Respiratory Effects of Spinal Immobilization in Children

Study objective: To assess the restrictive effects of two spinal immobilization strapping techniques on the respiratory capacity of normal, healthy children.

Design: Prospective study with each subject serving as his own control.

Participants: Fifty-one healthy children 6 to 15 years old.

Interventions: Participants' forced vital capacity (FVC) measurements were first obtained with children standing and lying supine and then in full spinal immobilization using two different strapping configurations, cross straps and lateral straps. Straps were tightened to allow one hand to fit snugly between the strap and child.

Measurements and main results: Supine FVC was less than upright FVC (P < .001). FVC in spinal immobilization ranged from 41% to 96% of supine FVC (80 ± 9%). There was no difference in FVCs between strapping techniques (P = .83).

Conclusion: Spinal immobilization significantly reduced respiratory capacity as measured by FVC in healthy patients 6 to 15 years old. There is no significant benefit of one strapping technique over the other. [Schafermeyer RW, Ribbeck RM, Gaskins J, Thomason S, Harlan M, Attkisson A: Respiratory effects of spinal immobilization in children. Ann Emerg Med September 1991;20:1017-1019.]

INTRODUCTION

Various accepted, but sometimes untested, techniques and devices are used in spinal stabilization of the trauma patient. Standard spinal stabilization entails the use of a hard backboard, cervical collar, sandbags, tape, and straps to ensure immobilization. Respiratory effects of immobilization are not well documented. However, Bauer and Kowalski reported that spinal immobilization produced significant restrictive effects on pulmonary function in a group of healthy, nonsmoking adults and cautioned that these effects might further compromise respiratory function in a setting of concurrent, underlying pulmonary pathology. Such findings warrant similar concerns in the pediatric population.

Our study examined the effects of two different strapping techniques for spinal immobilization, lateral and cross strapping, to determine the restrictive nature of spinal immobilization on normal, healthy children as assessed by forced vital capacity (FVC) measurements.

MATERIALS AND METHODS

Approval for this study was obtained from the Human Subjects Research Protection Committee of the Carolinas Medical Center. The study population consisted of 51 healthy children from 6 to 15 years of age who were selected from Boy Scout and Girl Scout groups in the local area. Children were asked to volunteer and were required to obtain the written permission of their parents before being accepted into the study. Children were excluded from participation if they had chronic respiratory illness or heart disease. The mechanics of the study were explained to the participants, but they were not told the exact purpose of the study. Each participant served as his own control.

One respiratory therapist obtained all FVC measurements using a Wright spirometer. One paramedic performed the spinal immobilizations on all
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FIGURE 1. Location of straps for immobilization with A) lateral-strap technique and B) cross-strap technique.

FIGURE 2. Comparison of supine FVC with FVCs obtained with spinal immobilization using either lateral or cross strapping.

Subjects using the same equipment throughout. Strap tensions were set to a subjective uniform tightness that allowed one hand to fit snugly between strap and child in all cases.

Weight and height measurements were taken on each child and recorded with age and sex. Each child was shown how to use the spirometer by the respiratory therapist. Two FVC measurements were obtained from each child in the standing position, followed by two measurements of FVC in the supine position.

Next, each subject was placed in full spinal immobilization and secured to the backboard with either of the two experimental strapping conditions, lateral or cross strap; the method of strapping to be used first was alternated in each case. The strap placements for lateral strap and cross strap techniques are shown (Figure 1). Two measurements of FVC were obtained, with the children supine under each strapping configuration. The children were allowed to rest for two minutes between each pair of FVC measurements [upright, supine, lateral strap, and cross strap].

Each set of duplicate FVC measurements was averaged to obtain one FVC per child in each position: upright, supine, supine, spine immobilized with lateral strapping, and supine, spine immobilized with cross strapping.

Data were analyzed by paired t test. For all analyses, P < .05 was considered statistically significant. All values reported are means ± standard deviations. An expected FVC measurement was calculated to ensure that each subject was performing with maximal effort on FVC measurements. FVC values are reported in liters.

RESULTS

All 51 healthy volunteers completed the study. Their ages ranged from 6 to 15 years (10.6 ± 2.4 years), with 22 males and 29 females participating. Heights of the participants ranged from 45.0 to 69.5 in. (57.7 ± 6.2 in.).

FVC measurements made in the upright position were compared with each subject’s calculated FVC obtained using height, age, and sex as determining factors. Thirty-eight children exceeded their calculated FVC in the upright measurement [calculated 2.35 ± 0.82 L; upright 2.63 ± 1.07 L, P < .0001]. Fourteen of 17 children (82%) 9 years old or younger had supine FVCs lower than calculated, and 29 of 34 children (85%), more than 9 years old had supine FVCs greater than calculated. All supine FVC measurements were less than upright measurements in the same individuals (P < .0001).

Once the children were placed in spinal immobilization with either strapping technique, FVC measurements in spinal protocol were consistently less than those obtained while supine, but unrestricted, ranging from 41% to 96% [80 ± 9%] of supine FVC with spinal immobilization (Figure 2). The differences in mean FVC measurements between supine and supine with spinal immobilization were statistically significant [P < .0001] [supine, 2.45 ± 0.99 L; lateral strap, 1.98 ± 0.87 L; cross strap, 1.97 ± 0.80 L].

There was no benefit of one strapping technique over the other based on the paired difference in mean FVCs [P = 0.83]. Of the 51 children, 25 had cross strap and lateral strap FVCs that differed by less than 100 mL, 13 had lateral strap FVCs greater than their cross strap FVCs by 100 mL or more, and 13 had cross strap FVCs greater than their lateral strap FVCs by 100 mL or more.

DISCUSSION

The effect of spinal immobilization on pulmonary function in children is not well understood. Children can have significant pulmonary or thoracic cage injury with minimal external signs of trauma. Gastric distention, severe abdominal hemorrhage, or diaphragmatic injury can impair ventilatory effort. Straps placed around the chest and abdomen of a child placed in spinal immobilization can restrict chest wall movement and diaphragmatic excursion.

The data presented here support
the findings of Bauer and Kowalski, who also have demonstrated that spinal immobilization significantly reduces respiratory capacity because of the restrictive strapping used. Our goal in this study was to determine whether one of two strapping techniques would be less restrictive for children's respiratory capacity. We were unable to identify a significant benefit of one strapping technique over the other, regardless of age or height differences in this representative population of healthy children 6 to 15 years old.

These findings emphasize the importance for the paramedic in the field to ensure that a child in spinal immobilization does not have excessive restriction to his respiratory mechanics. Children can have significant pulmonary injury or thoracic cage injury with minimal external signs of trauma. The emergency medical technician must first assure oxygenation and support ventilatory effort, and then consider the causes of ventilatory difficulty, which can include the restrictive effect of spinal immobilization.

CONCLUSION

Children vary markedly in height and body habitus as they mature from childhood to adulthood. Placing a child or adult in a supine position with spinal immobilization restricts FVC. There does not appear to be one best technique for attachment to the spine board. The mean reduction in FVC in spinal protocol was 80% of supine FVC in this study. Thus, prehospital personnel must evaluate whether the spinal immobilization technique used compromises ventilation.

REFERENCES