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Laryngeal Adjustment in Producing Voiceless Plosive [k]
—Videofiberscopic and Manometric study—

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ABSTRACTS

We examined the role of the intrapharyngeal pressure to the laryngeal adjustment during the production of voiceless plosive [k] in the running speech. By videofiberscopy and manometory, we analyzed the relationship between the degree of the glottal opening and the intrapharyngeal pressure.

In normal subjects, spindle shaped glottal opening was observed and the intrapharyngeal pressure was increased to about 4.7 cm H_2O.

In patients with velopharyngeal insufficiency after hemiglossectomy or pharyngeal resection, glottal openig was not observed and intrapharyngeal pressure was lower than that of normal subjects.

The same result was obtained, when artificial velopharyngeal insufficiency was produced.

In a tracheoesophageal shunt speaker after total laryngectomy, neoglottal opening was oserved.

These results suggested that spindle shaped glottal opening during the articulation of voiceless plosive [k] in the running speech was caused passively by increased intrapharngeal pressure.

INTRODUCTION

It is known that the glottal opening and stop of vocal cord vibration is observed during the production of voiceless consonants, and which has been believed to be regulated by the intrinsic laryngeal muscles.

On the contrary, we reported the possibility that intrapharyngeal pressure might cause the glottal opening and stop of vocal cord vibration during the production of plosive voiceless consonant [k] in the running speech[1].

Glottal opening means, spindle shaped opening of membranous vocal cords, but not the full abduction of vocal cord. (Figure 1)

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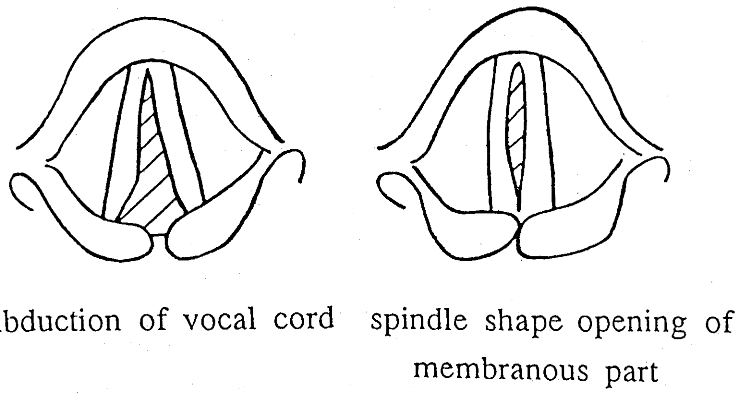

Fig. 1. Abduction of vocal cords and spindle shape opeing of menbranous part of vocal cords.

As mentioned above, glottal opening and stop of vocal cord vibration may be passive phenomenon induced by the increased intrapharyngeal pressure in the running speech.

Therefore we tried to elucidate the role of intrapharyngeal pressure to the laryngeal adjustment during the production of vioceless consonant [k].

METHOD

We examined the influence of the degree of velopharyngeal closure on the condition of vocal cord and the intrapharyngeal pressure by the following methods (Figure 2).

1: We examined the condition of vocal cord and the intrapharyngeal pressure of 12 normal subjects (7 males, 5 females) and those of 4 patients of post hemiglossectomy or partial pharyngectomy with velopharyngeal insufficiency. Table 1 shows the list of patients with velopharyngeal insufficiency.

2: In 5 normal subjects, before and after velopharyngeal insufficiency artificially produced by retracting soft palate, the condition of vocal cord and the intrapharngeal pressure were examined.

3: In a tracheoesophageal shunt speaker after total laryngectomy, the condition of neoglottis and the intrapharyngeal pressure was examined.

The subjects of analysis were two sets of consonant [k] in the Japanese running speech[yabunonakakara usagiga pyokonto detekimashita].

The underlined former [k] was indicated as [k1], the latter [k] as [k2]. Intrapharyngeal pressure was measured by the pressure transducer 4fr. in diameter inserted transnasally into the mesopharynx. Pressure signal was recorded on a videotape simultaneous with the image of larynx (30 frames/sec). We analyzed the relation between the degree of the glottal opening and the intrapharyngeral pressure frame by frame.

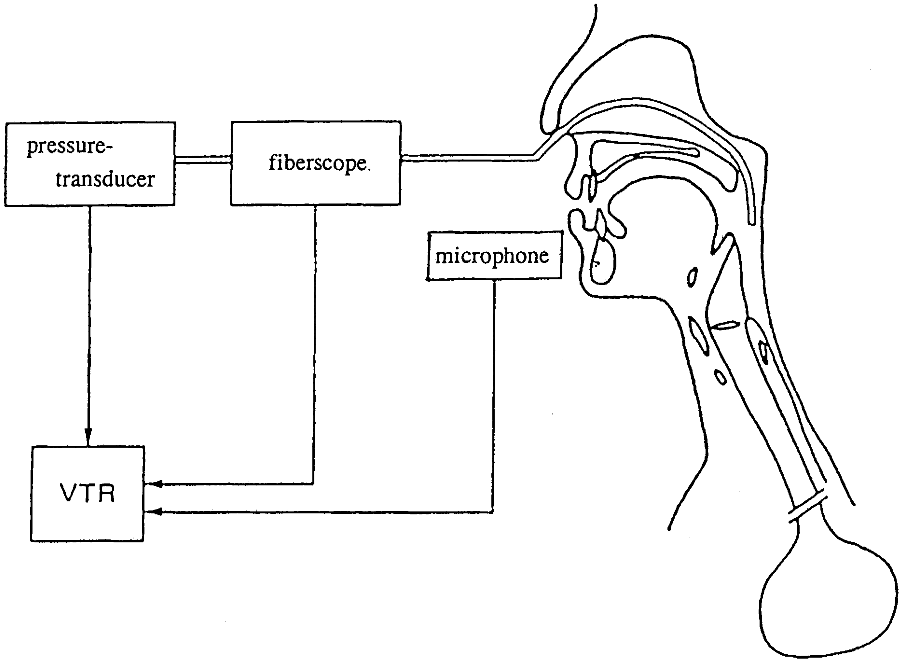

Fig. 2. Blockdiagram of videofiberscopy and manometry.

Table 1. List of patients with velopharyngeal insufficiency after hemiglossectomy or pharyngeal resection.

Patient	Age	Disease	Cause of velopharyngeal insufficiency
1	60	Lingual ca.	unable to elavate root of tongue
2	64	Lingual ca.	unable to elavate root of tongue
3	63	Lingual ca.	unable to elavate root of tongue
4	61	Tonsillar ca.	unable to close mesopharynx

In the analysis of the condition of vocal cord, (+ +) means both the spindle shape opening of vocal cord and stop of vocal vibration was observed clearly, (−) means both of them were not observed, (+) shows the median condition between (+ +) and (−).

RESULTS

1: Table 2 shows the condition of vocal cord during the production [k] in the running speech.

In all normal subjects, spindle shaped glottal opening was observed in both [k1] and [k2]. In the patients of post hemiglossectomy or partial pharyngectomy with velopharyngeal insufficiency, glottal opening was not observed clearly (Figure 3).

The mean intrapharyngeal pressure of both [k1] and [k2] in normal subjects was 4.7 cm H_2O. That of the latter group was 3.3 cm H_2O at [k1] and 2.3 cm H_2O at [k2], which was significantly lower than that of normal subjects (Figure 4).

2: The condition of vocal cord before and after artificial velopharyngeal insufficiency, are shown in table 3.

The spindle shaped opening of vocal cord was not observed at all with artificial velopharyneal insufficiency. Figure 5 shows one of the records of the vocal cord and the intrapharyngeal pressure before and after artificial velopharngeal insufficiency.

Table 2. Degrees of glottal opening of normal subjects and velopharyngeal insufficient patients.

degree of glottal opening		++	+	−
normal (n=12)	k_1	11	1	0
	k_2	10	2	0
patients (n=4)	k_1	0	2	2
	k_2	0	1	3

Table 3. Degrees of glottal opening before and after artificial velopharyngeal insufficiency.

degree of glottal opening		++	+	−
before	k_1	5	0	0
	k_2	5	0	0
after	k_1	0	0	5
	k_2	0	0	5

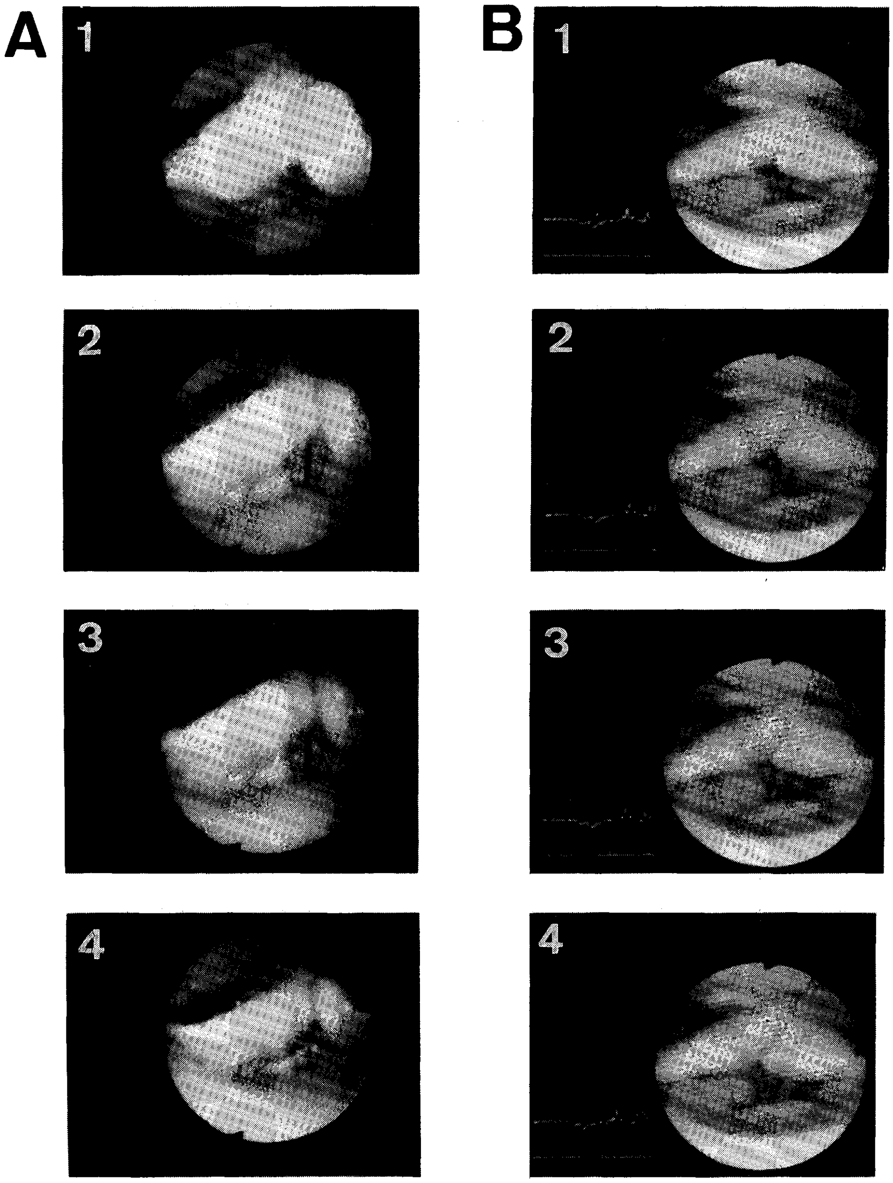

Fig. 3. Conditions of vocal cord during production [k].
A: normal subject; glottal opening of membranous vocal cords was observed (2～3)
B: velopharyngeal insufficient patient; glottal opening was not observed

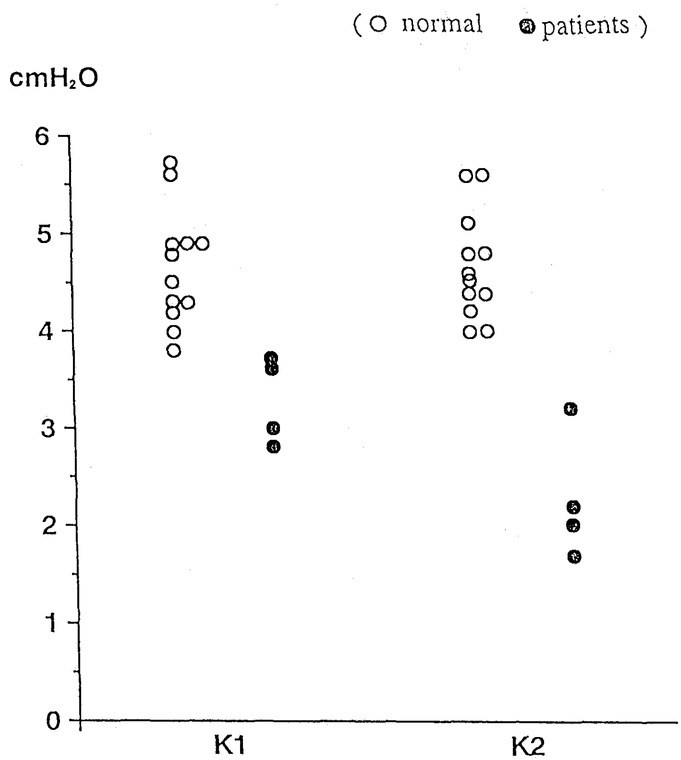

Fig. 4. Intrapharyngeal pressure of normal subjects and patients.

After artificial velopharyngeal insufficiency, the mean pressure of [k1] decreased from 4.7 cm H_2O to 2.3 cm H_2O and that of [k2] decreased from 4.6 cm H_2O to 2.6 cm H_2O (Figure 6).

3:In a tracheoesophageal shunt speaker, neoglottic opening and stop of mucosal vibration was observed together with the increased intrapharyngeal pressure during the production [k].

Figure 7 shows the neoglottis and the intrapharyngeal pressure signal.

DISCUSSION

The degree of glottal opening varies according to the type of consonants.

Hirose et al.[2] demonstrated by the electromyographic study of intralaryngeal muscles that glottal opening and the stop of vocal cord vibration during the phonation of voiceless consonants were controlled by the reciprocal activity of abductor muscle and adductor muscles.

In short, for the voiceless sound, there is activation of posterior cricoarytenoid muscle, the abductor, accompanied by suppression of interarytenoid muscle, one of the adductors. These muscle activities are applied certainly during the phonation of

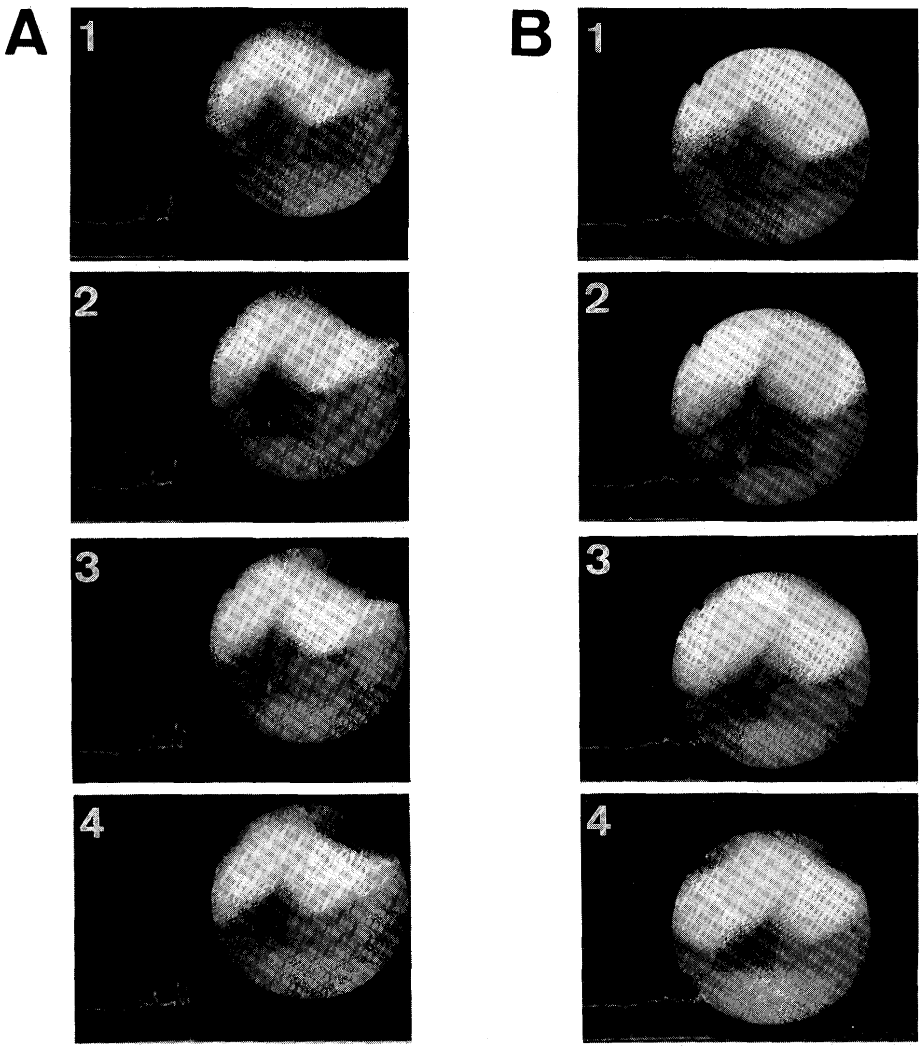

Fig. 5. Condition of vocal cord during production [k] before and after artificial velopharyngeal insufficiency.
A: before; glottal opening was observed together with the increased pharyngeal pressure.
B: after; glottal opening was not observed and pressure was low

voiceless [k] at the head of a single syllable. In the running speech, however, vocal cord did not abduct and spindle shaped glottal opening was observed between the membranous vocal cords by our careful fiberoptic examination.

These phenomena of the vocal cord in running speech made us think that there shoud be another mechanism to control laryngeal adjustment.

By the study of speech characteristics of aged persons, we mentioned intrapharyngeal pressure was taken into consideration for layngeal adjustment in

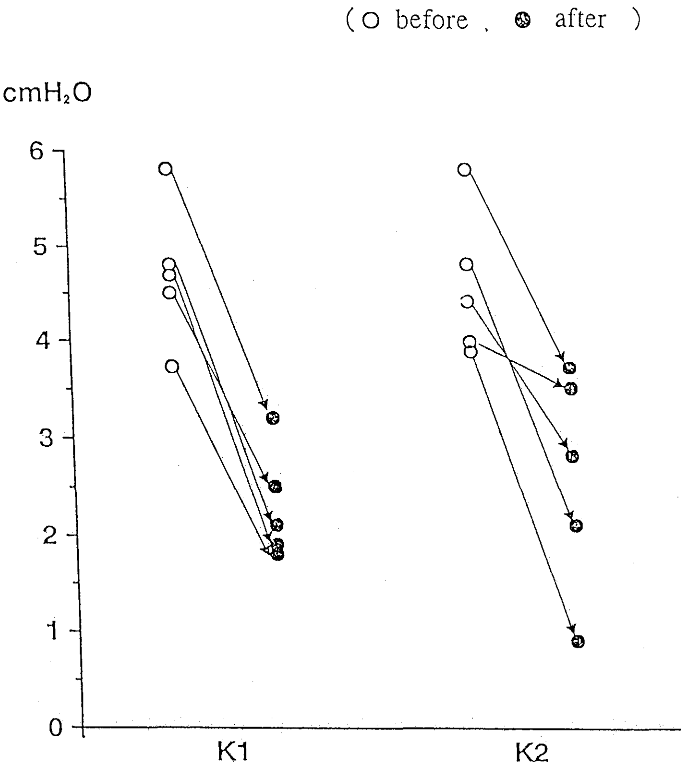

Fig. 6. Intrapharyngeal pressure before and after velopharyngeal insufficiency.

consonant production. We tried to elucidate the role of intrapharyngeal pressure to the laryngeal adjustment during the production of voiceless [k] by three method in this study.

Glottal opening was not observed clearly and the intrapharyngeal pressure was much lower in the patients of post hemiglossectomy or partial pharyngectomy with velopharyngeal insufficiency than that in normal subjects. When velopharyngeal insufficiency was produced by retracting the soft palate in normal subjects, glottal opening was not observed and intrapharyngeal pressure was reduced remarkably during the production [k]. The velopharyngeal insufficiency is considered to be the cause of the lower intrapharyngeal pressure which may cause poor glottal opening. Since neoglottal opening and stop of mucosal vibration was observed with the increasing of intrapharyngeal pressure during the production [k] in tracheoesophageal shunt speech, it is inferred that neoglottal opening might be induced passively by the increasing intrapharyngeal pressure. Figure 8 shows the influence of intrapharyngeal pressure on the condition of vocal cord schematically during the articulation of voiceless consonant [k]. During the production of [k], the closure at the articulation point followed by increased intrapharyngeal pressure, induced the glottal opening

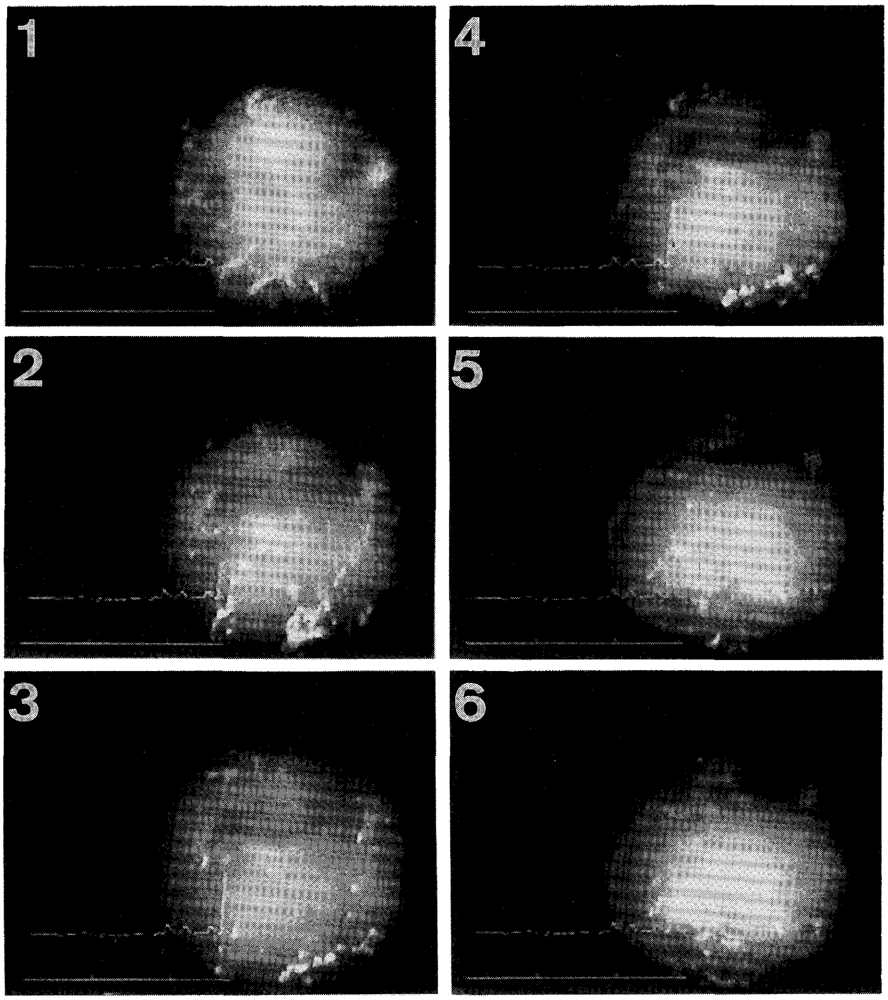

Fig. 7. Neoglottis and the intrapharyngeal pressure in tracheoesophageal shunt speech. Neoglottal opening was observed with the increased pressure.

and the stop of mucosal vibration. In velopharyngeal insufficiency, however, intrapharyngeal pressure is low and the vibration of mucosal wave dose not stop. In short, the vocal cord vibration is considered to be controlled passively by velopharyngeal closure at the articulation point during the production of voiceless plosive [k] in the running speech.

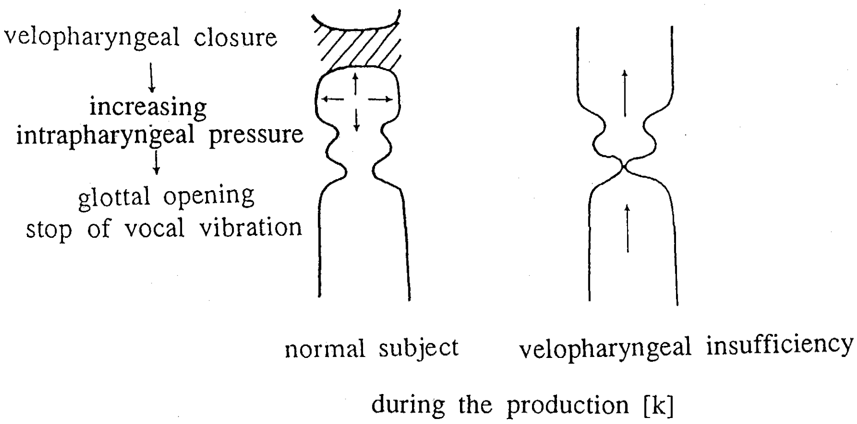

Fig. 8. Influence of intrapharyngeal pressure on the condition of vocal cord during the phonation [k].

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