HOW BELAYS ARE USED IN CLIMBING • CHOOSING A BELAY SPOT • APPLYING BRAKING FORCE TO THE ROPE • ANCHORS • BELAY POSITION AND STANCE • ROPE HANDLING • COMMUNICATION • ESCAPING THE BELAY • SECURING THE FREEDOM OF THE HILLS

CHAPTER 10

BELAYING

A fundamental technique for climbing safely, belaying is a system of using a rope to stop a fall if one should occur. This system can safely control the enormous energy that a falling climber generates, but belaying well takes practice and requires an understanding of its underlying principles.

In its simplest form, a belay consists of nothing more than a rope that runs from a climber to another person—the belayer—who is ready to stop a fall. Three things are necessary to make the system work: a method of applying and amplifying a stopping force to the rope, an anchor strong enough to resist the pull of the fall, and a skilled belayer. There are different ways to apply this stopping force and many methods of setting up and tying in to a *belay anchor* —a secure point to which the rest of the system is attached. This chapter introduces the principal techniques and major options of belaying so that climbers can choose the methods that work best in their own climbing.

HOW BELAYS ARE USED IN CLIMBING

On a climb, belay setups are usually established on the ground or on a ledge that provides reasonable comfort and the possibility of solid anchors. A long climb is divided into sections, with one climber taking the lead and, belayed from below, moving up the route to the next desirable stopping spot and setting up a new belay. The distance between belays is known as a *pitch* or a *lead*. Rope length and the location of a convenient spot to establish the next belay usually determine the length of each pitch. A short climb can be climbed in a single pitch; longer climbs are called *multipitch*.

THREE BELAY SCENARIOS

This section discusses how the mechanics work in each of three types of belay scenarios.

Slingshot top-rope belay. In this scenario, the anchor is on the top of the route and the belayer belays at the bottom of the route. The rope has already been set up, running from the bottom of the route to the top anchor and back to the ground (fig. 10-1). This scenario, which usually only applies to single-pitch routes, is typical at a climbing gym or a cragging area.

In the slingshot top-rope belay, the rope always runs down toward the belayer, who takes rope in as the climber heads up. The direction of rope travel never changes. As long as the belayer keeps the slack out of the rope, the force of a fall is similar to the weight of the climber.

The belayer is not always connected to a ground anchor, and instead often uses his or her weight as the counterforce for the climber. However, certain factors may demand an anchor—for example, if the weight difference between the climber and the belayer is significant or if they are starting the climb (or pitch) from an exposed ledge.

Fig. 10-1. Slingshot top-rope belay.

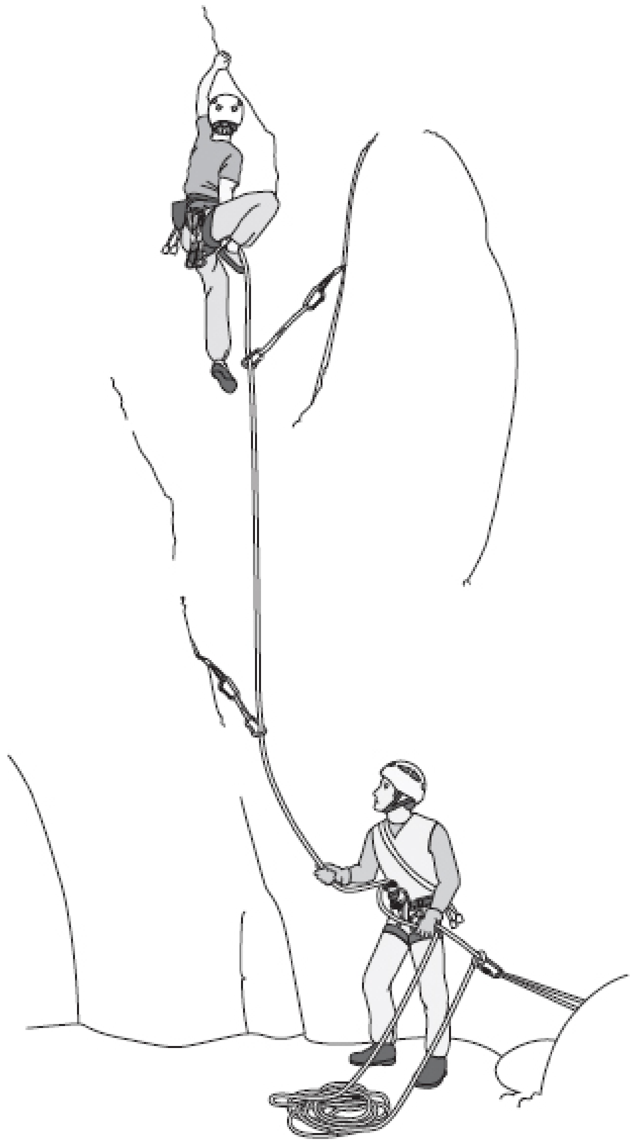

Fig. 10-2. Lead belay.

Lead belay. In a lead belay, the climber is leading the route, placing protection while climbing up. This scenario applies to both single-pitch and multipitch climbs. When the top of a route is not accessible by other means, a slingshot top rope has to be set up this way.

In a lead belay, most of the time the rope moves up and away from the belayer. The exception is that after the leader has clipped the rope to a piece of protection above waist height, as the leader resumes climbing the rope will drop down before going up again. The belayer should be vigilant and move the rope to keep slack at a minimum, without pulling down on the leader. In Figure 10-2, the leader has climbed above the last piece of protection.

In a lead belay, the force of a fall depends on how far the climber is above the last piece of protection—and the fall force could potentially be much greater than the climber's body weight. Thus, in belaying a leader, especially when a long fall could happen, the belayer is typically tied to a ground anchor to avoid being yanked off the ground in the case of a fall. This is extremely important if the belay is on an exposed ledge or under a roof. Exceptions can be made if there is no risk of falling off exposed ledges, if the belayer outweighs the climber significantly, or if the falls are expected to be short—for instance, in a climbing gym.

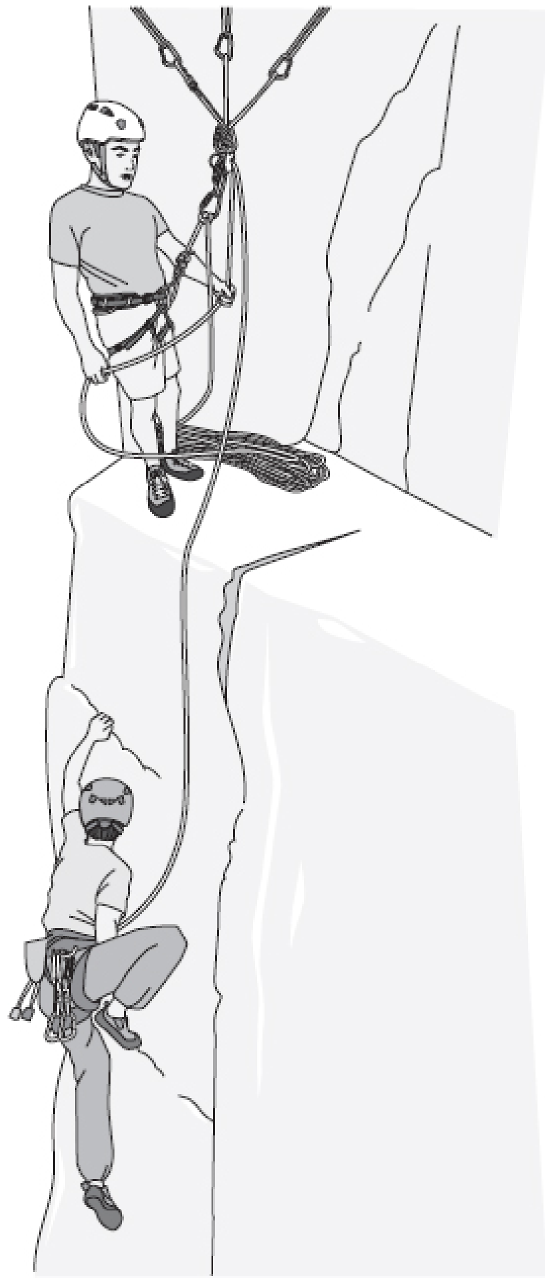

Fig. 10-3. Belaying a follower.

Belaying a follower. After a lead climber has finished leading a pitch, he or she can belay the other climber (who has finished belaying the leader) from the top of the pitch (fig. 10-3). Belaying the follower from the top is done for numerous reasons: it could be a multipitch route on which they both will continue climbing; the route could be too long for slingshot top roping; *rope drag* (friction that impedes the rope's travel) or traverses could make this scenario safer than slingshot top roping. In any case, the climber being belayed from above is known as a *follower* or a *second*; these terms are used interchangeably throughout this chapter.

In this scenario, the rope always moves up and toward the anchor. As in a slingshot top-rope belay, the force of a fall in this scenario should be similar to the follower's body weight as long as the belayer always keeps the slack in the rope at a minimum. The belayer is usually anchored to the belay anchor unless the belayer is belaying directly off the belay anchor and the belay is located on a sizable ledge where falls are not a concern.

CHOOSING A BELAY SPOT

Belaying is a demanding and important task that is often awkward, of long duration, and boring—yet it also requires constant vigilance for the safety of the climber. The belayer's job is much easier if the belayer is able to find a comfortable spot on which to establish a secure position. A good belay location should have three attributes:

1. Good placement for anchors (when an anchor is warranted)
2. Safe position
3. Reasonable comfort

Good placement for anchors. When choosing a belay position, always look for solid anchor placements. Critical to a safe belay, solid anchors are of paramount concern.

Safe position. When selecting a belay location, be aware of the possibility of rockfall or icefall, and pick a stance that will provide some shelter if they seem a likely hazard. If a belay location is exposed to imminent danger from rockfall or icefall, safety may require moving the belay to a location with less-desirable anchors. Additionally, it is useful, though not always possible, to find a position where climbing partners can see and/or communicate with each other.

Reasonable comfort. A leader may shorten a pitch because a comfortable stance at a partial rope length is of greater advantage than pushing the lead as far as possible.

Many factors ultimately determine the best choice for a belay spot. Longer leads are more efficient, so if several good belay ledges are available, climbers generally pick the highest one. However, the leader may decide to stop and set up the next belay early to mitigate rope drag. Belay spots can also be limited by the protection options on the leader's rack for building an anchor.

HOLDING A FALL

A belay serves two equally important purposes: to catch a fall so the climber doesn't hit the ground and to limit the impact force exerted on the climber so that the climber isn't injured.

Understanding Impact Force

The basic concepts of climbing physics discussed here provide an understanding of impact force.

Mass. The first concept climbers need to understand is mass. In simple terms, mass is the amount of material an object has. The bigger and the denser an object, the more mass it has.

Gravity is the downward force exerted by the earth. Gravity gives weight to objects that have mass. The direction of gravity is always downward, and the magnitude of gravity's pull is proportional to the mass of the object.

Acceleration is the rate at which the velocity of an object changes. *Velocity* is the speed and direction in which an object travels. If the speed and direction of travel don't change, the acceleration is zero. Note that deceleration is also acceleration, but in the opposite direction of the velocity. For example, if it takes 5 seconds for a car to reach the speed of 60 miles per hour and it also takes 5 seconds for it to come to a full stop, the average acceleration during the two events is of the same magnitude but in opposite directions.

Now, with an understanding of these three concepts, it is possible to explore how Newton's laws of motion are applied in climbing.

Newton's first law of motion states that an object at rest stays at rest, or an object in motion travels at the same velocity unless acted upon by a force or by forces that don't completely cancel each other (an unbalanced force). In other words, the acceleration of an object is zero unless there is an unbalanced force on it. Acceleration is not zero for the falling climber because of the force of gravity. And because any object on the earth that has mass is acted upon by the planet's gravity, for an object to stay at rest, there must be another force or forces to counter the pull of gravity. When a climber hangs on a rope, the rope provides that *counterforce* by holding the climber in the air against gravity's pull.

In a somewhat simplified model in which rope stretch and slippage are ignored, when someone is climbing or following on a top rope and the belayer always holds the rope tight, the climber's velocity is zero before and after a fall—therefore the acceleration is also zero during the fall. The rope only needs to provide enough force to counter the climber's weight.

However, when a climber is leading, the scenario becomes rather complicated. The lead climber places intermediate pieces of protection and clips the rope in to these pieces, then climbs past them until placing another piece. If the climber falls when he or she is above the last piece of protection, the climber will experience a free fall for double the distance from the last piece of protection (the climber falls to the last piece of protection, and then that much again beyond it). To better understand this scenario, consider Newton's second law of motion, in which unbalanced forces that don't cancel each other are called the *net force*.

Newton's second law of motion states that the net force on an object is equal to the mass of the object multiplied by the acceleration of the object. This relationship is expressed mathematically as F = m x a, or force equals mass times acceleration. In intuitive terms, the more mass an object has, the more force it exerts; the more acceleration an object has, the more force it exerts.

What this means for climbers is, due to gravity (an unbalanced force), a falling climber's velocity will increase as he or she free-falls. This acceleration will remain constant because the earth's gravity does not change. The longer the climber free-falls, the faster he or she will fall. The purpose of belaying is to use the rope to catch the climber, reducing the velocity of the climber's fall to zero. During the catch, an unbalanced net force must act upon the climber to cause that deceleration, and in a belay that force is upward, coming from the rope—this is called *impact force*.

Limiting Impact Force with Dynamic Rope

During the belayer's catch of a climber's fall, if the rope is allowed to slip or stretch more, stopping the fall will take longer—that is, the magnitude of the deceleration is reduced. Thus, according to Newton's second law, less force will be needed to stop the climber—but then the fall will last longer. Stopping a fall as quickly as possible may prevent the falling climber from hitting something, such as a ledge; however, stopping a fall too suddenly would subject every component of the system—including the falling climber—to dangerously high impact forces. Thus there is a trade-off to be made between minimizing the length of the fall and minimizing the fall's impact force. Climbers say a catch is "soft," or a belay is "dynamic," when the rope slips or stretches to limit the impact force to a comfortable range.

Because modern belay devices limit rope slippage, something else in the belay system must provide a soft catch for a falling climber. That something is rope stretch, and often movement of the belayer as well. In many situations, the belayer is confined in a small space and rope stretch is the only means of limiting impact force. Modern dynamic climbing ropes are designed to prevent dangerously high impact forces by elongating under load to absorb energy.

In the days of hemp ropes, the golden rule of belaying was "the rope must run." That was because the rope had neither the strength to withstand high impact forces nor the shock absorption to avoid injuring the climber. The only safe way to stop a fall was by making the belay dynamic, allowing some rope to slip through the belay to make a soft catch. This worked, but not without problems: it was difficult to learn, and the friction of the running rope could badly burn a belayer's hands.

For a rope to be safe for leading—an activity in which falls must be anticipated—it must be an approved dynamic climbing rope. The International Climbing and Mountaineering Federation (UIAA) and European Committee on Standardization (CEN) are two equipment safety organizations that test the designs of new climbing gear prior to production and help set safety ratings. All safe and tested climbing equipment will depict the UIAA safety label and/or the CEN mark (see Figure 9-2 in Chapter 9, Basic Safety System). For detailed information on how ropes are tested, see "The Standard Drop-Test Fall for Dynamic Ropes" sidebar.

Static ropes, webbing slings, and accessory cord, while fine for rappelling, constructing anchors, or other uses, do not stretch enough to safely catch a dynamic fall. Look at the manufacturer's specifications for climbing ropes. They are rated not by tensile strength but by impact force. This is because the rope does more than simply not break under the impact of a falling climber; it also stretches to absorb the energy of multiple falls. These two criteria align with the two purposes of the belay: to catch a fall and to limit the impact force.

The beauty of dynamic climbing ropes is that, because they limit the impact force of a fall, less force is exerted throughout the system. As a result, the anchor is subjected to lower stresses, the falling leader receives a softer catch, and the belayer has an easier task holding the fall.

Understanding Fall Factors

Impact forces generated by falls onto dynamic ropes are determined by both the length of the fall and how much dynamic rope is available to absorb the energy of that fall. Together, these determine the fall factor: the length of the fall divided by the length of rope fallen on. It may not seem intuitive, but fall factor, not length of fall, determines the impact force that is generated in a fall. This is written mathematically as follows: fall factor = length of fall ÷ length of rope fallen on.

THE STANDARD DROP-TEST FALL FOR DYNAMIC ROPES

In the standard UIAA-CEN single dynamic-rope drop-test fall, an 80-kilogram (176-pound) mass affixed to a solid fixed anchor is dropped 5 meters (16 feet 5 inches) on a 2.8-meter (9-foot and 2-inch) section of rope running over a 1-centimeter (3/8-inch) steel bar. To pass the test, a rope must withstand at least five standard drops and not exceed a 12 kilonewton (kN) impact force on the first drop.

This maximum 12 kN figure is derived from studies showing that the human body could briefly withstand 15 times its weight when dropped. Maximum impact forces for current single ropes usually range between 8.5 and 10.5 kN. Be aware that as a rope ages it loses some of its ability to absorb energy. A frequently used rope may generate considerably higher forces than the figures for new test ropes (see “Rope Care” in Chapter 9, Basic Safety System).

By design, the standard drop test produces a fall that would be considered severe in normal climbing situations. First, in most real-life situations any belay is, to a certain extent, a dynamic belay. Rope slippage, belayer movement, and rope friction against rock and through carabiners all dissipate impact force. The standard drop test is not a dynamic belay; the rope absorbs virtually all of the impact force of the fall.

Additionally, the standard drop-test fall is set up with a high *fall factor*: the length of the fall divided by the length of rope fallen on. In the UIAA-CEN standard drop test, the fall factor is calculated like this: fall factor = 5 m ÷ 2.8 m = 1.78, where 5 m is the fall length and 2.8 m is the rope length, as mentioned above.

This test gauges the rope's properties to ensure that it will absorb the impact force generated by a severe fall without subjecting the system to excessively high loads. While the maximum fall factor of 2.0 could be encountered under normal climbing circumstances, such high-factor falls are uncommon enough that 1.78 is an acceptable and more realistic fall factor.

The longer the fall, the bigger the fall factor; the more rope to fall on, the smaller the fall factor. Therefore, lower fall factors always mean lower impact forces because there is more rope relative to the length of fall, hence more rope to stretch and absorb impact.

In any normal climbing situation, a fall factor of 2.0 is the highest a climber could ever encounter, because this would mean falling exactly twice the length of the rope that the climber has run out. For example, assume that two climbers are on a smooth vertical face with no ledges or other hazards to hit in a fall. If the leader falls from 10 feet (3 meters) above the belay without any protection, there would have been 10 feet of rope played out. That climber would end up 10 feet below the belay stance (the point of protection), having fallen 20 feet (6 meters) on 10 feet (3 meters) of rope. Applying this example to the fall factor formula looks like this: fall factor = 20 feet ÷ 10 feet = 2.0.

This would be a fall factor of 2.0, also stated as a factor 2 fall. Such a fall would generate the maximum impact on anchors and climbers, creating a hazardous situation. If there is any slack in the rope, intermediate points of protection, rope slippage, or movement of the belayer, the fall factor would always be less than 2.0. When more rope is played out, falls of a similar length will generate much lower impact forces, putting less stress on the system. That same 20-foot fall on a 100-foot section of rope would still involve an exciting bit of air time, but the catch would be quite gentle by comparison: fall factor = 20 feet ÷ 100 feet = 0.2.

It is important to realize that any fall of the same factor will generate the same impact force, although this is not immediately obvious. An intuitive explanation without involving math is, the length of the fall determines the maximum speed the fallen climber reaches before being caught by the rope and starting to decelerate. Obviously, the longer the fall, the greater the speed. On the other hand, the length of rope catching the fall determines how fast the fall is stopped. The more rope, the more it stretches, and the longer it takes to stop the fall. So although a longer fall involves higher speed, if the fall factor is constant, reducing that speed to zero also takes longer. The deceleration rate remains the same.

Take the 5-meter UIAA-CEN drop-test fall described in the sidebar "The Standard Drop-Test Fall for Dynamic Ropes" and multiply it by 5; now it is a 25-meter (82-foot) fall on 14 meters (46 feet) of rope, but the fall factor remains the same: 1.78. The fall is much longer (and clearly riskier for the falling climber), but because the amount of rope available to absorb shock is also greater, the amount of impact force that the belay system is subjected to remains the same.

PROTECTING THE LEADER

Understanding fall factor and how it determines impact forces is fundamental to safe leading. As described in "Lead belay" above, the leader places intermediate points of protection to reduce potential fall length, and a leader fall is at least twice the distance between the climber and the last placement of protection. As described in "Understanding Fall Factors" above, the impact forces are highest when a fall occurs when the fall factor is 2.0. This would happen when the leader starts up a pitch and falls before any intermediate protection has been placed to limit the distance of that fall.

Therefore, climbers should always establish a solid first placement as soon as possible after starting a new lead. This will not only reduce the chance for a high-factor fall, but will also establish the direction from which the force of a leader fall will come (see "Judging the Direction of Fall Forces" in Chapter 14, Leading on Rock). Understanding the dynamics involved will help climbers make more sense of how belaying protects the leader.

APPLYING BRAKING FORCE TO THE ROPE

Climbing belays must be able to resist the large forces generated in a fall. With the dynamic climbing rope acting as the shock absorber in the system, the belayer's job is to quickly stop the rope from running. Any additional rope that runs through the belay system as the fall is caught has two related effects: reducing the impact forces and lengthening the distance fallen. Occasionally the belayer may want to deliberately provide a more dynamic belay—for instance, if protection is suspected to be weak. But there is always the trade-off of a longer fall, with increased possibility of the lead climber hitting a ledge or other hazard.

Because everything starts with the braking force applied by the belayer's grip, it is important to consider the factors that affect the generation of this force. Grip strength varies considerably from one person to another, with the average being somewhere around 50 pounds (about 0.2 kilonewton). This likely becomes reduced when the belayer is substantially fatigued or awkwardly positioned. Ropes that are thinner, as is the current trend, are more difficult to grip, and reduced rope friction, as occurs with wet, icy, or (possibly) dry-treated ropes, will lower braking force to some degree. Conversely, as ropes age they develop a rougher sheath with higher friction and therefore can be easier to grip.

However, in all cases, grip strength alone is not sufficient to stop a fall. Instead, climbers rely on a mechanical means of amplifying the force of their grip strength. This arresting force is greatly enhanced by the use of some friction-producing element, commonly a belay device, to stop the falling climber.

The belayer's hand that holds the rope coming from the climber is known as the *feeling hand* and is used to pay the rope in and out. The other hand, known as the *braking hand*, must never let go of its grip on the rope, remaining ready to catch a fall at any time. In any belay method, the rope from the climber goes around or through the friction-producing element—a belay device, the camming action of an assisted-braking belay device, a munter hitch on a carabiner, or the belayer's hips—and then to the belayer's braking hand. The braking hand gripping the rope produces the initial force. The braking method or belay device is the essential means by which the limited force of the belayer's grip strength can control the large impact forces generated in a fall.

Stopping a fall is accomplished when a belayer assumes the braking position, gripping the rope tightly with the braking hand, then pulls back on the free end of the rope (see Figure 10-10 as an example). This action must be practiced and learned well so that it becomes automatic; immediately going into braking position as soon as a fall is sensed is the best way to stop a fall.

Wearing gloves while belaying is an option some belayers consider for safety and comfort. Gloves protect the belayer's hands from friction burns in the case of rope slippage. The material of the gloves should be rough enough to add some friction to the system, essentially increasing the belayer's grip strength. Gloves should fit well enough that there are no wrinkles or folds of fabric. Some climbers dislike the fact that gloves may interfere with dexterity and tend to leave their hands damp and soft, which is undesirable for climbing rock; some wear fingerless gloves to mitigate the reduction of dexterity while still protecting the palm.

The most important thing for all belayers to do is to perfect whichever belay method they use. Having one method that you can absolutely count on is the first priority; after that, learning other methods for versatility is valuable.

USING BELAY DEVICES

When properly used, belay devices multiply the rope friction and the grip strength of the belayer's braking hand by passing the rope through an aperture, wrapping it around a post in the device, and passing the rope back out through the aperture. This configuration provides a wrap, or bend, in the rope to assist in producing a stopping force. The post is usually a locking carabiner or a part of the belay device itself. The belayer's braking hand is the initial, and critical, source of friction; without the braking hand on the rope, there is no belay.

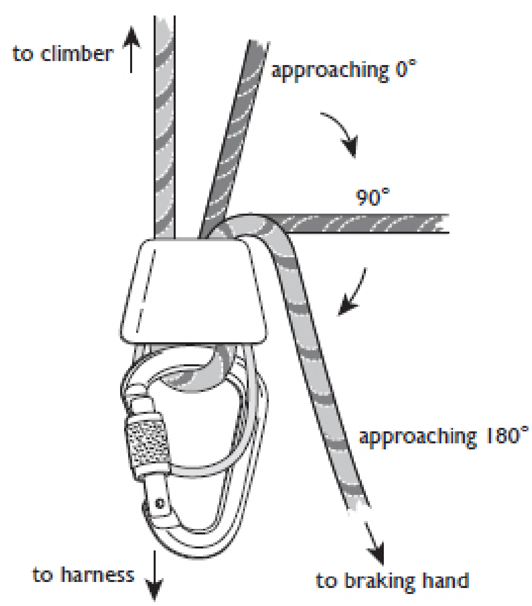

Fig. 10-4. Angle of separation between the two rope strands.

The total braking force exerted on the rope during the arrest of a fall depends on three things: (1) the total degree of bend that the belay device produces in the rope, as well as the rope's inherent resistance to bending and deforming; (2) the friction generated as the rope runs over the surfaces of the belay device; and (3) the force exerted by the belayer's grip. Fortunately, despite the variations in the strength of belayers' grips, modern belay devices work well enough that when they are properly used, adequate stopping force can be generated with even modest grip strength.

To stop a fall, the belayer pulls back on the free end of the rope with the braking hand to create a difference in angle of at least 90 degrees between the rope from the climber entering the belay device and the rope leaving the device to the braking hand. This angle of separation between the two strands of the rope (fig. 10-4) is critical to the strength of the belay. Figure 10-4 shows how the braking force is increased as the braking hand pulls the rope farther back to increase the angle of separation from 90 degrees toward 180 degrees. Nothing must be in the way of the braking hand or elbow (such as a rock wall behind the belayer's arm) when the belayer goes into the braking position; also, this critical task must not require an unnatural body twist or motion.

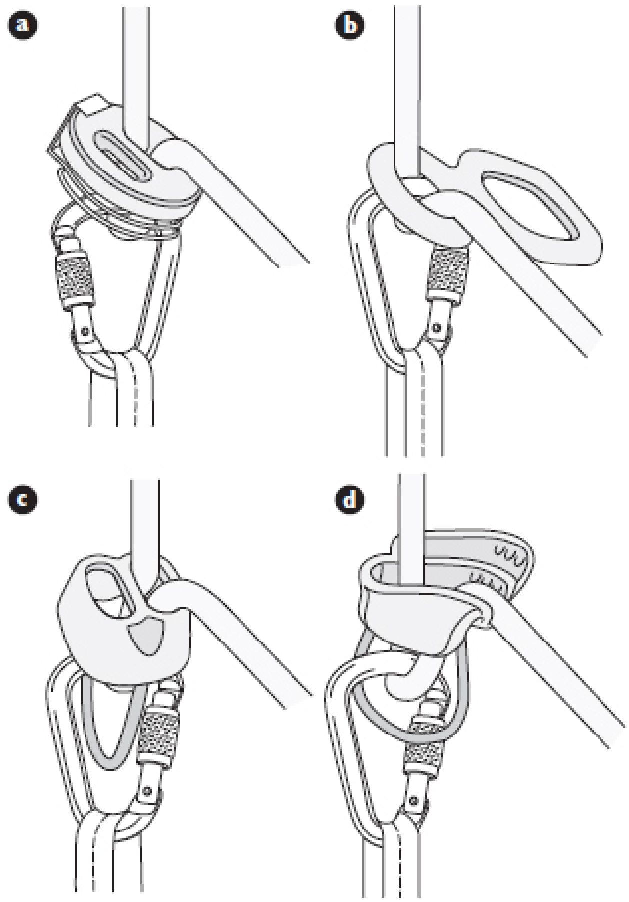

Fig. 10-5. Belay devices: a, Sticht plate; b, figure eight; c, tubular device; d, tubular device with friction grooves.

One of the simplest and most convenient belay methods is to clip a belay device in to a locking carabiner on the harness, which is typically clipped through a sewn belay loop, as shown in Figure 10-10. It is important to follow the manufacturer's instructions for clipping in properly, as to do otherwise loads the harness in ways it was not designed for and may lead to failure. Many harnesses have a sewn-in label showing the proper way to wear the harness and clip in to it.

Types of Belay Devices

Before mechanical belay devices were invented, climbers ran ropes around their hips and relied on the friction of the rope around their body to arrest a fall. Nowadays, with the advanced dynamic-rope technologies and mechanical belay devices, climbers should seldom rely on their body as a belay device, though the hip belay may be useful in some situations (see "Using the Hip Belay" later in this chapter).

There are many popular belay devices; this section describes some of them. When using any belay device, always read and follow the manufacturer's instructions carefully; be certain that you fully understand these instructions and that the device is properly rigged each time you use it. Note that each belay device works with only a certain range of rope diameters.

Aperture belay devices include Sticht plates (fig. 10-5a), figure eights (fig. 10-5b), and tubular devices (fig. 10-5c). These devices all work in a similar fashion: they simply provide an opening through which a bight of rope is pushed and then clipped in to the locking carabiner on the belay loop of the seat harness, as shown in Figure 10-10. The Sticht plate was the first mechanical belay and rappel device, created in the 1960s and named after its designer, Fritz Sticht. Sticht plates have become less popular now that more-modern tubular designs provide smoother control over the rope and are less prone to jamming. Figure-eight devices were originally designed for rappelling, not belaying, but some figure-eight devices can serve both functions. Make certain that the figure-eight device is intended for belaying use by the manufacturer; many are not. Although figure-eight devices are not used as much these days as a belay and rappel device because of their lack of versatility and because they tend to twist the rope, some climbers still prefer them for their smoothness, especially when the load is heavy.

Most current belay devices are a cone-shaped or somewhat square tube, as shown in Figure 10-5c; the Black Diamond ATC (air traffic controller), DMM Bug, and Trango Pyramid are examples of such devices. Plates and tubes must be kept from sliding down the rope and out of reach, so most of these devices include a wire loop that is clipped in to the locking carabiner on the seat harness, as shown in Figure 10-4. The connection to the harness must be long enough so that it does not interfere with belaying in any direction.

Many current tubular devices have a high-and a regular-friction mode, usually achieved by adding V-shaped slots and/or ridges to one side of the aperture: Figure 10-6a shows the regular-friction mode. In high-friction mode (fig. 10-6b), the device is rigged so that the rope going to the braking hand is pulled into the narrower V slot or over the ridges to increase the braking force. This is useful when extra friction is desirable for belaying and rappelling.

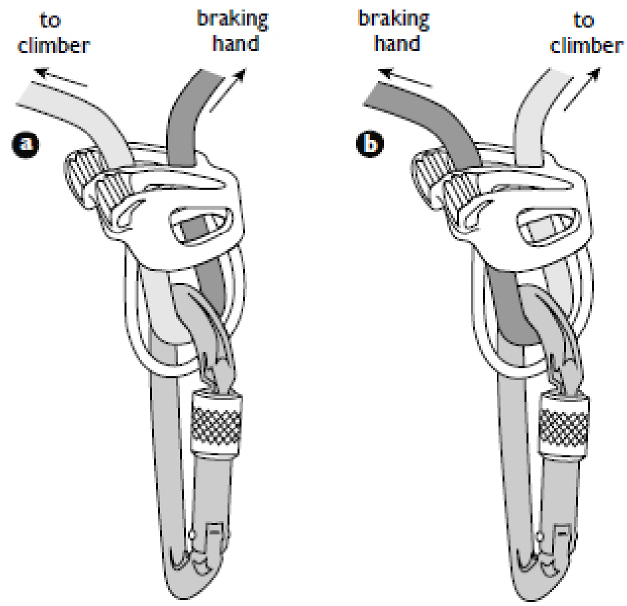

Fig. 10-6. Aperture belay device: a, in regular-friction mode; b, in high-friction mode.

Auto-locking belay devices are designed to function in the same way as a standard aperture device, but they also have an alternative rigging mode that provides a secure means of belaying one or two followers directly off an anchor. Typical examples include the Petzl Reverso 4 and Black Diamond ATC Guide, but many climbing equipment manufacturers have their own versions of auto-locking belay devices. Most work in a similar way. Most of these devices can be used to belay two followers at the same time. Follow the manufacturer's instructions to safely use these devices. Note that auto-locking belay devices are not hands-free devices: they still require the belayer's braking hand to provide the initial force. The braking hand must never lose its grip on the rope.

These devices look similar to other aperture devices and may be used off the harness in the same way as a standard aperture device; but in auto-locking mode, the device is connected directly to the anchor with a locking carabiner while the rope runs through the device and through a second locking carabiner (fig. 10-7). When the device is rigged this way, the belayer can easily pull the rope in, but if the climber's strand is loaded, as in a fall, the rope locks down on itself. When the climber falls, the climber's strand of the rope is loaded with the climber's weight, and that loaded strand presses on the braking strand, preventing it from moving, similar to trying to pull a rug out from under someone who is standing on it.

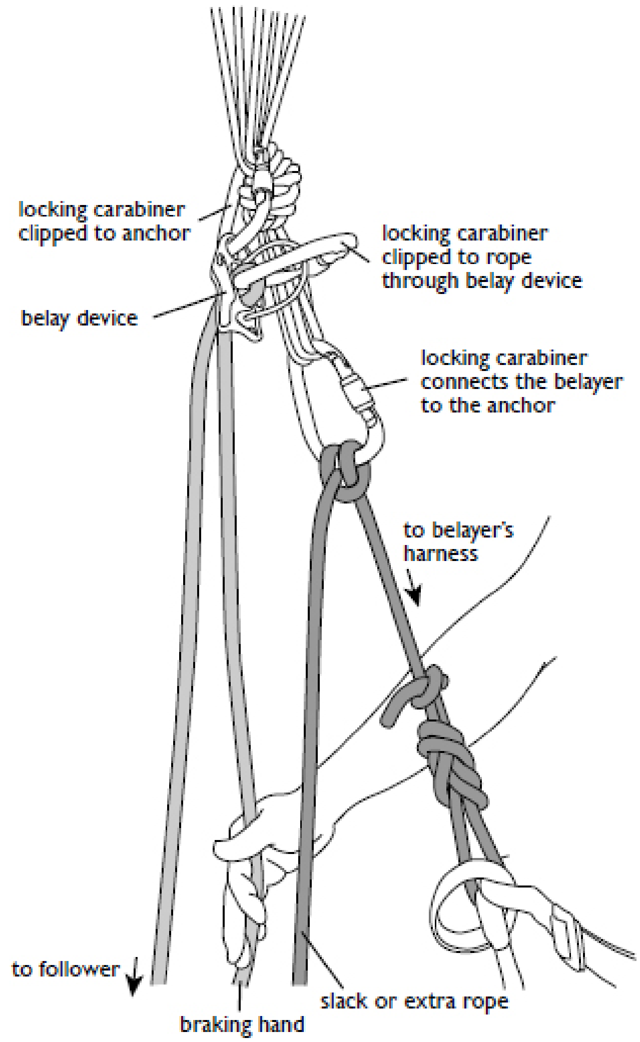

Fig. 10-7. Auto-locking belay device rigged in auto-locking mode.

If the belayed climber falls and is unable to unload the device, the belayer must have a way to unlock the device. To release the device, the belayer needs to find a way to lift the loaded climber's strand off the braking strand. A climber's fingers do not have enough strength to do that, so the belayer can use a carabiner (or any rod that is strong enough) as a lever—or, alternatively, the belayer can attach a cord and redirect his or her body weight to pull against the load. Many newer auto-locking devices have a hole specifically designed for attaching a cord or carabiner (fig. 10-8) to release a locked device in order to lower the fallen climber. Otherwise, it would be necessary to attach a raising system to the rope to take the fallen climber's weight off the device so it can be unlocked.

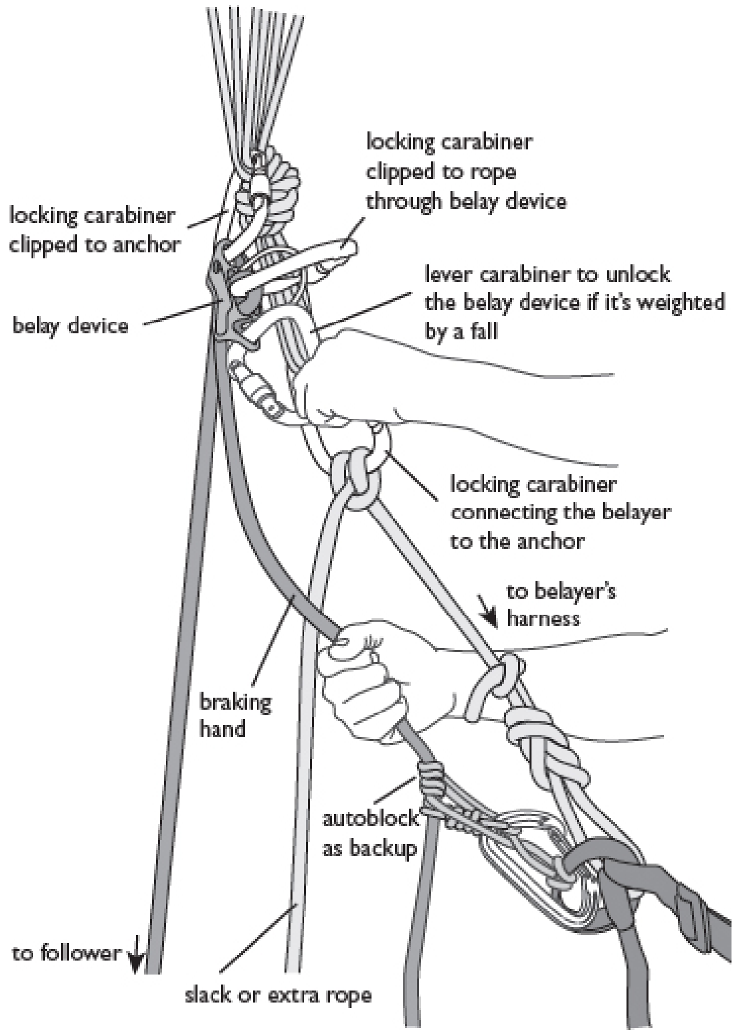

Fig. 10-8. Releasing a loaded auto-locking belay device.

Assisted-braking belay devices are specialized devices with an internal cam that locks down on the rope when the rope suddenly accelerates in a fall; this locking action creates a braking force that is not dependent on resistance from the belayer's grip (fig. 10-9b). Models include the Petzl Grigri+ (fig. 10-9a), Trango Vergo (fig. 10-9c), and Edelrid Eddy. Popular for gym, sport, and aid climbing, they have definite advantages when used properly. For example, they enable a smaller, lighter belayer to confidently arrest and hold even heavy partners or to stop long falls. All current models have a release mechanism, a lever, that allows controlled rappelling or lowering of a climber on top-rope (fig. 10-9d).

These devices have a tendency to lock up when the lead climber makes a sudden move up or when the belayer feeds the rope too quickly. It is extremely important to carefully follow manufacturer's instructions and test proper setup each time the device is rigged. Disadvantages include their greater weight and bulk. It is also harder to give a soft and dynamic belay with an assisted-braking belay device, compared with tubular belay devices, because the former catches the rope much more quickly. With assisted-braking belay devices, the belayer often must resort to body movement to soften the catch. These devices also cannot be used to rappel on two strands, hence they are not suitable for alpine climbing. Note that assisted-braking belay devices are not hands-free devices: they still require the belayer's braking hand to provide the initial force. The braking hand must never lose its grip on the rope.

Belaying Technique When Using a Belay Device

This section describes the technique of belaying a climber off the harness using a belay device. To assume the belay position, grab the rope with the braking hand, with the thumb pointing upward and the palm facing yourself or the ground. This is a natural position in which your hand has the greatest strength. Make sure the belay device, the rope, and the harness's belay loop are not twisted. Grip the rope with the feeling hand at your eye level, feeling the slack of the rope, but not pulling it, as shown in Figure 10-10a.

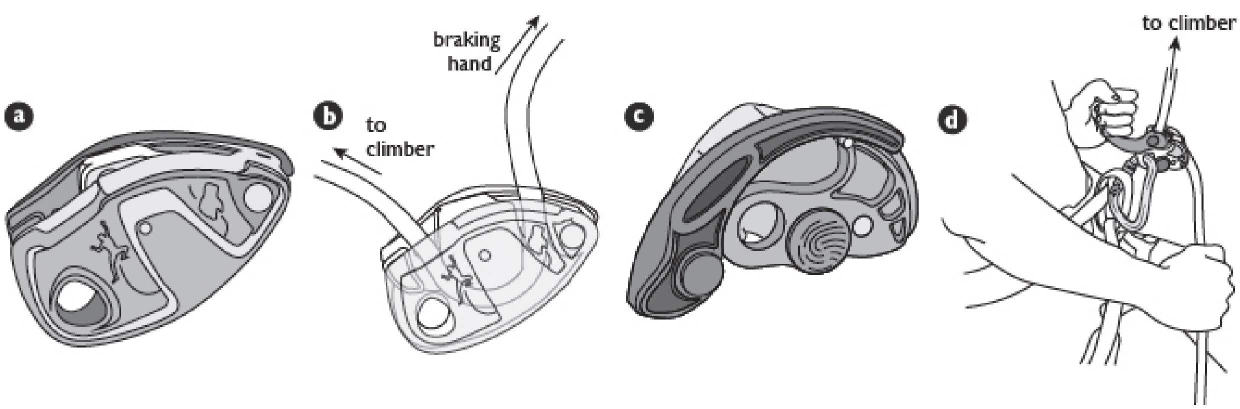

Fig. 10-9. Assisted-braking belay devices: a, Petzl Grigri+; b, Grigri+ in belaying mode; c, Trango Vergo; d, Vergo in lowering mode.

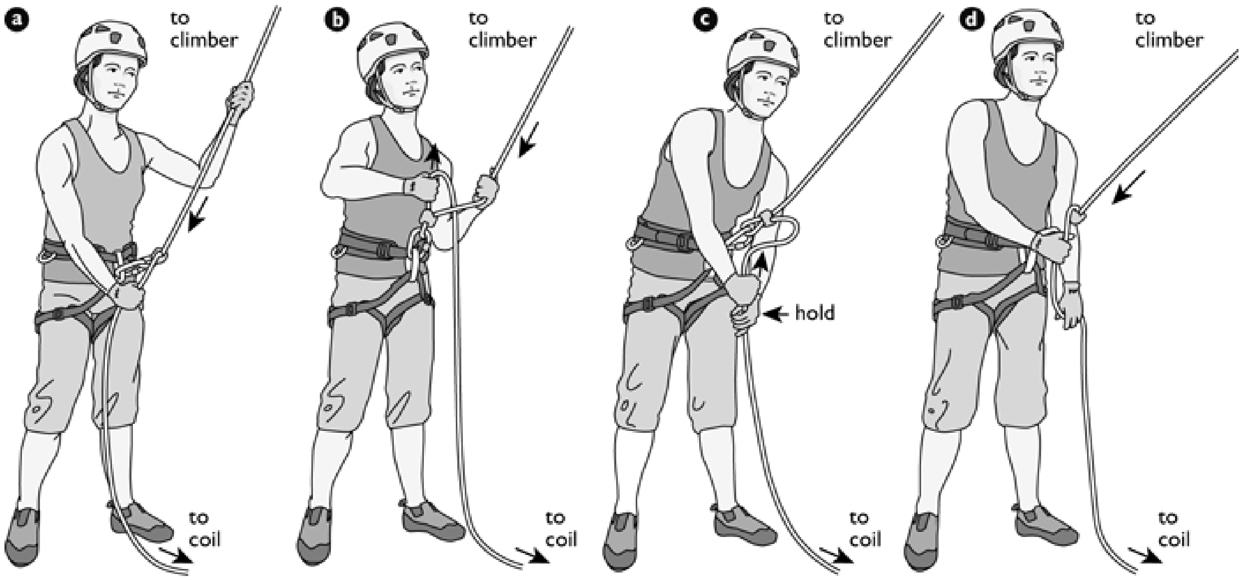

Fig. 10-10. Hand motions for taking in rope from a standing belay, with the braking hand never leaving the rope:
a, start with both hands on the rope with the feeling hand extended and the braking hand close to the body; b, pull the feeling hand toward your body and the braking hand away from your body; c, drop the braking hand into the braking position and move the feeling hand to grasp the rope under the braking hand; d, slide the braking hand back toward your body while maintaining the braking position.

Taking in the rope. Known as **PBUS** (pull, brake, under, slide), this current standard technique is taught at most rock gyms and by most climbing guides. With both hands on the rope, start with the braking hand close to the body and the feeling hand extended to eye level (fig. 10-10a). First, **pull** down the climber's strand of the rope with the feeling hand; at the same time, pull the braking hand away from your body to pull the rope through the belay device (fig. 10-10b). Then without losing the grip, **brake** by dropping the braking hand down to the braking position. Place the feeling hand **under** the braking hand and grasp the rope (fig. 10-10c). Without removing the braking hand from the rope, **slide** it up until it's close to the belay device and grasp the rope again (fig. 10-10d). Then move the feeling hand back up on the climber's strand of the rope. Repeat the sequence as often as needed to take in the appropriate amount of rope. Remember that the braking hand must never leave the rope.

Letting out the rope. It is easy and intuitive to let out the rope. With the feeling hand, pull the rope away from your body while using the braking hand to feed the rope toward the climber. Again, the braking hand must never leave the rope. If you are letting out a lot of rope quickly, slide your braking hand away from your body until it is fully extended, so you can maximize the amount of rope you can feed to the feeling hand in one motion.

USING THE MUNTER HITCH

The munter hitch is an effective alternative to using a belay device. It uses only the rope, a specialized carabiner, and a hitch to provide the friction necessary to stop a fall. Efficient belaying with a munter hitch requires an HMS-type (pear-shaped) carabiner with an opening large enough to allow the hitch to feed through smoothly. As a result of its configuration, the hitch multiplies the effect of the braking hand with friction created by the rope being wrapped on itself and around the HMS carabiner.

The munter hitch is unique in that it provides sufficient friction regardless of the angle at which the braking end of the rope is held. With regular aperture belay devices, maximum friction is generated when the braking hand strand of the rope is held at an angle of 180 degrees from the strand of rope attached to the climber, as shown in Figure 10-4. These devices are useless when both strands are aligned. In contrast, the munter hitch, because of the way it wraps around the HMS carabiner, actually generates *more* friction when both strands of the rope are aligned (see Figure 9-26 in Chapter 9, Basic Safety System). At an angle of 180 degrees, it still provides about 85 percent of the maximum friction. In other words, you can hold the munter hitch at any position and still have sufficient friction.

Because no special braking position is required, the munter hitch has an advantage over most belay devices in that if a climber fall takes a belayer by surprise, the hitch will function even if the belayer does no more than firmly grip the rope. With the munter hitch, rope handling is quick and easy, making the munter hitch an ideal method when climbers are moving rapidly over easy ground. Because no specialized equipment other than an HMS carabiner is required, the munter hitch provides a ready backup belay method if a belay device is lost.

The munter hitch has some drawbacks as well as advantages. It can kink the rope more than other belay methods, but this can be minimized by allowing the rope to feed freely unless needed to arrest a fall. To unkink the rope, shake it out while it is hanging free. The munter hitch can also unscrew the lock on a carabiner gate as the rope runs across the gate. Pay attention to the carabiner gate when using a munter hitch. After a big fall, the outermost layer of the rope's sheath may be glazed—which is only cosmetic; this glazing, which also occurs to some degree with mechanical belay devices, wears off with use.

USING THE HIP BELAY

The hip belay—also called the body belay—is a belay method in which the rope is wrapped around the belayer's body to generate enough friction to stop a climber's fall. The belayer clips in to a solid anchor and assumes a stable stance facing the direction of an anticipated pull on the rope. The rope from the climber passes around the belayer's back and rides just below the top of the hips (fig. 10-11a). To arrest a fall, grip the rope tightly with the braking hand and pull the braking arm across the stomach into the braking, or arrest, position (fig. 10-11b). The braking action must be practiced and learned well so that it becomes automatic; immediately going into arrest position as soon as a fall is sensed is the best way to stop a fall using the hip belay. The braking position increases the amount of friction-producing wrap of the rope around the body, thereby increasing the stopping force.

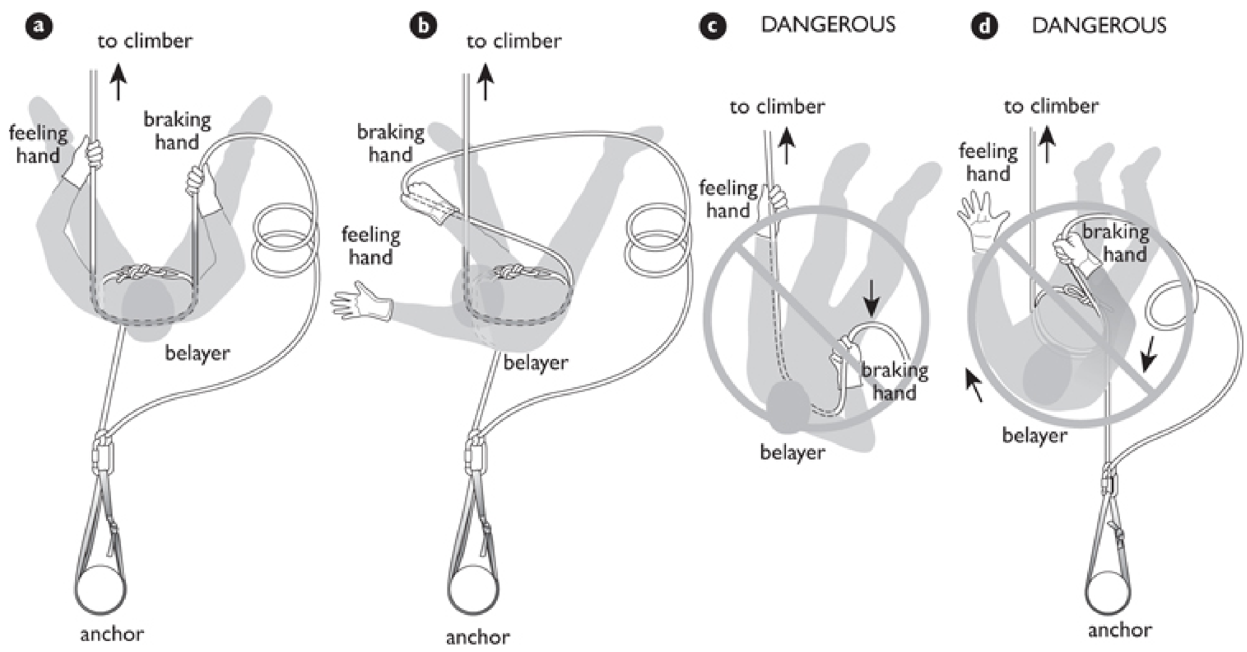

Fig. 10-11. The hip or body belay: a, the belayer is anchored and ready to arrest a fall—the rope goes from the braking hand around the back (to produce friction) and to the climber; b, the braking position—with the braking arm extended across the stomach to create additional friction; c, if the elbow of the braking hand is not straightened before braking begins, then the braking arm may be pulled into a helpless position (dangerous); d, having the anchor attachment on the same side as the braking hand can allow the hip belay to unwrap (dangerous).

Because the force of a fall is dissipated as friction against the belayer's body, a belayer stopping a severe fall can suffer serious rope burns. Protective clothes are required to prevent this. Even fairly minor leader falls can melt and severely damage expensive synthetic garments. If a belayer is burned badly enough, the belayer could drop a falling climber. Because the belayer's hands provide a greater proportion of friction in the hip belay than in other methods, gloves are essential to protect the hands from burns. A tighter grip causes less-severe burns because faster stops and less rope slippage generate less heat. Another problem with the hip belay is that if the climbing rope runs over the anchor attachment during a fall, the anchor attachment may be burned.

Because the hip belay requires more time for the belayer to attain braking position and generates less braking force than any other method, more rope slippage generally occurs and the climber usually falls farther. If the belay stance fails, it is much more likely that the belayer will lose control of the rope than with other methods. In summary, all elements of the hip belay must come together to make it work effectively during a long, hard fall.

Despite its drawbacks as a general-purpose belay method, the hip belay does have advantages that make it worth learning, if only for special purposes. With the hip belay, the belayer can take in rope much faster than with other methods, and the hip belay can be set up quickly with a minimum of equipment. It is probably most useful when belaying a fast-moving partner over moderate terrain. A common and efficient practice is to use a simple hip belay to bring a following climber up a relatively easy pitch and then switch to another method when this climber leads the next pitch.

The hip belay can also be useful for belaying on snow, where it may be desirable to have a more dynamic belay because anchors are absent or suspect (see Chapters 16, Snow Travel and Climbing, and 19, Alpine Ice Climbing). Also, if climbers have lost or forgotten their belay device and do not have the right kind of carabiner (pear-shaped carabiner is recommended) for a munter hitch, there may be no choice but to use the hip belay.

Special Considerations in Using the Hip Belay

When using the hip belay, climbers must keep a number of special considerations in mind. To catch a fall with this method, straighten the elbow of the braking arm before beginning to grip hard. Then bring the braking arm across in front of your body to increase the amount of wrap for maximum friction. The natural reaction is to grip the rope first, but this may pull the braking arm into a helpless position (fig. 10-11c), requiring the belayer to let go and grasp the rope again. An optimal braking position can be learned only with practice, ideally with actual weights being dropped and held.

When the belayer attaches to the anchor, rig the connection to the side opposite the braking hand. Note that this is different from tying in for belaying with a mechanical device. If the braking hand and anchor rope are on the same side of your body, the force of a fall can partly unwrap the rope from around your body (fig. 10-11d), decreasing both friction and stability.

Another precaution is to clip a control carabiner on your seat harness (fig. 10-12). The carabiner goes in front, or on the same side as the rope coming from the climber, but well forward of your hip bone. Clipping the rope in to this carabiner keeps the rope where it is needed (at your hip), counteracts body rotation, and adds friction to the system.

Be aware of any potential direction of pull from a fallen climber, and take advantage of a stable stance and the anchor attachment to keep you and the climbing rope from being pulled out of position, causing loss of control of the belay. Wrapping the rope around your back and above the anchor attachment will prevent the rope from being pulled below your seat. If the pull will come from above with no possibility of a downward pull, wrap the rope around your back and below the anchor attachment to prevent the rope from being pulled over your head.

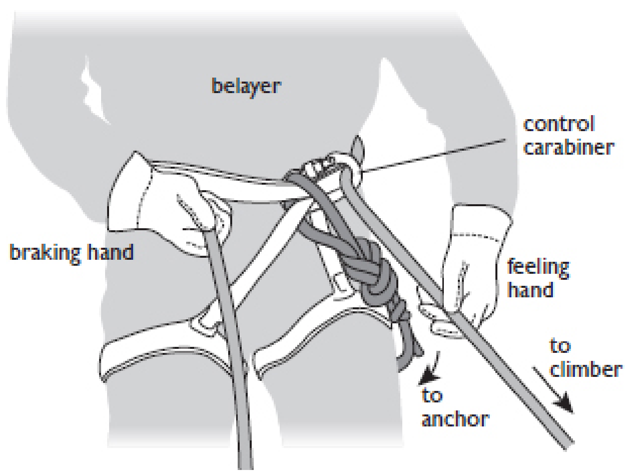

Fig. 10-12. Control carabiner added to a hip belay.

CHOOSING A BELAY METHOD

It might seem that the choice of a general-purpose belay method would be a simple matter of choosing the method that exerts the most stopping force. However, even if two belay methods differ significantly in the maximum stopping force they can exert, there may be little practical difference between them. For most falls, the belayer can exert sufficient force regardless of the method.

However, the choice of belay methods does matter in the case of a high-factor fall on steep terrain, with little or nothing to produce friction other than the belay; in this situation, the belay method can mean the difference between the rope running and not running. These types of falls are the critical ones, wherein there is little margin for error.

If the rope starts to run while the belayer is holding a fall, the climber will fall that much farther than if the fall were held with no run-through. A longer fall is generally undesirable and potentially dangerous. However, in any protected leader fall, it is important to consider that the force acts on the protection as well as the climber: the maximum force on the top piece of protection is one and a half to two times as high as the maximum force on the climber—in a high-factor fall on vertical rock, the maximum force on the climber can easily reach 7 kilonewtons (more than 1,500 pounds). If the protection fails under this force, the climber will definitely fall farther. To reduce this force on the protection, some belayers choose a relatively weak method of belaying, one that will let the rope start to run at a lower force to lessen the likelihood of the protection failing.

The leader can also effectively limit the maximum impact on individual protection placements by using a load-limiting runner (see "Runners" in Chapter 9, Basic Safety System). The leader may clip in to a suspect placement with one of these devices without compromising overall belay strength. During a fall, a force greater than the runner's activation point (usually 2 kilonewtons) will start to tear the load-limiting runner's weak bar tacks. As the total energy of the fall increases, more of the weak bar tacks on the load-limiting runner will fail and can reduce by 3 to 8 kilonewtons the peak load that the fall imposes on the placement.

ANCHORS

Secure anchors are vital. Climbers should remind themselves that they cannot anticipate the moment when they will have to stop an extreme leader fall. And when it happens, the anchor must hold, or the climbers—leader and belayer both—will suffer a catastrophic fall.

The word "anchor" refers to a whole system. An anchor can be composed of many components and one or more anchor points: it may include natural features, fixed protection pieces, removable protection pieces, runners, carabiners, and the climbing rope itself.

SELECTING AN ANCHOR

This section gives a few tips on selecting good anchors for belays, but for full details on finding and using natural features and on setting artificial anchors on rock, snow, and ice, study Chapters 13, Rock Protection; 14, Leading on Rock; 16, Snow Travel and Climbing; and 19, Alpine Ice Climbing. Also see Resources for all these chapters.

When selecting belay anchors, always consider every possible direction from which a force may load the anchors. Ideally, the anchor should be directly above the last piece of protection, or as close to it as possible. If a follower falls, the direction of the pull is from the last piece of protection below the belay anchor (fig. 10-13). Once that piece is removed or fails, then the follower pendulums to and past the fall line (fig. 10-14). In a free-hanging situation without friction, the follower can pendulum past the fall line to the same angle as the initial angle between the rope and the fall line. The leader should pay attention to the angle and distance between the anchor and the last piece of protection for the sake of the follower. A big angle puts the follower at a higher risk if he or she falls. A belay anchor directly above the last piece minimizes such a pendulum.

If a leader falls, the *belayer* is pulled toward the first piece of protection, which is usually upward. This is a good reminder to make sure the belay anchors will withstand a pull from any conceivable fall.

Natural Anchors

A large natural feature, such as a good-sized, well-rooted live tree or a pillar of sound rock, can make an ideal anchor. Climbers can also build and remove an anchor very quickly on such features.

Trees and large bushes provide the most obvious anchors, but do not trust a tree or shrub that is loose or appears weak or brittle. Carefully evaluate tree anchors near or on cliff faces; these trees may be shallow-rooted and not as solid as they appear. Test all trees by pushing against them with one foot.

Attaching to an unquestionably stout tree branch rather than low on the trunk helps limit the rope's contact with the ground, reducing abrasion on the rope and reducing the risk of falling rock. However, connecting to a branch rather than the trunk puts more leverage on the tree, increasing the danger that the tree could be uprooted. Be cautious about using a bush as an anchor. If you use one, consider placing an additional anchor or two for safety. Also be careful about using trees and bushes in very cold weather, when their wood can become brittle.

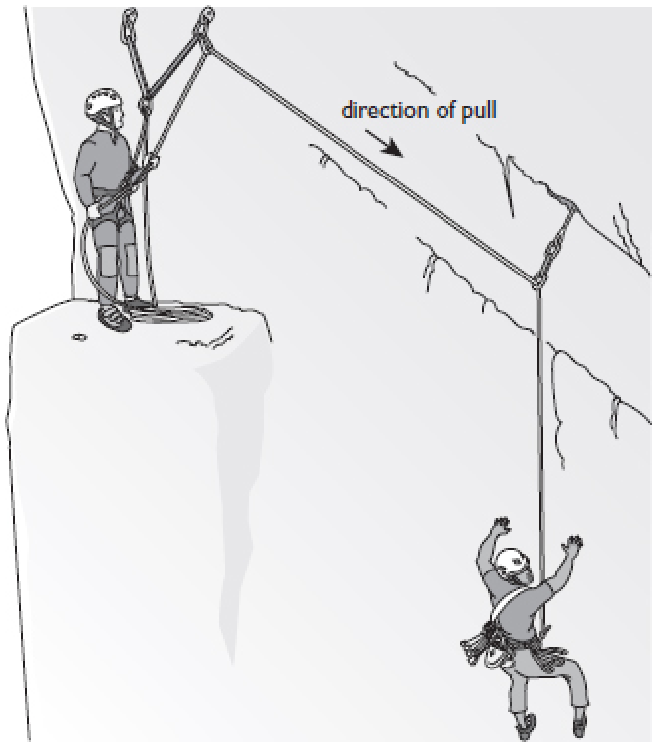

Fig. 10-13. When a follower falls, the direction of pull on the belayer is from the last piece of protection.

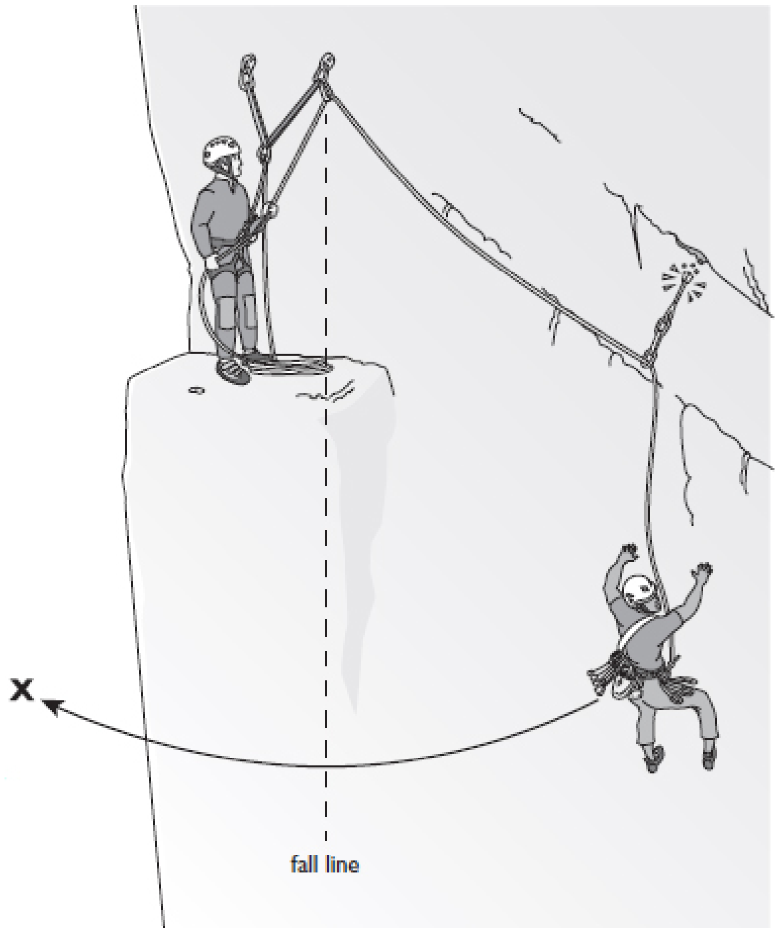

Fig. 10-14. If the last piece of protection is removed or fails, then the follower pendulums to and past the fall line.

Rock features—horns, columns, rock tunnels such as those formed by the contact point between two boulders, large and flat-bottomed boulders—are commonly used as anchors. Note that it is easy to overestimate the stability of large boulders. As important as size are the shape of the boulder's bottom, the shape of the socket it is sitting in or the angle of the slope it is on, and the ratio of its height to width. Imagine the hidden undersurface and the block's center of gravity: Will it pull over under a big load? Test it gently at first so you do not send it over the edge. Occasionally, climbers have to set up a belay at a jumble of large boulders, where some are resting on others. A boulder underneath other large boulders might be quite solid but can be difficult to assess even with careful checking.

Check any rock feature used as an anchor for fracture lines, which may be subtle and difficult to judge, such as at the base of a rock horn or near the edge of a crack. When using protection in a crack for an anchor, check to see whether one side of the crack may actually be a detachable block or movable flake; a crack has to widen only a fraction of an inch under the force of a fall for the protection to pull out.

Always evaluate the probable strength and stability of a rock feature or chockstone prior to using it as an anchor. Place a sling on a rock feature well below the feature's center of gravity to reduce the chance of it tipping or dislodging. If there is any question about a natural anchor, test it before gear is attached, never after the rope or the belayer is clipped in. (See also "Natural Protection" in Chapter 13, Rock Protection.)

Fixed Anchors

Artificial (manufactured) anchors include bolts and pitons that, once set, are usually left "fixed" permanently in place. On established routes, climbers may encounter previously placed bolts and pitons; in unknown alpine terrain, some climbers carry pitons and a hammer to set anchors.

Bolts are permanent pieces of artificial protection that are driven into a hole that has been drilled into the rock. Bolt hangers, which may or may not be permanent, allow carabiners to be attached to bolts (see Figure 13-6 in Chapter 13, Rock Protection). *Pitons* are metal spikes pounded into cracks. The blade of the piton is driven into the crack; the eye is the point of attachment for a carabiner (see Figure 13-8 in Chapter 13, Rock Protection). On rock climbing topo maps, bolts and fixed pitons are often shown as "x" and "fp" (for "fixed protection"), respectively (see Figure 14-3 in Chapter 14, Leading on Rock).

Climbers may also encounter other fixed pieces—hardware such as nuts, hexes, and so forth—which are normally removable protection that became fixed when someone could not remove them. Fixed pieces left in place by previous climbers must be evaluated for safety. Bolts and fixed pitons are often solid if of recent vintage, but older placements are notoriously difficult to assess (see "Fixed Protection" in Chapter 13, Rock Protection). Old 1/4-inch bolts are no longer the accepted standard and should not be trusted.

Many popular routes now feature fixed anchors at belay stations; commonly these consist of two or more bolts, sometimes connected with a short section or sections of chain.

Removable Anchors

Where natural features or fixed protection are not available, climbers build anchors and remove them as they complete a pitch (see Chapters 13, Rock Protection, and 14, Leading on Rock, for rock anchors; Chapter 16, Snow Travel and Climbing, for snow anchors; and Chapter 19, Alpine Ice Climbing, for ice anchors).

EQUALIZING THE ANCHOR

Commonly, belays use two or three anchor placements, so the anchor system has redundancy and is not dependent on any single anchor placement: if one anchor placement fails, one or both of the two other anchor placements may still hold. The reliability of multiple anchor placements is further increased by distributing the load among the placements, a technique called *equalization*.

Most ways of equalizing the load on multiple anchor points make use of runners or loops of accessory cord (both of which are called *legs*) to connect the anchor points into a single *power point*, or *master point*. These equalization methods can be roughly divided into two types: static equalization and self-equalization. *Static equalization* distributes the load in only one direction. *Self-equalization* distributes the load in a range of directions. Various commonly used equalization methods have advantages and disadvantages, and no one choice is preferable across all scenarios. It is important to understand the variables involved, to know how anchors function in different situations, and to make informed decisions about how best to construct anchors in various configurations. Ultimately, any multipart anchor is only as good as its individual components, and safety depends on skillful placement of individual pieces.

In building a multipoint anchor, the first question to ask is, how many anchor points are needed? There is no universal answer to this question. It depends on lots of factors: the maximum possible force, the quality of rock or natural protection, et cetera. But the general rule of thumb is, to build two bombproof pieces or three good pieces. As your confidence in pieces lowers, add more pieces and do a better job of equalizing them.

The next factor to consider is the angle formed by all the legs at the power point: the main connection point of the anchor system. This angle is sometimes called the *V-angle* because the legs form the shape of a V. Figure 10-15 shows a two-point anchor, in which the two legs are symmetric. According to rules of basic physics, the bigger the angle, the more force is delivered to each anchor point and the less effective the equalization is.

At a V-angle approaching 0 degrees, or when the two anchor points are perfectly aligned, each anchor point receives half the load (fig. 10-15a). Strive to keep the V-angle of a belay anchor system less than 60 degrees (fig. 10-15b). With a V-angle greater than 60 degrees, the load on each anchor point increases significantly (fig. 10-15c). When the V-angle is 120 degrees, the force on either anchor point is the same as the load itself (fig. 10-15d). In this case, the force is not reduced at all—the equalization serves no purpose other than providing redundancy (if one anchor point fails, the other takes over). When the V-angle exceeds 120 degrees, the force is amplified, and it grows rapidly as the V-angle increases (fig. 10-16). An anchor system with more than two anchor points is a little harder to analyze, but the principles remain the same: keep the overall V-angle relatively small.

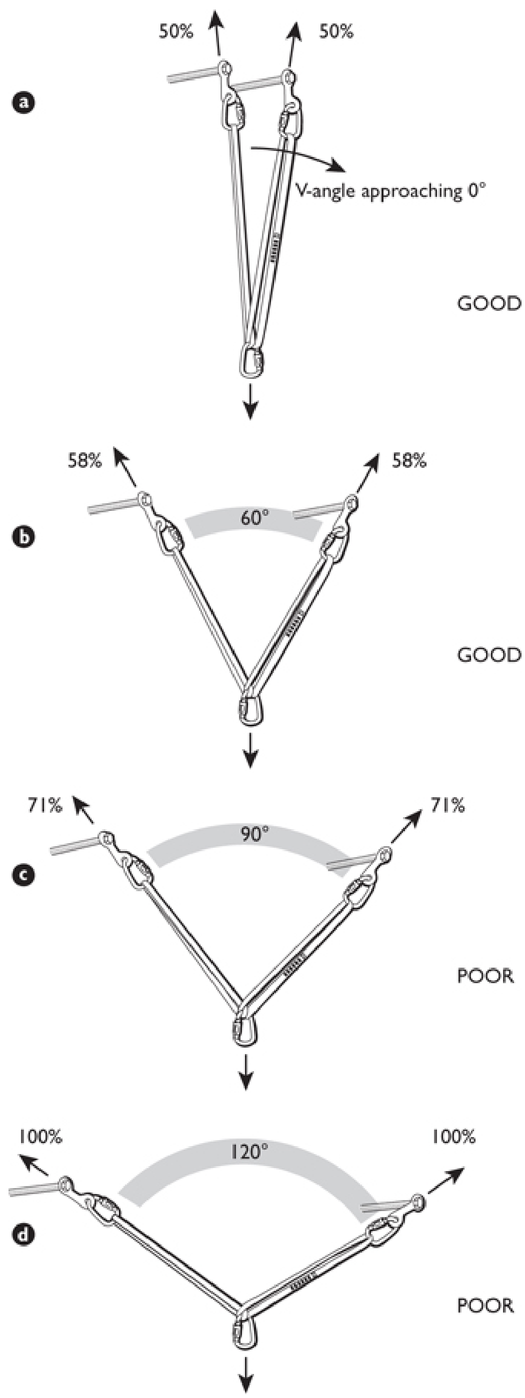

Fig. 10-15. V-angle effect on percent load or force in a two-point anchor system equalized with sewn runners: a, at a V-angle approaching 0 degrees the load is shared equally; b and c, as the V-angle increases, the load on each anchor point increases; d, at angles greater than 120 degrees, the load exceeds 100 percent on each anchor point. Strive to keep the V-angle of a belay anchor system less than 60 degrees.

Static Equalization

With static equalization, the anchor takes the load in only one direction.

Two anchor points. To statically equalize two anchor points, a common method is to clip a double-length (48-inch/120-centimeter) runner in to the two anchor points—one end of the runner to one anchor point, the other end of the runner to the other anchor point—then gather the resulting four strands of the runner, tie them in an overhand or figure-eight knot, and clip a locking carabiner to the resulting loop (power point) that is on the opposite side of the knot from the anchor points (fig. 10-17).

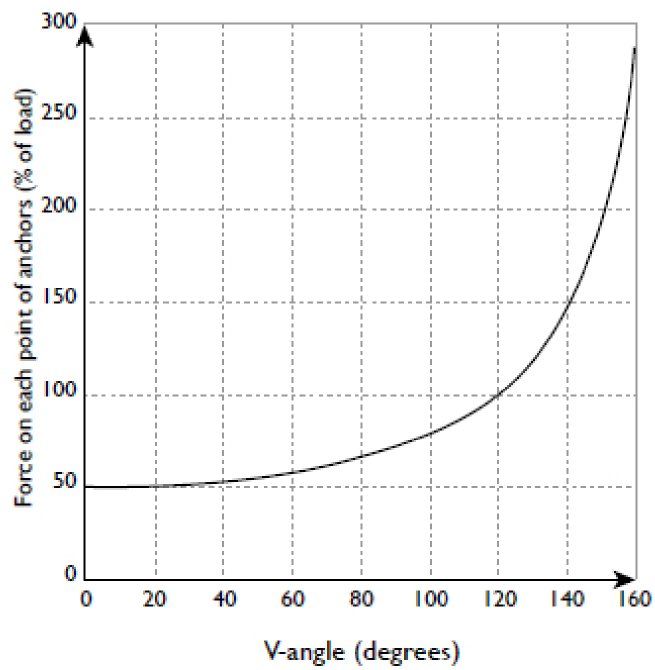

Fig. 10-16. V-angle effect on force multiplication.

Fig. 10-17. Statically equalizing two anchor points with a double-length runner.

The drawback of this method is that the overhand or figure-eight knot is hard to untie after it has been heavily loaded. Also, the knot is usually very small if the runner is skinny, and a small knot on a skinny runner significantly weakens the strength of the runner. To mitigate this problem, climbers can use a *cordelette*, a long runner of about 20 feet (about 6 meters) usually made of 7-to 8-millimeter nylon accessory cord or a small-diameter, high-strength cord of a material such as Spectra or Dyneema. First, double the cordelette to half its length, then create a power point with the loop (fig. 10-18) as for a double-length runner. Alternatively, if the power point must be extended a little farther from the anchor points, clip one bight of the cordelette in to one anchor point and clip both strands of the cordelette to the other anchor point (fig. 10-19a), then tie a figure eight or overhand knot with the resulting six strands to create the power point (fig. 10-19b).

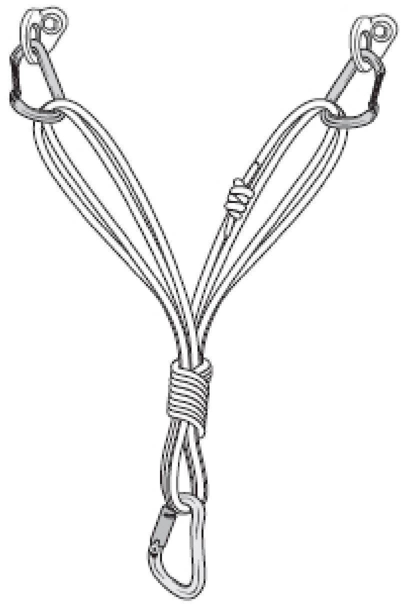

Fig. 10-18. Statically equalizing two anchor points with a cordelette by doubling it and tying an overhand knot to create a power point.

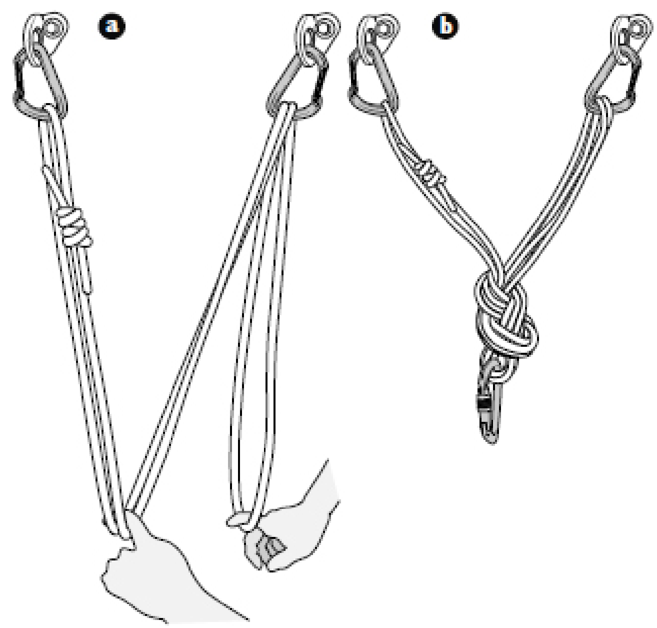

Fig. 10-19. When a bit more length is needed, alternative method of statically equalizing two anchor points with cordelette: a, clip one bight of the cordelette into one anchor point and clip both strands of the cordelette to the other anchor point; b, knot the resulting six strands together to create a power point.

Three anchor points. To equalize three anchor points, clip the cordelette in to each anchor point's carabiner and pull down the top segments between the anchor points (fig. 10-20a). Join these segments with the bottom part of the cordelette by gripping the resulting three loops and connecting a locking carabiner to all three loops (fig. 10-20b). Shift the carabiner around while you gather the strands together to even out the tension in all strands as best you can. Then, while pulling in the anticipated direction of force, tie all three segments together into an overhand or figure eight (fig. 10-20c). Either knot is acceptable; the over-hand requires less cord than the figure eight, but it will be much harder to untie if it is heavily loaded. Pull on the carabiner at the end loop (power point) to make sure all three legs are weighted. Static equalization with a cordelette can also be done with more than three anchor points.

The shelf. In either a two-point or three-point anchor, the end loop (power point) created by the overhand or figure-eight knot is the main attachment point to the belay anchor. Additional connection points, such as a second climber clipping in on arrival at the belay station, can be made by creating a "shelf" consisting of all anchor placements above the power point: clip a carabiner to one strand coming from each of the anchor points (fig. 10-20d). It is very important that only one strand from each anchor point is clipped. A shelf does not exist in an anchor system unless each anchor point has two strands. This shelf can simplify clipping in to or unclipping from a loaded anchor and can avoid much clutter and confusion.

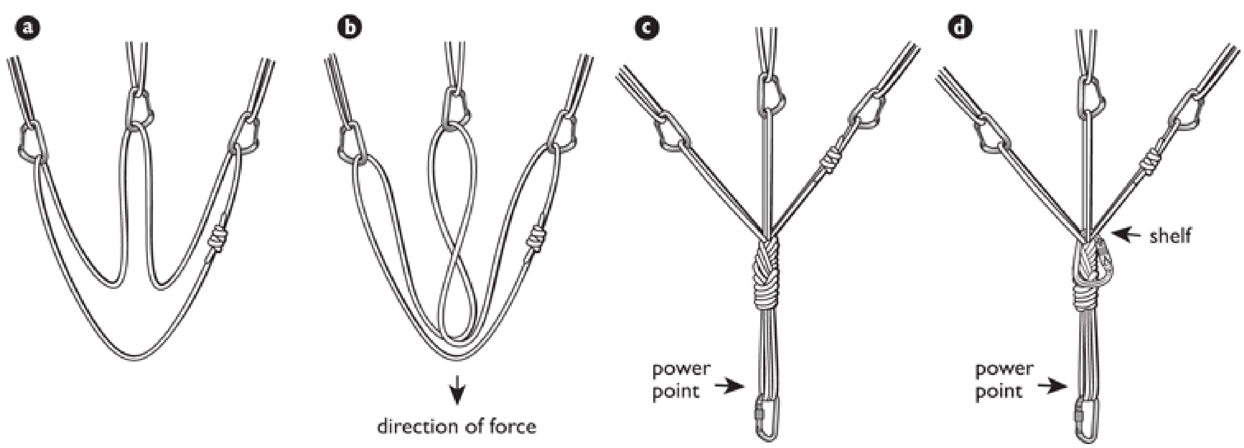

Fig. 10-20. Static equalization of three anchor points with cordelette: a, clip in to each of three anchor point carabiners and pull down the top segments between the anchor points; b, gather the strands together at an even length; c, knot the resulting six strands together to create a power point with a locking carabiner; d, clip another locker into the shelf.

Uneven distribution of forces in static equalization. Load-testing of cordelettes shows that the ideal, even distribution of forces is not usually achieved using three anchor points: even under ideal circumstances—with three anchor placements symmetrically arranged—the middle leg may be subjected to twice the load of the two side legs (fig. 10-21a). Asymmetrical configurations tend to primarily load the two legs closest to the direction of pull. As the lengths of the different legs become more uneven, as is common when an anchor is rigged in a vertical crack, the lowest leg is subjected to much higher loads than the longer legs (fig. 10-21b). These differences are due to greater elongation that occurs with longer sections of cord. The effects of unevenly rigged configurations can be reduced by extending the individual placements with low-stretch runners to equalize the length of the elastic cordelette legs. Any slack in a leg of the cordelette means that it supports negligible weight and is not equalized.

Self-Equalization

Self-equalization is intended to react to changing load direction and to distribute any force equally among all the anchor components. There are two primary methods of self-equalization.

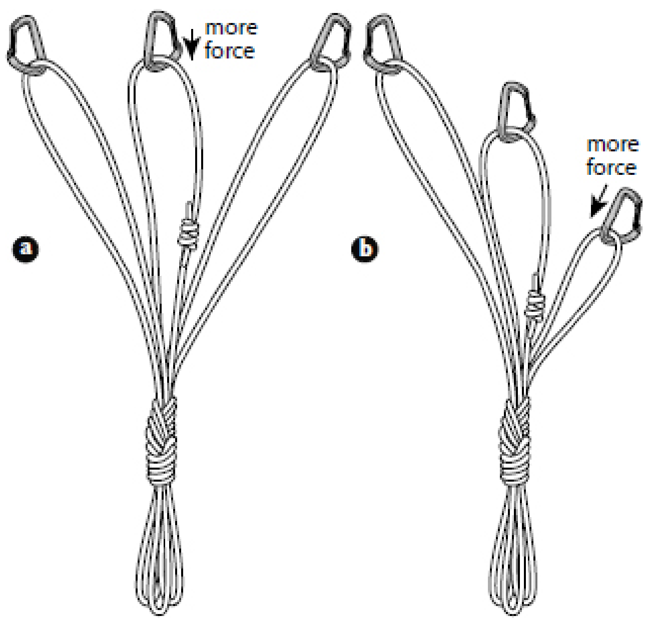

Fig. 10-21. Uneven distribution of forces in static equalization: a, in a symmetrical anchor, pull appears equal on both side strands, but the middle strand may be subjected to twice their load; b, in an asymmetrical anchor, the load is shifted to one side—now the lowest anchor point is subjected to higher loads than the other two longer legs.

Sliding X. Two-point equalizing is the simplest example of self-equalization. Clip a runner in to the two anchor carabiners; grasp the top part of the runner between the two anchor points and put a half twist in it, making an X and forming a loop (fig. 10-22a); then clip the loop and the bottom part of the runner together with a locking carabiner. Tie the rope to this carabiner (fig. 10-22b). It is essential to put the loop in the runner rather than just clipping the top and bottom of the runner. Otherwise, if one anchor point fails, the runner will simply slip through this carabiner, leaving the rope completely unanchored. With a longer runner, the sliding X can work well to equalize more than two anchor points.

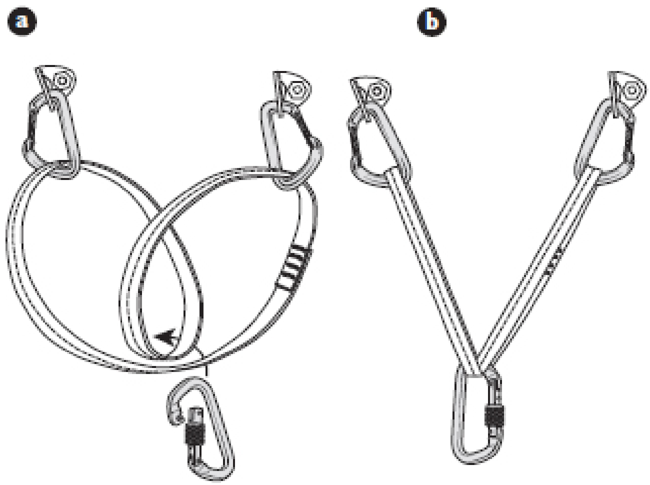

Fig. 10-22. Sliding X self-equalizing anchor: a, grasp the top part of the runner between the two anchor points and put a half twist in it, making an X and forming a loop; b, clip the loop and the bottom part of the runner together with a locking carabiner and tie the rope to this carabiner.

The sliding X method depends on the carabiner attachment sliding freely to self-equalize as the direction of pull changes. Take care in rigging this system to minimize friction between the sliding carabiner and the X. New, thinner sewn runners work better with this method than bulky 9/16-inch or wider webbing. Using larger-diameter carabiners also reduces friction.

Equalization always conflicts with the "No Extension" principle described in the "SERENE Anchor Systems" sidebar. To mitigate, you can use shorter slings or tie limiter knots (usually overhand knots) in the runner (fig. 10-23). Limiter knots minimize the length the anchor can extend as well as limit the extent to which the anchor is equalized. Without such limiter knots, if one anchor point fails, it shock-loads the remaining anchor points, creating a risk of failure.

SERENE ANCHOR SYSTEMS

A simple yet highly effective set of principles to follow when evaluating anchor systems goes by the acronym SERENE. Strive to fulfill these requirements, but note that the principles of "Equalized" and "No Extension" are inherently in conflict with each other. Climbers must make conscious compromises.

- **Solid.** Each individual component should be solid to the greatest extent feasible.
- **Efficient.** An anchor system should be efficiently built and dismantled.
- **Redundant.** Always use redundant components in setting up an anchor; this applies not only to anchor points but to all elements in an anchor system.
- **Equalized.** Use a rigging method that tries to equally distribute the load among the various individual anchor points, which greatly increases the reliability of each part of the system.
- **No Extension.** Minimize the possibility that failure of one component in the anchor system will cause the anchor to suddenly extend, which would cause subsequent shock loading and generate dangerously high impact forces on the remaining components.

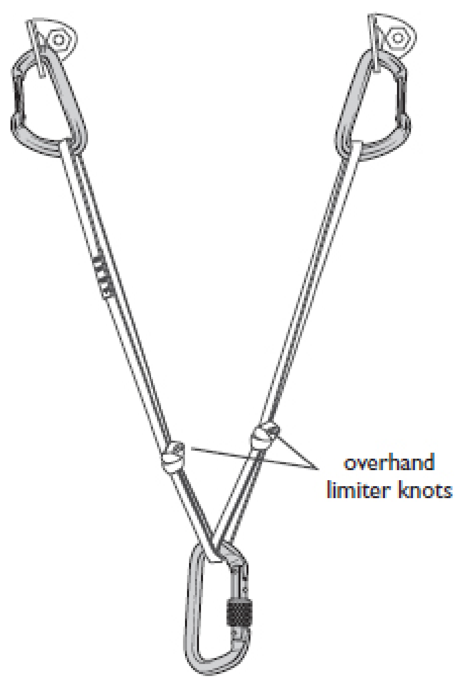

Fig. 10-23. Sliding X with limiter knots.

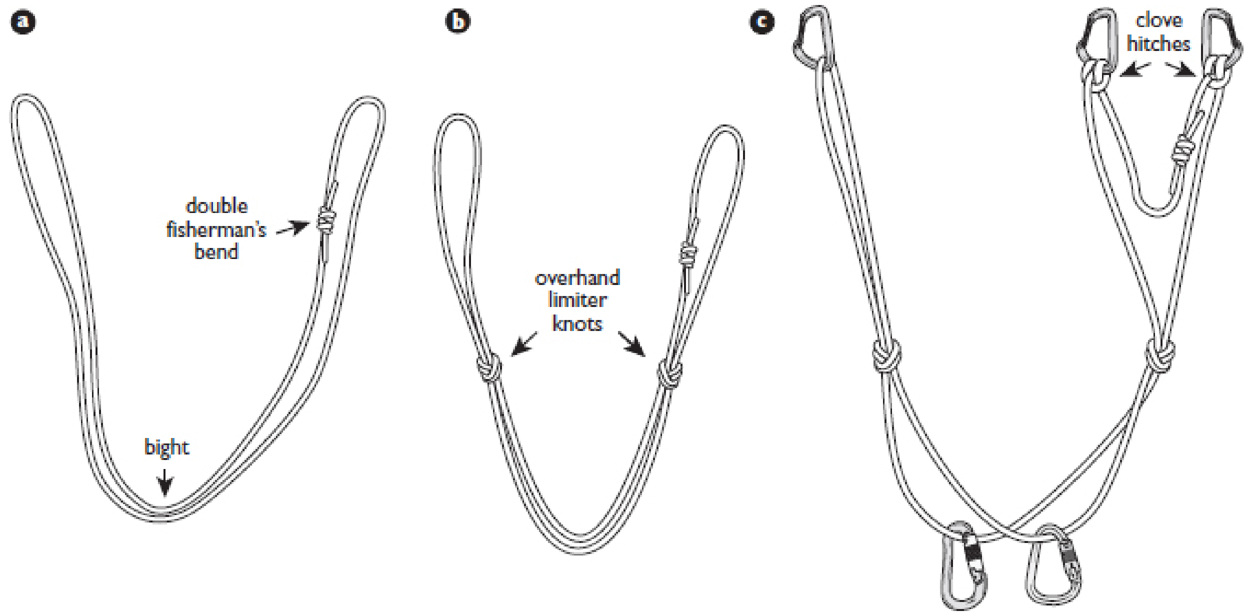

Figure 10-24. Self-equalizing with an equalette: a, grab a bight to form a double-stranded U, with the fisherman's bend slightly offset from one end of the loop; b, tie overhand limiter knots on both sides, creating an isolated center section with two longer side loops; c, connect the side loops to one or more anchor components, and clip in to the central section with two carabiners, one per strand. Here, the right-hand loop is connected to two anchors and equalized with clove hitches.

Equalettes. The equalette was developed to overcome the disadvantages of friction and elongation associated with the sliding X and the potentially poor equalization of a cordelette. It combines elements from both the sliding X and the cordelette.

Equalettes are normally constructed from 20 feet (6 meters) of 7-millimeter nylon or smaller-diameter, high-strength cord. Tie the cord into a loop with a double or triple fisherman's bend, as appropriate to the material. Grab a bight to form a double-stranded U, with the fisherman's bend slightly offset from one end of the loop (fig. 10-24a), then tie overhand limiter knots on both sides of the U to create a section about 10 inches (25 centimeters) long. You now have a loop about 8 feet (2.5 meters) long consisting of an isolated center section and two longer side loops (fig. 10-24b). To build a multipoint anchor using the equalette, estimate the most likely direction that the force of a fall will come from, and orient the central section toward that pull, just as is done when tying a power point in a cordelette anchor system.

Now connect both of the side loops to one or more anchor components. Various configurations are possible using one or more anchor elements per side, equalized with combinations of clove hitches, sliding Xs, and so on. Once the anchor is constructed, clip in to the bottom center section of the equalette, preferably using one locking carabiner for each of the two central strands (fig. 10-24c). If using one carabiner to clip in, instead of two, be sure to put a half twist and loop in one of the strands, just as with the sliding X, to prevent complete disconnection if one side of the equalette were to fail.

In action, this method is designed to self-equalize; the tie-in can redirect itself and maintain load distribution to both sides if the direction of pull changes. If one leg were to completely fail, the limiter knots would keep extension to a reasonable minimum. Though it might seem rather complicated at first, the equalette addresses the criticisms of static and self-equalized systems, and it does not add too much complexity or time to anchor setups.

TYING IN TO THE ANCHOR

The connection between the harness and the anchor, whether the belayer uses a tie-in or a clip-in, should be made with a separate carabiner. The best way for the belayer to connect to the anchor is to tie in with the climbing rope itself, using the first few feet of rope as it comes from its tie-in at the belayer's harness. This ensures that there will be a dynamic link between the belayer and anchor because the rope itself is dynamic.

Climbers often connect to the anchor using runners or their personal anchors. Although this may save time and keeps the maximum amount of rope available for climbing longer pitches, there are hazards associated with this practice. Runners and personal anchors usually have low stretch and do not react dynamically under load. If a climber is any distance above the anchor and falls, the climber may experience a high-factor fall, and even short falls on these low-stretch materials can generate extremely high impact forces. Despite their high strength, such runners, as well as carabiners, have failed under these circumstances. An even bigger risk is the high impact force on the climber in the case of a high-factor fall. Human bodies can usually tolerate 12 kilonewtons without serious or fatal injuries. If using a personal anchor, keep the slack minimal, and do not climb above the anchor.

BELAY POSITION AND STANCE

In deciding on a belay position in relation to the belay anchor, think through the possibilities of what could go wrong given varying positions and potential falls. Try to plan for worst-case scenarios and make sure that a bad fall would be caught by the belay anchor before the belayer would be pulled off the belay stance, which entails the very real possibility of losing control of the belay.

BELAYING A LEADER OR TOP-ROPE CLIMBER

When belaying a leader or a top-rope climber, belay directly off the seat harness. This position puts the belayer's hands and arms in the correct position to manage the rope and to apply braking force the instant a fall occurs.

Anticipate the direction of pull in case of a fall. That force tends to pull the belayer upward and into the rock. If you are not anchored (often the case in single-pitch cragging), you could be slammed into any object in the way. Therefore, it's best to stand close to the rock, with a stable bent-knee athletic stance. No matter which direction you are facing—in toward the mountain or out—keep in line with the anchor and the direction of pull. Otherwise the fall will spin you into an awkward position.

If the belay is anchored, tie in to the anchor no more than an arm's length away, so that you can still reach the anchor if your tie-in is pulled tight by a fall. At the same time, don't tie in awkwardly close to the anchor. Leave a little room for the braking hand, as well as a little slack in the rope should you need to move your body to give the climber a soft catch if a fall occurs.

When belaying a leader, there are many advantages to facing in toward the mountain. Facing in usually allows you to watch your partner climb, enabling you to anticipate movements and to pay out or take in rope more efficiently (see "Rope Handling" below). You may also be able to figure out how to get past some of the difficult sections when it is time for you to climb if you have seen where your partner had difficulty and how your partner negotiated these cruxes. You are better able to see rockfall early and take cover. And you are in the best position to see a leader fall start, so you can quickly brace and go into the braking position. Being able to see a leader's fall begin is a particular advantage when the first piece of protection is low and the force of the fall would tend to pull you into the rock.

These advantages of facing in are lost when belaying in an alcove with a roof or bulge overhead that prevents you from watching your partner. In this situation, you are no worse off facing out when it comes to holding a protected leader fall, and you are probably in a much better position to hold an unprotected leader fall because you are not in danger of being spun around.

When belaying a leader, the most likely direction of pull in the case of a leader fall is upward. But in the severe situation in which the leader falls past the anchor before placing the first piece of protection (factor 2 fall), the force is downward. A belayer with a fairly long attachment to an anchor at about waist height or lower—very commonly seen—is not prepared to stop an unprotected leader fall. If the belayer is standing on a ledge and the partner falls past the belayer, the downward force builds quickly beyond the point that the belay stance can hold. The belayer would then be pulled violently off the ledge or driven sharply down onto it, with almost certain loss of control of the belay and probable injuries. To prevent this possibility, attach tightly to an anchor above waist level so that you cannot be pulled down more than a few inches.

BELAYING A FOLLOWER

When belaying a follower, choose between belaying off the anchor or the harness.

Belay Off the Harness

The traditional way to belay a second is off the harness—that is, the belay device is clipped directly to the belay loop on the harness (fig. 10-25). The advantage is that you can use your body movement to provide a soft belay, which is useful when the anchor is less than bombproof. However, this method doesn't work very well if the terrain below is vertical, because the follower's weight will pull the belayer to the fall line. When that happens, the belayer could be pulled out of the belay stance and end up suspended awkwardly, unable to get the braking hand back into the brake position. Most belay device manufacturers also don't recommend belaying the second off the harness.

Fig. 10-25. Belaying a follower off the harness.

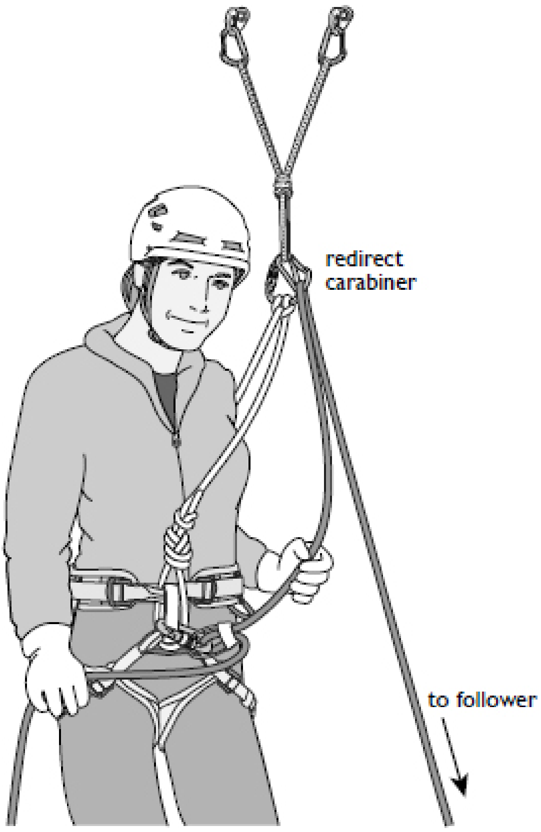

Fig. 10-26. Belaying a follower off the harness with a redirect.

Belay Off the Harness with a Redirect

An improvement over belaying off the harness is to redirect the rope through a carabiner above the belayer's harness, as shown in Figure 10-26. This way, the fall force would come from above instead of below, and the belayer is in a more comfortable position when holding a fall. However, when the belayer catches the fall, the force on the redirect carabiner is twice the body weight of the follower (not considering friction) due to the pulley effect. Be aware of the multiplied force when choosing this method. Also consider using the strongest point in the anchor system for redirection, which is usually the power point or shelf. However, the force multiplication is irrelevant in a hanging belay, wherein the weight of the belayer is already on the anchor.

Belay Off the Anchor

The preferred method of belaying a follower is directly off the anchor (from a belay device or munter hitch on the anchor), sometimes also called a "direct belay." One big advantage is that the belayer is out of the system, hence not subject to the forces created by a fall and therefore less likely to be injured or lose control of the belay. When something goes wrong, it's easy for the belayer to "escape" (see "Escaping the Belay" below). This is also very useful if the follower is less experienced and needs to be coached from above.

A common method for a direct belay is to use an assisted-braking belay device or an auto-locking belay device in its auto-locking mode clipped directly in to the anchor, as shown in Figure 10-7. An alternative method is to belay with a munter hitch on the anchor (fig. 10-27). Different manufacturers use different terminologies for auto-locking mode. For instance, Black Diamond calls it "guide mode"; consult the manufacturer's instructions.

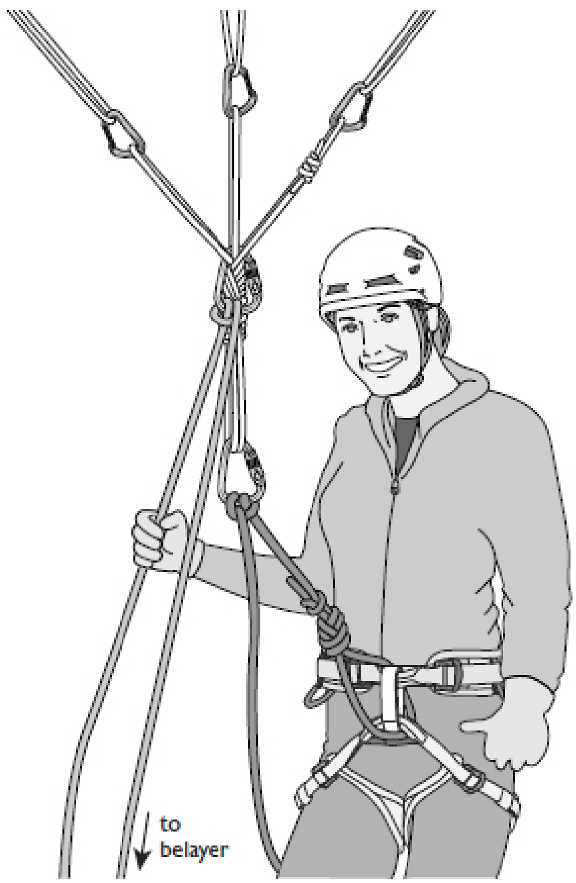

Fig. 10-27. Belaying off the anchor using a munter hitch.

A regular non-auto-locking belay device should not be used for a belay directly off the anchor. To arrest a fall, the belayer would have to push the braking hand away from the body and back behind the device in order to separate the rope strands by the minimum of 90 degrees. This can be awkward, perhaps impossible, and the braking hand grip will be comparatively weak. In fact, most manufacturers do not allow a regular aperture belay device to be used directly off the anchor at all. When an auto-locking belay device is not used in the auto-locking mode, it should be treated like a regular belay device.

Regardless of the belay device or method used to belay off the anchor, position the tie-in so that the anchor's power point is at roughly shoulder level when the belayer is leaning on the anchor. This way, the belayer has enough work space between the tie-in and the anchor to make pulling and coiling the rope easier. If the power point is too low, consider using the anchor shelf if there is one.

ROPE HANDLING

In addition to stopping a fall if one should occur, it is important for the belayer to maintain the correct tension on the rope: prevent excess slack, anticipate the climber's movements and rope needs, let out rope as the climber moves up or clips in to protection, take rope in as needed, and manage the accumulating rope. The techniques below are described in the stance for belaying the leader off the harness, but the techniques can easily be modified for other belay methods. Practice until you learn to quickly take in or let out rope with the feeling hand as needed while never removing the braking hand from the rope.

Maintaining the right amount of slack. Keeping just enough but not too much slack in the rope during a belay is a skill that requires practice. Obviously, too much slack will lengthen a fall and hence increase the impact force and the risk of the climber getting injured (fig. 10-28). Too much slack also makes it hard for the belayer to "feel" the rope movement and needs of the climber. Too little slack, on the other hand, can impede the climber's movement and balance. A good belayer uses the feeling hand and is always aware of how much slack is in the rope. Ideally, when belaying a follower, there is almost no slack in the rope (fig. 10-29), but at the same time, the rope should not be taut, especially on a traverse when balance is crucial.

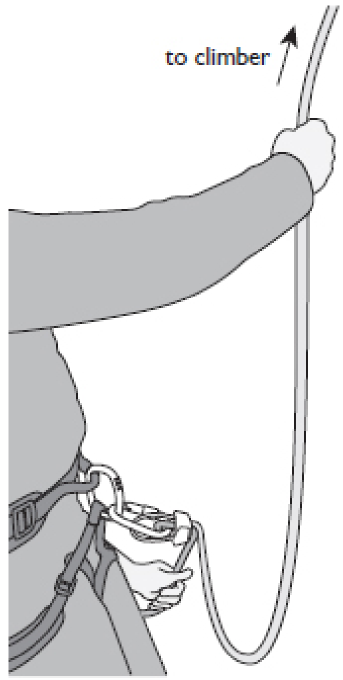

Fig. 10-28. Too much rope slack.

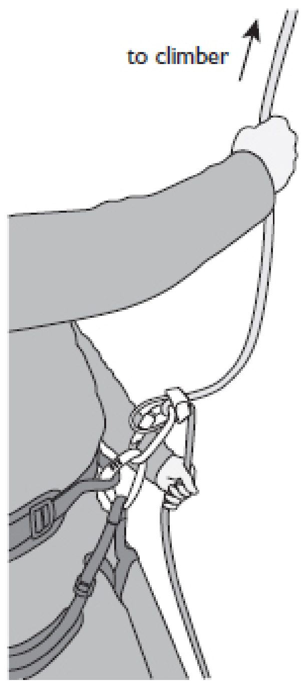

Fig. 10-29. Right amount of rope slack.

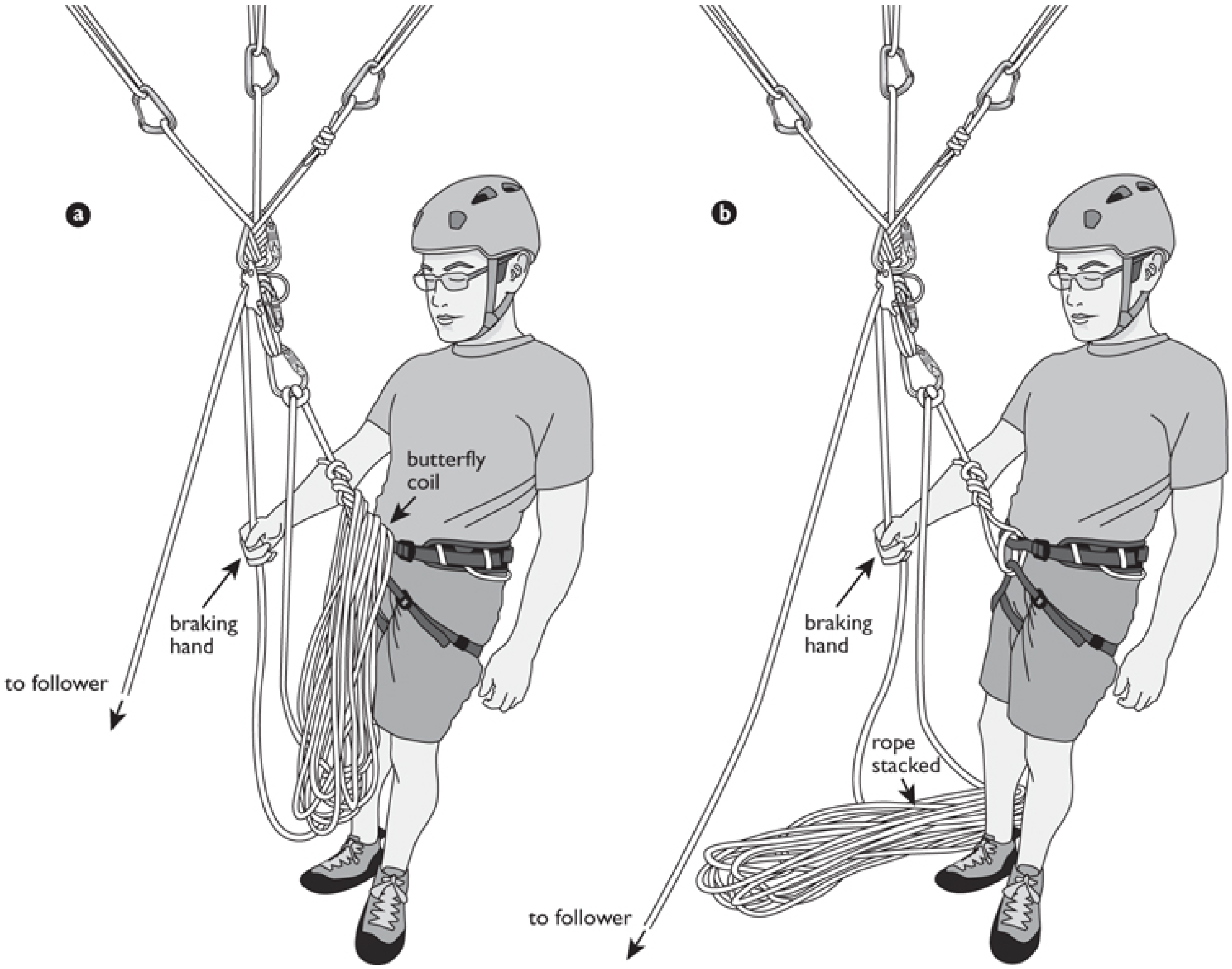

Fig. 10-30. Managing the rope at the belay: a, a butterfly coil laid across the belayer's anchor tie-in; b, stacking the rope on the ground.

Anticipating the leader's rope needs. To minimize falling distance, leaders preparing to make difficult moves often place protection well above their harness tie-in and clip in to that protection before moving up. In these cases, the leader needs some additional slack, and the direction of rope movement will reverse twice. After letting out rope for the leader to make a clip, the belayer will need to take in slack as the climber moves up to the protection. The belayer will then pay out rope again once the climber moves past the protection and uses up most of the slack in the rope. These switches call for extra attention, especially because this tends to happen at the most difficult spots on a route. It's worth noting, however, that when the leader clips above waist level and pulls extra rope to clip in, he or she is momentarily subject to a longer fall, so the leader should do this only from a comfortable and safe stance.

When belaying the leader, an alert belayer keeps just a hint of slack and responds immediately to the leader's advance by paying out more rope. The belayer is also always ready to transition between paying out rope and pulling in slack when the leader clips in to protection. Any friction applied by the belayer is multiplied, so if the leader says that rope drag is a problem, keep about a foot or so of slack in the rope and do everything possible to eliminate any pull. If the climber falls when there is a lot of friction in the system, the belayer may actually be unsure whether a fall even took place. If it is impossible to communicate with the climber, the belayer can find out by letting out a few inches of rope. If the same tension remains, then the belayer is probably holding the climber's weight.

Managing the rope. Proper rope management is essential so that the belayer may keep the right amount of slack at all times. The belayer does not want to be distracted by knots and tangles in the rope when belaying. Before belaying a leader, neatly pile or coil the rope with the climber's end on top. Do this by carefully flaking out the rope, shaking it out as needed to avoid unwanted twists, and stacking the rope on the ground before starting to belay.

When belaying a follower up to the belay station, either stack the rope on the ground if the belay station is big enough or coil it using the butterfly coil. For the butterfly coil, coil the rope back and forth across the belayer's anchor tie-in (fig. 10-30a); it helps to keep the tie-in under a little tension even if it's not a hanging belay. If the belayer stacks the rope on the ground, make sure the rope pile has a small footprint and is not tangled with rock flakes and tree branches (fig. 10-30b).

If the climbing team is swapping leads—that is, the follower will become the new leader on the next pitch—the belayer doesn't need to do anything with the rope because the leader's end is already on the top and the rope should be nicely piled or coiled for the next pitch. However, if the climbing team is leading in blocks—that is, the climber who led the last pitch is going to lead the next—the belayer must reverse the rope. If the rope is butterfly-coiled, grab the middle of the coil and flip it onto the follower's anchor tie-in. Reversing the rope is a little more difficult if the rope is stacked in a pile: the belayer can carefully flip the whole pile like a pancake, but if that fails, the whole rope must be reflaked, which is time-consuming.

COMMUNICATION

Effective and efficient communication between members of a climbing party is key to safe and speedy ascents. A set of standardized and concise commands understood by all climbers can tremendously reduce confusion and save time and hassle. Make sure everyone in the climbing party agrees upon the commands before they start climbing, especially if they are breaking in a new climbing partner. The commands in Table 10-1 have been developed to produce a distinctive pattern, and they are used universally, even among non-English-speaking climbers.

As climber and belayer get farther apart, they begin to have difficulty hearing each other. It is impossible to communicate in full sentences, and often the first syllable is not heard. When the belayer is a long way from the climbing partner, shout as loudly as possible and space out each syllable, using very big spaces if there are echoes. In a crowded area, clearly preface commands with your partner's name to avoid confusion about who is being safely belayed or lowered, who is off belay, et cetera. Prefixing commands with climbers' names also has the advantage that climbers will pause upon hearing their name as the first word and thus have a better chance of understanding the remainder of the command. Sometimes climbers may rely on a third party to relay their commands.

Verbal communication often becomes impossible because of wind or obstructions. In such cases, people have suggested using rope pulls. However, there is no universal protocol for rope signals. Also, if there is enough wind or obstructions to impede verbal communication, rope tugs usually cannot be easily or reliably felt.

Some climbers use two-way radios for communication. If you do, check local radio frequency regulations and make sure your radios conform. Also be aware of the limitations of radios. Battery life is shorter in cold conditions. When the batteries run out, make sure you have alternative means of communication. A useful tip for radios is to not start talking at the same time you press the "talk" button because the first couple of words will be lost. Instead, press the button, wait for a second or two, and then start talking.

Always use positive commands instead of negative ones. For example, when there is too much slack in the rope, use "Up rope" instead of "Too muck slack," because the latter can be misheard or mistakenly interpreted as "Slack," which is the exact opposite of what you mean. Always try to stick to the standard commands listed in Table 10-1 instead of creating your own commands, because standard commands can be understood by everyone.

The rule of thumb in communication is to keep it simple. Here are the recommended commands in Table 10-1 configured for exchanges between the climber and the belayer in two different scenarios.

SINGLE-PITCH CLIMB

In this scenario, the belayer is belaying a climber who is either leading or top-roping on a slingshot setup. The command exchange takes place after both parties have done the safety check.

Climber: "On belay?"
Belayer: "Belay on."
Climber: "Climbing."
Belayer: "Climb on."

The climber climbs to the top. If the climber is leading, he or she sets up the top anchor and clips the rope in to the anchor. Now the climber is ready to put the weight on the rope and be lowered.

TABLE 10-1. COMMONLY USED CLIMBING COMMANDS

COMMAND	SAID BY	MEANING
"On belay?"	Climber	Do you have me on belay? Are you ready to brake my fall?
"Belay on."	Belayer	Yes, I have you on belay. Can be a response to "On belay?"
"Climbing."	Climber	I'm about to climb.
"Climb on/climb away."	Belayer	Go ahead and climb. Response to "Climbing."
"Off belay."	Climber	I'm safe, either on the ground or attached to an anchor. Please take the rope out of the belay device.

“Belay off.”	Belayer	You are no longer on belay. Response to “Off belay.”
“Take.”	Climber	Pull all the slack in the rope and I’m going to put my weight on it.
“Got you.”	Belayer	All slack has been pulled out. Go ahead and lean on the rope. Response to “Take.”
“Lower me/lower.”	Climber	I have finished climbing. Please lower me to the ground.
“Lowering.”	Belayer	I’m starting to lower you. Response to “Lower me.”
“That’s me.”	Follower	You have taken in all the slack in the rope. The resistance to your pull is my body.
“Slack.”	Climber	Give me some slack. The rope is too tight.
“Up rope.”	Climber	Pull up some slack. The rope has too much slack.
“Watch me.”	Climber	Give me an attentive belay. I may fall.
“Falling!”	Climber	I’m falling. Brake my fall.
“Rock/ice!”	Anyone	Falling rock, ice, or other objects. Take cover, everyone!
“Clipping.”	Leader	I’m about to clip the rope into a piece of protection.

“Half rope.”	Belayer	You have led half the length of the rope.
“X feet/X meters.”	Belayer	You have X feet (meters) of rope left.

Climber: “Take.”
Belayer: “Got you.”
Climber: “Lower me.”
Belayer: “Lowering.”

The belayer lowers the climber to the ground.

Climber: “Off belay.”
Belayer: “Belay off.”

If the leader is cleaning the protection on the way down, he or she may also ask the belayer to pause at each protection point so he or she can remove them. The commands are “Stop” for pausing and “Lower” for resuming.

MULTIPITCH CLIMB

In this scenario, the follower belays the leader. When the leader gets to the top of a pitch, he or she sets up an anchor and belays the follower to the top. When they continue climbing the next pitch, they may or may not exchange roles as belayer and leader for the next pitch.

Leader: “On belay?”
Belayer: “Belay on.”
Leader: “Climbing.”
Belayer: “Climb away.”

The leader arrives at the top of the first pitch, sets up an anchor, and secures him-or herself to the anchor.

Leader: “Off belay.”
Follower: “Belay off.”

The leader pulls the rope and the follower gets ready to follow the pitch. As the rope gets taut, they communicate:

Follower: “That’s me!”
Leader: “Belay on.”

The follower removes the previous anchor, then starts ascending.

Follower: “Climbing.”
Leader: “Climb on.”

The follower arrives at the belay station and secures him-or herself to the anchor.

Follower: "Off belay."
Leader: "Belay off."

ACTIONS BASED ON THE COMMANDS

Specific actions are associated with particular commands that the belayer and follower use.

Slack is especially useful to a climber who is leading or traversing.

Up rope is used when there is too much slack in the system and the belayer should take up the slack.

Watch me is used when the climber is about to make some difficult moves and needs an especially attentive belay.

Clipping is used to indicate that the belayer should pay attention to the direction of the rope travel, and to warn of a possible pull on the rope made by the leader. If the protection is above the leader's waist, the rope will travel away from the belayer, then toward him or her before traveling away again.

Half rope gives the leader a sense of the length of the route.

X feet (X meters) is used in a multipitch scenario to help the leader decide when and where to build an anchor. Outside of the United States, people usually use meters (a meter is roughly 3 feet).

ESCAPING THE BELAY

One aspect of belaying that most climbers hope they will never have to use is tying off and escaping the belay in order to help an injured partner. If a climbing partner is seriously injured and other climbers are nearby, it is usually best to let them help while you continue to belay. By staying in place, you could also help in raising or lowering the victim if needed. But if two climbers are alone, it may be necessary to tie off the climbing rope to remove yourself from the belay system, so you can investigate, help your partner, or go for help. Escaping the belay is the first step of many rescue scenarios. The goal of belay escape is to have the load connected directly to the anchor and the belayer out of the system.

When belaying off the anchor. When you are belaying off the anchor using a munter hitch or auto-locking device, the fallen climber's weight is already on the anchor, and the only thing the belayer needs to do is to free the braking hand (remember, an auto-locking device is not a hands-free device). To do so, you simply need to tie a mule knot with the braking strand while still holding on to the braking strand, backing it up with an overhand knot (fig. 10-31; see also Figures 9-20 and 9-21 in Chapter 9, Basic Safety System).

When belaying using a belay device attached to the seat harness. If belaying from the harness, more steps are involved to escape the belay because the fallen climber's weight is on the belayer. The first step is to free the belayer's hands. With the braking hand still holding the rope, stick a couple fingers of your other hand through the belay carabiner and pull a bight of rope over so that now your other hand becomes the braking hand. The braking strand is now in line with the load. Use your free hand to tie a device-mule knot with an overhand backup knot (fig. 10-32a). Both hands of the belayer are now free.

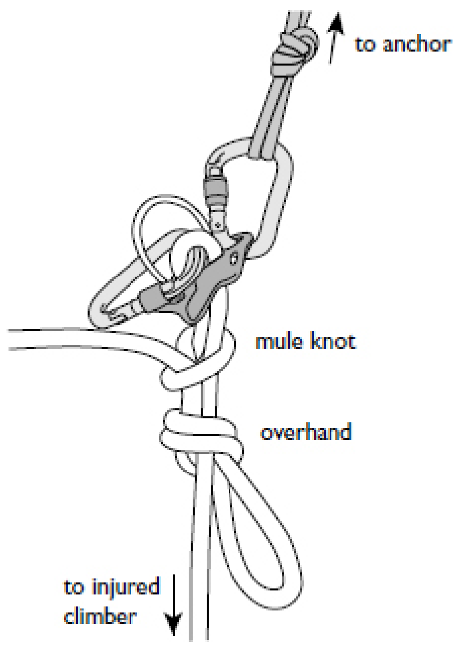

Fig. 10-31. Tying off a direct belay.

The next steps are to transfer the weight to the anchor so that the belayer can get out of the system. To achieve this, attach a cord tie-off loop to the climber's end of the rope with a prusik hitch and connect this loop to a locking carabiner. Attach this locking carabiner to the loose rope coming from the belayer tie-in at the anchor, using a munter hitch with a mule knot to connect the carabiner and rope, then back it up with an overhand knot; the entire knot is called a munter-mule-overhand, or MMO (fig. 10-32b; see also Figure 9-21 in Chapter 9, Basic Safety System). Now, put a braking hand back on the braking strand to backup the connection to the anchor as you follow the next step. Untie the first overhand knot backup and device-mule knot (from the belay setup on the harness), and slowly transfer the load to the tie-off loop using the belay device (fig. 10-32c).

Now the fallen climber's weight is secured to the anchor but on a potentially weak tie-off cord. Connect the rope from the fallen climber to the anchor with another MMO as a backup leaving just enough slack to disassemble the belay (fig. 10-32d). Now disassemble the belay, disconnect the belay device from the system, and untie from the anchor (fig. 10-32e).

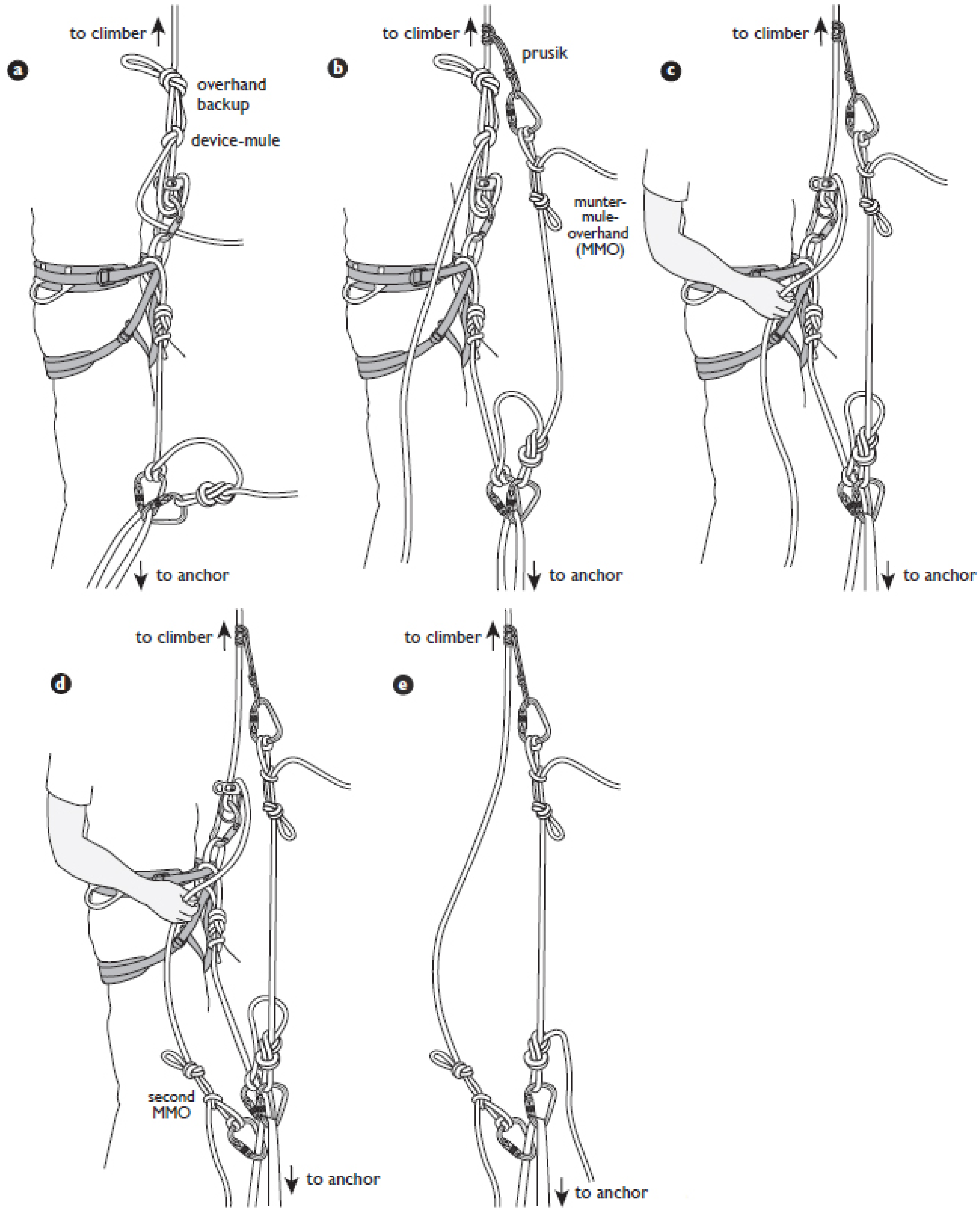

Fig. 10-32. Escaping the belay: a, tie off the belay device with a device-mule knot with overhand backup; b, attach a cord tie-off loop to the climber's end of the rope with a prusik hitch, connect this loop to a locking carabiner, and attach it to the loose rope coming from the belayer tie-in at the anchor using a munter-mule-overhand (MMO); c, untie the first overhand knot backup and device-mule knot (from the belay setup on the harness) and slowly transfer the load to the tie-off loop using the belay device; d, connect the rope coming out of the belay device to the anchor with another MMO; e, disassemble the belay by disconnecting the belay device, and then untie yourself from the anchor so you can help the climber, rappel for assistance, et cetera.

When belaying using a munter hitch attached to the seat harness. The steps involved are very similar except the first step. To free your hands, tie an MMO (see Figure 9-21). The rest of the steps to escape the belay are exactly the same. As the above steps illustrate, an MMO knot or a device-mule knot with an overhand backup is used in transferring a live load. Such a knot is also called a *releasable knot*. Releasable knots are extremely helpful in a rescue scenario because it should always be assumed that the fallen climber is incapacitated and cannot release the load from the rope, even momentarily. That's the reason a second MMO is used to hold the fallen climber's weight and a third MMO is used as the backup. This provides the flexibility needed later to either lower the fallen climber using the belay device or munter hitch or to rig a raising system.

SECURING THE FREEDOM OF THE HILLS

Belaying and anchor setup are the fundamental skills of technical climbing. Practice belaying often, alternating between using your right hand and left hand as the braking hand. Study and practice anchor techniques. There are many different ways of anchoring yourself. Always use the SERENE principles to evaluate your anchors.

Being proficient with belay technique and anchor setup helps climbers become good team partners. These methods are also related to skills required for rappelling; once climbers become proficient in belay skills, they will have more confidence when it comes time to rappel. Overall, solid skills in belaying and anchor setup will help climbers secure the freedom of the hills.