Near Infrared Spectroscopy Measurement of Sacral Tissue Oxygenation Saturation (StO2) in Healthy Volunteers Immobilized on Spine Boards

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Abstract. Immobilization of patients utilizing rigid spine boards (RSB) is standard practice in the management of trauma patients. Pressure ulcers (PU) have been associated with prolonged immobilization. The possibility exists that PU formation may begin when the patient is initially immobilized, the effects not fully recognized because of limited research on the direct tissue effects of prolonged immobilization. Near-infrared spectroscopy is an emerging tool to measure peripheral tissue oxygenation (StO2). The purpose of this pilot study was to study the effects of prolonged spinal immobilization on sacral tissue oxygenation of healthy volunteers. This cross-sectional study measured tissue oxygenation (StO2) in 73 volunteers at baseline and then after 30 minutes of immobilization on a RSB at two sites, the sacrum and a control site not subjected to direct pressure. Data were analyzed utilizing within-subjects analysis of variance. There was a significant increase in the StO2 percentage at the sacral (intervention) area following immobilization, p < .001, r pb = .48. No significant change in oxygenation was noted at the control site. An increase in oxygenation of sacral tissue following immobilization was an unexpected finding and may be a result of initial, rapid tissue reperfusion at the time of pressure release and the inability of this methodology to detect hypoperfusion during tissue compression.

1. Introduction

Immobilization of patients utilizing rigid spine boards (RSB) is standard practice in the initial management of trauma patients. Nationally recognized practice guidelines recommend spinal immobilization until spine injury is excluded [1]. Pressure ulcers (PU) of the skin have been associated with prolonged patient immobilization during medical procedures and may begin with initial immobilization [2]. Near-infrared spectroscopy is an emerging technology used to measure peripheral tissue oxygenation (StO2) [3]. The purpose of this study was to measure the effects of prolonged spinal immobilization on sacral tissue oxygenation of healthy volunteers.

2. Methods

This cross-sectional study received approval from the Wichita State University Institutional Review Board. Inclusion criteria included the following: healthy volunteers aged 18 or older; exclusion criteria included history of diabetes, smoking, or extensive skin rashes over spine. Participants were recruited from the WSU community using block stratification for sex, age, and BMI in order to obtain a representative sample.

Each study participant’s height and weight was measured prior to study initiation. Each participant had three baseline measurements of tissue oxygenation taken prior to the intervention: 1) at the intervention position (sacral area at top of buttocks); 2) at the local control position (area 8 to 10 cm above buttocks); and 3) at the distal control position (the thenar eminence). Tissue oxygenation measurements were taken with the InSpectra™ StO2 Tissue Oxygenation Monitor (Hutchinson Technology®, Hutchinson, MN). Tissue oxygenation measurements were taken by placing the near-infrared probe at the measurement site and waiting for 15 seconds for equilibration. The percentage of tissue oxygenation was recorded. All baseline measurements were taken by two independent researchers.

Participants were categorized into BMI classifications were defined as follows: underweight, < 18.50; normal, 18.50 – 24.99; overweight, 25.00 – 29.99; and obese ≥ 30.00. Participants were immobilized on a rigid spine board for a period of 30 minutes. At the end of the 30 minute period, participants were then log-rolled to one side and two tissue oxygenation (StO2) readings were taken: 1) at the intervention position (sacral area at top of buttocks) and the local control (area 8 to 10 cm above buttocks). Participants were then released from immobilization.
Baseline measurements were averaged for pre-rigid spine board (RSB) comparison analysis. Pearson correlation coefficient was used for inter-rater reliability and t-tests were used to evaluate mean comparison between raters for baseline measurements. Within-subjects analysis of variance was used to analyze differences between the three baseline measurements. Pre/post mean comparison was analyzed using repeated measure t-tests. Sub-group comparisons were analyzed using mixed-model analysis of variance. Similarities for age, sex, body mass index (BMI) groupings in sub-groups were analyzed using chi-square and t-tests where appropriate. Analyses were performed using SPSS 15.0 for Windows. Probabilities of < 0.05 were considered significant.

3. Results

There were 74 volunteers who were eligible to participate in this study. One participant was excluded from analysis because three of the eight tissue oxygenation measurements were less than two standard deviations from the mean; thus, 73 participants were included in the analysis. The study sample almost equal in sex with slightly more females (55%) and the average age was 37.7 (CI: 33.9 - 41.5) years old. Mean height (cm) was 170.1 (CI: 168.0 – 172.2); mean weight (kg) was 81.6 (CI: 76.6 – 86.6) and the mean BMI was 28.0 (CI: 26.3-29.6) Two participants fell within the “underweight” category with less than 18.5 BMI; thus, they were excluded from the BMI status comparison.

The pairs of baseline measurements for each location were averaged as all pairs of baseline measurements were significantly correlated and means were not statistically different. Variance accounted for was 66%. At the sacral area (contact with RSB), the tissue oxygenation measurement was significantly higher at post-RSB than at pre-RSB, \( p < .001, r_{pb} = .48 \). Forty-eight percent of the variance was accounted for. At the local control (above sacrum), there was not a significant difference in StO2 oxygenation in the pre/post RSB measurements, \( p = .274 \).

Sub-group analysis revealed no significant differences in StO2 measurements between participants of varying BMI, gender or age group.

4. Conclusion

An increase in sacral tissue oxygenation following immobilization was an unexpected finding and may be a result of initial, rapid tissue reperfusion at the time of pressure release and the inability of this methodology to detect hypoperfusion during tissue compression. If tissue damage resulting in an increased rate of PU formation is associated with compression, it is not well known if this results from tissue hypoperfusion or rapid reperfusion of the tissue. Future research is indicated with a larger sample size and possibly varying times of spinal immobilization.

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