Cervical Prevertebral Soft Tissue Standards: A Longitudinal Radiographic Study in a Normal Pediatric Population
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INTRODUCTION: Evaluation and management of cervical spine injuries is frequently difficult in pediatric populations. Prompt and accurate diagnosis of cervical spine trauma can be impeded by the absence of obvious radiographic evidence of injury. Unfortunately, this delay in diagnosis can lead to profound and irreversible neurologic consequences. For adult patients with suspected cervical spine injury, the measurement of prevertebral soft tissue (PVS) swelling is a commonly used radiographic parameter to detect the presence of cervical spine injury. However, because normal standards have not been adequately established in pediatric patients, assessment of soft tissue swelling following cervical trauma in this population is challenging. This is the first study to document the PVS measurements in normal individuals followed longitudinally in a prospective manner from infancy to adulthood.

METHODS: Thirty-two healthy subjects (16 male and 16 female) who had annual cervical spine radiographs from 3 months to 19 years of age were selected from the Bolton-Brush Growth Study collection. Radiographs were evaluated every 3 months during the first year of life, and at two-year intervals thereafter. At C1, PVS measurements were made from the anterior ring to the posterior airway shadow parallel to the C1 axis (Fig. 1). Measurements at C2-6 were made parallel to the cervical endplates from the anteroinferior vertebral margin to the posterior margin of the airway shadow. A total of 1716 cervical levels were measured from 332 lateral cervical radiographs at all observed levels. The Laryngoesophageal Junction (LEJ), defined as the radiolucent junction of the larynx and esophagus (Fig. 1), was identified and used as a radiographic marker to study the normal growth and caudal descent of the laryngeal airway and its effect on cervical PVS measurements. Statistical analysis of data was performed using the t-test when comparing two independent samples, and ANOVA when multiple samples were being compared. Statistical significance was regarded as p<0.05. Pearson coefficients were calculated to assess the relationship between PVS changes over time to the caudal descent of the LEJ.

RESULTS: The mean PVS measurements (and standard deviation) for all subjects at each cervical level were as follows: At C1, 6.1mm (±2.7); at C2, 3.4mm (±1.2); at C3, 3.9mm (±1.8); at C4, 5.5mm (±2.5); at C5, 8.4mm (±2.1); at C6, 8.8mm (±2.3) (Fig. 2). From three months of age to skeletal maturity, the
PVS measurement at the C2-4 levels decreased over time. In contrast, the PVS measurements at the C5-6 levels increased over the same time period. This correlated with a concurrent caudal descent of the LEJ (Pearson coefficient, r = -0.83 when compared to C6; r = +0.89 when compared to C4). Males had larger PVS values at every cervical level, except at C4. In addition, there were statistically significant differences PVS differences between male and female subjects at C1, C2, C3, and C6 (p<0.05). When comparing the PVS measurements of 0-5 year old subjects to those of 6-19 year old subjects, statistically significant differences were found at the C2-6 levels (p<0.01).

CONCLUSIONS: Measurement of prevertebral soft tissues is a commonly used radiographic parameter that may suggest the presence of cervical spine injury. In order to identify abnormal soft tissue swelling, normal standards must first be established. Upper cervical prevertebral soft tissues parameters (C2-4) appear to decrease during normal growth and development. Younger subjects (0-5 year olds) had statistically larger PVS values at upper cervical levels (C2-4) than older subjects (6-19 year olds). This is in contrast to lower cervical PVS levels (C5-6) which increase with normal development. At C5 and C6, younger subjects had statistically smaller PVS values compared to older subjects. Regarding gender differences in PVS measurements, males had larger PVS values than females. Based on the normal caudal descent of the LEJ, C2 and C6 appear to be reliable levels when measuring prevertebral soft tissues. That is, in comparison to the effect of the LEJ on mid-cervical levels (C3-5), soft tissue measurements taken at C2 and C6 are less likely to vary significantly over time. We, therefore, recommend that PVS measurements be taken at C2 and C6 in pediatric populations. Mean PVS values in addition to two standard deviations at C2 and C6 (which represent 95% of the population), result in values of 6 mm and 14 mm, respectively. Values greater than 6 mm at C2, and 14 mm at C6 can then be considered abnormal cutoff values in pediatric patients. Normal PVS standards presented in this study may help differentiate between normal and abnormal soft tissue swelling in pediatric patients with suspected cervical spine trauma.
Figure 1. Measurement of prevertebral soft tissues (PVS) at C1 is performed from the anterior ring to the posterior airway shadow parallel to the C1 axis (black arrows). Measurement of PVS at C2-C6 is performed from the anteroinferior margin of the vertebral body to the posterior airway shadow parallel to the inferior endplate. LEJ = Laryngoesophageal Junction (arrowhead).

![Prevertebral Space vs Cervical Spine Level](image)

Figure 2. Mean prevertebral soft tissue measurements (in millimeters) at cervical levels 1-6.