



Tissue-interface pressures on three different support-surfaces for trauma patients

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Summary The purpose of this study was to evaluate and compare tissue-interface pressures on three different support-surfaces for trauma patients. The support-surfaces were a semi soft overlay mattress, a vacuum mattress and a spine board. Tissue-interface pressures were measured in a standardised way between the scapulae, the sacrum, the heels and the different support-surfaces in 20 healthy volunteers. Appreciation of comfort of the support-surface was assessed using a 10-point visual analog scale. High and potentially ischaemic interface pressures were found on all three support-surfaces, with the highest pressures (exceeding 170 mmHg) measured on the spine board. The spine board got the worst comfort score. It was also noted that no support was given to the normal lumbar lordosis by the spine board. There is a need for new support-surfaces for trauma patients, which reduce interface pressures and are comfortable.

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Introduction

In the Netherlands, polytrauma patients are often transferred on a spine board, as required by protocol, for spinal immobilisation during transportation. Originally, the spine board was developed as an extrication device, for which reason it has to be rigid and light. Its use as a transportation device is good for the paramedics but not for the patient. In

many emergency departments, patients may not be lifted from the spine board before the presence of spinal injury has been ruled out on clinical and radiological grounds. This means that these patients generally spend a significant period on the spine board, as is illustrated in a study by Lerner and Moscati.³ They found that the total time a trauma patient spent on a spine board (including the period of transportation) averaged 63 min. When patients required radiological evaluation before removal from the backboard, the total spine board time averaged 3 h.

Patients with supposed critical injury often enter a cascade of prolonged immobilisation in a supine

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position during transport and in the emergency room, often followed by immobilisation on the OR table and eventually during ICU stay. A known risk of this immobilisation is the development of pressure ulcers, with reported incidences in trauma patients up to 31%.^{1,6} Few studies have addressed the discomfort and potential harmful consequences of the use of spine boards. Although it is supposed and generally advocated that a spinal fracture is best treated by rigid immobilisation on a flat surface, this can be questioned, and it may be argued that this way of immobilisation may have harmful consequences. Moreover, the use of the rigid spine board is supposed to lead to the development of pressure ulcers in critically injured patients, because the hard surface produces high interface pressures between the skin and spine board.

In many European countries, alternative methods are used for the transportation of trauma patients, for example the vacuum mattress.

The purpose of our study was to evaluate tissue-interface pressures on the spine board as well as on alternative transportation devices, e.g. a semi soft emergency department mattress and a vacuum mattress.

Material and methods

We prospectively collected data from 20 healthy volunteers, who were not experiencing any pain at the time of the study, and did not have a history of chronic back pain. The study group consisted of 7 men and 13 women, with an average age of 40 years (range 20–56 years). The subjects average body mass index (BMI) was 24 (range 20–27). The three different surfaces were tested by all volunteers, lying in a supine position for a period of 5 min on each surface. Devices were tested in a fixed order for all subjects: (1) the standard semi soft overlay mattress, which has a 5 cm thick foam core (Etesmi/JW Koch; Tilburg, The Netherlands) that is in use in our Emergency Department; (2) a vacuum mattress (Ambu[®], Germa AB; Kristianstad, Sweden) and (3) a spine board (Ferno-Washington, Inc.; Wilmington, OH, USA).

During the measurements, subjects were allowed to wear their normal clothing, but no shoes. The

vacuum mattress was folded comfortably around the body before applying negative pressure, as if it were used for transportation. At the end of each 5-min period, subjects were asked to assess the tested surface for comfort on a 10-point visual analog scale.

Tissue-interface pressures were measured with the XSENSOR X2-6912 pressure-mapping device (XSENSOR Technology Corporation; Calgary, Canada). This system consists of a thin, easily foldable full body pressure-mapping pad, equipped with 6912 capacitive sensors. This pad was placed between the subject and the support-surface, without folds. Placing pressure on the sensors results in the generation of a voltage difference, which increases linearly with the amount of pressure. Connection of the pad to a laptop computer with special XSENSOR software (version 4.0) allowed real-time pressure registration. Peak-pressure (in mmHg) measured at the scapulae, the sacrum and the heels were noted and compared for the three different surfaces.

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS[®]), version 11.0.1. Peak-pressure were compared using a Paired-Samples *t*-test. Differences were regarded significant if $p < 0.05$.

Results

The mean peak interface pressures on the three different surfaces are presented in Table 1. For all three contact sites, the interface pressures measured on the spine board were highest. Our standard overlay mattress compared favourably to both the vacuum mattress and the spine board for interface pressures measured at the scapulae and the sacrum. These differences were highly significant. At the heels, the pressures on the overlay mattress were comparable to those on the spine board and significantly higher than those on the vacuum mattress. At the sacrum, the pressures on the vacuum mattress and spine board did not differ significantly.

A striking, but expected finding was that the spine board did not give any support to the normally lordotic lumbar spine, as is illustrated in Fig. 1.

Table 1 Mean peak interface pressures (mmHg) by contact site and support-surface

Contact site	ER-overlay mattress, mean ($\pm$ S.D.)	Vacuum mattress, mean ($\pm$ S.D.)	Spineboard, mean ($\pm$ S.D.)
Scapulae	89.9 ($\pm$ 35.8)	131.6 ($\pm$ 50.9)	176.6 ($\pm$ 3.6)
Sacrum	118.0 ($\pm$ 28.4)	165.6 ($\pm$ 29.0)	174.9 ($\pm$ 15.8)
Heels	147.3 ($\pm$ 22.0)	123.3 ($\pm$ 45.2)	153.0 ($\pm$ 16.1)

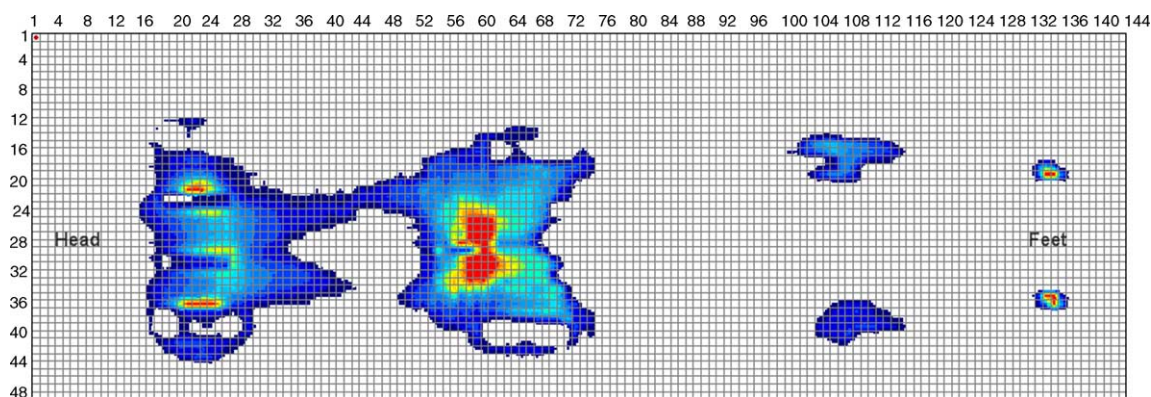


Figure 1 Contact sites on spine board, without support of lumbar lordosis.

The volunteers appreciated the overlay mattress with a mean comfort score of 7.0 (± 0.8), the vacuum mattress with a mean score of 6.6 (± 1.3) and the spine board with a mean score of 4.6 (± 1.2). When considering these comfort scores, the difference in appreciation for the overlay mattress and the vacuum mattress was not significant. Appreciations for the overlay mattress and the vacuum mattress were both significantly better when compared with the spine board.

Discussion

The results of our study confirm that high and potentially "ischaemic" pressures between the surface and the skin were reached on all of the three tested support-surfaces at all three exposed contact sites. To put these interface pressures in perspective, we must consider that maximum pressures that are measured on a good quality hospital mattress vary between 30 and 60 mmHg.²

High interface pressures on the spine board have previously been reported. Lovell and Evans found mean pressures in the sacrum area up to high as 147 mmHg and they were able to reduce this to 115 mmHg by padding the surface.⁴ It is therefore remarkable that during the past decade, in which the pressure ulcer problem gained attention, the layout of the spine board was not changed. In the same study, interface pressures dramatically reduced to 37 mmHg by using a vacuum stretcher. This finding could, however, not be reproduced in our study.

The extent of the pressure ulcer problem in critically injured patients, with an incidence figure up to 30.6%, is illustrated by several studies.^{1,6} In the study by Watts et al., 20% of trauma patients who were hospitalised more than 2 days developed at least one area of skin breakdown. In almost 50% of the cases, positional pressure was the most common cause for pressure ulcers.

One of the weaknesses of interface pressure measurements, as these were performed, is the interpretation of the outcome. It is uncertain whether pressures measured at the skin actually reflect the pressures that are present in the underlying tissues, the place where the ischaemic damage originates.⁵

The good subjective appreciation for the vacuum mattress is remarkable, considering the fact that interface pressures at the shoulders and the sacrum are significantly higher than those on the ER overlay mattress are.

Conclusions

Given the high, potentially harmful pressures found on three different and frequently used support-surfaces for trauma patients and the related unsatisfactory subjective comfort scores for two of them, there is a task for industrial designers to develop new, safe and more comfortable surfaces for the transportation of trauma patients. If there is no useful alternative, the time spent on a spine board should be kept as short as possible.

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