Ann.Bull.RILP No.28(1994)27-32

Vocal Cord Vibrations Associated with Involuntary Voice Changes in Certain Pathological Cases

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The present paper describes vibratory patterns of vocal cords associated with sporadic involuntary voice changes occurring during sustained phonations in certain pathological cases.

A high-speed digital image recording system developed by the authors is compact and simple to operate, and therefore convenient for clinical observations. At the same time, on-line use of the personal computer in the system has improved efficiency of data processing and made feasible data recording and analysis for observing vocal cord vibrations in relatively long phonations.[1),2)] Thus, analysis of sporadic phenomena occurring during sustained phonations has become possible. In the present study, vocal cord vibrations associated with involuntary voice changes in the cases of the essential voice tremor , spasmodic dysphonia and voice breaks were observed using this high-speed digital image recording system.

Method of data recording and analysis

The high-speed digital image recording system. Consists of an oblique-angled solid endoscope, an image sensor and digital image memory. The output video signal from the image sensor is fed into the image memory through a high-speed A/D converter. Stored images are later displayed as a slow motion picture.

In order to fully exploit the advantage of the system, a special high-speed digital video unit was constructed. The system consists of a large size, 64 MByte digital image memory. The image memory can store the image data for the utterances of about 6 seconds at a frame rate of 2500 per second with pixels of 126 x 32. The image can be reproduced as an ordinary video signal and can be monitored on the TV monitor.

Results

Case 1 Essential voice tremor.

The subject does not show any apparent organic lesion but his voice is characterized by voice tremors.[3)] The spectrogram in figure 1 (a) demonstrates guasi-periodic modulation of pitch and intensity. Especially, there is an extreme lowering of pitch at point B indicated in the figure.

Figure 1 (b) compares vocal cord vibrations near point A (normal pitch) and point B (lowered pitch) in figure 1 (a). As seen in the figure, the supra-glottal structure shows a sphincteric contraction during the period of pitch lowering. It also can be seen in the figure that the elongation of the pitch period is due mainly to the longer closure period. Thus, the open quotient is considerably smaller at point B than at point A. However, it is noted that during the period of pitch lowering, the open period becomes longer and the maximum area of glottal opening also becomes slightly wider. These phenomena suggest that during the period of pitch lowering, the vocal cords are vibrating in a lax state. There is no apparent indication of increase in the glottal tension such as suggested to be existing in the production of glottalized sounds.[4] In accordance with this speculation, the spectrogram in figure 1 (a) shows a marked decrease in high-frequency components at the time of pitch lowering.

Case 2 Spasmodic dysphonia.

Perceptual characteristics of voice symptoms in this subject are intermittent momentary interruptions of voicing during sustained phonation.[3] Figure 2 (a) shows the speech signal of the subject. At point A in the figure, the speech signal shows a short period of irregular waveform. The duration of this period corresponds approximately to 2-3 pitch cycles in the surrounding period of normal voicing. After this period of distorted waveform, the speech signal resumes a regular waveform nearly the same as that in the previous part. A similar period of irregular waveform is also seen at point B in the figure. However, in this case, when the speech signal resumes periodicity, the waveform changes from that in the previous part. The amplitude is lower and the waveform is noisy, indicating that the pattern of vocal cord vibration is different from that in the previous part. Figure 2 (b) compares vocal cord vibration at points B1 and B2 in figure 2 (a). The glottal images show that at point B2, the amplitude of the vocal cord vibration is smaller and the glottal closure is incomplete.

It appears that in this voicing, vocal cords have two modes of vibration. During sustained phonation, vocal cord vibration tends to switch involuntarily from one mode to the other. In the transitional state between the two modes, movements of the vocal cords are quite irregular and a noisy aperiodic speech wave is produced. This pattern of speech signal corresponds to the perceptual impression of voicing interruption. When the vocal cords fall into this state, they may return to the previous mode of vibration or jump to the other mode of vibration. It is noted that there is no apparent, marked change in the laryngeal conditions associated with these voicing interruptions as far as we can detect using the present high-speed image recording technique.

Case 3 Voice breaks

The subject has an accumulative lesion of the type seen in the case of autoimmune disease. Phonation of this subject shows sporadic sudden changes in pitch, intensity and voice quality.

A spectrogram of his voice is shown in figure 3 (a). There is a peculiar sudden increase in the number of harmonic components, for example, at point A in the figure. The speech signal after point A shows alternation between cycles of higher speech amplitude (cycle A1) and lower speech amplitude (cycle A2).

Vocal cord vibrations for these two cycles are shown in figure 3 (b). In these vibrations, the glottal opening proceeds from the front to the back part of the glottis. In cycle A1, propagation of the glottal opening proceeds smoothly from the front to the back end of the glottis. However, in cycle A2, propagation of the glottal opening is clumsy. When the glottal opening reaches near the middle point of the glottis (apparently around the location of the lesion), further glottal opening propagation is slowed down. This is presumably due to the fact that vocal cord vibration is weaker in the cycle with lower speech amplitude than in the cycle with higher speech amplitude. It can be seen in the glottal images that the maximum opening is narrower and the glottal closure is less tight in the cycle with lower speech amplitude. Thus, the sudden increase in the number of harmonics in this voicing is due to the change from the normal mode vibration to the vibration with bicyclic modulation.

Concluding remarks

A high-speed digital image recording system developed by the authors has made feasible data recording and analysis for observations of vocal cord vibrations in relatively long phonations. Consequently, analysis of sporadic phenomena occurring during sustained phonations has become possible. In the present study, vocal cord vibrations associated with involuntary voice changes in certain pathological cases such as voice tremor and spasmodic dysphonia have been reported.

Specifically, it was confirmed that in a case of essential voice tremor, quasi-periodic pitch lowering is synchronized with sphincteric contraction in the supra-glottal structure. However, there was no apparent indication of active glottal contraction, and it was suggested that the vocal cords are vibrating in a lax state during the period of pitch lowering. In the case of spasmodic dysphonia, it has generally been suggested that adductive muscles are active at the time of voicing interruptions. However, for the present subject, there was no apparent, marked change in the glottal conditions such as can be detected by the image recording method in this study. The results of the present study suggest that further studies with electromyographic investigation will be useful for clarifying the mechanisms of such pathological voice qualities.

References

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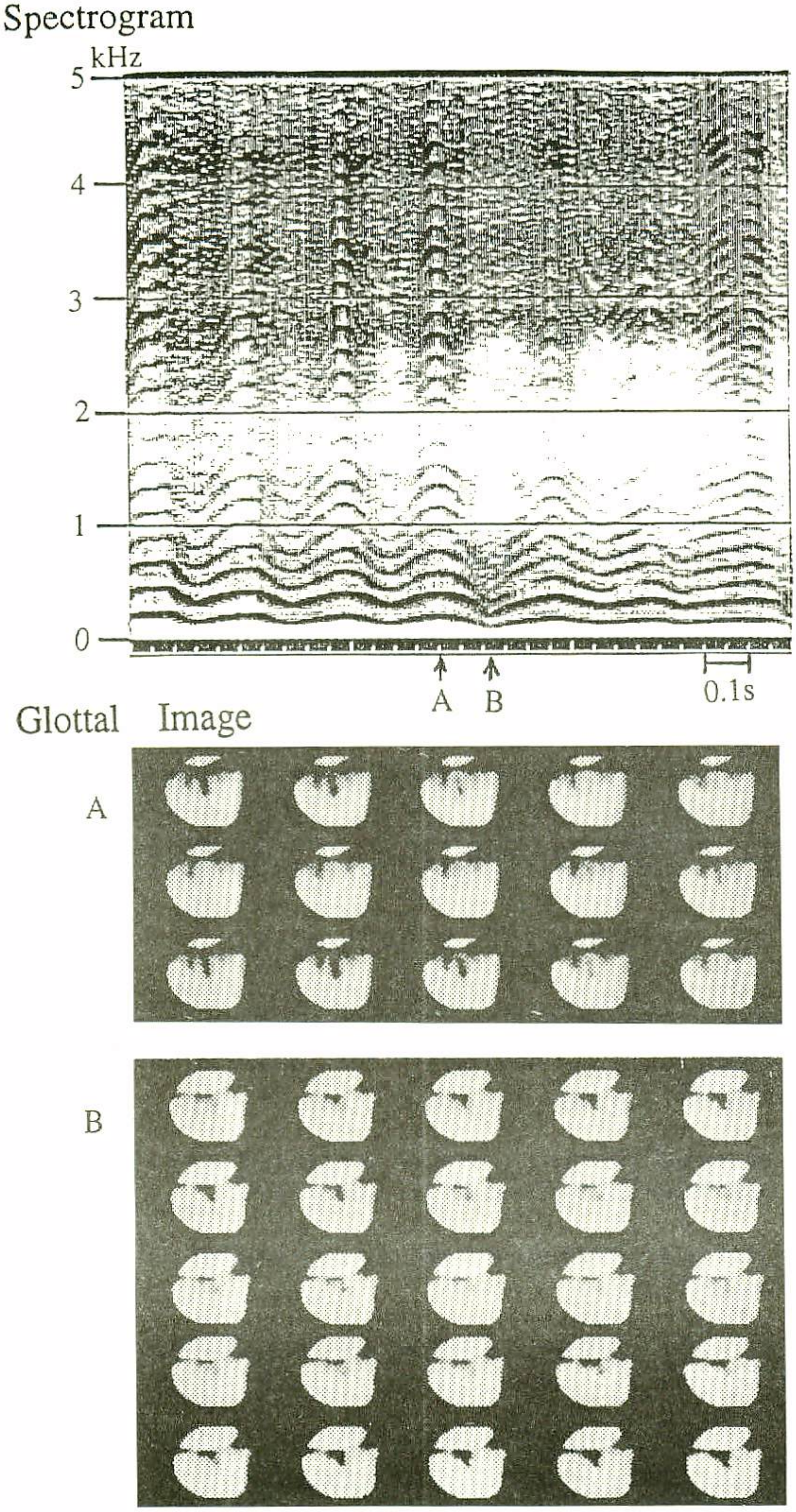

Figure 1 Spectrogram and glottal images of case 2: essential voice tremor.

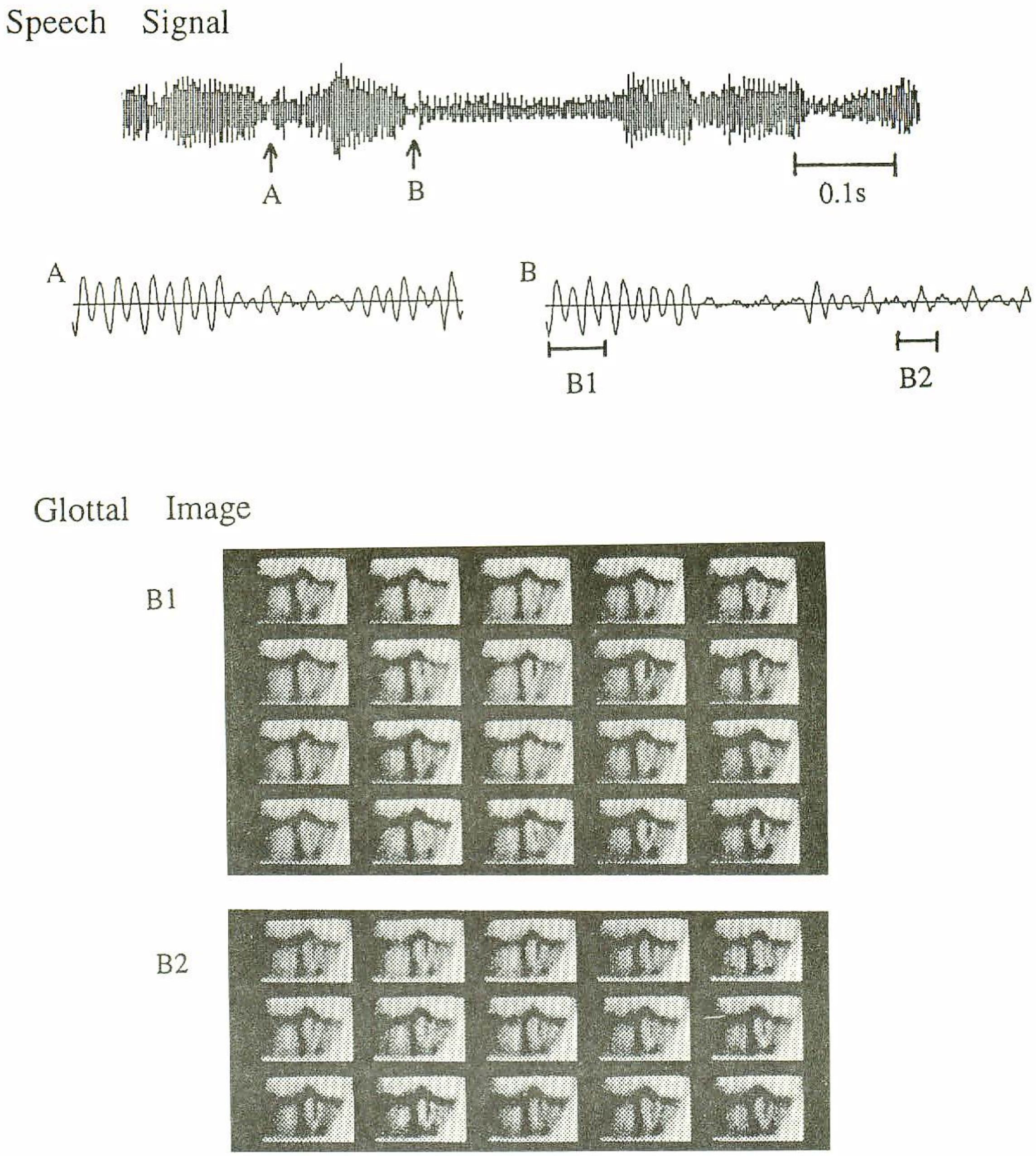

Figure 2 Speech signal and glottal images of case 3: spasmodic dysphonia.

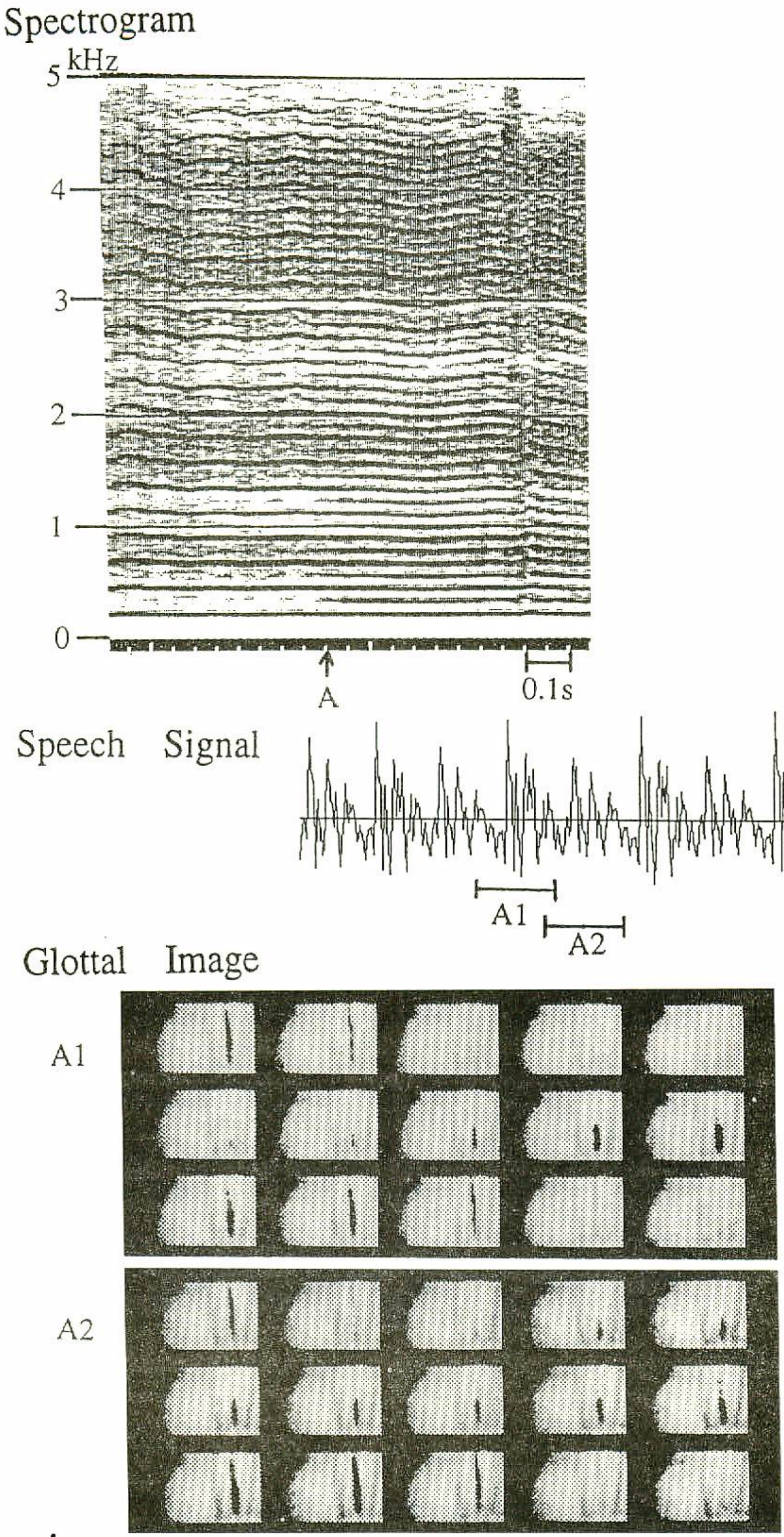

Figure 3 Spectrogram and glottal images of case 4: voice break.