicates that cold packs should be applied for at least 30 min during immediate care.[59] As Figure 5.18 indicates, ankle rewarming after 30, 45, and 60 min ice pack application is significantly slower than after 10 and 20 min ice applications. Thus metabolism remains lowered during the time between intermittent ice pack applications.

The area of the body also affects the length of application. The ankle and forearm temperatures remain depressed for hours after application, whereas the finger rewarms within minutes (see Fig. 5.12).[34,36] The knee reacts like the ankle and forearm. Thick muscular tissues, such as the thigh, require longer to cool than bony areas, such as the ankle,[33,37] and rewarm more quickly.

Deeper tissues cool more slowly than superficial tissues (see Fig. 5.11). The deeper the injury is, the longer the cold pack application. There are few data on which to base specifics. A good guideline is to treat moderately fleshy muscle pulls for 45 min and more fleshy injuries, such as the calf and thigh, for up to 60 min.

The length of cold applications should be adjusted according to the patient's skinfold thickness. The amount of adipose tissue (skinfold thickness) influences cooling.[49,50] In one study, scientists measured how long it took to decrease the intramuscular (anterior thigh, 1 cm below adipose) temperature by 44.6°F (7°C). It took ~8 min in tissue with 0–10 mm skinfold vs. ~59 min in tissue with 31–40 mm skinfold thickness.

RATE OF INTERMITTENT APPLICATION

The question of how long ice packs should be applied involves not just the initial application, but the repeated applications and the time between the applications.

The activity level of the patient determines how quickly subsequent applications should be administered. Generally after the first application, patients will shower and go home. Cold packs should be reapplied immediately. If the patient is inactive, however, applications of more than 30 min every 2 hr will cause a progressive decrease in the temperature of the ankle.[37]

Because reapplication is usually done by the patient or family or friends, **compliance** is a factor. The more complicated the treatment regimen, the less likely it will be followed. Recommendations such as "30 min on and 1 hr off" require too much thinking. A simplified recommendation, which is consistent with the variable application times for various tissues and the data from ankle reapplication,[37,39] is to apply ice packs every 2 hr, rounded to the nearest whole hour (e.g., 2:00, 4:00, 6:00 or 1:00, 3:00, 5:00).

DURATION OF THERAPY

Duration, as used here, refers to the calendar or the length of time that intermittent 30 min applications of cold packs should be continued. How long should RICES continue? There are no available data to indicate an optimal dura-

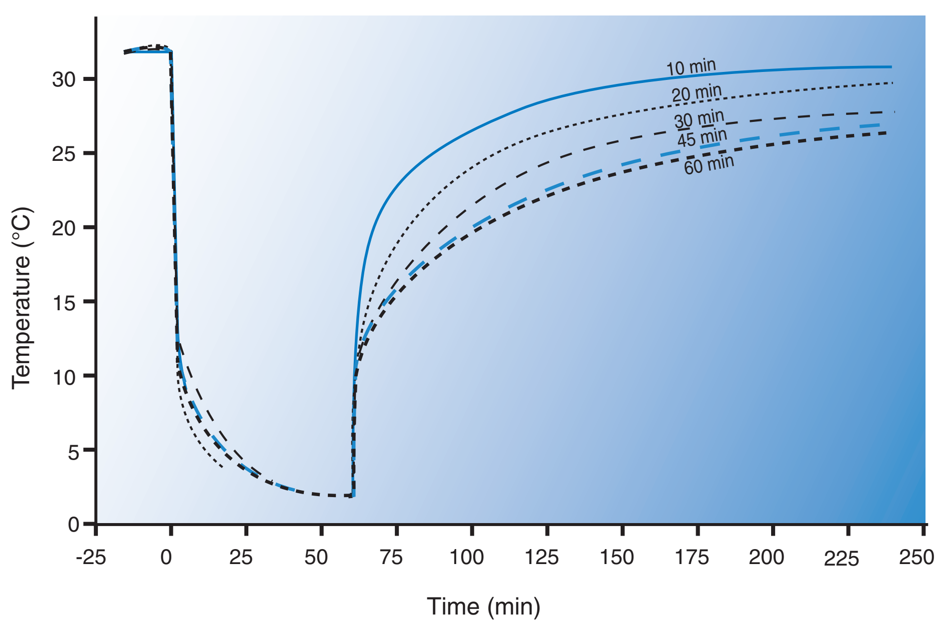

FIGURE 5.18. Ankle cooling and rewarming during and after crushed ice pack applications of 10, 20, 30, 45, and 60 min. The quicker rewarming after 10 and 20 min applications indicates that cold packs should be applied for at least 30 min during immediate care. (Reprinted with permission from Mlynarczyk.[59])

tion. Most clinicians recommend applications for 12–72 hr or until the tendency for swelling has passed.[59] One consideration is the severity of the injury. Immediate care procedures can be terminated earlier when treating a mild injury than when treating a severe injury. Another consideration is the therapy chosen for subacute care. It is possible to transition from immediate care to subacute rehabilitation procedures earlier when using a cryotherapeutic technique for rehabilitation than when using a thermotherapeutic technique. But a definitive answer to the question of the optimal duration of cold applications during immediate care awaits further research.

Two examples of cryotherapy techniques for subacute care are cryokinetics and cryostretch. Both combine cryotherapy with exercise. **Cryokinetics** consists of alternating cold application and active exercise for rehabilitating acute joint sprains. **Cryostretch** consists of alternating cold application, passive stretch, and resistive muscle contraction for rehabilitating acute muscle strains (see Chapter 13).

For first-degree injuries, transition to one of the these cryotherapy techniques after the initial RICES treatment (30 min after the injury) is advisable. For second-degree injuries, continuing RICES treatments until bedtime and until the patient has been evaluated (and possibly via x-ray) the next day is the recommendation. The question is moot for most third-degree injuries, because they generally are treated with surgery and/or immobilization until beyond the acute phase.

PREVENTING SWELLING VS. REDUCING OR REMOVING IT

Cold is effective in preventing or limiting swelling, but it is of little or no value in removing swelling after it has occurred (see Table 5.2). The cause of edema after traumatic injury is excess free protein in the tissue. As explained earlier, cold limits secondary injury. With less total injury, there is less tissue debris, less free protein in the tissue, and less edema. Once swelling has occurred, however, it can be removed only by removing the free protein from the extracellular spaces. As long as free protein remains in the tissue spaces, TOP will be abnormally high, thereby retaining excess fluid in the tissue. The only way to permanently remove edema is to remove the excess free protein.

Protein debris is much too large to be absorbed into the circulatory system. It is removed via the lymphatic system, and such removal requires intermittent compression. The lymphatic system consists of vessels that begin in the tissue and run proximally to the large veins. They have no built-in pumping force, such as the heart, to cause fluid flow. They depend primarily on external compression to force fluid flow (Fig. 5.19). A series of one-way valves allows fluid to flow proximally, but prevents backwash. External compression on the vessel forces the valves open and the fluid to move proximally. When the compression is released the valves close, preventing fluid from returning distally. This leaves a vacuum at the distal end of the lymph vessel. This vacuum pulls edema (fluid and free protein) into the vessel.[26] Subsequent compression then forces lymph distally, and the process continues.

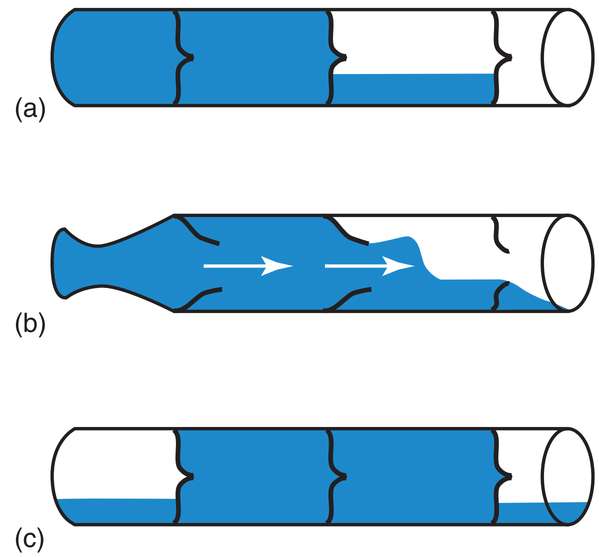

FIGURE 5.19. **(a)** Lymph vessels contain a series of one-way valves. **(b)** Pressure on the vessel forces fluid to flow proximally. **(c)** Release of the pressure creates a vacuum in empty sections of the vessel, which draws lymph into the vessel from surrounding tissue. Ongoing flow occurs from intermittent compression (repeated compression and release).

Intermittent external force from massage, compression, or lymphedema devices such as the Jobst pump, or the muscle pump, during active exercise stimulates lymph flow.[80,81] Neither heat nor cold applications promote lymph flow. They can be helpful, however, in facilitating one of the other modalities. For instance, with cryokinetics, ice applications decrease pain so that active exercise can begin sooner and be more vigorous. Thus cold application, which has no effect by itself, can facilitate active exercise, which in turn compresses lymph vessels and stimulates lymph flow. (Specific techniques for removing swelling by stimulating lymph flow are presented in Chapter 13.)

Misunderstanding the difference between preventing or limiting swelling and removing it after it has occurred leads many clinicians to use cold applications to “treat” swelling, an effort that is both ineffective and delays proper therapy. An example of this misunderstanding is demonstrated by research on the effects of cold during immediate care that includes patients who were not treated until 12–36 hr after their injury.[6,82] Further, this research included reduction in edema as one of the outcome variables. If a patient's treatment is not initiated within an hour or so of the injury, she is not receiving immediate care.

Intermittent vs. Continuous Cold and Compression

Cold is always applied intermittently. Applications longer than 60 min are unnecessary and potentially dangerous. Compression is applied either intermittently or continuously, depending on the therapeutic goals (see Table 5.2). Preventing swelling during RICES requires continuous application, whereas removing swelling during transitional or subacute care require intermittent compression to stimulate lymphatic drainage.

Compression Application Principles

There are three key considerations for applying compression during RICES: what to apply, where to apply it in relation to cold, and how to apply it.

RICES COMPRESSION DEVICES

Elastic wraps are preferred during RICES. When combined with ice packs, they provide more combined cold and compression than other devices (Table 5.3).[83] Despite its popularity and ease of application, plastic wrap should not be used during RICES (Fig. 5.20). It does not provide either the compression or the cooling of an elastic wrap. Although the ice packs under the plastic wrap and elastic wraps are the same, the greater compression exerted by the elastic wrap assists in providing greater cooling (see earlier discussion).

A Cryo Cuff is used as a cold/compression device, but it should not be used as an alternative for elastic wraps with ice. Dura*Kold should be used strictly as a cold modality because little compression is given by this device.

APPLYING ELASTIC WRAPS OVER ICE PACKS

Elastic wraps should be applied over ice packs, as explained earlier, to maximize tissue cooling (see Fig. 5.17). Some clinicians argue against this, claiming that it compromises compression. Compression is not compromised, however; compression over the anterior talofibular ligament is the same whether the elastic wrap is under or over the ice pack, as long as the ice pack is tied so that it maintains a constant volume.[33,84]

FIGURE 5.20. Plastic wraps are convenient for holding on ice packs, but they do not provide either the compression or the cooling effect of elastic wraps.

STRETCHING ELASTIC WRAPS

We recommend that an elastic wrap be stretched to about 75% of its capacity as it is applied. There is no scientific basis for this recommendation, but it is the naturally selected, or intuitive, stretch that students and professionals apply.[33]

CONTRAINDICATIONS AND PRECAUTIONS TO CRYOTHERAPY

Inappropriate use of cryotherapy can cause excessive pain and tissue damage. These fit into three broad categories: cryotherapy that is too cold or applied too long,[85] cryotherapy applied with excessive compression, and applications to patients who suffer from conditions that cause abnormal responses to the cold.[86] These are discussed in general in this section and specific contraindica-

TABLE 5.3 *Temperature and Compression on the Ankle by Various Techniques*

MODALITY	AVERAGE 30 MIN TEMPERATURE (°C)	AVERAGE 30 MIN PRESSURE (MM)
Cryo Cuff	13.9 ± 1.8	39.8 ± 6.2
Dura*Kold	14.1 ± 4.1	6.0 ± 2.0
Elastic wrap + ice	7.1 ± 4.8	50.7 ± 21.0
Flexi-Wrap + ice	9.8 ± 5.3	28.6 ± 13.7

tions and precautions are listed in the application section later in the chapter.

There is neither a specific temperature nor a length of application that causes tissue damage. It is the combination of the two that is dangerous.[87] For example, exposure to −9°F (−4°C) for <1 min is safe,[88] yet exposure to 45°F (7°C) for 7 days resulted in gangrene. Intermittent ice water immersion (32°F or 0°C) for 20–30 min is common during rehabilitation of acute ankle sprains. Yet near continuous immersion for 36–72 hr has caused loss of part of the foot.[71,85] Gel packs (which are frozen to about 1°F, or −17°C) should never be applied directly to the skin (see Fig. 5.15). Ice water immersion and crushed ice packs should be applied to the skin, but not for longer than 1 hr.

Elastic wraps applied over a cold pack can be problematic if applied too tightly, especially in thin people and to body parts where the major nerves are superficial, such as the elbow or knee. Do not apply the wrap too tightly. Cases of temporary **nerve palsy** (local paralysis) from cryotherapy have been reported, but analysis reveals that the combination of an elastic wrap and cold pack probably caused the palsy, not the cryotherapy alone.[18] The incidence of such cases is extremely small compared to the numbers of cryotherapy treatments given, so the risk is minimal.

The most common conditions that cause an abnormal response to cryotherapy include Raynaud disease, cold hypersensitivity, and urticaria. **Raynaud disease** is a circulatory disorder caused by cold or emotion, in which the hands, and less commonly the feet, become discolored and painful. Even mild cold exposure, such as reaching into a refrigerator, causes vascular spasm and extreme pain. Patients with these diseases generally know they have them and will refuse cold application. **Cold hypersensitivity** is a condition manifested by severe pain during cryotherapy.

Cold applications can cause urticaria (hives), in some people.[18] A temporary allergic reaction, **urticaria** is characterized by **wheals—**slightly raised, rounded, or flat-topped areas of skin—usually accompanied by burning or intense itching. It is also caused by exercise, eating certain foods, or from taking certain medicines.

Our experience is that patients with cold urticaria consider it more of a nuisance than a cause for concern. It manifests in patients who have used cold packs previously, often for a number of years. It usually is more intense in the beginning and becomes less severe if the patient continues to receive cold treatments. Our policy is to discuss the situation with patients after the first occurrence and let them decide whether to continue cryotherapy. Most feel the advantages of the cryotherapy outweigh the nuisance of the urticaria, especially as the urticaria decreases in severity over time. Calamine also helps some patients.[89]

Be aware that problems could arise if caution is not exercised when using cryotherapy in the following situations:

- Cardiac disorder
- Compromised local circulation

Electrical Stimulation During Immediate Care

Some clinicians advocate electrical stimulation for the immediate care of orthopedic injuries.[90] We do not recommend this technique at present, for reasons that will become apparent. There have been two schools of thought concerning this issue (see Chapter 9):

- The mistaken belief that high-volt pulsed current stimulation causes vasoconstriction and therefore limits swelling.[91]
- The belief under investigation that sensory-level high-volt pulsed stimulation limits edema development.

THE VASOCONSTRICTION THEORY

The belief that high-volt pulsed current stimulation causes vasoconstriction grew out of early marketing efforts by manufacturers who presented the devices as galvanic simulators. Because galvanic currents are thought to cause vasoconstriction, presumably these units would do so.[91] They are pulsed monophasic, but not galvanic, so they do not cause vasoconstriction. Also, even if they were vasoconstrictive, the goal of immediate care is to decrease secondary injury, not blood flow.

Another problem is that you sacrifice the full benefits of RICES with this technique. Many apply it by immersing the limb in a tub of ice water and inserting one of the electrodes into the bath. This sacrifices elevation. You also have to sacrifice either compression or some cooling. If you apply an elastic bandage to the limb for compression, the bandage will insulate the limb so you have less cooling. On the other hand, to get full cooling you have to sacrifice compression.

Applying electrical stimulation under the traditional RICES does not solve the problem. The thick rubber electrode will insulate the tissue from the cooling of the ice pack.

THE EDEMA-LIMITING THEORY

Limiting edema development by sensory-level high-volt pulsed current stimulation is based on extensive research on small laboratory animals.[90,92–102] The hind limbs of these animals were injured, and the animals were suspended in a sling with the traumatized limbs in a dependent position.[93] The traumatized limbs were immersed in a beaker of water, into which an electrode was placed.

Although research has clearly demonstrated that edema is curbed with high-volt pulsed stimulation, applying this concept is difficult. One problem is that it cannot be used in conjunction with RICES, as scientists suggest doing.[93] Their research suggests that near-continuous treatment is needed throughout the acute inflammatory response.[90,91] A single 30 min treatment decreases edema for 4 hr but does not significantly decrease long-term edema formation.[65,79,87–89] In addition, the animal model involved no compression or elevation.

Another concern is that the research has not been tested against RICES. Therefore, we do not know whether edema retardation is more, less, or the same as that provided by RICES. Scientists have compared electrical stimulation with cold,[92–94] but the protocols used fail to answer the question. The cold water immersion was at a temperature of 55°F (~13°C), which is not as cold as an ice pack. Also, the electrical stimulation and control were applied with room temperature water (75°F, or 23°C), which is ~15°F cooler than tissue, and so the control was actually a mild form of cryotherapy.

We recommend against using electrical stimulation in place of RICES for immediate care. It may have a place if it is used between ice applications and in conjunction with compression and elevation. Further research will, no doubt, clarify how electrical stimulation can augment RICES.

5 Application of RICES

STEP 1. FOUNDATION

A. Definition. Procedures used immediately after an acute orthopedic injury to limit the negative sequelae of the injury

B. Effects
   1. Resting the injured structure minimizes aggravating the injury.
   2. Ice cools the tissue, thereby minimizing secondary injury. There is less total injured tissue, less tissue debris, less free protein from phagocytosis of the tissue debris, and less edema. It also limits pain and muscle spasm.
   3. Compression helps contain edema and increases the cooling effect of ice.
   4. Elevation helps lessen the increase in capillary filtration pressure.
   5. Stabilization reduces muscle guarding and pain.

C. Advantages. Less total tissue damage and edema

D. Disadvantages. None, if applied correctly

E. Indications. Acute orthopedic or soft tissue injury

F. Contraindications
   1. Do not apply cryotherapy directly to the skin for >1 hr continuously; it can cause frostbite.
   2. Do not apply cold packs that have been chilled in a freezer directly to the skin (see Fig. 5.15).
   3. Do not apply a compression bandage over a chilled gel pack; it can cause frostbite.
   4. Do not apply cryotherapy of any type to patients who have any of the following conditions:
      a. Raynaud disease or any other vasospastic disease
      b. Cold hypersensitivity, manifested by severe pain
      c. Cardiac disorder
      d. Compromised local circulation

G. Precautions
   1. The longer you wait after injury, the less effective it is.
   2. Unyielding compression: Despite your best efforts, edema may develop. If the edema is excessive, and the compression is unyielding, the pressure may damage tissue in a manner similar to a *compartment syndrome,* as can occur in the lower leg.
   3. Be extremely cautious when using cryotherapy for treating patients who:
      a. Have certain rheumatoid conditions
      b. Are paralyzed or in a coma
      c. Have coronary artery disease
      d. Have certain hypertensive diseases
   4. Be very careful when applying an elastic wrap over a cold pack, especially in thin people and to body parts for which the major nerves are superficial, such as the elbow or knee.
   5. Be aware that cold applications can cause urticaria (hives) in some people.

STEP 2: PREAPPLICATION TASKS

A. Selecting the proper modality
   1. Evaluate the injury or problem to:
      a. Rule out life-threatening situations; if one exists, initiate an emergency action plan.
      b. Collect data about the injury. Once muscle guarding develops, the information you obtain from palpation and stress tests will be decreased.
      c. Perform the evaluation thoroughly but quickly.
   2. Check for possible contraindications to cold.

B. Preparing the patient psychologically
   1. Explain the procedure.
   2. Warn about precautions.
   3. Reassure the patient; pain and frustration from the injury are usually quite disconcerting.

C. Preparing the patient physically
   1. Remove clothing as necessary.
   2. Remove bandages, braces, and so on, as necessary.
   3. Position the patient in a manner that will be comfortable and allow the injury to be elevated.

D. Preparing the equipment
   1. Make an appropriately sized ice pack.
      a. Place crushed ice in a plastic bag. The bag must be big enough so the finished pack will extend 2–3 in. (5–8 cm) beyond the borders of the injury. (Some injuries may require two ice packs.)
      b. Remove as much air as possible from the bag (see Fig. 5.14).
      c. Tie the end of the bag in a knot.
   2. Get appropriately sized (width) elastic wrap(s).
      a. For most situations, a 6 in. (15 cm) width is adequate. Never use one <4 in. (10 cm) for immediate care. Smaller wraps don't adequately cover the area and have a greater tendency to roll up and become a tourniquet.
      b. Double-length or multiple wraps are necessary for applications to the knee, thigh, abdomen, chest, and shoulder.
      c. Get a splint or sling.

3 STEP 3: APPLICATION PARAMETERS

A. Procedures
   1. Apply the ice pack so it is centered over the middle of the injury.
      a. Apply directly to the skin.
      b. Shape to the general contour of the body part.
   2. Apply the elastic wrap(s) around the ice pack and body part to hold the ice pack in place and to apply compression.
      a. The wrap must extend 2–3 in. (5–8 cm) beyond the borders of the ice pack.
      b. Stretch the wrap to about 75% of its capacity during application.
      c. Secure the end of the wrap with clips or tape, or by tucking it under itself.
   3. Check the patient every 5 min to see if the wrap is too tight. Also at this time, shake the ice pack to break up the thermal gradient.
   4. Apply a splint, sling, or brace to stabilize the injured body part. The goal is to allow muscles surrounding the joint to relax. (See Fig. 5.7.)
   5. Elevate the limb or situate the patient so that the injury is elevated about 6 in. (15 cm) above the heart.

B. Dosage. Use enough ice so that the ice pack(s) and elastic wrap extend 2–3 in. (5–8 cm) beyond the borders of the injury.

C. Length of application
   1. Cold, 20–60 min, depending on the injury and the skin-fold thickness of the patient. In general:
      a. 20 min for finger
      b. 30 min for ankle or arm
      c. 45 min for thigh
      d. Add 5 min for each millimeter of skin-fold >1 mm.
   2. Rest, compression, elevation, and stabilization continuously. Reapply the elastic wrap and stabilization after removing the ice pack.

D. Frequency of application
   1. Begin application 5–10 min after the injury; immediately after the injury evaluation.
   2. Second ice application should be 30–60 min later; after the patient has showered and gone home.
   3. Apply compression, elevation, rest, and stabilization constantly.
   4. Subsequent applications every 2 hr until bedtime. Tell the patient not to stay up into the night just to apply RICES.

E. Duration of therapy
   1. Most first-degree injuries: 30–45 min (a single treatment).
   2. Second-degree and third-degree injuries: 12–24 hr, if followed by a transitional cryotherapy technique, such as cryokinetics or cryostretch.

4 STEP 4: POSTAPPLICATION TASKS

A. Equipment replacement; area cleanup

B. Instructions in writing to the patient (Fig. 5.21). These include the following:
   1. Time of appointment for the next day (morning if possible).
   2. Resting the injury—that is, not stressing the body part to the point of causing pain. Use a sling or crutches as necessary.
   3. Specific times for reapplication of the ice pack.
   4. *Caution:* Do not reapply more or less frequently than the written instructions specify.
   5. Phone number to call if pain or swelling becomes excessive.

C. Record of treatment, including unique patient responses

5 STEP 5: MAINTENANCE

A. Routine maintenance. Keep the ice machine in good repair, and replace elastic wraps as they deteriorate.

The Use of Crutches

Any patient who is unable to walk without a limp should be on crutches. Crutches make it possible for an injured person to walk properly by using the arms to substitute for, or supplement, leg power. Failure to use crutches will result in the following complications:

- Delayed healing. A person limps because the body weight aggravates the injury and causes pain. Neural inhibition results, thereby prolonging the rehabilitation process.
- Compensating muscle problems. The abnormal gait produced by limping causes muscles and other soft tissue surrounding the hip, knee, and/or ankle or the uninjured limb to shorten and tighten. Sometimes the resulting tightness will persist long after the original injury has healed.

Both of these complications can be minimized by the proper use of crutches. Correct crutch use requires the proper fitting of the crutches, selecting the appropriate crutch walking gait, instructing the patient to walk properly with the selected gait, observing the patient practicing the gait, and periodic reevaluation of the patient to ensure that he is using the crutches properly.

Extended Immediate Care Procedures
University of Moab Sports Medicine

Your activities during the next 12-72 hours are critical to the resolution of your injury. Failure to follow the following procedures may delay your return to full sport participation by as much as two weeks. Help us to help you by doing the following:

Before leaving the Athletic Training Clinic make sure you have:

_____ Had an initial 30- to 45-minute application of ice, compression, and elevation.

_____ Had a second evaluation of the injury.

_____ Showered.

_____ Had an elastic wrap applied to the injured area.

_____ Been fitted for a sling (if shoulder or arm injury) or crutches (if lower extremity injury).

_____ Received instructions in proper use of the sling or crutches (if fitted with them).

After you return to your dorm/apartment/home:

1. Apply an ice or cold pack to the injury for 40 minutes at the times circled below. To do this, remove the elastic wrap, put the ice pack directly over the injury, and reapply elastic wrap. The wrap should be snug, but not real tight (remove about 3/4 of the stretch).

1:00 2:00 3:00 $\boxed{4:00}$ 5:00 $\boxed{6:00}$ 7:00 $\boxed{8:00}$ 9:00 $\boxed{10:00}$ 11:00 $\boxed{12:00}$

2. After each 40 minute ice-pack application, remove the ice pack and **reapply** the elastic wrap (snugly, as above). Following the last ice-pack application, wear the elastic wrap through the night until you return for treatment tomorrow.
3. Keep the injured part above the level of your heart as much as possible (constantly if possible) until you go to bed tonight.
4. Tomorrow, report to:

   The Student Health Center at _____ am/pm

   The Athletic Training Clinic at 10 am/pm

   ____________________ at _____ am/pm

   ____________________ at _____ am/pm
5. AT: k.knight
6. If you have problems that you feel need immediate attention, call me at 555-1896

FIGURE 5.21. Giving written instructions to the patient after the initial RICES treatment increases patient compliance.

PROPER CRUTCH FITTING

Fitting the crutches to the patient is essential to proper use. First, adjust the length of the crutches so that there are 2–3 in. (4.4–6.6 cm) between the axillae and the axillary pads (Fig. 5.22). This adjustment is usually made by removing the two wing nuts and then the two screws near the bottom of the crutches. (Aluminum crutches have a push-button adjustment.) A preliminary adjustment can be made with the patient lying, but the wing nuts should not be tightened until the adjustment has been confirmed with the patient standing.

Second, adjust the handpiece so that the elbow is flexed to ~30°, and the wrist is in a comfortable weight-bearing position (Fig. 5.22). If the position is correct, the patient should lift herself slightly off the floor when pushing down and extending her arms. This adjustment is made by removing the wing nut and screw through the handpiece.

MODALITY MYTH

CRUTCHES GO IN THE ARMPIT

A common misconception is that crutches should fit into the axillae (armpits) so that the shoulders bear the body weight. This is wrong! The weight of the body must be supported almost entirely by the hands; the remainder is supported by the upper lateral chest wall. Carrying the weight of the body in the axillae can cause contusion or concussion to the nerves of the brachial plexus, resulting in **crutch palsy,** a temporary or permanent loss of either sensation or the ability to move or control movement.

SELECTING THE PROPER GAIT

Selecting the appropriate crutch walking gait depends on how much weight the injured limb can take. Although there are a number of crutch walking gaits, two are most applicable to lower extremity trauma patients: the non-weight-bearing gait and the partial-weight-bearing gait. The **non-weight-bearing gait**, also known as the *swing-through gait,* is used when the objective is to completely remove weight from one leg or foot (Fig. 5.23a). The injured limb is lifted and the patient walks alternatively on the good leg and the two crutches. This gait should not be used any longer than necessary, though, because it can cause the same hip and knee tightness as caused by limping.

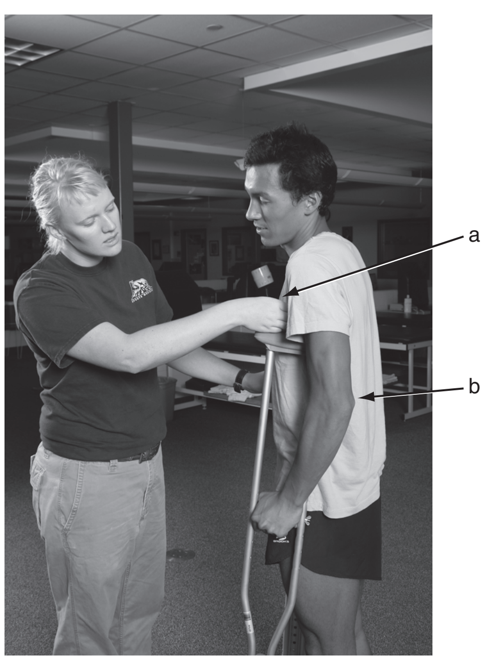

FIGURE 5.22. Crutches are properly fitted when **(a)** there are 2–3 in. (4.4–6.6 cm) between the axilla and axillary pad of the crutch, and **(b)** the elbow is bent ~30°.

The preferred gait for patients with acute orthopedic trauma is the **partial-weight-bearing gait**, also called the *three-point gait* (Fig. 5.23b). The patient walks as with a normal gait, except for using the crutches to remove just enough weight from the injured limb to eliminate pain and limping. Weight borne by the injured leg will vary from light toe touching to almost full body weight. As the patient's injury heals, more weight is taken by the foot, and less by the hands and crutches.

WALKING INSTRUCTIONS

Instructing the patient in the selected gait is merely telling him when to move the crutches.

- "Think of the crutches as part of your injured limb."
- For the partial-weight-bearing gait: "The two crutches are in contact with the ground simultaneously with the injured limb. As you move the injured limb forward, move both the crutches forward also."
- For the non-weight-bearing gait: "Your body weight is totally supported by the uninjured leg while both crutches are placed 12–24 inches in front of your feet. Then transfer your weight to the crutches as you lift your body and swing through to a point 12–23 inches in front of the crutches."

Walking up and down stairs requires special training, because swinging may cause a loss of balance. The following instructions apply no matter which gait the patient uses on level ground:

- For going downstairs: "Begin by lowering the crutches down a step, follow with the injured leg, and then lower the hips down between the crutches. The uninjured leg is brought down last."
- For going upstairs: "The uninjured leg is lifted first, followed by the injured leg, and then the crutches."
- "The phrase 'The good go up to heaven, the bad go down to hell' may help you remember which foot or leg goes first when walking upstairs and downstairs."

The patient should also be instructed not to use a single crutch. With a single crutch, the patient will not stand up straight when walking, and the leaning will cause tightness in the lower back, hip, or knee. Although minimal, the tightness will affect postinjury activities and make the patient susceptible to further injury.

OBSERVING THE PATIENT PRACTICING THE GAIT

Watch the patient walk around until you are satisfied that she has mastered the technique. Going up and down some stairs is part of the practice that should be observed.

A B

FIGURE 5.23. The purpose of crutch walking is to remove weight from the injured limb or foot. It can be **(a)** total, as with the non-weight-bearing or swing-through gait, or **(b)** partial, as with the partial-weight-bearing or three-point gait.

PERIODIC REEVALUATION

Periodic reevaluation of the patient should be done so that he will not subconsciously develop a deviant gait pattern that will result in problems after the crutches are no longer needed. This is best done when the patient is unaware that he is being watched. The important thing is for you to make sure that he is walking with as near to a normal gait as possible.

Medicated Ice for Abrasions

Athletes often suffer skin abrasions. An abrasion can become a complicated injury if not handled properly. Proper management includes the standard injury first aid of ice, compression, and elevation to limit pain, swelling, and secondary injury and managing potential bacterial contamination.[103]

Neither of the two most popular treatments for abrasions is comprehensive. One treats the injury like a sprain or strain with RICES and ignores the possibility of infection. The other treats the open wound by cleaning it and applying an antiseptic and sterile wound dressing, but ignores the possibility of secondary injury and swelling. MacLeod[103] suggested combining cryotherapy with an antiseptic by applying ice massage to abrasions with medicated ice cups (Fig. 5.24).

A medicated ice cup is sometimes referred to as a medicated Popsicle. The povidone-iodine in the ice, like all antiseptics, discourages the formation and propagation of bacteria. The indications, contraindications, and precautions for the povidone-iodine and lidocaine are provided with each medicine.

Ice also acts as an analgesic. Using medicated ice composed of 2% lidocaine produces an even greater analgesic effect, which is necessary when brushing or picking dirt and debris out of an open wound. The decrease in pain from the ice and lidocaine also leads to a slowing of the pain–spasm–pain cycle, which helps enhance muscle function around the injury. It is easy to avoid wound infection when the injury is treated early and properly.

PREPARING A MEDICATED ICE CUP

The following materials and medicines are needed to make medicated ice cups:

- Four 2-oz disposable cups
- Plastic stir sticks
- 2% lidocaine
- 10% povidone-iodine
- Distilled or boiled water

Here are the steps:

1. Mix 3 oz of povidone-iodine, 1 oz of lidocaine, and 3 oz of water.
2. Pour the mixture into the four cups.
3. Secure a stir stick vertically in the center of each cup with adhesive tape.

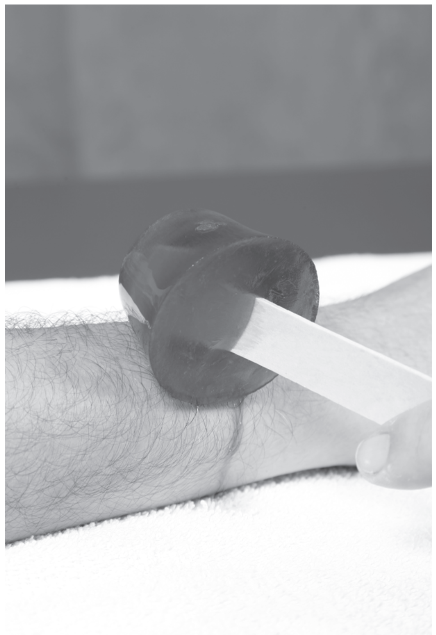

FIGURE 5.24. Ice massage with a medicated ice cup treats abrasions with antiseptic and cryotherapy.

4. Freeze overnight.
5. Clearly label the cups.
6. Isolate the medicated ice cups from other ice cups in the freezer so they are not accidentally used for general ice massage (this wouldn't cause problems, but it would be a waste of resources).

HOW TO APPLY MEDICATED ICE

Here are the steps for applying ice massage to an abrasion using medicated ice cups. Do this as soon as possible after the injury:

1. Seek the advice and approval of a physician before applying medicated ice.
2. Hold the stir stick and roll the ice back and forth along the lacerated skin for about 10 min. As the ice melts, the medicines will flow into the damaged region and produce analgesic and antiseptic effects.
4. Débride the area (remove foreign materials) with gentle sweep with a moist gauze pad, picking out foreign material with tweezers.
5. Treat and protect the injured area as you would any open wound, emphasizing sterility.
6. Apply, or instruct the patient to apply, an ice pack for 20–30 min each hour until bedtime and apply compression constantly (except when applying or taking off the ice pack) for the first 24–72 hr after the injury.

CLOSING SCENE

If Sammy would have read this chapter, he would have realized that there is a lot more to ice application than filling a bag full of ice and putting it on the injury. Among other things, he would have learned the advantages and disadvantages of several types of ice application. He would have learned that applying an ice pack directly to the skin is not only safe but preferred because it provides better cooling than placing a towel between the skin and the ice bag. He would know how long ice should be applied in various circumstances.

CHAPTER REFLECTIONS

1. Read and ponder each of the following points. Do you feel you have a clear understanding of each concept? If not, reread the appropriate section of the chapter.
   - What is immediate care, and when would you use it?
   - List seven modality myths about the immediate care of orthopedic injuries. For each one, briefly state the myth and the truth.
   - Are the terms *immediate care* and *acute care* synonymous? Why or why not?
   - List the stages of acute injury care. Generally when does each occur?
   - What is meant by general time frames for the stages of acute injury care?
   - What does the mnemonic RICES stand for? Briefly

describe each element and say why and when each one is most effective.
- What is swelling, and why and when does it occur?
- Explain what is meant by this statement: Cold during immediate care is more than swelling control.
- What are the two most prominent theories about why cryotherapy is used during immediate care? State the major elements of each theory, and their strengths and weakness.
- What is cold? How is cold transferred from a cold pack to the body?
- Briefly discuss each of the seven factors that influence the rate of heat conduction from the body to a cold pack.
- What is meant by the latent heat of fusion? What role does it play in RICES?
- What is a phase change? How does it apply to cryotherapy?
- Briefly explain the temperature response to cold pack application. Consider surface, tissue, intra-articular, and rewarming after application.
- Briefly discuss each of the four major types of cold packs.
- Should ice be applied directly to the skin? Why or why not?
- What is meant by the depth of target tissue, and how does this apply to RICES?
- What effect does skin-fold thickness have on RICES?
- What is the basis for stretching an elastic wrap to 75% of its capacity when applying it?
- What is the difference between preventing and removing swelling?
- Explain the difference between continuous and intermittent compression. How is each is used?
- Briefly explain the use of crutches during acute orthopedic injury care. Say why and how you would use them.
- What is a medicated ice cup? Why and how is it used?
- Briefly review the five-step process for RICES application.

2. Write three to five questions for discussion with your class instructor, clinical instructor, classmates, and clinical colleagues.
3. Get together with classmates and quiz each other on the concepts of this chapter. Use the points in exercise 1 and questions you wrote for exercise 2 as a beginning. Explaining concepts out loud to others requires a deeper grasp of the material than feeling you understand it as you read.
4. Once you feel you understand the principles of application of RICES and crutch walking, practice applying RICES using the five-step approach with a classmate or clinical colleague. Also, fit crutches to a classmate or clinical colleague and instruct her in properly using them. Alternate applying the modalities to each other. When it is being applied to you, listen and observe carefully to determine whether your classmate is using proper application. Consult your notes when the modality is applied to you and for the first few times you apply the modality to another person. Continue practicing the application until you can do so without using your notes.

CRITICAL THINKING RESPONSES

Critical Thinking 5.1

The swing gait removes all weight from the injured limb, whereas with the three-point or walking gait, the patient uses the crutches to take enough weight off the injured limb that he can walk with a normal gait. As the injury heals, the crutches support less and less weight. It is a matter of total rest (undesirable) vs. relative rest (desirable). One case aggravates the injury and the other helps resolve it.

Critical Thinking 5.2

Agree: Cold application is the only element of RICES that limits additional injury. Thus, in a sense, it is a preventive measure. It also reduces pain and swelling (edema).

Disagree: Focusing attention on ice application might cause you to think rest, compression, elevation, and stabilization are not that important. This could potentially result in your not using these additional elements, which would be a big mistake. Each of these elements contributes to controlling the injury sequelae.

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