**Abstract**—Immobilization of the spine is an important skill for all emergency providers. This article reviews the literature regarding the equipment, adjuncts, and techniques involved in spinal immobilization. Current prehospital practice is to apply spinal immobilization liberally in cases of suspected neck or back injury. Rigid cervical collars, long backboards, and straps remain the standard implements for immobilizing supine patients. Tape, foam blocks, and towels can complement the basic items and improve stability. Padding may improve positioning and comfort. Intermediate-stage devices include the short backboard and newer commercial devices. Properly used, all provide reasonable immobilization of the sitting patient. Future directions for study include refinement of optimal body position, dynamic performance of all devices, and broadening study populations to include children and the elderly.

**Keywords**—spinal immobilization; cervical spine; prehospital care

**INTRODUCTION**

Estimates of spine injuries in the United States range from 30 to 50 survivors per 1 million population, or about 10,000 annually (1,2). The prevalence is approximately 250,000, with most victims being male and sustaining the injury between the ages of 10 and 30 years (1). Costs of long-term rehabilitation and medical treatments are estimated at US $2 billion annually (2). Motor vehicles cause nearly half of all injuries, with falls, sports, and assaults constituting most of the remaining half (3). Half of all spine injuries occur in the cervical region, often resulting in quadriplegia (4). Several cases of poor neurologic outcome following mishandling of cervical injuries have been reported (5–7). Because of this devastating potential, current prehospital practice dictates that all suspected cases of cervical injury must be immobilized (8). In unclear cases, the error must fall on the side of caution, that is, “when in doubt, immobilize” (9).

Prehospital providers should suspect a cervical injury in any patient suffering trauma and complaining of neck pain or exhibiting signs of neck injury or peripheral neurological impairment (10). If the patient is unconscious, cervical injury must be assumed (11). Mechanism of injury is felt to be an important predictor of cervical injury (8,12). Spinal injuries can be classified as flexion, flexion-rotation, extension, axial, or a combination of motions (2,13). These can be further subdivided into stable and unstable injuries. Knowledge of the specific injury type can help predict morbidity and guide acute management, particularly neurosurgical interventions (2). However, in the prehospital environment, there is rarely sufficient information to determine specific injury patterns. Instead, the prehospital provider must rely on gross indicators of the sc-
The term *positive mechanism* of spinal injury has an acknowledged degree of ambiguity (15). Some declare that “no patient should be extricated from a crashed vehicle or transported from an accident scene without spinal stabilization” (1). In contrast, Pennardt and Zehner retrospectively showed that paramedics can assess most, if not all, criteria necessary to judge clinically if immobilization is required (16). Among other factors, they used level of consciousness, alcohol or drug intoxication, cervical pain and tenderness, and neurological deficits to determine the risk of cervical spine injury. However, these guidelines are not yet widely accepted; an accompanying editorial cautions that prospective validation is lacking (17). However, prehospital clinical guidelines for spine injury with prolonged transport are available (18).

Kossuth is recognized as the first physician to champion the need for accepted methods of extrication, which include protection of the cervical spine (19). Farrington is credited with thrusting the concept of prehospital immobilization into the arena of conventional medicine (20,21). According to Dick and Land, the first widely distributed emergency medical service (EMS) textbook to address the specific techniques of immobilization was Grant and Murray’s Emergency...
Immobilization Techniques

According to Wolf and Johnson, control of the spine may be necessary for any combination of protection, immobilization, support, or correction of deformity (24). Prehospital care is primarily concerned with protection, immobilization, and support and for this discussion will be generalized to the term immobilization. Although there is general agreement as to the ultimate goal of immobilization, considerable controversy and diversity exists in accomplishing this goal (9,12,25–28).

McSwain stated that “the joint above a cervical fracture is between C₁ and the skull, and the joint below . . . is between C₇ and T₁,” and all require immobilization (29). Similarly, he emphasized the need to immobilize the pelvis to immobilize the entire spine effectively (29). Smith et al. stated that it is critical to immobilize the “rest of the body” to minimize the risk of severe neck forces should the body move while the head and neck remain fixed (12). Butman and Vomacka specifically recommended that arms and legs be immobilized in addition to the trunk (30). Current practice favors full-body immobilization for patients suspected of having cervical spine injury.

The proper position of the head and neck is somewhat controversial (31,32). Virtually all investigators have cited a “neutral position” as being best but define this position differently or not at all. Schriger quoted Butman’s definition of the neutral position as “the normal anatomical position of the head and torso that one assumes when standing looking straight ahead,” or in 12° of radiographic extension (32–34). Nypaver and Treloar established neutrality in children as a “gaze preference directly upward and perpendicular to the horizontal plane of the backboard” (35). From a practical standpoint, published definitions of neutral are difficult to reproduce in the prehospital environment. From a functional perspective, there is no evidence to suggest that these positions produce an anatomic position favorable to the injured spinal cord and neck.

Some investigators have favored splinting the head and neck in the position in which it is found; however, most recent reports favor the “neutral” position (31,36). Similarly, it has been recommended in the past to use “traction” to align the head and neck (27,31,37). More recently, investigators have favored less distractive terms.
such as alignment and stabilization (8, 9, 12, 30, 34, 38). Figure 1 depicts manual stabilization of a supine patient. Listed contraindications to moving the head and neck include increased pain or neurologic deficits, muscle spasm, or promotion of airway compromise (30).

In adults, padding under the occiput may promote the neutral position (30, 32, 34). Schriger et al. recommended a mean of 1.5 inches (3.8 cm) of padding (32). McSwain stated that more than 80% of adults require 0.5–2 inches (1.3–5.1 cm) of padding to achieve the neutral position (39). Body habitus and muscular development alter the cervical-thoracic angle and thus affect positioning (40). Recent data using internal anatomic measurements suggest that slight flexion equivalent to 2 cm of padding provides the most favorable ratio of spinal cord to spinal canal (41). Most investigators have favored a modest (perhaps 2 cm) amount of occipital padding to achieve optimal position in the majority of adult patients.

Pediatric patients probably require scapular padding to achieve a more physiologic neck position (30, 35, 42). Curran et al. used radiographs to determine the neck position of immobilized trauma patients (43). They concluded that no single device or technique appears superior in protecting against spinal angulation. Furthermore, a semirigid cervical collar is unlikely to compensate for a lack of padding in children.

A radical approach for positioning neck-injured patients is termed the HAINES modified recovery position (44). By using padding and the patient’s own arm for support, the patient is positioned laterally. Radiographic
measurements suggest decreased lateral flexion of the spine when compared with the standard lateral recovery position. Comparison with standard supine immobilization has not been conducted.

The traditional method of moving a patient onto a long backboard involves the log-roll maneuver (Figure 2) (45). This time-honored technique has come under scrutiny, however (46,47). Substantial lateral movement of the lumbar spine can occur, and slight variations in technique such as whether the arms are crossed or flexed can produce substantial differences in spine movement (48,49). Alternatives to the log-roll include the HAINES method and the multihand or fireman lift (44,50). Despite its limitations, the log-roll maneuver is widely taught and remains an accepted method of positioning prone patients onto a backboard.

The technique involved in moving a patient from a confined space, usually a crashed automobile, has been well described and generally involves the use of an intermediate-stage device, such as the prototypical short backboard (8,12,27,30,34). The seated patient is first placed in a cervical collar and then secured to the intermediate-stage device (Figure 3). The patient is then transferred and secured to a long backboard. The intermediate-stage device is not removed until the patient has been removed from the long backboard in the hospital.

Rapid extrication is the term used to describe the procedure of patient removal (e.g., from a crashed automobile) and spinal immobilization using an abbreviated, quick technique. The primary indication is the unstable patient who cannot tolerate the usual, meticulous process of immobilization (33). Spinal immobilization is maintained during movement by manual means and the patient transferred directly to the backboard without using an intermediate-stage device (51). The entire procedure should take less than 1 min versus the usual 6–8 min for conventional removal (52).

Immobilization of patients found in the standing position can be accomplished by using a two-rescuer method: one to stabilize the head and neck by hand and the other to hold the patient and board as both are simultaneously lowered to the horizontal position (53,54). Dulaney recommended that stable standing patients be strapped to the board prior to lowering it (Figure 4) (55).

Patients wearing protective helmets are encountered frequently in prehospital practice. If the helmet does not interfere with airway management, cervical spine immobilization, and hemorrhage control, then prehos-
IMMOBILIZATION DEVICES

In general, three pieces of equipment are used for spine immobilization: the long and short backboards and the cervical collar (29,61). The cervical collar, or more properly, cervical orthosis, can be subdivided into three categories: cervical, head-cervical, and head-cervical-thoracic, each available as soft or rigid varieties (24). Most prehospital collars are modified rigid head-cervical-thoracic devices, where the collar contacts the occiput, chin, clavicles, and sternum for added stability (Figure 5). Contraindications to applying a cervical collar include fixed neck angulation, massive cervical swelling, and the need to perform cricothyrotomy (62).

To be effective, cervical collars must meet the two criteria of restricting cervical movement and ease of application (63). Dick and Land suggested that collars should restrict lateral, flexion, extension, and rotational motions (61). More specific criteria have been proposed but have not been generally accepted (64). Recent studies have compared various collars alone and in combination with other devices. McSwain comments that Podolsky et al. were the first to examine...
the efficacy of cervical spine immobilization methods systematically (65). Among other findings, they showed that tape and sandbag immobilization is more effective than any single device and is effective in achieving cervical immobilization when used alone or in combination with a Philadelphia®-style (Philadelphia Collar Co., Westville, NJ) rigid collar. McSwain underscored the apparent limited effectiveness of cervical collars alone, and Rosenthal emphasized the need for proper collar sizing if these collars are to be of any value (65,66). Cline et al. thought that the standard short board is superior to any tested collar alone, but differences between collars alone were not significant (67). In contrast, McCabe and Nolan demonstrated differences between collar types, showing the “flat” polyethylene type to be generally more effective than either the Philadelphia-type or hard-foam-extrication collar (25). A recent study by Manix et al. evaluated different immobilization techniques by using video photography and electromyography to judge neck movement and forces (68). They showed differences among the corrugated collar, the foam block device, and rolled towels and adhesive tape in terms of lateral, flexion, and extension movements. However, no one device seems to be superior in all planes of movement. In general, differences among collars are less important than proper sizing and application, and use of adjunctive equipment.

More recent studies have examined devices other than collars and short boards. Graziano et al. demonstrated that the Kendricks Extrication Device (KED®; Ferno-Washington, Inc., Wilmington, OH) and the Extrication Plus-One (XP-One®; Medical Specialties, Inc., Charlotte, NC) are nearly as effective in immobilization as the short board and clearly superior to a collar alone (69). Howell et al. reached similar conclusions regarding the KED® and the short board (70). An interesting prehospital immobilization device, the Ammerman® halo orthosis (Ammerman Trauma Systems, Pacific Palisades, CA) was as effective as a collar, with the head taped to a backboard (71). When combined with a spineboard, Howell et al. believed the device to be comparable to a conventional halo vest but without the need for cranial pins. A different concept (Red E.M.®; Philadelphia Collar Co.) that combines the Philadelphia® collar and rigid torso extensions was found by Joyce and Moser to be as effective as other devices (72).

The standard device to immobilize the supine patient is the rigid backboard. The modern version has been around since at least 1965 (73). Although it may be used alone as a simple litter, it is most often em-

Figure 7. Left: Aluminum Scoop®-style stretcher. Center: Molded backboard. Right: Conventional wooden backboard.
Pediatric positioning for cervical immobilization differs as mentioned previously, several investigators feel that devices have been suggested to substitute for the plain backboard, such as the aluminum Scoop Stretcher® (Figure 7) (Ferno, Inc., Wilmington, OH), vacuum stretcher (e.g., Evac-U-Splint®, Hartwell Medical, Carlsbad, CA), and folding Army litter (9,27,76). Interestingly, in mainland Europe, the device of choice is the vacuum stretcher, and the backboard is used mainly in the United States and Britain (76).

Adverse effects of spinal immobilization appear to be modest, although not insignificant. Bauer and Kowalski reported that pulmonary restriction from a properly applied immobilization device is measurable, and at least one case of detrimental effects has been reported (77,78). Discomfort is a more common problem and is partly due to the rigid nonconforming nature of backboards (79). A small amount of padding may improve comfort without reducing effectiveness (80). Cordell et al. reported tissue interface pressure sufficient to be concerned about necrosis (81). Interposed air mattresses reduced tissue pressures and improved comfort in the study volunteers. Vacuum splints may be more comfortable and produce lower tissue pressures than backboards (74,76,82). However, despite its limitations, the long backboard remains the standard device for immobilizing supine patients. Attention to prolonged immobilization will alleviate discomfort and detrimental effects.

Pediatric immobilization devices have been infrequently examined. Huerta et al. surveyed a number of cervical collars and tested these on a mannequin (83). They concluded that a collar alone was ineffective for immobilization of children. They also believed that rigid short immobilization devices perform better on children than devices designed to be attached to backboards, such as the Head Immobilizer® (Ferno-Washington, Inc.) and Head Brace® (Medix Choice, Inc., El Cajon, CA). As mentioned previously, several investigators feel that pediatric positioning for cervical immobilization differs from that for adults (30,35). The infant car seat is advocated as an effective transport device for children already seated in one at the time of crash; however, objective data are lacking (26).

Most studies suggest that a collar alone is ineffective, and the standard short board, at least in the static environment, is as good as virtually all other intermediate-stage devices. Curiously, its use has been declining, supplanted by more modern devices (e.g., KED® and XP-One®), probably because they are easier to apply and may offer superior dynamic performance. Dick condemned the shortboard as an "antique" left over from the days when bench seats were standard in automobiles (84). Graziano tempered this assertion by noting that the data are not conclusive in this regard (85). The standard shortboard remains an acceptable means of immobilizing the sitting patient.

Because of its mobility and vulnerability, most emphasis in prehospital care is placed on the cervical spine (2). However, lower segment (thoracolumbosacral) injuries can occur frequently in particular subsets of patients. Motorcycle crashes, falls, and direct trauma are risk factors (86–88). Dick and Land emphasized the need for pelvic immobilization in any patient requiring thoracolumbar immobilization (61). McSwain, in his text on cervical spine trauma, emphasized the need to immobilize not only the cervical spine but also the chest, torso and pelvis (29). Daya et al. recommended a full-length spine board or, alternatively, an aluminum clamshell or Scoop Stretcher® or full-body immobilizers (e.g., Miller Body Splint®, Life Support Products, Inc., Irvine, CA) (62).

**ADJUNCTS FOR IMMOBILIZATION**

In addition to the three main spinal immobilization components, long and short backboards and cervical collar, several other items are needed to complete the technique. Straps, or a variant, are the most commonly used device to attach the body to the boards. There is no standard technique or method of strap application (89). The Farrington method of strapping a patient to a shortboard involves a crisscrossed strap across the torso and around the upper thigh (27). Variations include crisscrossing or looping over the shoulders and a "backpack" type of arrangement (30). Dulaney stated that any technique that works is acceptable (90). Recently, Mazolewski and Manix found that the addition of an abdominal strap can reduce lateral motion without adversely affecting respirations in healthy volunteers (91). Several investigators and manufacturers have recommended leg or groin straps when using intermediate-stage or short-board devices (27,30). Leg straps were initially intended for support in vertical extrication, as they were originally employed in the KED®. However, leg straps alone do not provide adequate pelvic immobilization.

Strapping the head to the short or long board frequently involves some type of support on either side of the head (26). Sandbags were the original imple-
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ments but fell into disfavor because of their weight and tendency to shift position (30). Towels, blanket rolls, or a commercial head immobilizer are preferred (12). Tape or straps can be used to secure the forehead to the board. One investigator has cautioned against using the common practice of placing a gauze pad under the tape (to avoid adhering to the patient's eyebrows) because this may defeat the desirable tape friction (12). The hazard of placing a chin strap that restricts mouth opening (consequently raising the aspiration risk) is echoed by several investigators (11, 26, 29, 30, 90). Alternative sites include the anterior portion of the rigid collar, upper lip, and maxillary region (26, 30, 90).

The order of head-to-torso immobilization is important according to some investigators, although disagreement over the sequence exists. Batchelor wrote that torso immobilization must precede head and neck fixation to avoid creating a lever arm should the unfixed torso move against a fixed head and neck (9). Butman and Vomacka concurred but for a different reason (30). They believed that routine adjustment of torso or groin straps might inadvertently affect the cervical spine. Others have not emphasized any particular order (8, 12). More important is snug (but not restrictive) application and avoidance of undesirable movement during strapping.

CONCLUSION

Spinal immobilization remains an important technique, with a growing body of scientific support. Current prehospital practice is to apply spinal immobilization liberally in cases of suspected neck or back injury. Rigid cervical collars, long backboards, and straps remain the standard implements for immobilizing supine patients. Tapes, foam blocks, and towels can complement the basic items and improve stability. Paddling may improve positioning and comfort. Intermediate stage devices include the short backboard and newer commercial devices. Properly used, all provide reasonable immobilization of the sitting patient. Future directions for study include refinement of optimal body position, dynamic performance of all devices, and broadening study populations to include children and the elderly.

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