Objectives—Pediatric tonsillar infections are common, particularly in adolescents. Ultrasonography (US) has high sensitivity and specificity for diagnosing peritonsillar abscesses and can diagnose tonsillitis by enlargement of the gland. In this study, we established normal tonsillar measurements and volumes according to age in pediatric populations.

Methods—Transcervical US of the peritonsillar region to measure tonsillar size and volume was performed in patients who had undergone neck US without throat symptoms from October 2016 to May 2017. Transverse and anteroposterior diameters, length, and volume were measured.

Results—In total, 161 patients (age range, 1 month–18 years) were enrolled in the study. The mean tonsillar volumes ± SD were 1.58 ± 1.26 (total), 0.30 ± 0.14 (<1 year), 1.27 ± 0.57 (1–<5 years), 2.06 ± 1.09 (5–<10 years), and 2.19 ± 1.48 (>10 years) cm³. Mean measurements for the sums of both tonsils for the transverse diameter, anteroposterior diameter, and length were 1.98 ± 0.61, 2.17 ± 0.66, and 2.28 ± 0.69 cm, respectively. Tonsillar size and volume increased according to age. Simplified models for volume estimation showed that anteroposterior diameters had the highest coefficients of determination ($R^2 = 0.71$ and 0.74). Regression models for the tonsillar volume of 6 measurements in the multiple linear regression models showed an $R^2$ of 0.89. Regression models for log(volume) showed an improved coefficient of determination ($R^2 = 0.96$).

Conclusions—These normal tonsillar sizes on transcervical ultrasound in pediatric patients can be used to diagnose tonsillar lesions.

Key Words—child; head and neck; infection; pediatrics; peritonsillar abscess; tonsil; tonsillitis; ultrasonography

Peritonsillar infections include tonsillitis, peritonsillar cellulitis, and peritonsillar abscesses and are common in pediatric populations. The infection extends into the surrounding tissue, resulting in peritonsillar cellulitis or a peritonsillar abscess. Peritonsillar abscesses are characterized by purulent fluid collections. Inaccurate diagnosis can result in delayed management and potentially life-threatening complications such as extratonsillar extension into the deep neck space or mediastinum, aspiration pneumonia, and sepsis. The differential diagnosis of peritonsillar cellulitis and an abscess is insufficient based on the clinical history and physical examination. However, distinction is important, since management often differs. Medical treatment is sufficient for cellulitis, whereas needle aspiration, drainage, or surgery may be needed for a peritonsillar abscess. Needle aspiration is frequently required to treat abscesses. However, it is difficult to perform in children and patients with...
trismus and carries a risk of vascular injury. Thus, clinical diagnosis is often supplemented by imaging.5–7

Computed tomography (CT) has been used to diagnose suspected peritonsillar abscesses and to understand vascular anatomy, and it is more often applied in younger children.5 However, CT requires radiation exposure, a contrast agent, and sometimes sedation. Radiation exposure in children should be limited because of the risk of malignancy.8–10 Ultrasonography (US) is a commonly used imaging modality in pediatric populations, following an increasing awareness of the risks associated with radiation exposure. In children, US is an ideal imaging modality for investigations of various tissue and organ systems. Thus, any adjuvant US study that can decrease the use of additional CT scans would be helpful. Ultrasonography effectively distinguishes peritonsillar abscesses from peritonsillar cellulitis.2–4,6,7 Intraoral US and transcervical US have both been used for the diagnosis of peritonsillar abscesses, and these examinations showed similar accuracy.4,6,7 Tonsillitis appears as an enlarged gland with a striated appearance and preserved hypoechoic echo texture, whereas peritonsillar abscesses appear as an enlarged tonsil with cystic changes.5 Here, we established normative values for the tonsil in pediatric populations.

Materials and Methods

This retrospective study was approved by our Institutional Review Board. Data were collected prospectively and analyzed retrospectively. Verbal consent for tonsillar evaluation was obtained from the mothers or patients for all of the children and adolescents during US examinations.

In total, 322 normal tonsils were examined from 161 patients who underwent neck US between October 2016 and May 2017. Patients were scanned for torticollis, abnormal thyroid function, enlarged thyroid glands, and palpable masses other than lymphadenopathy in the cervicofacial region. Patients with clinical evidence of pharyngotonsillitis and cervical lymphadenopathy were excluded from the analysis. The included patients took no immunosuppressive drugs and had no history of disease (including hematologic or malignant disease). Patients were classified into 4 groups according to age: younger than 1 year, 1 to younger than 5 years, 5 to younger than 10 years, and older than 10 years. Transcutaneous US was performed with a hyperextended neck in the supine position. The US examinations were performed with a 5–12-MHz linear array transducer (iU21; Philips Healthcare, Bothell, WA), a 6–15-MHz linear array transducer (LOGIQ E9; GE Healthcare, Milwaukee, WI), and a 5–12-MHz linear array transducer (Aplio 500; Toshiba Medical Systems Corporation, Otawara, Japan). Transcervical US was performed with the transducer located at the submandibular space. Transverse and anteroposterior diameters and length were measured from transverse and longitudinal scans. The transverse diameter, anterior diameter, and length were used for calculations (Figure 1). The volume of each tonsil (a prolate ellipsoid) was calculated by the formula transverse diameter × anteroposterior diameter × length × 0.523. The sums for both tonsils were obtained by adding the right and left measurements from each tonsil. Multiple regression analyses were used to determine the dimension most strongly associated with tonsillar volume. All 6 parameters were included in the initial
multiple regression model, and variable selection was performed on the basis of backward elimination using the Akaike information criterion. To assess multicollinearity among the variables, variance inflation factors were computed in each model, and the explanation power of each model was represented as the adjusted coefficient of determination ($R^2$).

Results

In total, 161 patients (79 male and 82 female; age range, 1 month–18 years) were enrolled in the study. Sex was not statistically different between the groups ($P = .311$). A normal tonsil appears as hypoechoic soft tissue with alternating linear hyperechoic and hypoechoic lines and has lower echogenicity than that of the submandibular gland. The means, standard deviations, and normal ranges of tonsillar measurements according to age are summarized in Table 1. The mean tonsillar volumes

| Variable | Total | Age, y | $P$ for Trend |
|----------|-------|-------|--------------|
|          |       | <1    | 1–4          | 5–9 | 10–14 | ≥15     |
| Male     |       |       |               |     |       |         |
| Right lobe | n = 79 | n = 19 | n = 13 | n = 29 | n = 8 | n = 10 |
| RT       | 1.01 ± 0.36 | 0.58 ± 0.13 | 1.05 ± 0.24 | 1.17 ± 0.30 | 1.13 ± 0.26 | 1.21 ± 0.34 | < .001 |
| RAP      | 1.10 ± 0.37 | 0.72 ± 0.18 | 1.10 ± 0.24 | 1.19 ± 0.24 | 1.35 ± 0.32 | 1.40 ± 0.51 | < .001 |
| RL       | 1.16 ± 0.39 | 0.70 ± 0.16 | 1.14 ± 0.23 | 1.25 ± 0.26 | 1.58 ± 0.41 | 1.43 ± 0.35 | < .001 |
| RV       | 0.85 ± 0.75 | 0.16 ± 0.11 | 0.72 ± 0.33 | 0.99 ± 0.52 | 1.39 ± 0.90 | 1.48 ± 1.19 | < .001 |
| Left lobe |        |       |               |     |       |         |
| LT       | 0.96 ± 0.32 | 0.55 ± 0.13 | 1.03 ± 0.22 | 1.11 ± 0.23 | 1.10 ± 0.24 | 1.10 ± 0.29 | < .001 |
| LAP      | 1.08 ± 0.37 | 0.67 ± 0.17 | 1.07 ± 0.23 | 1.12 ± 0.26 | 1.26 ± 0.38 | 1.32 ± 0.48 | < .001 |
| LL       | 1.15 ± 0.39 | 0.67 ± 0.11 | 1.08 ± 0.25 | 1.31 ± 0.22 | 1.54 ± 0.52 | 1.35 ± 0.34 | < .001 |
| LV       | 0.77 ± 0.65 | 0.14 ± 0.07 | 0.70 ± 0.40 | 0.96 ± 0.46 | 1.17 ± 0.73 | 1.23 ± 1.04 | < .001 |
| Both lobes combined |       |       |               |     |       |         |
| ST       | 1.97 ± 0.63 | 1.13 ± 0.22 | 2.08 ± 0.42 | 2.28 ± 0.45 | 2.23 ± 0.39 | 2.31 ± 0.54 | < .001 |
| SAP      | 2.18 ± 0.69 | 1.39 ± 0.30 | 2.18 ± 0.42 | 2.40 ± 0.44 | 2.61 ± 0.65 | 2.72 ± 0.93 | < .001 |
| SL       | 2.30 ± 0.74 | 1.38 ± 0.23 | 2.22 ± 0.44 | 2.56 ± 0.37 | 3.12 ± 0.89 | 2.79 ± 0.66 | < .001 |
| SV       | 1.62 ± 1.35 | 0.30 ± 0.16 | 1.42 ± 0.65 | 1.95 ± 0.86 | 2.56 ± 1.61 | 2.71 ± 2.17 | < .001 |
| Female   | n = 82 | n = 15 | n = 15 | n = 27 | n = 16 | n = 9 |
| Right lobe |        |       |               |     |       |         |
| RT       | 1.00 ± 0.36 | 0.55 ± 0.12 | 0.95 ± 0.23 | 1.21 ± 0.37 | 1.13 ± 0.21 | 1.00 ± 0.36 | < .001 |
| RAP      | 1.09 ± 0.35 | 0.75 ± 0.17 | 0.98 ± 0.32 | 1.24 ± 0.31 | 1.26 ± 0.28 | 1.12 ± 0.38 | < .001 |
| RL       | 1.12 ± 0.34 | 0.70 ± 0.16 | 1.02 ± 0.26 | 1.26 ± 0.27 | 1.39 ± 0.25 | 1.07 ± 0.28 | < .001 |
| RV       | 0.79 ± 0.68 | 0.16 ± 0.08 | 0.58 ± 0.32 | 1.09 ± 0.81 | 1.09 ± 0.42 | 0.76 ± 0.82 | < .001 |
| Left lobe |        |       |               |     |       |         |
| LT       | 0.98 ± 0.28 | 0.57 ± 0.11 | 0.99 ± 0.16 | 1.17 ± 0.24 | 1.06 ± 0.19 | 0.93 ± 0.14 | < .001 |
| LAP      | 1.07 ± 0.34 | 0.63 ± 0.12 | 0.95 ± 0.18 | 1.23 ± 0.27 | 1.28 ± 0.29 | 1.11 ± 0.35 | < .001 |
| LL       | 1.14 ± 0.36 | 0.68 ± 0.14 | 1.05 ± 0.25 | 1.28 ± 0.36 | 1.36 ± 0.21 | 1.19 ± 0.31 | < .001 |
| LV       | 0.75 ± 0.56 | 0.13 ± 0.07 | 0.55 ± 0.26 | 1.08 ± 0.57 | 1.00 ± 0.44 | 0.71 ± 0.57 | < .001 |
| Both lobes combined |       |       |               |     |       |         |
| ST       | 1.98 ± 0.61 | 1.11 ± 0.18 | 1.94 ± 0.36 | 2.38 ± 0.57 | 2.20 ± 0.33 | 1.93 ± 0.42 | < .001 |
| SAP      | 2.16 ± 0.63 | 1.38 ± 0.24 | 1.93 ± 0.38 | 2.47 ± 0.52 | 2.54 ± 0.51 | 2.23 ± 0.71 | < .001 |
| SL       | 2.25 ± 0.64 | 1.37 ± 0.27 | 2.08 ± 0.38 | 2.55 ± 0.54 | 2.75 ± 0.37 | 2.27 ± 0.53 | < .001 |
| SV       | 1.54 ± 1.18 | 0.29 ± 0.13 | 1.13 ± 0.48 | 2.17 ± 1.30 | 2.08 ± 0.73 | 1.47 ± 1.37 | < .001 |

Data are reported as mean ± SD. LAP indicates left anteroposterior diameter; LL, left length; LT, left transverse diameter; LV, left volume; RAP, right anteroposterior diameter; RL, right length; RT, right transverse diameter; RV, right volume; SAP, sum of the anteroposterior diameters of both tonsils; SL, sum of the lengths of both tonsils; ST, sum of the transverse diameters of both tonsils; and SV, sum of the volumes of both tonsils.
were 1.58 ± 1.26 (total), 0.30 ± 0.14 (<1 year), 1.27 ± 0.57 (1–<5 years), 2.06 ± 1.09 (5–<10 years), and 2.19 ± 1.48 (>10 years) cm³. The mean measurements for the sums of both tonsils for the transverse diameter, anteroposterior diameter, and length were 1.98 ± 0.61, 2.17 ± 0.66, and 2.28 ± 0.69 cm, respectively. There were no sex differences in the tonsillar volumes. The distribution of tonsillar measurements and volumes, with 3% and 97% ranges according to age, are summarized in Table 2. Tonsillar size and volume increased with age. Figure 2 represents the normal range (mean ± standard deviation) of the tonsillar volume according to age. There were positive correlations between the height, weight, and tonsillar volume in the simple linear regression analysis; however, the coefficient of determination was low and showed no significance in the multiple linear regression analysis (Table 3).

Simplified models for volume estimation showed that the right and left lobe anteroposterior diameters had the highest coefficients of determination ($R^2 = 0.71$ and 0.74; Table 3). Multiple regression models for the total volume using the 6 measurements, including right transverse diameter, right anteroposterior diameter, right length, left transverse diameter, left anteroposterior diameter, and length, were developed. The models showed the highest coefficients of determination for the right and left lobe anteroposterior diameters ($R^2 = 0.71$ and 0.74; Table 3).

### Table 2. Distribution of Tonsillar Volume on US in Healthy Children (N = 161)

| Age, y | Right Side | | | Left Side | | | Sum of Both Sides | | |
|-------|------------|---|---|------------|---|---|------------|---|---|
|       | n          | Mean ± SD | 3rd Percentile | 97th Percentile | Mean ± SD | 3rd Percentile | 97th Percentile | Mean ± SD | 3rd Percentile | 97th Percentile |
| Male  |            |            |               |               |            |               |               |            |               |               |
| <1    | 19         | 0.16 ± 0.11 | 0.06           | 0.43           | 0.16 ± 0.08 | 0.06           | 0.30           | 0.16 ± 0.09 | 0.06           | 0.39           |
| 1–<5  | 13         | 0.72 ± 0.33 | 0.31           | 1.21           | 0.58 ± 0.32 | 0.13           | 1.06           | 0.65 ± 0.32 | 0.13           | 1.14           |
| 5–<10 | 29         | 0.99 ± 0.52 | 0.24           | 1.90           | 1.09 ± 0.81 | 0.33           | 2.67           | 1.04 ± 0.87 | 0.26           | 2.42           |
| ≥10   | 18         | 1.44 ± 1.04 | 0.46           | 3.39           | 0.97 ± 0.60 | 0.14           | 2.12           | 1.17 ± 0.84 | 0.18           | 2.86           |
| Female|            |            |               |               |            |               |               |            |               |               |
| <1    | 15         | 0.14 ± 0.07 | 0.05           | 0.27           | 0.13 ± 0.07 | 0.07           | 0.27           | 0.13 ± 0.07 | 0.05           | 0.29           |
| 1–<5  | 15         | 0.70 ± 0.40 | 0.32           | 1.50           | 0.55 ± 0.26 | 0.19           | 1.04           | 0.62 ± 0.34 | 0.23           | 1.32           |
| 5–<10 | 27         | 0.96 ± 0.46 | 0.39           | 1.97           | 1.08 ± 0.57 | 0.28           | 2.43           | 1.02 ± 0.51 | 0.32           | 2.18           |
| ≥10   | 25         | 1.20 ± 0.89 | 0.32           | 3.07           | 0.90 ± 0.50 | 0.38           | 2.03           | 1.02 ± 0.70 | 0.33           | 2.70           |
| Total |            |            |               |               |            |               |               |            |               |               |
| <1    | 34         | 0.30 ± 0.16 | 0.14           | 0.68           | 0.29 ± 0.13 | 0.13           | 0.54           | 0.3 ± 0.14  | 0.11           | 0.65           |
| 1–<5  | 28         | 1.42 ± 0.65 | 0.68           | 2.45           | 1.13 ± 0.48 | 0.32           | 1.87           | 1.27 ± 0.57 | 0.36           | 2.25           |
| 5–<10 | 56         | 1.95 ± 0.86 | 0.73           | 3.78           | 2.17 ± 1.30 | 0.62           | 5.14           | 2.06 ± 1.09 | 0.67           | 4.20           |
| ≥10   | 43         | 2.64 ± 1.89 | 0.98           | 6.46           | 1.86 ± 1.02 | 0.72           | 4.12           | 2.19 ± 1.48 | 0.80           | 5.55           |

Figure 2. Tonsillar volume according to age.
eter, and left length, as independent variables (ie, predictors) were examined. In addition, models for the log of the sum of the volume, using the logs of the 6 measurements as independent variables, were used to determine whether the models could be improved. The regression models for tonsillar volume with the best single-predictor model showed an $R^2$ of 0.89. Regression models of log tonsillar volume for the logs of the 6 measurements showed an $R^2$ of 0.96 (Table 4). The logarithmic transformation of independent variables (the 6 measurements) and the dependent variable (tonsillar volume) resulted in significant improvement. Simplified models for volume estimation were obtained and are shown in Table 4.

**Discussion**

Ultrasonography has been used for the evaluation of tonsillar infections. The infection begins in the peripheral tonsillar crypts and then penetrates the capsule and abscess, into the peritonsillar space. Differentiation between peritonsillar cellulitis and abscesses is important to determine the appropriate treatment. Most peritonsillar abscesses resolve with appropriate management. It can be difficult to determine when tonsillar cellulitis progresses to a frank abscess, since they have overlapping clinical presentations. Differentiation between a peritonsillar abscess and peritonsillar cellulitis remains challenging for clinicians. Inadequately treated peritonsillar abscesses may progress unfavorably, leading to the development of aspiration pneumonia, extension of the infection into deep neck spaces and the mediastinum, jugular vein thrombophlebitis, sepsis, and cavernous sinus thrombosis, and they can even be fatal.

Diagnostic imaging, usually with CT, is indicated for the evaluation of tonsillitis and a suspected abscess or the extratonsillar spread of an infection. However, CT scans use radiation, and radiosensitive organs such as the thyroid gland are included in the scanning fields. Magnetic resonance imaging provides improved soft tissue details, allowing assessment of the carotid artery without radiation. However, it takes longer, is more expensive, and is not as widely available as CT. Ultrasonography has been used as an alternative to CT for the diagnosis and drainage of peritonsillar abscesses. It is a useful, simple, and noninvasive technique that can be used to accurately differentiate

**Table 3. Simple Linear Regression Analysis for Tonsillar Volume**

| Variable          | Total (N = 161) | Male (n = 79) | Female (n = 82) |
|-------------------|-----------------|--------------|----------------|
|                   | B (95% CI)      | P  | $R^2$   | B (95% CI)      | P  | $R^2$   |
| Tonsil volume     |                 |    |        |                 |    |        |
| Height            | 0.02 (0.01 to 0.03) | <0.01 | 0.26 | 0.03 (0.02 to 0.04) | <0.01 | 0.37 | 0.01 (0.01 to 0.02) | <0.01 | 0.18 |
| Weight            | 0.03 (0.02 to 0.04) | <0.01 | 0.14 | 0.04 (0.02 to 0.06) | <0.01 | 0.25 | 0.02 (0.00 to 0.03) | <0.01 | 0.08 |
| Body mass index   | -0.01 (-0.07 to 0.06) | 0.85 | 0.00 | -0.03 (-0.16 to 0.10) | 0.64 | 0.02 | 0.01 (-0.06 to 0.09) | 0.74 | 0.00 |
| Right lobe        |                 |    |        |                 |    |        |
| RT                | 2.87 (2.56 to 3.19) | <0.01 | 0.67 | 2.98 (2.45 to 3.52) | <0.01 | 0.62 | 2.77 (2.40 to 3.14) | <0.01 | 0.73 |
| RAP               | 3.00 (2.70 to 3.30) | <0.01 | 0.71 | 3.23 (2.82 to 3.64) | <0.01 | 0.76 | 2.76 (2.32 to 3.19) | <0.01 | 0.66 |
| LL                | 2.91 (2.61 to 3.21) | <0.01 | 0.70 | 3.00 (2.60 to 3.40) | <0.01 | 0.74 | 2.81 (2.35 to 3.27) | <0.01 | 0.65 |
| Left lobe         |                 |    |        |                 |    |        |
| LT                | 3.26 (2.84 to 3.69) | <0.01 | 0.59 | 3.24 (2.61 to 3.87) | <0.01 | 0.57 | 3.31 (2.73 to 3.89) | <0.01 | 0.62 |
| LAP               | 3.07 (2.79 to 3.36) | <0.01 | 0.74 | 3.18 (2.78 to 3.59) | <0.01 | 0.76 | 2.94 (2.52 to 3.36) | <0.01 | 0.71 |
| LL                | 2.71 (2.40 to 3.02) | <0.01 | 0.65 | 2.82 (2.38 to 3.27) | <0.01 | 0.67 | 2.59 (2.15 to 3.02) | <0.01 | 0.64 |
| Log(tonsillar volume) |             |    |        |                 |    |        |
| Height            | 0.02 (0.01 to 0.02) | <0.01 | 0.41 | 0.02 (0.01 to 0.03) | <0.01 | 0.50 | 0.02 (0.01 to 0.02) | <0.01 | 0.32 |
| Weight            | 0.02 (0.02 to 0.03) | <0.01 | 0.23 | 0.03 (0.02 to 0.04) | <0.01 | 0.28 | 0.02 (0.01 to 0.03) | <0.01 | 0.19 |
| Body mass index   | 0.02 (-0.03 to 0.07) | 0.35 | 0.01 | 0.00 (-0.09 to 0.08) | 0.91 | 0.00 | 0.04 (-0.02 to 0.10) | 0.152 | 0.04 |
| Right lobe        |                 |    |        |                 |    |        |
| RT                | 2.22 (2.01 to 2.42) | <0.01 | 0.74 | 2.34 (2.04 to 2.64) | <0.01 | 0.75 | 2.11 (1.83 to 2.39) | <0.01 | 0.74 |
| RAP               | 2.13 (1.89 to 2.36) | <0.01 | 0.67 | 2.23 (1.92 to 2.55) | <0.01 | 0.72 | 2.01 (1.66 to 2.37) | <0.01 | 0.62 |
| LL                | 2.23 (2.04 to 2.42) | <0.01 | 0.77 | 2.19 (1.93 to 2.45) | <0.01 | 0.78 | 2.30 (2.01 to 2.59) | <0.01 | 0.76 |
| Left lobe         |                 |    |        |                 |    |        |
| LT                | 2.68 (2.44 to 2.92) | <0.01 | 0.75 | 2.62 (2.28 to 2.97) | <0.01 | 0.75 | 2.76 (2.41 to 3.11) | <0.01 | 0.75 |
| LAP               | 2.29 (2.09 to 2.49) | <0.01 | 0.76 | 2.25 (1.96 to 2.54) | <0.01 | 0.75 | 2.33 (2.05 to 2.61) | <0.01 | 0.78 |
| LL                | 2.04 (1.83 to 2.25) | <0.01 | 0.69 | 2.05 (1.74 to 2.35) | <0.01 | 0.70 | 2.03 (1.72 to 2.34) | <0.01 | 0.68 |

B indicates regression coefficient; and CI, confidence interval; other abbreviations are as in Table 1.
Table 4. Multiple Linear Regression Analysis for Tonsillar Volume

| Variable | Total (N = 161) | Male (n = 79) | Female (n = 82) |
|----------|----------------|---------------|-----------------|
|          | B (95% CI)     | P             | VIF  | R²   | B (95% CI)     | P           | VIF  | R²  |
| Intercep | −2.56 (−2.8 to −2.32) | <.001 | 0.89 |     | −2.62 (−2.97 to −2.26) | <.001 | 0.89 | −2.44 (−2.77 to −2.10) | <.001 | 0.90 |
| RT       | 0.63 (0.31 to 0.96) | <.001 | 3.26 |     | 0.38 (−0.10 to 0.87) | 0.121 | 3.80 | 0.96 (0.51 to 1.41) | <.001 | 3.59 |
| RAP      | 1.02 (0.68 to 1.36) | <.001 | 3.57 |     | 1.11 (0.57 to 1.65) | <.001 | 4.25 | 0.91 (0.46 to 1.36) | <.001 | 3.38 |
| RL       | 0.39 (0.04 to 0.73) | 0.28 | 3.76 |     | 0.62 (0.09 to 1.16) | 0.023 | 2.69 | 0.15 (−0.30 to 0.60) | 0.506 | 3.22 |
| LT       | 0.29 (−0.08 to 0.65) | 122 | 2.86 |     | 0.26 (−0.26 to 0.78) | 0.326 | 3.97 | 0.26 (−0.28 to 0.79) | 0.341 | 4.39 |
| LAP      | 0.72 (0.35 to 1.09) | <.001 | 4.11 |     | 0.95 (0.41 to 1.49) | 0.001 | 3.50 | 0.43 (−0.08 to 0.94) | 0.096 | 3.14 |
| LL       | 0.79 (0.48 to 1.1) | <.001 | 3.24 |     | 0.55 (0.07 to 1.03) | 0.025 | 2.95 | 1.01 (0.60 to 1.41) | <.001 | 3.92 |
|          | −3.06 (−3.37 to −2.96) | <.001 | 0.96 |     | −3.05 (−3.30 to −2.90) | <.001 | 0.96 | −3.10 (−3.25 to −2.95) | <.001 | 0.96 |
| RT       | 0.55 (0.41 to 0.68) | <.001 | 3.26 |     | 0.64 (0.43 to 0.84) | <.001 | 3.80 | 0.46 (0.26 to 0.66) | <.001 | 3.59 |
| RAP      | 0.21 (0.06 to 0.36) | <.005 | 3.57 |     | 0.25 (0.02 to 0.47) | 0.031 | 4.25 | 0.21 (0.01 to 0.41) | 0.042 | 3.38 |
| RL       | 0.55 (0.40 to 0.70) | <.001 | 3.76 |     | 0.53 (0.30 to 0.75) | <.001 | 2.69 | 0.62 (0.42 to 0.82) | <.001 | 3.32 |
| LT       | 0.79 (0.63 to 0.95) | <.001 | 2.86 |     | 0.81 (0.60 to 1.03) | <.001 | 3.97 | 0.73 (0.49 to 0.97) | <.001 | 4.39 |
| LAP      | 0.50 (0.34 to 0.65) | <.001 | 4.11 |     | 0.47 (0.24 to 0.77) | <.001 | 3.50 | 0.49 (0.26 to 0.72) | <.001 | 3.14 |
| LL       | 0.41 (0.28 to 0.54) | <.001 | 3.24 |     | 0.30 (0.10 to 0.50) | 0.004 | 2.95 | 0.52 (0.34 to 0.70) | <.001 | 3.92 |

VIF indicates variance inflation factor; other abbreviations are as in Tables 1 and 3.

aTonsillar volume (cm³): total = −2.56 + 0.63 × RT (cm) + 1.02 × RAP (cm) + 0.39 × RL (cm) + 0.29 × LT (cm) + 0.72 × LAP (cm) + 0.79 × LL (cm); male = −2.62 + 0.38 × RT (cm) + 1.11 × RAP (cm) + 0.62 × RL (cm) + 0.26 × LT (cm) + 0.95 × LAP (cm) + 0.55 × LL (cm); and female = −2.44 + 0.96 × RT (cm) + 0.91 × RAP (cm) + 0.15 × RL (cm) + 0.26 × LT (cm) + 0.43 × LAP (cm) + 1.01 × LL (cm).
bTonsillar volume (cm³): total = exp(−3.06 + 0.55 × RT (cm) + 0.21 × RAP (cm) + 0.55 × RL (cm) + 0.79 × LT (cm) + 0.5 × LAP (cm) + 0.41 × LL (cm)); male = exp(−3.05 + 0.64 × RT (cm) + 0.25 × RAP (cm) + 0.53 × RL (cm) + 0.81 × LT (cm) + 0.47 × LAP (cm) + 0.3 × LL (cm)); and female = exp(−3.10 + 0.46 × RT (cm) + 0.21 × RAP (cm) + 0.62 × RL (cm) + 0.73 × LT (cm) + 0.49 × LAP (cm) + 0.52 × LL (cm)).
peritonsillar abscesses from peritonsillar cellulitis. It decreases the exposure to radiation and iodinated contrast media and eliminates blind needle aspiration of the tonsil. Intraoral US and transcervical US have high sensitivity and specificity for correctly diagnosing tonsillar infections; however, they remain underused. Miziara et al\textsuperscript{14} reported 92.3% sensitivity and 62.5% specificity in the diagnosis of an abscess using intraoral US. However, 10.3% of patients were unable to tolerate intraoral US because of trismus. Filho et al\textsuperscript{7} performed transcutaneous US in all patients, with sensitivity of 80% and specificity of 92.8%. Transcutaneous and intraoral US showed high diagnostic accuracy, without a significant difference between them.\textsuperscript{7} Ultrasound-guided abscess puncture can prevent multiple blind punctures and also determine the relationship of the abscess with the carotid artery. However, little information is available regarding the normal values for the tonsil.

This study was performed to determine the normative values for tonsils in a pediatric population and to determine whether any measurement could serve as a valid predictor of tonsillar volume. This study provides reference measurements of tonsils in children and adolescents that can be used for the diagnosis of tonsillar infections. Pediatric patients grow remarkably, and a previous study reported that the tonsil volume has a relationship with weight.\textsuperscript{14} Additionally, the tonsillar size increases with age. However, in this study, there was no correlation between the tonsillar volume and height and weight; there were also no sex differences. In children presenting with lymphadenopathy, the tonsils can be scanned easily during US, and abnormalities can be identified. However, there are limited referral data,\textsuperscript{14} and our results can be used as normative values. Although we can estimate the tonsillar volume from a single dimension (eg, anteroposterior diameter), all 6 dimensions were required to generate a good model to estimate tonsillar volume. Regression models of log(volume) showed an improved coefficient of determination ($R^2 = 0.96$).

In conclusion, tonsillar US is feasible in pediatric populations and is a well-tolerated, noninvasive technique. Not only does it prevent radiation exposure, but normal tonsillar measurements can allow the radiologist to correctly diagnose tonsillar infections. These normal values can be used to diagnose tonsillar lesions.

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