ARTICLE IN PRESS

YAJEM-56633; No of Pages 6

American Journal of Emergency Medicine xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

Do we need a change in ED diagnostic strategy for adult acute epiglottitis?

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ARTICLE INFO

Article history:
Received 14 March 2017
Received in revised form 17 April 2017
Accepted 18 April 2017
Available online xxxx

Keywords:
Adult
Epiglottitis
False negative
Risk factor
Radiograph

ABSTRACT

Objectives: To retrospectively evaluate the diagnostic performance of qualitative and quantitative radiographic parameters for diagnosing adult acute epiglottitis, and identify the prevalence and risk factors of false-negative neck radiography-based diagnosis of acute epiglottitis.

Methods: An emergency physician and a radiologist independently reviewed neck radiographs of 91 patients with laryngoscopy-confirmed acute epiglottitis and 91 control subjects between March 2010 and June 2016 for qualitative and quantitative radiographic parameters of acute epiglottitis, and concluded a diagnosis. Receiver operating characteristic (ROC) curves were constructed to assess the diagnostic performance of radiographic parameters, while independent risk factors of false-negative diagnosis were determined by multivariate logistic regression analysis. Inter-observer agreement was also calculated.

Results: All radiographic parameters showed good diagnostic performance with sensitivities and specificities of 33.0–80.2% and 64.8–100%, respectively. Epiglottis width (EW) > 6.3 mm showed the highest diagnostic performance (area under the ROC curve [AUC]: 0.867, sensitivity: 75.8%, specificity: 97.8%). Interobserver agreement for all radiographic parameters was excellent (range: 0.893–0.991). The lateral neck radiography-based false-negative diagnosis rate was 31.9%, and previous oral antibiotic usage was an independent risk factor of false-negative results.

Conclusion: EW > 6.3 mm showed the best diagnostic accuracy, facilitating a neck radiograph-based diagnosis of acute epiglottitis. However, false-negative results on neck radiograph are quite common and previous oral antibiotic usage is a risk factor. Based on the knowledge of the usefulness and risk factors of false-negative results of neck radiography, diagnostic process for acute epiglottitis using neck radiography need to be changed.

1. Introduction

1.1. Background

Acute epiglottitis is a supraglottic inflammatory condition that can cause fatalities due to airway obstruction. Acute epiglottitis in children is marked by an acute onset of high fever, sore throat, and rapid progression of toxicity. Previous studies have reported that 85% of children with epiglottitis were symptomatic for <24 h before presenting to the hospital [1,2]. Conversely, adults with acute epiglottitis typically experience a prodrome, similar to that of upper respiratory infection, over a period of 1–2 days [3]. Patients have a sore throat, dysphagia, dyspnea, hoarseness, and stridor, particularly when in the supine position. Fever may develop only in the later stages of the disease in adult patients [4].

While the incidence of acute epiglottitis in children has markedly decreased as a result of vaccination for *Haemophilus influenzae* type b [2,5,6], the incidence of acute epiglottitis in adults has been reported to be increasing [7-10]. There are approximately 1.9 cases of epiglottitis per 100,000 adults, as compared to 0.5 cases per 100,000 children in the United States [11]. Most adult cases are caused by a broad range of bacteria, viruses, and fungi, although most frequently, no organism can be isolated [10]. Owing to the high mortality rate, accurate and early diagnosis is important [12].

Lateral neck radiographs are low-cost and readily available, and are often used as a screening tool in the emergency department (ED) for suspected acute epiglottitis [13]. Many radiographic features have been reported as useful signs for diagnosing acute epiglottitis in lateral neck radiographs [14-19]. Radiologists and clinicians use different radiographic features for diagnosing acute epiglottitis on lateral neck radiographs, depending on their knowledge. Additionally, we have observed that some patients with normal lateral neck radiographs show acute epiglottitis on neck computed tomography (CT) and/or laryngoscopy.

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http://dx.doi.org/10.1016/j.ajem.2017.04.039
0735-6757/

Please cite this article as: Lee SH, et al, Do we need a change in ED diagnostic strategy for adult acute epiglottitis?, American Journal of Emergency Medicine (2017), http://dx.doi.org/10.1016/j.ajem.2017.04.039

We hypothesized that each radiographic parameter in neck radiographs may have different diagnostic performance, and some clinical factors may predispose to a false-negative diagnosis based on neck radiographs. In order to test our hypothesis, we designed a case-control study, owing to the rarity of acute epiglottitis. The primary goal of this study was to evaluate the diagnostic performance of known, measurable radiographic parameters for diagnosing acute epiglottitis in adults. The secondary goal of this study was to evaluate the prevalence and risk factors of false-negative diagnoses of acute epiglottitis based on neck radiographs.

2. Methods

2.1. Study population

Our institutional review board approved this retrospective study and waived the need for informed consent. Using a computerized data retrieval system, we searched the hospital database for patients in our institution who met the following criteria. The inclusion criteria were as follows: 1) adults who visited the ED of our hospital between March 2010 and June 2016, and 2) adults in whom a diagnosis of acute epiglottitis (ICD-9 diagnosis code 464.3) was made by means of laryngoscopy performed by an otolaryngologist. The exclusion criteria were as follows: 1) lack of lateral neck radiographs and 2) poor image quality that could jeopardize accurate measurement. Pediatric patients (<18 years) were not included, because pediatric patients with suspected acute epiglottitis underwent neck radiography with conservative treatment only, rather than CT or laryngoscopy.

According to our institute's routine protocol, as of March 2010, CT in the emergency department and/or laryngoscopy (by an otolaryngologist) were performed for the following patients: 1) adults (≥18 years) with a thumb sign on neck radiographs, performed in order to evaluate the severity or complications of acute epiglottitis, 2) adults with hoarseness or dysphagia, performed to confirm or exclude a diagnosis of acute epiglottitis, even though the thumb sign, on neck radiographs, and tonsillar enlargement, on physical examination, were not seen.

One radiologist (D.H.K.) collected the reports of the laryngoscopy and clinical data. The latter included sex, age, underlying comorbid conditions (hypertension, diabetic mellitus, cardiovascular disease, asthma); the presence of clinical symptoms, such as sore throat, dyspnea, hoarseness, dysphagia; the duration from symptom onset to ED visit, initial vital signs in the ED, including systolic blood pressure, diastolic blood pressure, pulse rate, respiratory rate, and body temperature; laboratory results, including white blood cell (WBC) count, and C-reactive protein (CRP) level; additional radiological examination findings, such as neck CT; and the management provided to the patients.

2.2. Control subjects

Control subjects were recruited using a Picture Archiving and Communication Systems (PACS) (Maro-view 5.4, Infinitt, Seoul, Republic of Korea) to search for adult patients who had undergone neck radiography. Patients were recruited by pairing them as age- and sex-matched controls to acute epiglottitis patients in a 1:1 ratio. The radiologist (D.H.K.) reviewed the demographic data, electronic medical records, and radiology reports of the lateral neck radiographs of the selected control subjects. Patients were included if they met the following criteria: 1) the normal lateral neck radiograph interpreted by a neuroradiologist (H.H.J.), 2) absence of a history of trauma or infection, 3) absence of a history of head and neck malignancy, and 4) absence of a history of neck or cervical spine surgery.

The neck radiographs of the patients and control subjects were blinded, mixed, and placed in a random order, to minimize sequential bias, for review.

2.3. Image acquisition and image analysis

All patients and control subjects in the study underwent standard lateral neck radiography. The radiographs were obtained in the standing position with a 15-degree extension of the neck.

All radiographs were evaluated retrospectively by one board-certificated emergency physician (S.H.L.) and one board-certificated radiologist (S.J.Y.), who were not involved in the selection of patients and control subjects. The two reviewers were unaware of the final clinical diagnoses and the prevalence of acute epiglottitis. The two reviewers independently evaluated the patients' and control subjects' lateral neck radiographs for: 1) the presence or absence of the thumb sign, 2) the presence or absence of the vallecula sign, 3) the aryepiglottic folds width (AEW), the epiglottis width (EW), the hypopharynx width (HW), retropharyngeal space (RPS), and retrotracheal space (RTS) on lateral neck images, and 4) the ratios of the AEW and third cervical vertebral body width (C3W), the EW and C3W, and the HW and C3W (Fig. 1). The definition of the radiographic parameters was based on previous studies [14-17]. All measurements were obtained by using electronic calipers in a PACS and the average values of two reviewers were determined. Additionally, reviewers concluded a diagnosis based on the radiographs as “acute epiglottitis” or “normal”.

2.4. Comparison of the final assessments between radiographs and laryngoscopy

To evaluate risk factor of false-negative diagnosis, the final assessments based on the radiographs and laryngoscopy were compared and divided into “true-positive” and “false-negative” results. In cases of discordance about the concluded diagnosis, one emergency physician and the two reviewers evaluated the causes of the discordance and reached a consensus. If both reviewers concluded “acute epiglottitis” and if it was in accordance with the laryngoscopy report, the case was regarded as “true-positive”. Conversely, if both reviewers' conclusions were “normal”, but laryngoscopic assessment concluded “acute epiglottitis”, the case was regarded as a “false-negative”.

2.5. Statistical analysis

Statistical analyses were performed using MedCalc software (Version 12.3.0, Mariakerke, Belgium). Independent *t*-tests were performed for continuous variables, and Pearson's chi-squared test or Fisher's exact test was used for nominal variables. Assessment of diagnostic performance of each radiographic parameter was analyzed by using receiver operating characteristic (ROC) curves. Inter-observer agreement was assessed by calculating the intraclass correlation coefficient (ICC) or weighted-kappa value. Independent risk factors for false-negative diagnosis were identified using multivariate logistic regression analysis. ICCs and kappa values were defined as follows: 0–0.20, poor agreement; 0.21–0.40, fair; 0.41–0.60, moderate; 0.61–0.80, good; and 0.81–1.00, excellent. We also generated adjusted odds ratios (ORs) and 95% confidence intervals (CIs) from multivariate analysis. p-Values < 0.05 were considered statistically significant.

3. Results

3.1. Characteristics of patients and control subjects

Ninety-five patients with a diagnosis of acute epiglottitis were recruited. Three patients were excluded as no lateral neck radiographs were available; one patient was excluded because of the poor image quality of the neck radiograph. A total of 91 patients (mean age: 45.0 ± 16.3 years; range: 18–81 years; male:female 49:42) were finally included in the study. Among them, 27 patients also underwent CT. Ultrasound (US) or magnetic resonance (MR) examination was not performed in any of the patients. Of the 91 patients, 84 patients were

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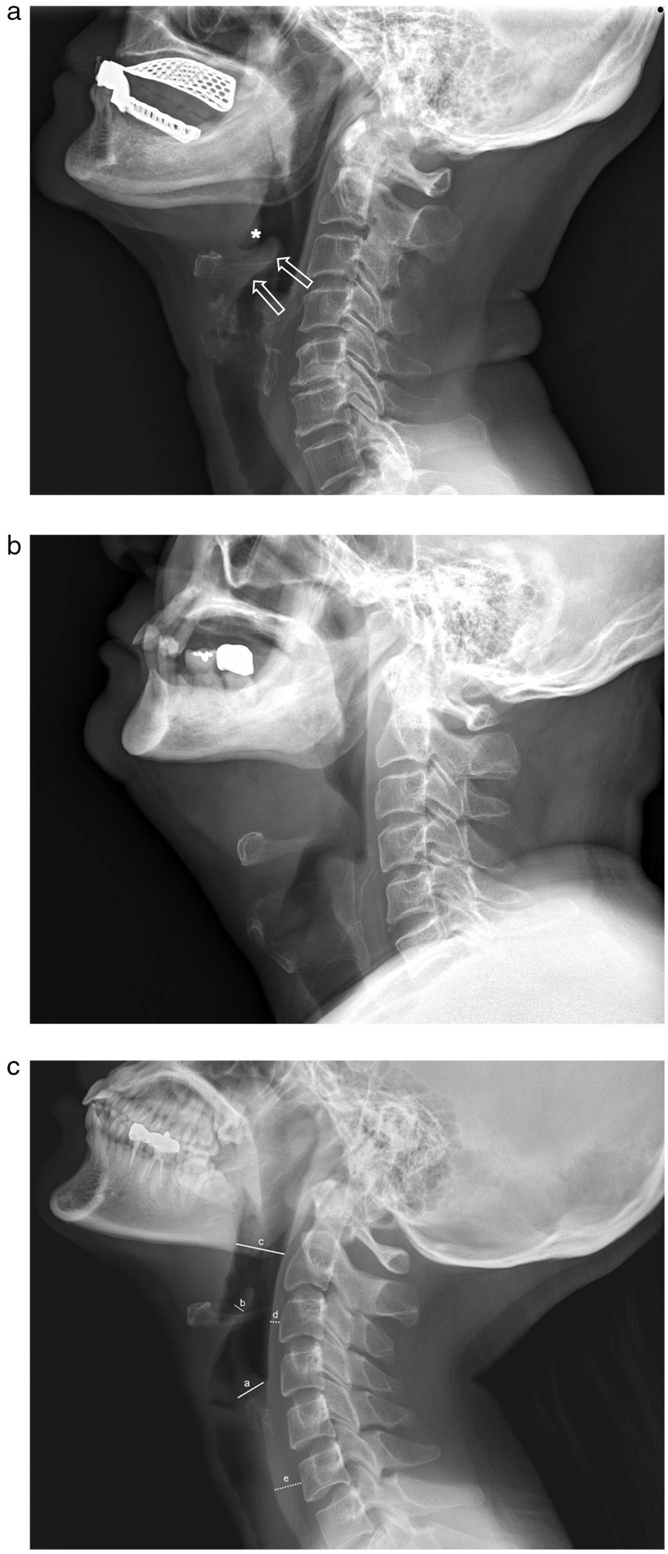

Fig. 1. Definition of the radiographic parameters. A, The thumb sign is defined as the wide, rounded configuration of an inflamed epiglottis (arrow). Asterisk indicates vallecula. B, The vallecula sign is defined as obliteration of the valleculae. C, The aryepiglottic fold width (AEW) is defined as the width of the aryepiglottic folds at the widest point (line a). Epiglottis width (EW) is defined as the width of the epiglottis at its widest point (line b). The hypopharynx width (HW) is defined as the width of the hypopharynx at the mid-second cervical vertebral body (C2) level (line c). The retropharyngeal space (RPS) is defined as the thickness of the retropharyngeal soft tissue at the mid-third cervical vertebral body (C3) level (dotted line d). The retrotracheal space (RTS) is defined as the thickness of the retrotracheal soft tissue at the mid-sixth cervical vertebral body (C6) level (dotted line e).

admitted to the Department of Otolaryngology (Ward, 77 patients; intensive care unit, 7 patients). The mean hospital stay was 6.4 days (range: 3–28 days). The remaining seven patients were not admitted because they declined hospitalization.

Ninety-one randomly selected control individuals, who were age- and sex-matched to the patients, were included in the study. They presented to the ED for ingested foreign bodies and neck pain. These patients were not admitted, and were discharged in the ED.

3.2. Values and interobserver reliabilities of radiographic parameters

The results and interobserver agreements of radiographic parameters are shown in Table 1. The frequencies of the qualitative radiographic parameters (thumb sign and vallecula sign) were significantly different between patients and control subjects. All quantitative radiographic parameters, except C3W, were significantly larger in the patients than in the control subjects. Interobserver agreement for all radiographic parameters was excellent (range: 0.893–0.991).

3.3. Diagnostic performance of each radiographic parameter

The diagnostic performance of the radiographic parameters for diagnosing acute epiglottitis is shown in Table 2. The thumb sign, AEW > 8.7 mm, EW > 6.3 mm, HW > 17 mm, AEW/C3W > 0.49, EW/C3W > 0.31, and HW/C3W > 0.84 showed excellent diagnostic performance with AUC > 0.8 (all $p < 0.001$). Among these significant parameters, EW > 6.3 mm showed the greatest diagnostic performance with an AUC of 0.867, sensitivity of 75.8%, and specificity of 97.8% (Fig. 2). The remaining radiographic parameters (RPS, RTS) showed a diagnostic performance with 0.6 < AUC < 0.8 (all $p < 0.001$). Sensitivities and specificities of radiographic parameters were 33.0–80.2% and 64.8–100%, respectively.

3.4. Risk factors for false-negative diagnosis

Sixty-two patients (68.1%) were diagnosed with acute epiglottitis based on neck radiographs. However, the remaining 29 patients (31.9%) were diagnosed with acute epiglottitis based on laryngoscopy with or without CT. These 29 patients were negative for the thumb sign, negative for the vallecula sign, and had an EW < 7 mm in neck radiographs, although swelling of epiglottis was seen on laryngoscopy (Fig. 3). Among them, 22 patients admitted to the Department of Otolaryngology (Ward, 19 patients; intensive care unit, 3 patients). The mean hospital stay was 6.1 days (range: 3–19 days). Detailed demographic

Table 1
Radiographic parameters in patients and control subjects, with interobserver reliabilities.

	Patients (n = 91)	Control subjects (n = 91)	*p*-Value	Kappa or ICC[a]
Thumb sign			<0.001	0.962 (0.920–1.0)
Yes	60 (65.9)	0 (0)		
No	31 (34.1)	91 (100)		
Vallecula sign			<0.001	0.893 (0.801–0.985)
Yes	49 (53.9)	0 (0)		
No	42 (46.1)	91 (100)		
C3W (mm)	18.9 ± 2.2	18.6 ± 1.4	0.27	0.949 (0.932–0.962)
AEW (mm)	10.7 ± 3.9	6.7 ± 2.6	<0.001	0.973 (0.964–0.980)
EW (mm)	9.3 ± 4.4	4.4 ± 0.9	<0.001	0.957 (0.942–0.967)
HW (mm)	20.6 ± 6.0	13.8 ± 3.8	<0.001	0.991 (0.987–0.993)
RPS (mm)	5.7 ± 2.8	3.7 ± 0.7	<0.001	0.977 (0.969–0.984)
RTS (mm)	15.0 ± 3.4	13.3 ± 1.7	<0.001	0.977 (0.970–0.983)

Data are number of patients with percentage *in parenthesis* or mean ± standard deviation. C3W, third cervical vertebral body width; AEW, aryepiglottic fold width; EW. epiglottis width; HW, hypopharynx width; RPS, retropharyngeal space; RTS, retrotracheal space; ICC, intraclass correlation coefficient.

[a] Data are 95% confidence interval *in parenthesis*.

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Table 2
Diagnostic characteristics of various radiographic parameters.

	Cut-off value	AUC (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)	Positive LR (95% CI)	Negative LR (95% CI)
Thumb sign	Yes	0.830 (0.767–0.881)	65.9 (55.3–75.5)	100 (96.0–100)	∞	0.3 (0.3–0.5)
Vallecula sign	Yes	0.769 (0.701–0.828)	53.9 (43.1–64.4)	100 (96.0–100)	∞	0.5 (0.4–0.6)
AEW (mm)	>8.7	0.812 (0.748–0.866)	73.6 (63.3–82.3)	81.3 (71.8–88.7)	3.9 (2.5–6.2)	0.3 (0.2–0.5)
EW (mm)	>6.3	0.867 (0.809–0.912)	75.8 (65.7–84.2)	97.8 (92.3–99.7)	34.5 (8.7–136.5)	0.3 (0.2–0.4)
HW (mm)	>17	0.848 (0.787–0.897)	73.6 (63.3–82.3)	82.4 (73.0–89.6)	4.2 (2.6–6.6)	0.3 (0.2–0.5)
RPS (mm)	>4.2	0.764 (0.705–0.810)	73.5 (64.3–80.5)	81.3 (71.8–88.7)	3.5 (1.9–5.9)	0.2 (0.1–0.3)
RTS (mm)	>15.1	0.643 (0.569–0.713)	46.2 (35.6–56.9)	87.9 (79.4–93.8)	3.8 (2.1–6.9)	0.6 (0.5–0.8)
AEW/C3W	>0.49	0.805 (0.740–0.860)	71.4 (61.0–80.4)	83.5 (74.3–90.5)	4.3 (2.7–7.0)	0.3 (0.2–0.5)
EW/C3W	>0.31	0.840 (0.779–0.890)	76.9 (66.9–85.1)	91.2 (83.4–96.1)	8.8 (4.5–17.1)	0.3 (0.2–0.4)
HW/C3W	>0.84	0.811 (0.746–0.865)	80.2 (70.6–87.8)	68.1 (57.5–77.5)	2.5 (1.8–3.5)	0.3 (0.2–0.4)

AEW, aryepiglottic fold width; EW, epiglottis width; HW, hypopharynx width; RPS, retropharyngeal space; RTS, retrotracheal space; C3W, third cervical vertebral body width; AUC, area under the receiver operating characteristic curve; CI, confidence interval; LR, likelihood ratio.

characteristics of true-positive and false-negative groups are listed in Table 3.

Among the clinical factors, previous oral antibiotic usage ($p = 0.005$), symptom duration ($p = 0.048$), and WBC count ($p = 0.004$) were significantly different between the true-positive and false-negative groups. However, there was no significant correlation between the false-negative group and other clinical factors (all $p > 0.5$; Table 3).

Multivariate logistic regression analysis was conducted based on "previous oral antibiotic usage", "symptom duration", and "WBC count" factors that were found to be statistically significant on univariate analysis. Of these factors, only previous oral antibiotic usage (OR: 8.0; 95% CI: 1.8–40.2; $p = 0.02$) was a significant factor for false-negative diagnosis of acute epiglottitis based on neck radiographs (Table 4).

4. Discussion

The results of the present study suggest that all radiographic parameters measured using neck radiographs offer complementary information for diagnosing acute epiglottitis. In particular, EW > 6.3 mm showed the greatest diagnostic performance as compared with other radiographic parameters. However, all radiographic parameters, including EW, showed relatively low sensitivity. The false-negative diagnosis rate of neck radiographs was 31.9% in our study. Cases with false-negative diagnoses tended to have previous oral antibiotic usage, long symptom duration, and low WBC count. Among these factors, previous oral antibiotic usage was revealed as a significant, independent risk factor of false-negative diagnoses based on neck radiography.

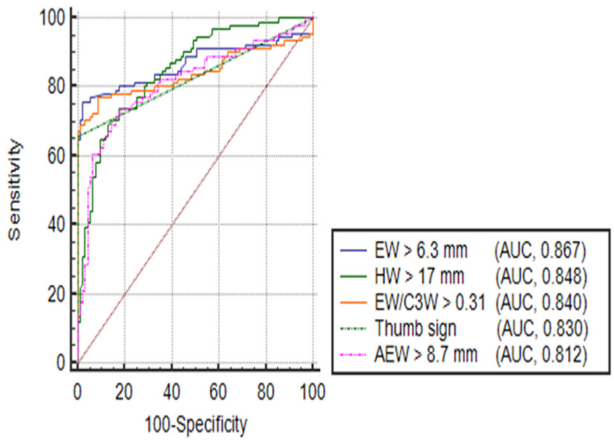

Fig. 2. Receiver operating characteristic (ROC) comparisons of five significant parameters for diagnosing acute epiglottitis. The area of the ROC curve (AUC) is calculated for each parameter and used for comparison of diagnostic performance.

For diagnosing acute epiglottitis, laryngoscopy is regarded as the gold standard [6]. However, laryngoscopy has several limitations, such as invasiveness, intraobserver/interobserver variability, and severe procedure-related complications [3,20]. It is also difficult to repeat during follow-up, because of these limitations. To date, acute epiglottitis has been diagnosed by noninvasive means, using imaging modalities, including neck radiography, neck US, CT, and MR imaging [14-19, 21-24]. However, in neck US, radiologists and physicians with experience and special training in neck US are needed to perform procedures to visualize and diagnose acute epiglottitis. Bedside US is rarely used in patients who cannot be examined adequately by neck radiography [21,22]. CT and MR examinations are also less favorable and not easily available in most clinical settings; furthermore, dyspnea may be aggravated when patients are in the supine position required for these investigations. Therefore, CT and MR examinations are seldom used to exclude complications [23,24]. Thus, neck radiography is the imaging tool most commonly used to diagnose acute epiglottitis [13].

During interpretation of neck radiographs, the thumb sign and the vallecula sign are the most easily and commonly used signs for diagnosing acute epiglottitis [25,26]. Although the specificity of the thumb sign and the vallecula sign were 100% in our case-control study, the true specificities of these two signs were not 100% in a previous observational study (thumb sign, 94.0%; vallecula sign, 88.1%) [26]. Moreover, some quantitative parameters (EW, HW, and EW/C3W) showed a greater AUC and sensitivity than the thumb sign and the vallecula sign. Compared with adjusted quantitative parameters (in reference to C3W), the AUCs of the original quantitative parameters were greater. Thus, the original quantitative parameters, in particular, EW, may be helpful for diagnosing acute epiglottitis on neck radiographs. In terms of cut-off values, our values were smaller, and it is possible that false-negative cases were included in our study.

Previous studies [14-19] have reported that the sensitivity and specificity of neck radiographs for diagnosing acute epiglottitis were 83–100% and 100%, respectively. Although the specificities in our results were similar, the sensitivities were lower compared with those reported in previous studies. We considered that the reason was the use of an older diagnostic strategy for acute epiglottitis. In practice, acute pharyngitis is commonly diagnosed in patients without enlargement of the epiglottis on neck radiographs. Thus, physicians may not be overly concerned and might miss acute epiglottitis when the neck radiograph shows negative findings.

Not only the prevalence of false-negative diagnosis of acute epiglottitis based on neck radiography, but also the risk factors for such a diagnosis need to be investigated. According to our study, cases with false-negative diagnosis tended to have used oral antibiotics, had long symptom duration, and a low WBC count. Among these factors, previous oral antibiotic usage was identified as an independent risk factor of false-negative diagnosis on neck radiographs. Additionally, it is presumed that the inflammatory process and symptoms might be temporarily resolved and progress of the condition slowed by taking oral

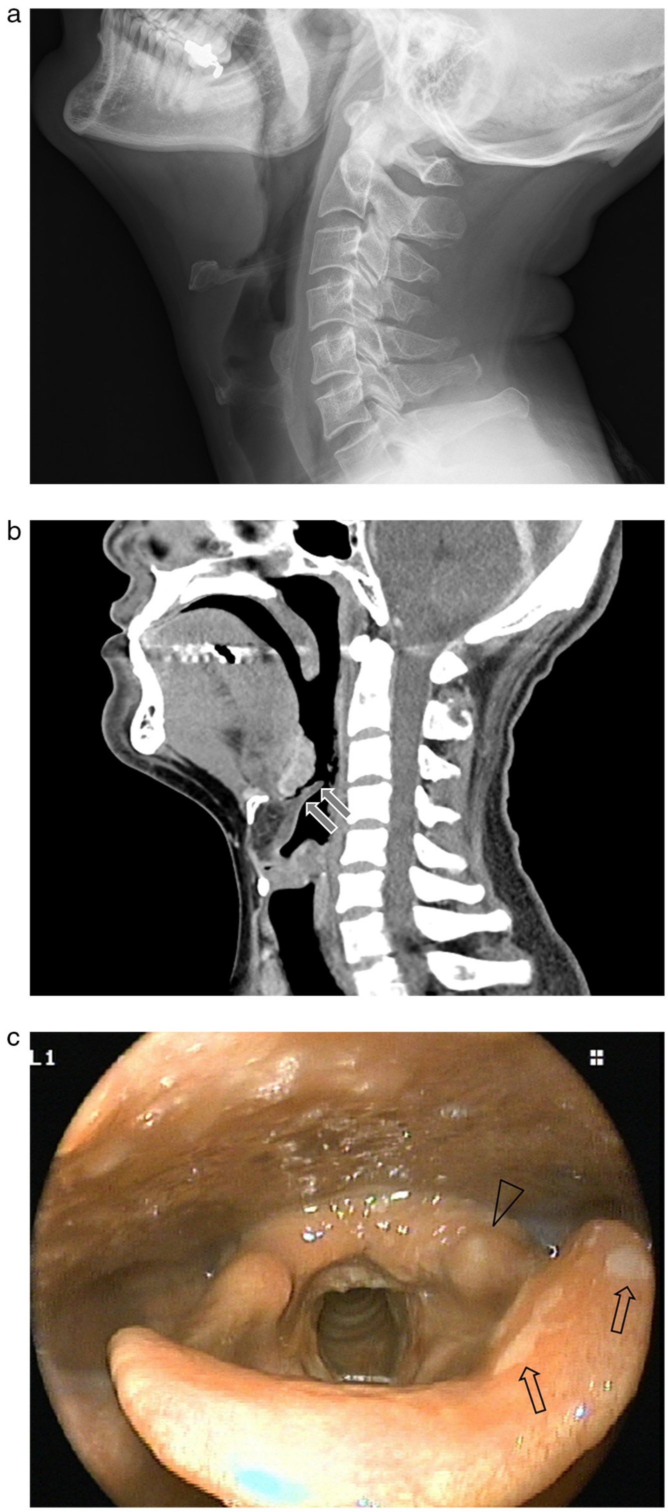

Fig. 3. False-negative result in a 45-year-old man with acute epiglottitis. A, A lateral neck radiograph shows a normal epiglottitis and vallecula. Both reviewers interpreted this as a "normal" lateral neck radiograph. B, Sagittal contrast-enhanced CT image taken on the same day shows a mildly edematous change of the entire epiglottis (arrows), suggestive of acute epiglottitis. C, A laryngoscopic examination performed on the same day shows mild swelling, with a whitish plaque (arrows) on the epiglottis and mild swelling of the left arytenoid area (arrowhead). The airway is intact. Acute epiglottitis is confirmed.

antibiotics. Another possible reason may be the extension of the infection to a wider area in adults. In adults, infection often extends to the soft palate, base of the tongue, uvula, and vallecula, in addition to the epiglottis [27]. Thus, even though the epiglottis seems to have a normal

Table 3
Univariate analysis of factors associated with false-negative results.

		True-positive (n = 62)	False-negative (n = 29)	*p*-Value
Underlying comorbid conditions	Yes	10	1	0.16
	No	52	28	
Sore throat	Yes	59	29	0.55
	No	3	0	
Dyspnea	Yes	25	7	0.16
	No	37	22	
Hoarseness	Yes	32	13	0.65
	No	30	16	
Dysphagia	Yes	38	12	0.11
	No	24	17	
Previous oral antibiotic use	Yes	10	13	**0.005**
	No	52	16	
Symptom duration (day)		1.6 ± 2.2	2.9 ± 3.9	**0.048**
Blood pressure (mm Hg)	Systolic	132.2 ± 20.7	130.9 ± 16.0	0.76
	Diastolic	77.9 ± 10.5	77.1 ± 10.1	0.76
Temperature (°C)		37.1 ± 0.82	76.9 ± 0.84	0.36
Purse rate (/min)		89.1 ± 15.9	87.3 ± 17.9	0.64
Respiratory rate (/min)		21.0 ± 2.3	20.7 ± 1.9	0.59
WBC count (/μL)		14.4 ± 5.1	11.1 ± 5.2	**0.004**
C-reactive protein (mg/dL)		6.4 ± 8.5	6.3 ± 9.1	0.95

Data are number of patients or mean ± standard deviation. Bold type indicates significant. WBC, white blood cell.

thickness on neck radiographs in patients who have previously used oral antibiotics, it shows edematous change on CT and/or laryngoscopy.

Clinically, detection of false-negative diagnosis based on neck radiography should not be ignored, because the treatment strategies for acute epiglottitis and acute pharyngitis are somewhat different. In patients with acute pharyngitis, 10-day penicillin or amoxicillin is used as initial treatment and patients are discharged from the ED without additional examination or hospital admission [3,28]. However, in patients with acute epiglottitis, intravenous ceftriaxone once daily is used as the first-line drug. Alternative antibiotics include ampicillin-sulbactam, cefotaxime, piperacillin-tazobactam, and the anti-staphylococcal agents against methicillin-resistant *Staphylococcus aureus* should be considered [29,30]. Additionally, steroids are used to decrease airway inflammation and edema, although this remains controversial [31]. Most importantly, additional measures, such as laryngoscopy and hospital admission are needed to ensure closer observation and prevent complications, such as airway obstruction [6,25].

Overall, our results indicate that the diagnostic process for acute epiglottitis using neck radiography might need to be changed owing to its fallibility. We speculated that neck radiography is still appropriate as an initial screening tool for patients with suspected acute epiglottitis. If acute epiglottitis is suspected on neck radiographs (EW > 6.3 mm), immediate treatment is started. If acute epiglottitis is not suspected from neck radiography, a history of previous oral antibiotic usage may be important. If the patient had a history of previous oral antibiotic usage, there is a risk of false-negative diagnosis based on neck radiography. Thus, our study opens up the feasibility of neck CT as a secondary approach for diagnosing acute epiglottitis.

Table 4
Multivariate analysis of factors associated with false-negative results.

	OR	95% CI limit	*p* value
Previous oral antibiotic use			0.02
No	Reference		
Yes	8.0	1.8–40.2	
Symptom duration	1.0	0.82–1.3	0.70
White blood cell count	1.0	1.0–1.0	0.15

OR, odd ratio; CI, confidence interval.

Our study has some limitations. First, this was a retrospective review conducted at a single center emergency department. Only a small number of patients were included in this study. Second, we did not consider the effect of the divergence of the X-ray beams. This divergence can lead to errors in radiographic measurements made on neck radiographs with a different center and can theoretically lead to different measurements. Third, the soft tissue structures may vary in size, depending on the phase of respiration and the radiographic technique. The recommended view for diagnosing acute epiglottitis is a true lateral soft tissue radiograph of the neck in extension, with the patient in expiration. Because of the retrospective nature of our study, the imaging position and timing of the respiratory cycle could not be controlled. Fourth, we did not consider acute epiglottitis based on different microbiological pathogens. In our institution, throat cultures for microbiological examination were not performed, because we considered that potentially life-threatening conditions could be aggravated by manipulating supraglottic structures affected by inflammation. In future, a prospective study with a larger number of patients will be needed to investigate diagnostic performance with cut-off values of radiographic parameters and false-negative results in diagnosing acute epiglottitis.

5. Conclusion

In summary, our case-control study identified EW > 6.3 mm as the objective radiographic parameter with the best diagnostic accuracy, which may help in the diagnosis of acute epiglottitis on neck radiographs. The false-negative rate on neck radiographs is 31.9% and previous oral antibiotic usage is an independent risk factor for false-negative results. Based on the knowledge of the usefulness and risk factors of false-negative results of neck radiography, radiologists and clinicians can diagnose acute epiglottitis more precisely, facilitating appropriate treatment.

Conflict of interest

There is no potential conflict of interest related to this article.

References

[1] Losek JD, Dewitz-Zink BA, Melzer-Lange M, Havens PL. Epiglottitis: comparison of signs and symptoms in children less than 2 years old and older. Ann Emerg Med 1990;19:55–8.
[2] Shah RK, Stocks C. Epiglottitis in the United States: national trends, variances, prognosis, and management. Laryngoscope 2010;120:1256–62.
[3] Alcaide ML, Bisno AL. Pharyngitis and epiglottitis. Infect Dis Clin North Am 2007;21: 449–69.
[4] Marx JA, Hockberger RS, Walls RM. Rosen's emergency medicine. Concepts and clinical practice. 8th ed. Philadelphia, PA: Elsevier-Saunders; 2014 969.
[5] Reilly BK, Reddy SK, Verghese ST. Acute epiglottitis in the era of post-Haemophilus influenzae type B (HIB) vaccine. J Anesth 2013;27:316–7.
[6] Al-Qudah M, Shetty S, Alomari M, Alqdah M. Acute adult supraglottitis: current management and treatment. South Med J 2010;103:800–4.
[7] Nonoyama H, Arimoto M, Inagawa S, Uchida I, Tanigawa T, Ogawa T, et al. A clinical study of acute epiglottitis in adults. Nihon Jibiinkoka Gakkai Kaiho 2014;117:191–5.
[8] Qazi IM, Jafar AM, Hadi KA, Hussain Z. Acute epiglottitis: a retrospective review of 47 patients in Kuwait. Indian J Otolaryngol Head Neck Surg 2009;61:301–5.
[9] Chu HS, Jung JY, Woo JS, Woo JS, Hwang SJ, Lee HM. Acute epiglottitis in adults: a review of 85 patients. Korean J Otolaryngol 2004;47:558–61.
[10] Nakamura H, Tanaka H, Matsuda A, Fukushima E, Hasegawa M. Acute epiglottitis: a review of 80 patients. J Laryngol Otol 2001;115:31–4.
[11] Shah RK, Nussenbaum B, Kienstra M, Glenn M, Brereton J, Patel MM, et al. Wrong-site sinus surgery in otolaryngology. Otolaryngol Head Neck Surg 2010;143:37–41.
[12] Khilanani U, Khatib R. Acute epiglottitis in adults. Am J Med Sci 1984;287:65–70.
[13] Tintinalli JE, Stapczynski JS, Ma OJ, Yealy DM, Meckler GD, Cline DM. Emergency medicine. A comprehensive study guide. 7th ed. New York: McGraw-Hill; 2011 1585.
[14] Podgore JK, Bass JW. The "thumb sign" and "little finger sign" in acute epiglottitis. J Pediatr 1976;88:154–5.
[15] Schabel SI, Katzberg RW, Burgener FA. Acute inflammation of epiglottitis and supraglottic structures in adults. Radiology 1977;122:601–4.
[16] Rothrock SG, Pignatiello GA, Howard RM. Radiologic diagnosis of epiglottitis: objective criteria for all ages. Ann Emerg Med 1990;19:978–82.
[17] Schumaker HM, Doris PE, Birnbaum G. Radiographic parameters in adult epiglottitis. Ann Emerg Med 1984;13:588–90.
[18] Nemzek WR, Katzberg RW, Vanslyke MA, Bickley LS. A reappraisal of the radiologic findings of acute inflammation of the epiglottis and supraglottic structures in adults. Am J Neuroradiol 1995;16:495–502.
[19] Yong MG, Choo MJ, Yum CS, Cho SB, Shin SO, Lee DW, et al. Radiologic laryngeal parameters in acute supraglottitis in Korean adults. Yonsei Med J 2001;42:367–70.
[20] Chang YL, Lo SH, Wang PC, Shu YH. Adult acute epiglottitis. Experiences in Taiwanese setting. Otolaryngol Head Neck Surg 2005;132:689–93.
[21] Ko DR, Chung YE, Park I, Lee HJ, Park JW, You JS, et al. Use of bedside sonography for diagnosing acute epiglottitis in the emergency department: a preliminary study. J Ultrasound Med 2012;31:19–22.
[22] Hung TY, Li S, Chen PS, Wu LT, Yang YJ, Tseng LM, et al. Bedside ultrasonography as a safe and effective tool to diagnose acute epiglottitis. Am J Emerg Med 2011; 29:359.e1-3.
[23] Smith M, Mukherji S, Thompson J, Castillo M. CT in adult supraglottitis. AJNR Am J Neuroradiol 1996;17:1355–8.
[24] Ozanne A, Marsot-Dupuch K, Ducreux D, Meyer B, Lasjaunias P. Acute epiglottitis: MRI. Neuroradiology 2004;46:153–5.
[25] Ng HL, Sin LM, Li MF, Que TL, Anandaciva S. Acute epiglottitis in adults: a retrospective review of 106 patients in Hong Kong. Emerg Med J 2008;25:253–5.
[26] Fujiwara T, Okamoto H, Ohnishi Y, Fukuoka T, Ichimaru K. Diagnostic accuracy of lateral neck radiography in ruling out supraglottitis: a prospective observational study. Emerg Med J 2015;32:348–52.
[27] Shapiro J, Eavey RD, Baker AS. Adult supraglottitis: a prospective analysis. JAMA 1988;259:563–7.
[28] Shulman ST, Bisno AL, Clegg HW, Gerber MA, Kaplan EL, Lee G, et al. Clinical practice guideline for the diagnosis and management of group A streptococcal pharyngitis: 2012 update by the Infectious Diseases Society of America. Clin Infect Dis 2012;55: 1279–82.
[29] Gilbert DN, Moellering Jr RC, Eliopoulos GM, Chambers HF, Saag MS. The Sanford guide to antimicrobial therapy. 40th ed. Sperryville, VA: Antimicrobial Therapy Inc.; 2010 65.
[30] Ward MA. Emergency department management of acute respiratory infections. Semin Respir Infect 2002;17:65–71.
[31] Glynn F, Fenton JE. Diagnosis and management of supraglottitis (epiglottitis). Curr Infect Dis Rep 2008;10:200–4.

Please cite this article as: Lee SH, et al, Do we need a change in ED diagnostic strategy for adult acute epiglottitis?, American Journal of Emergency Medicine (2017), http://dx.doi.org/10.1016/j.ajem.2017.04.039