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Comparison of Scope Classifications for Predicting the Need for Airway Intervention in Acute Supraglottitis

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Abstract

Background Acute supraglottitis (AS) can cause airway obstruction, sometimes necessitating airway intervention. Some scope classifications were developed to predict the need for airway intervention in patients with AS; however, the most suitable classification for predicting the need for airway intervention remains unclear.

Objective This study was performed to validate and compare the usefulness of three scope classifications (Katori's, Tanaka's, and Ovnat-Tamir's classifications) for predicting the need for airway intervention in patients with AS.

Materials and Methods We recruited 75 patients (44 males and 31 females aged 20–94 years) with AS who visited Kurashiki Central Hospital between January 2015 and September 2019. The areas under the receiver operating characteristic curves (AUCs) of the scope classifications for predicting the need for airway intervention were measured.

Results Of the 75 patients, airway intervention was needed in 23 patients. The AUC was 0.818 (95% confidence interval [CI]: 0.715–0.922) for Katori's classification, 0.803 (95% CI: 0.699–0.907) for Tanaka's classification, and 0.814 (95% CI: 0.705–0.922) for Ovnat-Tamir's classification.

Conclusion Although all three classifications appeared to be useful, the AUC tended to be the highest for Katori's classification.

Keywords
- supraglottitis
- ROC curve
- sensitivity
- specificity

Introduction

Acute supraglottitis (AS) is characterized by inflammation of the epiglottis and may be caused by bacterial, viral, or fungal pathogens.[1–3] AS has typically been reported as a disease of children in Western countries, but its incidence in childhood has declined over the past decade since the introduction of *Haemophilus influenzae* type B vaccination. Adult cases of AS have recently attracted increasing attention.[4,5] AS can cause sudden life-threatening airway obstruction, but the prognosis is favorable in cases with adequate airway management.

The focus of AS treatment is maintenance of a patent airway, and several classification systems have been developed to determine the indications for airway intervention (e.g., intubation and tracheostomy). Friedman et al classified AS severity according to the severity of the symptoms,[6] and their classification system was used to determine the need for airway intervention.[6,7] Recently, laryngeal endoscopy, which provides direct visualization of swelling of the epiglottis, has been widely adopted and is commonly used in AS patients. In 2005, Katori et al developed a new classification for AS patients

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based on the results of laryngeal endoscopy (Katori's "scope classification"); they reported that a scope-based classification system would be more useful than one based on the symptoms to predict the need for airway intervention.[8] In 2015, Tanaka et al and Ovnat-Tamir et al proposed new scope classifications for AS patients[9,10] (Tanaka's classification and Ovnat-Tamir's classification).

To our knowledge, few studies have sought to validate the diagnostic value of Katori's classification. In addition, it is unclear whether the scope classification is adequate to predict the need for airway intervention in AS patients. This study was performed to validate and compare the diagnostic value of these scope classification systems for predicting the need for airway intervention in adult patients with AS.

Methods

Study Design and Setting

We conducted a single-center, retrospective validation study in Kurashiki Central Hospital from January 1, 2015 to September 30, 2019. The study was approved by the institutional review board of Kurashiki Central Hospital, and was conducted and reported in accordance with the STARD principles (Standards for Reporting of Diagnostic Accuracy Studies).[11] We included AS patients aged 20 years or older who were treated at our hospital during the study period. Potentially eligible patients were identified using code J051 of the 10th revision of the International Statistical Classification of Diseases and Related Health Problems 10 (ICD-10). We confirmed that patients met the inclusion criteria through a chart review of electronic medical records. Patients in whom AS was accompanied by deep neck infection were excluded.

Airway Management

In our hospital, the decision for airway intervention is made by the attending otolaryngologist (board certified by the Oto-Rhino-Laryngological Society of Japan).

Outcome Measures

The primary outcome was the diagnostic value of scope classification systems for predicting the need for airway intervention, including tracheal intubation, tracheostomy, and cricothyrotomy. We extracted data on patient age, gender, symptoms on presentation (sore throat, dysphagia, odynophagia, drooling, fever, voice change, and dyspnea), comorbidities (laryngeal cyst, diabetes mellitus, smoking), and Friedman grade from the medical records. In Friedman grade, respiratory status represented by respiratory complains and vital signs was classified from I to IV (►**Table 1**).[6]

Two otolaryngologists (Takashi Fujiwara and Machi Nonomura) evaluated each patient using the scope classification systems of Katori, Tanaka, and Ovnat-Tamir. Disagreements were resolved by discussion with a third author (M.M.). In Katori's classification, swelling of the epiglottis was classified from I to III; the presence of arytenoid swelling was also evaluated[8] (►**Table 2**). In Tanaka's classification, swelling of the epiglottis was graded from 1 to 3 and arytenoid swelling was assigned a score of 1 or 2 (►**Table 3**).[9] In Ovnat-Tamir's classification, the severity of swelling in three subsites, that is, the epiglottis, the aryepiglottic folds and arytenoids, and the rima glottidis, was graded from 0 to 3 (►**Table 4**).[10]

Statistical Analysis

We compared the baseline characteristics of patients with and without airway intervention using the Fisher's exact test for dichotomous data and Student's *t*-test for continuous data. The prognostic capability of the each scope classification system for predicting the need for airway intervention was evaluated by plotting a receiver operating characteristic (ROC) curve and calculating the area under the ROC curve (AUC) and the 95% confidence interval (95% CI). When conducting ROC analysis, we defined the ordinal order of Katori's classification as the following; IA, IB, IIA, IIB, IIIA, and IIIB. All statistical analyses were performed using Stata SE version 15.0 (Stata Corp., College Station, Texas, United States).

Results

Patient Characteristics

During the study period, 75 cases of AS were identified. Airway intervention was performed in 30.7% of the patients (23/75). The characteristics and symptoms of the enrolled patients are shown in ►**Table 5**. Of the patients with airway intervention, 11 (47.8%) underwent intubation and 12 (52.2%) underwent tracheostomy.

Diagnostic Value of Each Scope Classification

►**Fig. 1** shows the ROC curves for each scope classification system. The ROC curves of all of the classification systems were relatively symmetrical and similar to each other. The AUC value was 0.818 (95% CI: 0.715–0.922) for Katori's

Table 1 Friedman grade

	Respiratory complaint	Sign	Respiratory rate (rr)/P_{CO_2}
I	No	No	rr < 20/min
II	Subjective complaints	Dysphagia, dysphonia, sore throat, pooling of secretion	rr > 20/min
III	Mild respiratory distress	Stridor, perioral cyanosis, chest retractions	rr > 30/min PCO_2 > 45 mm Hg
IV	Severe respiratory distress	Severe stridor, severe chest retractions, cyanosis, hypoxia, delirium, loss of consciousness	Respiratory arrest

Note: The severity of supraglottitis is given by respiratory status in the following order: I, II, III, and IV.

Table 2 Katori's scope classification

	Definition/description	
Epiglottis	I (slight swelling)	Slight swelling of the epiglottis and the entire length of the vocal folds can be seen with the scope
	II (moderate swelling)	Moderate swelling of the epiglottis and more than half of the posterior vocal folds can be seen with the scope
	III (severe swelling)	Severe swelling of the epiglottis and less than half of the posterior vocal folds can be seen with the scope
Arytenoid	A (no swelling)	No extension of the swelling to the arytenoids or aryepiglottic folds
	B (swelling)	Extension of the swelling to the arytenoids and the aryepiglottic folds

Note: The severity of supraglottitis increases in the following order: IA, IB, IIA, IIB, IIIA, and IIIB.

Table 3 Tanaka's scope classification

		Definition/description
Epiglottis	1	Slight swelling of the epiglottis; the swelling is localized to the lingual side of the epiglottis
	2	Moderate swelling of the epiglottis; the swelling has spread to the laryngeal side of the epiglottis and the epiglottis has taken on a U-shaped appearance
	3	Severe swelling of the epiglottis; the epiglottis has a globular or heart-shaped appearance
Arytenoid	1	Unilateral severe swelling
	2	Bilateral severe swelling

Note: The severity of supraglottitis is given by the sum of the scores of the epiglottis and arytenoid, e.g., $3+2=5$. Severe swelling of the arytenoid is defined as swelling of sufficient severity to obscure the pyriform sinus.

Table 4 Ovnat-Tamir's scope classification

		Definition/description
Epiglottis	0	No edema
	1	Mild edema
	2	Moderate edema
	3	Severe edema
Aryepiglottic folds and arytenoid	0	No edema
	1	Mild edema
	2	Moderate edema
	3	Severe edema
Rima glottidis	0	No edema
	1	Mild edema
	2	Moderate edema
	3	Severe edema

Note: The severity of supraglottitis is given by the sum of the scores of the epiglottis, aryepiglottic folds, and rima glottidis, e.g., $1+3+2=6$.

classification, 0.803 (95% CI: 0.699–0.907) for Tanaka's classification, and 0.814 (95% CI: 0.705–0.922) for Ovnat-Tamir's classification. There were no significant differences among the AUC values.

Table 5 Characteristics of patients included in the study

	Conservative treatment ($n=52$)	Airway intervention ($n=23$)	*p*-Value
General characteristics			
Mean age (y)	52.5 ± 17.2	59.1 ± 18.5	0.146
Gender (male/female)	33/19	11/12	0.217
Symptom			
Sore throat	52 (100.0%)	22 (95.7%)	0.307
Odynophagia	28 (53.8%)	19 (82.6%)	0.028
Drooling	1 (1.9%)	4 (17.4%)	0.028
Fever	12 (23.1%)	14 (60.9%)	0.003
Voice change	10 (19.2%)	9 (39.1%)	0.087
Dyspnea	12 (23.1%)	11 (47.8%)	0.055
Scope classification			
Katori III (%)	5 (9.6%)	12 (52.2%)	<0.001
Katori II (%)	11 (21.2%)	7 (30.4%)	
Katori I (%)	36 (69.2%)	4 (17.4%)	
Mean Tanaka's score	1.81 ± 1.09	3.35 ± 1.40	<0.001
Mean Ovnat-Tamir's score	2.38 ± 1.42	4.43 ± 1.67	<0.001
Comorbidities			
Laryngeal cyst	5 (9.6%)	1 (4.3%)	0.660
Diabetes mellitus	8 (15.4%)	2 (8.7%)	0.714
Smoking	22 (42.3%)	9 (39.1%)	1.000
Airway intervention			
Tracheostomy		12 (52.2%)	
Intubation		11 (47.8%)	

The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of Katori's classification are shown in ►**Table 6**.

Discussion

In this study, we calculated the diagnostic value of three scope classification systems for predicting the requirement

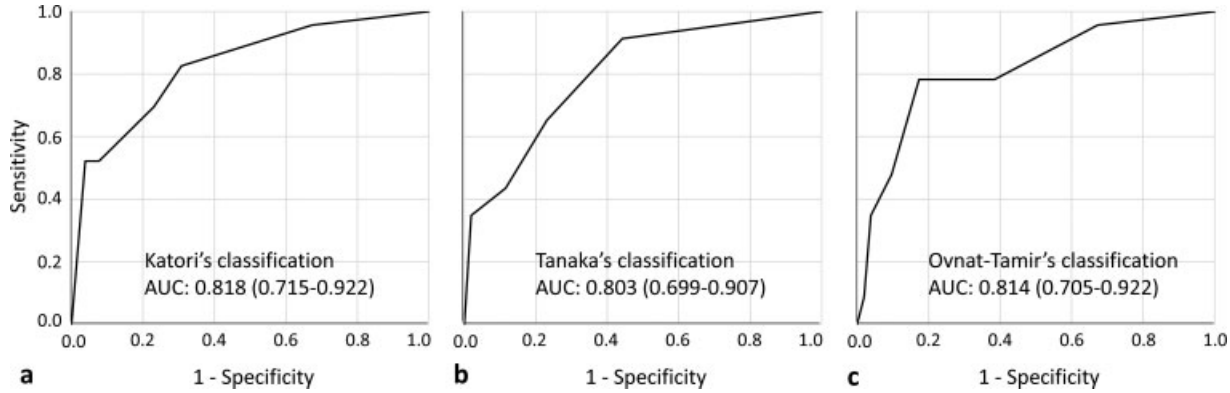

Fig. 1 Receiver operating characteristic (ROC) curves of the scope classification systems. The ROC curves of Katori's, Tanaka's, and Ovnat-Tamir's classifications for prediction of the requirement for airway intervention. The areas under the ROC curve (AUC) of each classification are shown with 95% confidence intervals. (**a**) ROC curve of Katori's classification. (**b**) ROC curve of Tanaka's classification. (**c**) ROC curve of Ovnat-Tamir's classification.

Table 6 Sensitivity, specificity, PPV, and NPV of Katori's classification

Katori's classification	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
IIIB or more severe	52.2% (30.6–73.2)	94.2% (84.1–98.8)	80.0% (51.9–95.7)	81.7% (69.6–90.5)
IIIA or more severe	52.2% (30.6–73.2)	90.4% (79.0–96.8)	70.6% (44.0–89.7)	81.0% (68.6–90.1)
IIB or more severe	69.6% (47.1–86.8)	75.0% (61.1–86.0)	55.2% (35.7–73.6)	84.8% (71.1–93.7)
IIA or more severe	82.6% (61.2–95.0)	69.2% (54.9–81.3)	54.3% (36.6–71.2)	90.0% (76.3–97.2)
IB or more severe	95.7% (78.1–99.9)	32.7% (20.3–47.1)	38.6% (26.0–52.4)	94.4% (72.7–99.9)

Abbreviations: CI, confidence interval; NPV, negative predictive value; PPV, positive predictive value.

for airway intervention in AS patients. All of the classification systems showed moderate accuracy, with AUC values of around 0.8.

Katori et al were the first to propose a scope classification system for AS; their system evaluates swelling of the epiglottis and arytenoid separately (e.g., IA, IIA, IIIB). Katori's classification focuses mainly on the epiglottis, and only indicates the presence/absence of arytenoid edema. The two new classification systems, of Tanaka et al and Ovnat-Tamir et al, assess swelling of the arytenoid and aryepiglottic edema in detail, and generate a total score for swelling in the larynx. Tanaka et al did not compare their classification system with those of Katori et al in terms of diagnostic value, while Ovnat-Tamir et al reported that classification 5 in their system is equivalent to grade II of Katori's classification.[10] Published data indicated 100.0% (81.0%–100.0%) sensitivity and 61.8% (range: 55.9–67.4%) specificity for Katori's classification, and 65.4% (range: 44.3–82.8%) sensitivity and 81.9% (range: 77.0–86.2%) specificity for Ovnat-Tamir's classification, although the AUCs were not calculated.[10]

In this study, we calculated the AUCs of the scope classification systems of Katori et al, Tanaka et al, and Ovnat-Tamir et al, and showed that there were no differences between them. We also calculated the sensitivity, specificity, PPV, and NPV of Katori's classification. However, this study had some limitations. First, the indications for airway intervention would differ among hospitals, so the sensitivity, specificity, PPV, and NPV values determined here (►**Table 6**) cannot be generalized, although the AUCs could be applicable to other institutions. The decision to perform airway intervention is informed by the level of clinical expertise, patients' preferences, and other circumstances. Among previous reports, the rates of airway intervention in AS patients varied from 0 to 30%.[7,8,12–15] Otolaryngologists are not always on hand at our hospital, and it is difficult to conduct tracheostomy immediately when AS patients develop airway obstruction. Indeed, 75% of AS patients with Katori IIIB grade received airway intervention in our hospital, compared with 30.8% in Katori's hospital.[8] Second, the attending physician makes the decision to perform for airway intervention based not only on scope evaluation, but also on the patients' symptoms. Some studies have suggested a correlation between airway intervention and patient characteristics, including body mass index, comorbidities, and comorbid epiglottic cysts.[14–16] In this study, the baseline characteristics (age, gender, symptoms, and comorbidities) between the conservative treatment and airway intervention groups were not balanced (►**Table 5**), and we cannot rule out an influence of these factors on the results. Finally, the physicians in our hospital may have read articles discussing previous scope classification systems,[8–10] which may have affected their decision-making process regarding airway intervention in patients with AS.

In our study, there was no difference among these three classifications. Therefore, Katori's classification, which is the first and common scope classification, is likely to be suitable for a standard method for predicting the need for airway intervention in AS.

Conclusion

We validated and compared the utility of three scope classifications (Katori's, Tanaka's, and Ovnat-Tamir's classification) for predicting the need for airway intervention in AS. Although all three classifications were similar, the AUC tended to be highest in Katori's classification.

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Conflict of Interest
None declared.

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