

Description and Evaluation of the Vallecula Sign: A New Radiologic Sign in the Diagnosis of Adult Epiglottitis

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Study objective: To describe and prospectively evaluate a new radiologic sign with the potential to increase the diagnostic accuracy of soft-tissue radiography of the neck in the identification of adult epiglottitis.

Methods: We conducted a prospective, before-and-after blinded study at two tertiary care institutions. A convenience sample of four staff emergency physicians, three otolaryngology residents, four radiology residents, and four senior medical students volunteered to participate. We assembled 26 soft-tissue radiographs of the neck from consecutive patients ED with the diagnosis of epiglottitis made on the basis of direct visualization. Twenty-six control radiographs were identified from ED patients who were being evaluated for the presence of foreign bodies or minor cervical trauma. We then randomly mixed the two sets of radiographs. Participants were asked to identify epiglottitis among the 52 randomly sequenced radiographs. A standardized 5-minute tutorial on the vallecula sign was presented to all participants after the first interpretation. We then asked the participants to make a second interpretation of the 52 radiographs without knowledge of correct answers from the initial evaluation.

Results: The participants accurately classified 80.5% of all radiographs reviewed before the tutorial and 98.8% after the tutorial ($P<.0001$). Similarly, sensitivity improved from 78.5% to 98.2% ($P<.0001$) and specificity improved from 82.8% to 99.5% ($P<.0001$). We found no significant differences in performance characteristics among the different types of participants.

Conclusion: We have described a new radiographic sign that improves the diagnostic accuracy of soft-tissue radiography of the neck. If reproduced in prospective studies, the absence of the vallecula sign on radiography might obviate the need for routine use of direct visualization as an initial screen.

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INTRODUCTION

Epiglottitis is a potentially fatal infectious inflammation of the epiglottis and surrounding structures. A presumptive diagnosis may be established with the use of soft-tissue radiography of the neck, but direct visualization of the epiglottis by means of nasopharyngolaryngoscopy (NPL) or indirect laryngoscopy remains the gold standard in the diagnosis of this condition.¹⁻³ When epiglottitis is suspected in a patient in stable condition, soft-tissue films are often used as a screening procedure before direct visualization.⁴⁻⁸ This diagnostic option is important because radiography is easily performed and readily available in most EDs, whereas NPL and indirect laryngoscopy require special training and expertise.⁹

Several radiologic signs used to establish the diagnosis of epiglottitis from soft-tissue radiographs of the neck have been described. Many of these signs are qualitative, such as the thickening of the epiglottis termed the "thumb sign," swelling of the arytenoids and aryepiglottic folds, a pencil-thin airway, prevertebral soft-tissue swelling, and a poorly defined vallecula.^{1-4,7-15} Although reports of abnormalities of the vallecula in epiglottitis have been published, there has been no description of how the vallecula may be used alone in the radiographic diagnosis of adult epiglottitis.^{8,11,13,15} In addition, most of these qualitative signs are based solely on observation and have not been prospectively evaluated. To date, in only two articles have prospective studies of radiographic

signs in adult epiglottitis been described.^{11,16} The authors of both articles focused on quantitative radiologic criteria rather than on qualitative signs. Because of limitations in study design, the criteria themselves, or their questionable accuracy, several authors have suggested that soft-tissue radiographs^{1,9,17-20} are not useful as a screen for epiglottitis. Despite these concerns, soft-tissue radiography is routinely performed in many EDs and is considered a valuable tool. In an attempt to improve the diagnostic accuracy of neck radiography, we described and prospectively evaluated a new radiographic sign in the diagnosis of epiglottitis.

MATERIALS AND METHODS

In the descriptive phase, we conducted a structured Medline review of the English-language literature using the key words "epiglottitis," "diagnosis," "radiography," and "laryngoscopy," to identify all published radiologic signs used in the diagnosis of epiglottitis. We then examined five soft-tissue radiographs of the neck from five cases of epiglottitis confirmed with NPL or direct laryngoscopy to determine the usefulness of published signs. In this small sample we empirically evaluated the clinical utility and accuracy of the published signs. A detailed examination of the five radiographs revealed the absence of a deep and well-defined vallecula, approaching the level of the hyoid bone, in all cases of epiglottitis. We hypothesized that this new diagnostic sign would be more accurate and easier to apply than the established radiographic signs of epiglottitis.

Once we had described the vallecula sign, we conducted a prospective single-blind evaluation of the sign using radiographs from cases and controls.

We identified 26 radiographs from patients with epiglottitis who had presented to one of two tertiary care institutions between 1989 and 1994. The diagnosis of epiglottitis was confirmed with NPL or direct laryngoscopy in all patients. The 26 control radiographs were identified by a review of records from ED visits for minor cervical trauma (n=12) and suspected foreign bodies (n=14). In all control cases, radiography had been performed without the use of a cervical collar. All controls were afebrile, and none had historical features consistent with epiglottitis. The case and control radiographs were then randomly mixed.

A convenience sample of four staff emergency physicians, three otolaryngology residents, four radiology residents, and four senior medical students completing an ear, nose, and throat rotation were asked to interpret the 52 radiographs before and after a standardized tutorial. For the initial interpretation, participants were instructed to attempt the identification of cases of epiglottitis without guidance. All readers

Figure 1.

Standardized step-by-step approach in teaching the use of the vallecula sign.

Step 1	If the patient's mouth was open on the first film, repeat radiography.
Step 2	Identify the base of the tongue.
Step 3	Trace the base of the tongue inferiorly to the hyoid bone.
Step 4	Locate the epiglottis.
Step 5	Locate the air pocket extending nearly to the hyoid bone: This is the vallecula.
Is the vallecula deep and roughly parallel to the pharyngotracheal air column?	
Yes	No
No epiglottitis	Epiglottitis present

Standardized instruction sheet administered by a research assistant or one of the investigators to each of the participants.

were required to make a diagnosis of positive or negative to ensure the exercise accurately simulated a real-life situation. A postdiagnosis questionnaire was used to determine which signs, if any, had been used to make the diagnosis. Once the questionnaire was complete, participants were provided an information sheet describing the vallecula sign. A 5-minute standardized tutorial illustrating the sign was also administered to each participant (Figure 1). The 52 radiographs were again presented for interpretation; the readers had no knowledge of correct answers from their initial evaluations. At the end of each session, participants were told to refrain from discussing the study with their colleagues.

Descriptive statistics were used for all study variables. Performance characteristics including sensitivity, specificity, and predictive values were computed with the use of standard equations. Positive and negative likelihood ratios were calculated.²¹ Ninety-five percent confidence intervals (CIs) around all proportions and likelihood ratios were also calculated. Fisher's exact test was used to compare pre- and posttutorial performance characteristics. We considered an α -value of .05 significant. No corrections were made for multiple comparisons. Absolute *P* values are reported.

RESULTS

Demographic characteristics of the cases and controls from whom soft-tissue radiographs were obtained were comparable. The mean age in cases was 44±18.5 years, compared with 40±19.5 years for controls. The proportions of men in the two groups were 58% and 65%, respectively. Review of the medical records of the 26 cases of epiglottitis showed that patients had symptoms ranging from mild to severe dyspnea, and intubation was performed in 16 of the 26 shortly after ED presentation. None of the control patients had signs or symptoms compatible with epiglottitis. In the official radiology reports, epiglottitis was correctly diagnosed

Table 1.

Characteristics of soft-tissue radiographs of the neck before and after a standard 5-minute tutorial.

Parameters	Before Tutorial	After Tutorial	<i>P</i>
Sensitivity (%)	78.5	98.2	<.0001
Specificity (%)	82.8	99.5	<.0001
Positive predictive value (%)	82.0	99.5	<.0001
Negative predictive value (%)	79.4	98.2	<.0001
Accuracy (%)	80.6	98.8	<.0001

in 75% of the 26 confirmed cases. All control radiographs were reported to demonstrate normal findings.

During the initial evaluation, 11 of the 15 participants reported using the thumb sign in the initial interpretation. Four of the 15 participants also reported that they reached a diagnosis by "eyeballing" the epiglottis. In the pretutorial phase, radiographs were read with an accuracy of 80.5%. We noted a statistically significant improvement in all performance characteristics from the initial to the posttutorial evaluation (Tables 1 and 2). After the tutorial, participants correctly diagnosed epiglottitis with an accuracy of 98.8% (95% CI, 98.0% to 99.6%). Sensitivity improved to 98.2% (95% CI, 90.8% to 100%), and specificity improved to 99.5% (95% CI, 92.0% to 100%) after the tutorial (Table 1). The positive likelihood ratio increased from 4.6 (95% CI, 3.7 to 5.7) to 192 (95% CI, 48 to 763), and the negative likelihood ratio also improved, from .26 (95% CI, .21 to .32) to .018 (95% CI, .009 to .04). We noted few differences between physicians and medical students or among physician groups in any of the performance characteristics after the tutorial.

DISCUSSION

In this study, we describe a new diagnostic sign seen on soft-tissue radiographs of the neck in adult patients with epiglottitis. In this first evaluation, the vallecula sign appears to be sensitive and specific enough to be used as an initial screening procedure in patients with suspected epiglottitis. The absence of the sign would eliminate the need for direct or indirect visualization if it is proved accurate and reliable in prospective studies. We have also demonstrated that this radiographic sign is easy to teach and use, regardless of the level of training.

Table 2.

All radiographic interpretations in the full evaluation before and after the tutorial.

Tutorial Status	Disease		Total
	Present	Absent	
Before tutorial			
Positive findings	306	67	373
Negative findings	84	323	407
Total	390	390	780
After tutorial			
Positive	383	2	385
Negative	7	388	395
Total	390	390	780

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Figure 2.

Four radiographs demonstrating soft-tissue findings in the neck. **A**, Normal upper airway. Note that the vallecula is well defined and reaches the level of the hyoid bone. **B**, Full-size film of a patient with epiglottitis. Both the thumb sign and the vallecula sign are visible. **C**, Ill-defined, difficult-to-identify epiglottitis. The vallecula is not well defined. This is therefore a case of acute epiglottitis. **D**, Epiglottitis and vallecula have been completely obliterated. Epiglottitis would have been difficult to diagnose from this soft-tissue radiograph with the use of other criteria. Again, the absence of a vallecula was the only reliable sign in this radiograph. This radiograph was interpreted as showing normal findings by almost all the participants before the tutorial session. However, the epiglottitis was actually severe enough to warrant intubation.



a, aryepiglottic fold edema; b, base of the tongue; e, epiglottis; ff, cornua of hyoid bone; h, body of hyoid bone; t, trachea; v, vallecula. Arrowhead denotes absence or obliteration of the vallecula.

One of the most important characteristics of the vallecula sign is that it is consistently affected by varying degrees of epiglottic swelling (Figure 2). Both anatomically and on soft-tissue radiographs of the neck, the vallecula is a well-defined air pocket that runs approximately parallel to the pharyngo-tracheal air column. Its anterior and posterior boundaries are the base of the tongue and the epiglottis, respectively. As epiglottic edema develops, it causes the epiglottis to swell in a predominantly anteroposterior direction. The anterior swelling of the epiglottis results in the partial or complete obliteration of the vallecula. Thus the normal shape, size, and presence of this well-demarcated air pocket extending nearly to the level of the hyoid bone is lost. These changes appear to accurately reflect findings noted on direct visualization independent of anatomic differences and the degree of disease severity. In the 26 confirmed cases, which included patients with mild and severe symptoms, as well as patients who did and did not require urgent airway intervention, the vallecula was judged abnormal by the investigators in all cases. In several radiographs the epiglottis was difficult to identify (and therefore the thumb sign and other previously defined signs could not be applied). However, the vallecula was always noted to be obliterated (no well-defined air pocket at the level of the hyoid bone) in cases of epiglottitis. Thus the vallecula sign was present more frequently than the thumb sign, the most widely used of the qualitative signs. On the other hand, the presence of a completely normal vallecula—indicated by a depth approximately at the level of the hyoid bone and an orientation roughly parallel to the pharyngotracheal air column—was associated with a normal epiglottis. The vallecula sign accurately predicted the absence of epiglottitis in this study. Its reliability may diminish when implemented more widely by practitioners who have limited exposure to this condition.

Several investigators have developed and prospectively assessed quantitative diagnostic radiographic signs despite having never evaluated qualitative signs described in the literature. Schumaker et al¹¹ proposed that an epiglottic width of greater than 8 mm and an aryepiglottic width greater than 7 mm would accurately indicate epiglottitis. More recently, Rothrock et al¹⁶ suggested that an epiglottic width-to-epiglottic height ratio greater than .6, an epiglottic width-to-C3 vertebral body width ratio greater than .5, or an aryepiglottic width-to-C3 vertebral body width greater than .35 are predictors of epiglottitis. The quantitative signs described by Schumaker and Rothrock were noted to be accurate when interpreted by a few unblinded observers in a study with only a few cases and no controls. Also, these radiographic measurements are not always well visualized on radiography and are complex and difficult to teach. Ana-

tomotic variation may further increase the difficulty of using these radiologic signs. In this study, we documented the ease of use of the vallecula sign and the accuracy of interpretations from a wide variety of potential users.

Are the performance characteristics of this new sign sufficiently accurate to replace visualization as an initial screen for this potentially life-threatening illness? Ideally, sensitivity and specificity of 100% are sought. However, few tests are so accurate. For a screening procedure for a serious condition, we prefer to rule out the disease 100% of the time. As a result, the sensitivity is the more important of the two values. Although the sign was present in all cases of epiglottitis and absent in all controls, its use was 98.2% sensitive, with a sensitivity potentially as low as 90.8% on the basis of the CI. If the results hold true in further studies, we believe the test will be useful in the ED diagnosis of epiglottitis. Our sample of participants represents many of the different types of physicians who interpret soft-tissue radiographs under urgent conditions. Although few radiology staff members participated in the pilot or the full evaluation, the proportion of confirmed cases of epiglottitis correctly diagnosed on official radiology reports was only 75%, in the same range as the pretutorial interpretation by all participants. Furthermore, MayoSmith and colleagues¹ reported an accuracy rate in confirmed cases of epiglottitis of some 75%, suggesting that the official interpretations in this study were generally representative.

All cases of epiglottitis were confirmed through direct visualization in this study. Controls had no signs or symptoms of epiglottitis, and many but not all underwent NPL or indirect laryngoscopy. In addition, all interpretations were performed without knowledge of the NPL results. One of the potential limitations of the study is the possibility of spectrum bias. We deliberately included radiographs from all patients with confirmed epiglottitis with a range of symptoms, signs, and disease severity. The control radiographs were also from ED patients. However, the controls were, by definition, normal and may not have represented the full range of disease (eg, retropharyngeal abscess) with presentations similar to epiglottitis. Other diseases, such as tumors or cysts of the base of the tongue, theoretically might also obliterate the vallecula. However, these conditions often present with a different spectrum of symptoms and occur over a longer period compared with epiglottitis. The finding of an abnormal vallecula on a soft-tissue radiograph, with the use of the vallecula sign, should in any case warrant careful examination of the base of the tongue and the epiglottis.

One additional concern was the possibility that the increased accuracy after the tutorial was partly explained

by a teaching or practice effect. Such an effect might have been overcome through the use of a randomized, controlled clinical trial design, in which physicians given a tutorial on the vallecula sign would be compared with a group who did not receive the tutorial. However, we deemed this approach unfeasible and concluded that it would shift the focus to evaluation of the teaching rather than the use of the diagnostic sign. Finally, as a cautionary note, one factor was noted to interfere with the reliability of the vallecula sign. As the mouth opens, the epiglottis moves toward the base of the tongue, occasionally obliterating the vallecula even in patients without epiglottitis. Thus a correct diagnosis using the vallecula sign is achieved only with films obtained when the patient's bite is fully occluded. We therefore suggest that films be repeated if the patient's mouth was open in the initial set.

In conclusion, the use of the vallecula sign improves the diagnostic accuracy of soft-tissue radiographs of the neck used in the evaluation of epiglottitis. Its performance characteristics may enable a broad range of physicians to use this diagnostic sign as a screen in patients who do not require immediate airway intervention. Prospective validation of the day-to-day use of the vallecula sign in patients with suspected epiglottitis will be necessary to determine its true effectiveness as a screening tool.

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