Pediatric Lateral Atlantodental Interval: How Much Asymmetry is Normal?

Heather L. Borders, MD,†‡ Joseph J. Junewick, MD,*†‡ John M. Sherwood, MD,*†‡ and Michael R. Macke, MD§*

Abstract: Imaging of the cervical spine is commonly performed in the pediatric patient population, typically after trauma, as well as for a variety of nontraumatic reasons. There are many challenges in the interpretation of these studies, particularly at the level of the atlantoaxial joint. We recognized a particular problem with assessing the lateral atlantodental interval in our emergency radiology department. Mild lateral atlantodental interval asymmetry in relatively asymptomatic patients was being interpreted as indicative of atlantoaxial rotatory fixation, which leads to the recommendation for dynamic computed tomographic examinations. The goal of this study was to define the reference range of the lateral atlantodental interval in pediatric patients to help avoid misinterpretation of radiographic findings and resultant excessive imaging.

Key Words: cervical spine, atlantoaxial joint, atlantoaxial rotatory fixation

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Interpretation of imaging studies of the pediatric cervical spine is challenging. Numerous anatomic and developmental variants and factors such as ligamentous laxity, weak neck muscles, horizontal facet joints, and synchondroses contribute to unique pediatric patterns of injury and interpretive challenges.[1] Normal rotation of the head, which occurs mainly at the C1–C2 level, results in asymmetry of the lateral masses of the atlas and the lateral atlantodental interval (LAI). Asymmetry of the LAI is used as a diagnostic clue for the presence of Jefferson burst fracture and atlantoaxial rotary fixation,[2,3] but this needs to be interpreted with caution, as a certain degree of asymmetry can be attributed to normal variation and normal rotation.

Knowledge of the normal range of asymmetry of the LAI is necessary information when interpreting cervical spine imaging studies in the pediatric patient to avoid misdiagnosis and unnecessary imaging. To date, only one study known to us has specifically defined the LAI in children, whereas several have addressed this in adults.[4–6] The current study addresses the following questions: What is the natural asymmetry of the LAI in children? Is LAI asymmetry related to C1 lateral mass width, patient' age, or the presence of minor inflammation?

MATERIALS AND METHODS

An institutional review board–approved retrospective review was conducted for the period January to December 2007. All nontrauma patients younger than 18 years who underwent computed tomography of the neck were included in the review. Patients with congenital spinal abnormalities, insufficiently ossified vertebral elements precluding accurate measurement, or those whose images were not able to be manipulated in picture archiving and communication system were excluded. Axial 2.5-mm images were obtained using General Electric multislice scanners and reconstructed at 1.25-mm intervals. An optimized coronal image (for measurements) was reformatted by correcting for rotation in the axial plane, for tilt in the coronal plane, and for flexion and extension in the sagittal plane, using the 3-dimensional tool embedded in McKesson picture archiving and communication system (Fig. 1). Measurements obtained included (1) the LAI (from coronal images) between the lateral odontoid margin and the medial margin of the lateral mass and (2) the lateral mass width at its midpoint. In addition, LAI asymmetry was compared to age and the presence of inflammation (defined for this study as adenopathy and/or subcutaneous edema). Statistical evaluation was performed using the Student *t* test, analysis of variance, and the Pearson correlation coefficient.

RESULTS

A total of 138 patients were analyzed. The mean (SD) asymmetry of the LAI in all patients was 1.39 (1.26) mm. This is similar to the mean (SD) value of 1.6 (1.4) mm obtained by Pennecot et al.[6] Patients with abnormal CT scan findings that indicated the presence of an inflammatory process (n = 70) had a mean (SD) LAI asymmetry of 1.46 (1.29) mm. Those without evidence of an inflammatory process (n = 68) had a mean asymmetry of 1.32 (1.33) mm. No significant difference was found in the mean asymmetry between these 2 groups ($t = 0.60$, $P = 0.55$).

Patients aged 7 to 18 years (n = 70) had a mean (SD) LAI asymmetry of 1.53 (1.39) mm. Patients aged 1 to 6 years 11 months (n = 54) demonstrated a mean (SD) asymmetry of 1.35 (1.17) mm. The mean (SD) LAI asymmetry for the 0-to-11-months age group (n = 14) was 0.80 (0.65) mm. The mean LAI asymmetry was not significantly different between the 3 groups ($F = 2.01$, $P = 0.14$). No significant correlation was demonstrated between lateral mass width asymmetry and LAI asymmetry ($r = 0.07$, $P = 0.39$).

DISCUSSION

Evaluation of cervical spine injuries in children is often complicated by normal anatomic variation and pediatric-specific disease processes.[1] Lack of knowledge of the pediatric cervical spine anatomy can lead to misdiagnosis of normal variation, delayed diagnosis of cervical spine injury, or excessive imaging (radiation exposure).

Normal rotation of the head largely occurs at the C1–C2 level and results in the asymmetry of the LAI. In a patient with no or minor clinical symptoms and absence of significant trauma, asymmetry of the LAI is likely normal if within the limits defined in this study (Fig. 2). However, clinical correlation

From the *Michigan State University, East Lansing, MI; †Department of Radiology, Spectrum Health, Grand Rapids, MI; ‡Advanced Radiological Services, Grand Rapids, MI; and §Radiology Consultants of Iowa, Cedar Rapids, IA.

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Reprints: Heather L. Borders, MD, 3264 N Evergreen Grand Rapids, MI 49525 (e-mail: heatherborders@gmail.com).

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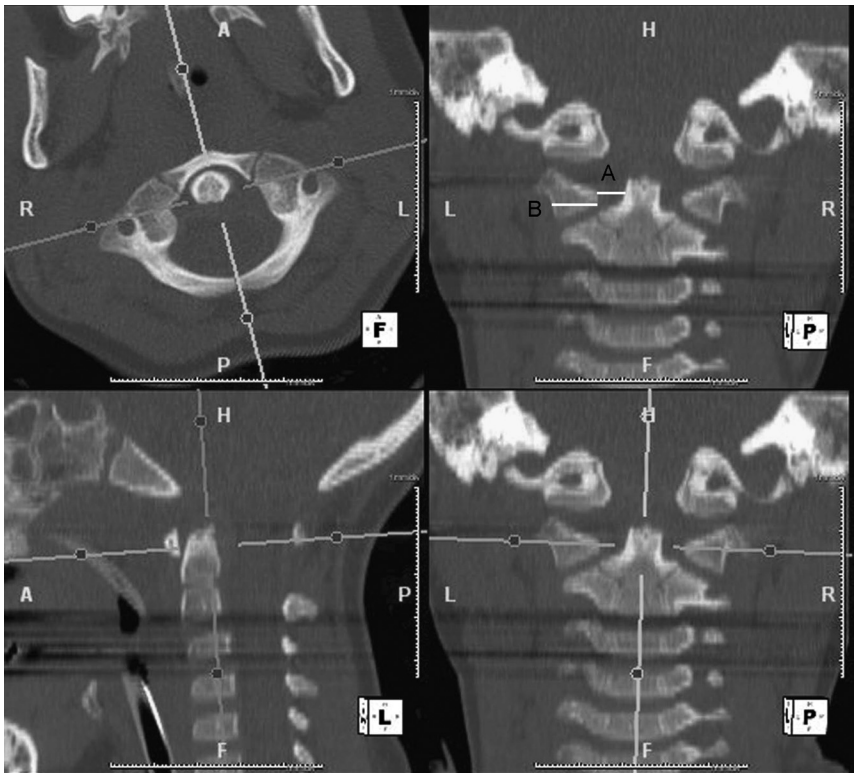

FIGURE 1. Image manipulation methods: Rotation was corrected in the transverse plane, tilt was corrected in the coronal plane, and flexion and extension were corrected in the sagittal plane to obtain the optimal image bisecting the mid-dens for measurement of the right and left LAI. A, Measurement 1 and (B) measurement 2 as described in the ''Materials and Methods'' section.

is necessary to determine if the head is fixed in a rotated position because in certain situations, asymmetry of the LAI will likely be related to rotatory pathology despite falling within a reference range. A patient in this category would likely benefit from evaluation with a dynamic CT study, the test of choice in patients with suspected rotatory fixation, with the degree of LAI asymmetry being less relevant in this situation.[7] If the LAI is outside the range defined in this study, particularly in a patient suspected of having rotatory pathology clinically, imaging findings support the clinical diagnosis (Figs. 3 and 4).

Our study was limited by reviewing CT scans only of relatively asymptomatic patients. Patients with torticollis were not included in the study to allow assessment of the overlap in LAI asymmetry in patients with and without torticollisfs. This study

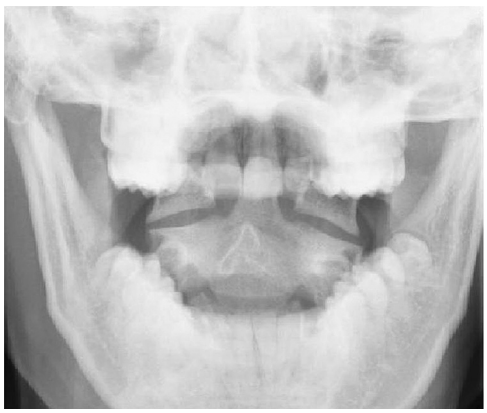

FIGURE 2. Anteroposterior radiograph in a 17-year-old girl with a history of minor trauma demonstrates an asymmetric LAI: 6.4 mm on the right and 4.1 mm on the left. The difference of 2.4 mm falls within the reference range of asymmetry based on our results. This helps to increase the confidence of normal.

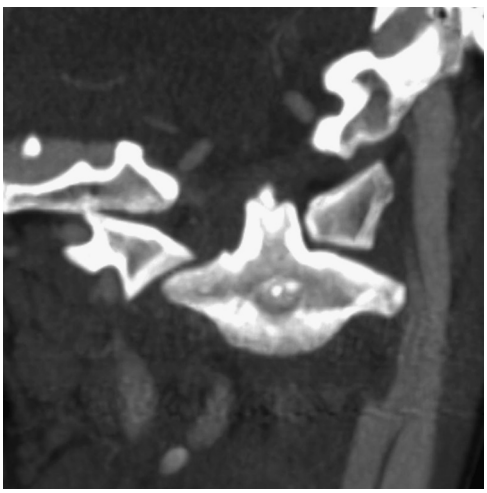

FIGURE 3. Contrast-enhanced CT to evaluate for abscess in a 5-year-old boy with neck inflammation demonstrates an asymmetric LAI: 8.4 mm on the right and 0.7 mm on the left. The difference of 7.7 mm is abnormal based on our results. This helps to confirm pathologic torticollis.

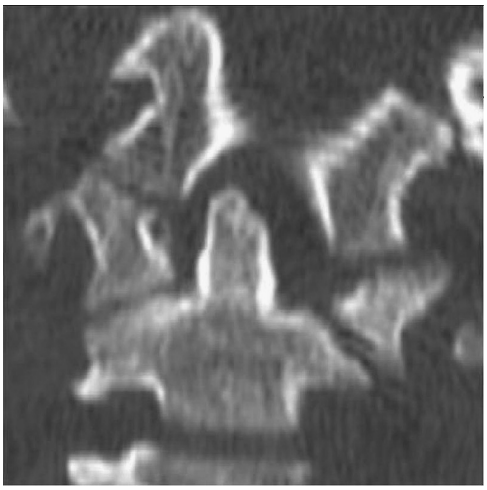

FIGURE 4. Noncontrast CT in a 4-year-old girl with symptoms of atlantoaxial rotatory fixation demonstrates an asymmetric LAI: 2.6 mm on the right and 8.5 mm on the left. The difference of 5.9 mm is abnormal based on our results. This helps to confirm atlantoaxial rotary fixation.

does call into question the usefulness of the LAI in the evaluation of suspected rotatory fixation of the C1–C2 level. It would be interesting to compare the LAI measurements in patients with known traumatic rotatory fixation to the results from this study to determine the overlap with the "normal" established by this study.

CONCLUSION

We found the mean (SD) asymmetry between LAI to be 1.39 (1.26) mm independent of lateral mass width or the presence of inflammation. Consequently, up to 3.91 mm of asymmetry between the right LAI and the left LAI is most likely normal. This is particularly true in a patient with no or minor clinical symptoms and/or history of minor trauma and is likely also valid in a patient with this history whose head is in a mildly rotated or tilted position. We conclude that the LAI asymmetry in our study represents natural variation seen in the pediatric population and will aid in the accurate diagnosis of rotational injury compared to normal variation.

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