Knots & Hitches

The loop formed by a knot should be about the size of the item that is going to clip into it. Huge knots waste rope, get in the way, are cumbersome and inefficient. Cave rescue demands compact, efficient rigging.

Figure Eight on a Bight

Figure Eight Bend

Figure Eight Follow-through

Double Figure Eight
Trucker’s Hitch

A slip knot is commonly used to create the in-line loop, but for rescue work, a fixed loop is often preferable.

Münter Hitch
(For one-person load belays)

Trucker’s Hitch on slip knot

Tied-Off Trucker’s Hitch
(backup not shown)

Trucker’s Hitch on fixed loop
(preferred for rescue)

Prusik Hitch

Double-wrap
(1-person loads)

Triple-wrap
(rescue loads)

Clove Hitch
(overhand backup)

Tying a Trucker’s Hitch:

Step 1: Attached end of rope to an anchor or object (not shown)
Step 2: Tie a loop (slip knot, butterfly, 8 or overhand bight, etc.)
Step 3: Pass rope around or through an anchor/attachment point.
Step 4: Thread end of rope through in-line bight. Pull to tighten. Configuration provides modest mechanical advantage and allows tension to be retained and secured.
Step 5: Secure with a half-hitch on a bight, then back up with an overhand on the bight (backup not shown)
Anchoring

Tensionless Hitch (round turn)

Wrap 3, Pull 2 (webbing or rope)

Basket Rigging (knot at back)

Load Sharing Anchor System (fixed length legs). Appropriate for Levels 1 and 2.

Girth Hitch (reduces rigging strength ~ 25%)

Load Distributing Anchor Systems (aka self-equalizing, self-adjusting) Failure of any one leg could lead to shock load and catastrophic failure of entire anchor system. Application of these techniques is a Level 3 skill.
Pre-tensioned Backties

Front rigging point is focal point, back-up is primary anchor.

Backup Anchors

Backup using long-tail bowline
Backup using in-line figure eight
Backup using double figure eight

Backup using long-tail bowline
Backup using in-line figure eight
Backup using double figure eight

Pre-tensioned backtie is an adjustable stabilizer that utilizes mechanical advantage (typically 3:1).

If the anchor for a backtie is not reasonably in line with the direction of load, multiple backties will be necessary to stabilize focal point.

The effective length of a pre-tensioned backtie may be extended by using a trucker’s hitch, but this configuration will have more stretch under load than the full-length 3:1 version.

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Belays

Münter Hitch - Allowed for single person load only, moderate to low angle.

Tandem Triple-wrapped Prusiks
- NCRC’s primary rescue belay system
- Prusik cord must be flexible and of appropriate diameter for rope
- Short prusik must be sized to work efficiently with PMP
- Long prusik must be 3 to 4 inches longer than short prusik
- Use PMP when belaying during raising operation
- Have students remove PMP for lowering operation, and belay using proper handling technique
- Minimize slack in the belay system

Mechanical Rescue Belays
- Available for demonstration
- 540 belay: highly sensitive to rope diameter
- Nano Rack belay: essentially a 3-bar rack loaded upside down

Simple Pulley System rules
1. The number of support lines determines the IMA.
2. If the haul rope starts at the load the IMA will be Odd.
3. If the haul rope starts at the anchor the IMA is Even.
4. If the last pulley in the system is secured to an anchor it is a directional.

Compound Pulley System rules
1. Compound systems are 2 or more simple systems acting on each other.
“Even” Hauling Systems

PCD Option 1: between load and haul system

Anchor

Haul rope fastened to anchor

PCD Option 2: at anchor

To Load

“Odd” Hauling Systems

Haul rope fastened to load

Anchor

PCD

Progress capture at anchor

To Load

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Basics of Counterbalance Systems

- Avoid Friction!
- Consider rockfall potential
- Main anchor takes double load
- Prepare for transition when load reaches top

Rappelling Counterbalance

Counterbalance line with PCD
Belay Line
Fixed Line
Rappeller (using rack on fixed line)
Tether
Second person for counterweight

If the counterweight is heavier than the load, the load goes up and the counterweight goes down!
Climbing Counterbalance

- Avoid Friction!
- Consider rockfall potential
- Main anchor takes double load
- Getting climbers in position requires forethought
- Prepare for transition at top

Diminishing Loop Counterbalance

- Avoid Friction!
- Consider rockfall potential
- Main anchor takes double load
- Prepare for transition at top
- Rescuer AND patient must be secure before either disconnects from the counterbalance line!
To Anchor

Start with small Fig-8 on bight

Münter hitch with in-feed on gate side of carabiner

Reduce distance between carabiners to about 4 inches

Form a bight and fabricate a half hitch (steps 3 & 4)

Tie an overhand around the bundle (using the bight created above) as shown in steps 5 & 6

Illustrations courtesy Rick Lipke, Contera Technical Systems, Inc.

- Use 10 meters of 8mm accessory cord to fabricate the Radium Release Hitch
- Control release by slipping the Münter hitch

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Litter Rigging

Allowable focal point connections: long-tail butterflies or bowlines, not interlaced, long-tail bowlines, interlaced. Attaching the lines without long tails (and using tethers for the attendant and patient connections) are allowed but discouraged.

End of belay line attaches to patient. Line passes through neck opening in packaging.

Carabiner gates oriented in and down

Litter attendant clips to tail of mainline, moves up and down on ascending system, and clips to one spider leg using tether as second point of attachment.

Rig short, bridle will stretch when loaded.

Fig 8 on bight, tied compact

Clove hitches

Double overhand bend (better if tied on outside of litter)

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NCRC Packaging with Double V Restrain System

1: Place tarp over litter, offset to one side.

2: Place blankets over tarp, offset similarly.

3: Place OSS (if needed) and seat harness on packaging.

4: Place patient in litter, secure harness and OSS. Pad under knees, small of back, neck – as appropriate. If supporting by seat harness, pad groin carefully.

5: Fold bottom of tarp and blanket over feet. Girth hitch two 20' webbing sections to harness. Attach belay tether.

6: Secure upper webbing to litter rigging points (snug, not tight), then secure lower webbing. Fold blankets & tarp to encase patient.

7: Support patient with foot loop (or foot board) and knee strap (above knee) when injuries permit.

8: Use litter restraints or webbing lashing to secure patient and packaging in litter.

9: Blanket roll (secured with tape) can be used to insulate patient’s head. (Note: spinal stabilization is achieved with OSS). Protect eyes with goggles or shield. Check airway, injuries, pressure points.
NCRC System Safety Ratio

NCRC targets a minimum system safety ratio of 7:1 for its instructional events.

Assessing System Safety Ratio

• Identify minimum breaking strength of each component, as configured in system
• Identify load experienced by each component in system, as configured
• Calculate component load ratio on each component (MBS/expected load)
• Lowest component load ratio (weakest link) is system load ratio
• Determine if this ratio is high enough to satisfy your safety criteria