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Original Contribution

Revolutionary advances in enhancing patient comfort on patients transported on a backboard ☆

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Abstract

Background: Patients with suspected spinal cord injuries are immobilized to a backboard during ambulance and helicopter air transport. It has been well documented that patients who are immobilized to a backboard experience discomfort and eventually become susceptible to pressure ulcer formation. Because the patient lying on a backboard is subjected to high skin interface pressures, it is imperative to improve patient comfort and prevent pressure ulcer formation.

Objective: Realizing the dangers of the potentially preventable pressure ulcers, our team of scientists, surgeons, and trauma nurses performed a comprehensive study of the Back Raft system that was designed to reduce patient discomfort and skin interface pressure.

Methods: Pressure under the occipital, scapula, and sacral regions of the back was measured using the Tactilus pressure analyzer of 10 healthy volunteers immobilized on a backboard and a backboard with a Back Raft air mattress system. Discomfort levels of each volunteer were measured using a Visual Analog Scale.

Results: Data from this study indicated that the Back Raft significantly reduces discomfort as well as tissue interface pressure in the occipital, scapula, and sacral regions of the back.

Conclusions: The implementation of an air mattress system analogous to the Back Raft would facilitate the prevention of pressure ulcer formation during prehospital care and transportation. In 2008, The

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Centers for Medicare and Medicaid Services enacted a policy in which the Centers for Medicare and Medicaid Services can refuse payment for hospital-acquired conditions. Pressure ulcers were among the hospital-acquired conditions within the final rule.

1. Introduction

In 1979, a team of nurses, trauma surgeons, and neurosurgeons wrote one of the first comprehensive reviews on the prehospital treatment of patients with spinal cord injuries (SCIs) [1]. In this clinical report, the authors pointed out that the lowered morbidity and mortality rates of patients with SCIs can be traced to improved techniques in patient care in the prehospital phase of the system. One of the highlights of the prehospital care of a patient with a SCI was to stabilize the patient before transport. It was pointed out that the cardinal principal in moving a patient with a suspected SCI was to prevent any motion of the spinal column that can further damage the spinal cord or nerve roots. This stabilization can be accomplished by immobilizing the patient's head, neck, and back, on a backboard before the transport.

Although SCI is uncommon in the relation of total prehospital patient encounters, up to 20 000 cases may occur annually in the United States and Northern Europe [2]. It is estimated that between 500 and 700 people in the United Kingdom and 10 000 people in the United States sustain a traumatic SCI each year [3]. Acute traumatic SCI occurs in approximately 3% of trauma admissions to hospitals, and half of these injuries involve the cervical spine [3]. Spinal cord injury can result in long-term disability, often with profound effects on the quality of life.

Backboards are routinely used throughout the world as a means of spinal immobilization during the course of trauma patient care. In the United Kingdom, it is acknowledged that spinal board usage is imperative for safe patient transport of patients with suspected SCI [4]. In an article by Anne Brownlee, a Registered Nurse from the Emergency Department (ED) of Prince of Wales Hospital in Randwick, NSW, Australia, it was pointed out that random control trials comparing spinal immobilization strategy on healthy volunteers provide strong support for early removal of spinal immobilization devices as a priority of management [5]. Immobilizing patients with backboards is a common procedure in our country used by Emergency Medical Technicians and Paramedics for all patients with SCIs [6]. These patients are fully immobilized before transport to the ED or trauma center, regardless of presenting signs or symptoms. Many studies have shown that this is a potential source of patient discomfort and pressure ulcer formation [6,7]. Several studies have also shown that immobilizing noninjured, healthy patients for 30 to 80 minutes on a backboard causes most subjects to have pain and discomfort [6]. Lerner and Moscati [6] point out in a prospective study that a patient spends an average 77 minutes on a backboard.

This report has the following components: (1) a detailed description of the Back Raft system, highlighting how it is attached to the backboard; (2) a narrative description of the technology of measuring patient discomfort on a standard backboard compared with that of a standard backboard with a Back Raft mattress; (3) a review of the skin interface measuring system for patients lying on a backboard as well as the same patients lying on a backboard containing a Back Raft; (4) the results of the level of discomfort and pressure mapping measurements of the occipital, scapula, and sacral regions of the back; and finally, (5) a discussion of the potential impact of pressure ulcer development on patients immobilized to a backboard, including malpractice liability, as well as reimbursement implications to the ED or trauma center.

The purpose of our study was to record the level of patient discomfort and to measure the tissue interface pressures at the occipital, scapula, and sacral, surface contact area of the standard backboard as well as on the backboard with a Back Raft system attached.

2. Materials and methods

The Back Raft is an inflatable air mattress and spinal stabilization apparatus that is applicable to a standard spinal

Fig. 1 The inflated Back Raft System attached to a standard backboard and inflation hand pump.

Fig. 2 Volunteer immobilized on inflated Back Raft system attached to a standard backboard.

backboard (compatible with 16- and 18-in backboards) (Fig. 1). The Back Raft was designed to reduce the pressure to critical pressure points by the inflation of 7 columns that support the shoulders and lower back. In addition, there are 3 columns of air support that stabilize the head and neck, reducing the pressure point on the back of the head, while increasing the effectiveness of spinal immobilization. The Back Raft is 100% latex-free and 100% x-ray translucent.

The Back Raft is applied and remains on the backboard before a patient is being immobilized on a backboard. The Back Raft can be inflated with a hand pump within seconds, filling the space between the patient and the backboard, relieving the stress on tissue interface pressures (Fig. 2). The function of the backboard is not compromised when the mattress is fully inflated, allowing transport of a patient to maintain the same level of efficiency.

Ten healthy volunteers who had not taken any pain medications in the preceding 24 hours and were not experiencing any back pain of any kind were studied on a backboard in 2 separate trials, lying on a backboard without a Back Raft, and then on a backboard with a Back Raft attached. Of the 10 healthy volunteers, 5 (50%) were men and 5 (50%) were women, with an average age of 45.3 years (range, 33-59 years). Height and weight of the volunteers were measured to calculate the body mass index (BMI) and pound-to-inch ratio (Table 1) [8].

Volunteers were placed horizontal on a wooden back board that was placed on a 3-ft high wooden assembly. The backboard used was a 16-in-wide XTRA backboard manufactured by Allied Healthcare Products Inc (St. Louis, Mo). The volunteers were studied for 30 minutes on a backboard without the Back Raft and then allowed off the board for 30 minutes to rest. They were then studied for a second 30-minute interval on a backboard with a Back Raft support attached.

Level of pain was measured at baseline (time 0) and at 15-minute intervals (15 and 30 minutes). At the end of each 15-minute period, subjects were asked to assess the tested surface for comfort on a 10-point Visual Analog Scale. The horizontal Visual Analog Scale was measured from 1 to 10, with 1 being “no pain” and 10 being “worst possible pain.” After each interval, the subject was asked to rate comfort. Interface or contact pressures between the subject and board or Back Raft were measured at the occipital, scapula, and sacrum with a Tactilus pressure evaluator. The Tactilus software is the creation of sensor products LLC (Madison, NJ). Tactilus takes data from Tactilus sensors, and displays images of pressure distribution as well as measures and calculates the average minimum and maximum pressure. The Tactilus software generates a 2-dimensional and 3-dimensional model from the calculations of the region or area of interest. An average of pressure in millimeter mercury was obtained at each location (occipital, scapula, and sacrum) at baseline and at 15-minute intervals. After the subject’s height and weight was recorded, we determined BMI by dividing weight by height (pounds-per-inch ratio).

Surface contact areas of a standard spinal backboard (16-in-wide XTRA backboard manufactured by Allied Healthcare Products) and the Back Raft were compared in 10 volunteers. Each subject’s examination resulted in a computer-generated diagram indicating the pressure distribution in each surface contact area (occipital, scapula, and sacral regions) on a Back Raft and on the standard backboard without a Back Raft. The evaluation was performed by using a computerized system that collects pressure data.

Table 1 Volunteers’ general data

Patient	Sex	Age (y)	Weight (lb)	Height (in)	BMI (kg/m^2)	PI Pound-to-Inch Ratio
1	M	56	165	71	23	2.32
2	F	59	155	66	25	2.35
3	M	56	165	70	23.7	2.36
4	F	37	140	63	24.8	2.22
5	F	51	160	66	25.8	2.42
6	M	39	270	72	36.6	3.75
7	M	33	148	71	20.6	2.08
8	F	38	120	63	21.3	1.90
9	M	40	085	73	24.4	2.53
10	F	44	135	66	21.8	2.05
Min		33	120	63	20.6	1.90
Max		59	270	73	36.6	3.75
Average		45.3	147.8	68.1	22.2	2.4
SD		9.38	41.3	3.73	4.52	0.512

The tactile pressure mapping sensor system shows how the pressure and body temperature are distributed as well as the magnitude of pressure occurring.

Statistical analysis was performed comparing *t* test for the 2 groups using Microsoft excel (2007). According to this analysis, a number of 10 volunteers in each group would provide a study with a power of 95%. For all statistical tests, a *P* value ≤.05 was considered significant.

3. Results

Of the 10 volunteer studied, 5 (50%) were female and 5 (50%) were male. The average (SEM) age was 45.3 (2.97) years (range, 33-59 years), the average (SEM) height was 68.1 (1.18) in (range, 63-73 in), the average (SEM) weight was 147.8 (13.06) lb (range, 120-270 lb), and the average (SEM) pound-to-inch ratio was 2.4 (0.16; range, 1.90-3.75). The average BMI was 24.7 kg/m^2. One Volunteer had a slight increase in their BMI (25.8 kg/m^2) suggesting that the patient was slightly overweight, and another Volunteer had a significant increase in their BMI (36.6 kg/m^2) indicating that the patient was obese. It is important to point out that the 2 patients with abnormal BMIs did not have a varied level of pain measurement and interface pressure level and had comparable levels to those of patients within normal BMI.

Pain measurements and interface pressure levels are reported in Table 2. The mean pain was 6.0 at the end of the period with no Back Raft and 0.9 at the end of the period with the Back Raft ($P \leq .05$). These measurements indicate that pain levels changed significantly over time ($P \leq .05$) and that the backboard by itself differed significantly in amount of pain than with the Back Raft attached ($P \leq .05$). All subjects reported that the Back Raft was "much more comfortable" than being immobilized on the backboard itself.

Interface pressure levels were significantly higher during the period with the backboard without the Back Raft mattress attached then during the period with the Back Raft at the occipital ($P \leq .05$), scapula ($P \leq .05$), and sacral ($P \leq .05$).

Table 2 Pain measurement and interface pressure levels

Parameters	No Back Raft		Back Raft		*P*
	Mean	SEM	Mean	SEM	
Pain					
0 min	0.10	0.10	0.20	0.20	NS [a]
15 min	3.15	0.32	0.40	0.22	<.05
30 min	6.00	0.53	0.90	0.18	<.05
Tissue interface pressures					
Occipital					
0 min	56.20	3.12	40.60	2.06	<.05
15 min	55.30	3.07	40.10	2.19	<.05
30 min	55.30	3.07	39.80	1.87	<.05
Mean	55.60	3.09	40.20	2.04	<.05
Scapula					
0 min	53.10	1.61	36.60	1.57	<.05
15 min	50.90	1.63	36.00	1.38	<.05
30 min	51.70	1.47	35.70	1.27	<.05
Mean	51.90	1.57	36.10	1.41	<.05
Sacral					
0 min	61.20	2.10	46.70	1.88	<.05
15 min	59.80	2.37	46.50	2.17	<.05
30 min	59.10	2.33	45.30	1.91	<.05
Mean	60.00	2.27	46.20	1.99	<.05

[a] Not significantly different from 0 ($P > .05$).

4. Discussion

In United States, backboards are routinely used to immobilize patients with suspected SCIs. Backboards are a critical component of the advanced traumatic life support protocol [9]. Emergency medical services (EMS) provide out-of-hospital or prehospital care and transportation to trauma or emergency facilities for patients experiencing a medical emergency. The practice of prehospital spine immobilization has been adopted as a standard EMS practice for trauma patients in the United States and many other countries [10]. Burton et al [10] reported that injury attributed to the immobilization intervention, including pain and discomfort, pressure sore development, respiratory compromise, and inadequate spine immobilization, is cited as a substantial consequence that outweighs the potential benefit derived form routine EMS immobilization of trauma patients.

In Kwan and Bunns systematic review of prehospital spinal immobilization, they found that there was a significant improvement in comfort associated with the use of vacuum mattress splints compared with wooden backboards. The medical and legal concern of missing a SCI has lent strong support for the conservative approach of liberal prehospital spinal immobilization to almost all patients with trauma and possible neck injury, regardless of clinical complaint [3]. The adverse effects of immobilization on a backboard of patients with suspected SCI, especially pressure ulcer formation, have been well documented.

A pressure ulcer is defined as an area of tissue damage appearing after a prolonged period of ischemia in the tissue. There are several factors that contribute to the formation of pressure sores. Extrinsic factors are externally applied pressure, shear forces, and increases in surface temperature and humidity [11]. Most researchers agree that the primary cause of pressure sores is externally applied pressure, leading to ischemia [11].

Pressure ulcers develop at bony sites where sustained pressure results in compromised perfusion, ischemia, and necrosis [12]. Low-grade ulcers can appear in as few as 2 hours [12]. As many as 3 million adults have at least 1 pressure ulcer, with an estimated cost of treatment being from

$500 to $70 000 per ulcer [13]. The United States spends an estimated 11 billion dollars per year on pressure ulcers, 60% of which begin during acute care admissions [14].

In 2007, a special advisory came out that the Center for Medicare and Medicaid Services released a final rule for its fiscal year 2008 hospital inpatient prospective payment system. Center for Medicare and Medicaid Services announced its decision to cease paying hospitals for some of the care made necessary by "preventable complications"—conditions that result from medical errors or improper care and that can reasonably be expected to be averted [15]. This rule implements a congressionally mandated change in hospital reimbursement. Pressure ulcers were listed under hospital-acquired conditions that would fall within this new rule. In 2006, it was reported that there was 322 946 Medicare cases of pressure ulcers, with an average payment for admissions being $40 381 [15]. As of October 1, 2008, medical conditions, if not present at the time of admission, are no longer calculated in the payments to the hospitals [15].This rule has resulted in hospitals seeing substantial reductions in payment for the care of individual patients with preventable complications.

Because of Center for Medicare and Medicaid Services' new policy, there has been new strategies implemented to prevent hospital-acquired conditions. Daily skin assessments, maximized nutrition and repositioning are some of the key strategies in published guidelines and hospital protocols for pressure ulcer prevention [16,17]. It was reported that the incidence of pressure ulcers acquired in the hospital has decreased from 6.1% to 3.9% between May 2007 and March 2008 [17]. With this new policy in place, physician and staff involvement in hospital-acquired conditions is imperative. Using a mattress system such as the Back Raft during medical emergencies and trauma accidents in which a backboard is used is taking prevention to a prehospital level that is necessary for avoiding hospital-acquired conditions such as pressure ulceration.

Pressure ulcer development in patients with SCI is a problem of great clinical significance. Sheerin and Frein [7] estimated that pressure ulcers will develop in up to 40% of patients in the immediate post injury period and up to 80% of patients overall. The National Pressure Ulcer Advisor Panel defines a pressure ulcer as the disruption of normal and anatomic structure and function of the skin that results from external force associated with a bony prominence and does not heal in an orderly and timely fashion [18]. Realizing the potential dangers of pressure ulcer development in patients immobilized to a backboard, a team of trauma surgeons, emergency medical technicians, and scientists provided scientific information on the performance of a revolutionary, inexpensive ($19.99 per Back Raft and $12.50 per hand pump) spinal board immobilization system, the Back Raft, developed by MediTech, Inc, distributed by Thomas EMS (Salt Lake City, Utah), that can dramatically reduce patient discomfort and skin interface pressure during transport of a patient stabilized to a backboard.

4.1. Limitations

The evaluation of the Back Raft system was done on healthy volunteers using a pressure mapping analyzer. Although the results of this evaluation documented positive results, we do not at this time have documentation that the use of a Back Raft system can prevent pressure ulcer formation in clinical patients during transport. Realizing this limitation, we are now initiating an additional study that will measure the frequency of pressure ulcers in patients being transported with the Back Raft used on a backboard. Because there are still ambulance services that do not use the inflatable air mattresses during transport, the data should be relatively easy to collect regarding the frequency of pressure ulcer formation in patients during transport.

5. Conclusions

Our findings demonstrated that the Back Raft provided relief of the tissue interface pressures of the occipital, scapula, and sacral regions of the back. In addition, the Back Raft system significantly reduced patient discomfort while lying on a backboard.

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