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Abstract: Aim: This study aimed to investigate the effects of tongue-holding maneuver (THM) during swallowing using a novel high-resolution manometry (HRM) system.
Materials and Methods: Thirty three asymptomatic Japanese adults were studied. A solid-state HRM assembly with 36 circumferential sensors spaced 1 cm apart was positioned to record pressures from the velopharynx to the upper esophagus at rest and during swallowing. The maximum values of the dry swallowing pressures at velopharynx, meso-hypopharynx, upper esophageal sphincter (UES), and distance from the nostril to each point of maximum values with and without THM were measured.

Results: The maximum pressure was significantly greater when swallowing with THM than without THM only at UES ($p = 0.0478$), while there was no difference in the pressures between swallowing with or without THM at any other site. The distance from the nostril to the UES was significantly shorter ($p = 0.0132$) when swallowing with THM than without THM, while there was again no significant difference between swallowing with or without THM at any other site.

Conclusion: These findings indicate that THM is likely to have a potential to facilitate compensatory swallowing power of the upper esophageal sphincter.

Effects of a Tongue-holding Maneuver (THM) during Swallowing Evaluated by High-resolution Manometry

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Abstract

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Key words: high-resolution manometry (HRM), pharynx, swallowing pressure, tongue-holding maneuver (THM)

Introduction

Several rehabilitative maneuvers have been applied in the management of patients with swallowing disorders (1-5). Tongue-holding maneuver (THM) was reported by Fujiu et al.(6) to have a potential for compensatory anterior movement of the posterior pharyngeal wall (PPW) during swallowing, and they recommended it as one of the good maneuvers for the rehabilitation of the patients with dysphagia. To our best knowledge, however, there has been only one preliminary report examining the effect of THM by comparatively measuring the pharyngeal pressure using a manometer with only two channels, and the study was done only on three patients with head and neck cancer (7).

The advent of high-resolution manometry (HRM) came with the development of micro-manometric water-perfused assemblies with 36 sensors in 2006 (8). At the same time, advances in computer technology allowed the large volume of data acquired by HRM to be presented in real time not only as conventional 'line plots', but also as 'spatiotemporal plots' (sometimes referred to as a 'contour' or 'topographic' plots) that display the direction and force of esophageal pressure activity. Esophageal HRM is now being used not only for research but in clinical practice (9).

This study aimed to investigate the effects of THM during swallowing along the velopharynx and upper esophagus of normal Japanese adult subjects using this system.

Subjects and Methods

Subjects

We studied 33 healthy Japanese volunteers (19 male, and 14 female) without a history of dysphagia, gastrointestinal symptoms, upper gastrointestinal tract surgery, or any other significant medical condition. Their ages ranged from 22 to 46 years with the average of 26 ± 5.0 (mean ± standard deviation). The study protocol was approved by the institutional review board committee of Nagasaki University Medical Dental Hospital, and written informed consent was obtained from each participant.

High Resolution Manometry (HRM)

A solid-state manometric assembly with 4.2 mm outer diameter having 36 circumferential sensors spaced at 1 cm intervals was used (Sierra Scientific Instruments Inc., Los Angeles, CA). This HRM device uses proprietary pressure transduction technology (TactArray™) that allows each of the 36 pressure sensing elements to detect pressure over a length of 2.5 mm in each of 12 circumferentially dispersed sectors. The sector pressures are then averaged to obtain a mean pressure measurement, making each of the 36 sensors a circumferential pressure detector with the extended frequency response characteristic of solid-state manometric systems.

Prior to recording, the transducers were calibrated at 0 and 100 mmHg using externally applied pressure. The response characteristics of each sensing element were such that they could record pressure transients in excess of 6000 mmHg/sec, and were accurate to within 1 mmHg of atmospheric pressure after thermal calibration correction. The data acquisition frequency was 35 Hz for each sensor. All pressure measurements were referenced to atmospheric pressure.

Protocol and Analysis

After a brief interview and examination to assure the absence of gastrointestinal symptoms, participants underwent transnasal placement of the manometric assembly in a natural supine position. Real-time pressure imaging during catheter intubation enabled accurate placement. The catheter was fixed in place by taping it at the nostril. For THM, the examinees were asked to protrude their tongue anteriorly and hold it between the central incisors (Figure 1). Examinees were asked to swallow their saliva (dry swallowing) three times each with and without THM, and the mean values were adopted. Manometric data were initially analyzed using ManoView™ analysis software (Sierra Scientific Instruments Inc., Los Angeles, CA,). Using ManoView™ analysis software, we could easily obtain digital data of the pressure in mmHg and of the distance in centimeters anywhere along the manometer

(Figure 2, 3). The maximum values of the swallowing pressures at the velopharynx, meso-hypopharynx, UES, and the distance was measured from the nostril to the above-mentioned points of pressure. Statistical analysis was made using Student's t-test, and p-values below 0.05 (two-tailed) were regarded as significant.

Results

All results measured in the present study are summarized in Tables 1. The maximum pressure was significantly greater when swallowing with THM than when without THM only at UES (p= 0.0478), while there were no differences in the pressures between swallowing with and without THM at any other site. The distance from the nostril to the UES was significantly shorter when swallowing with THM than when without THM (p= 0.0132), while there was again no significant difference between swallowing with and without THM at any other site. These findings indicate that THM is likely to have a potential to facilitate compensatory swallowing power of the upper esophageal sphincter.

Discussion

THM is one of the maneuvers applied in the management of patients with dysphagia (6). It was known that an increase in anterior bulging of the PPW has been observed videofluorographically in some surgically treated oral cancer patients during their postoperative course (10, 11). Fujiu et al. (6) reported that the anterior bulge of PPW during swallowing was significantly greater with THM than without the maneuver, at the level of the second cervical vertebra~~e~~ (C2) or slightly lower level, which was the level of the mesopharynx.

The present study revealed different results from those of Lazarus et al (7).　The maximum swallowing pressure at meso-hypopharyx did not show any significant difference with or without THM, although the anterior bulge of PPW during swallowing with THM is sometimes observed.　This finding suggests that the anterior movement of PPW and the anterior movement of the tongue base with THM may offset each other with the increase in swallowing pressure in the pharynx.　We also found that the maximum value of swallowing pressure at UES, which was located at the level of the forth cervical vertebr~~e~~a (C4) or slightly lower level, was significantly higher, and that the distance from the nostril to the UES was significantly shorter when swallowing with THM than without THM, respectively.　These effects of THM may be due to possible stronger influence of THM on the lower pharyngeal constrictor muscle forming the UES than on the middle pharyngeal constrictor muscle; the latter was suggested by Fujiu et al (6).　Further study is required to clarify it.

The pressure changes in the pharynx during swallowing are more rapid than those of peristalsis within the esophagus, because the muscles related to swallowing in the pharynx and upper esophagus are striated muscle.　Thus the pressure-measurement equipment for the pharynx and upper esophagus must have a very short response time.　Some authors applied several maneuvers for the assessment and diagnosis of patients with swallowing disorders (2-5) using a conventional manometer with three or four sensors and/or videofluorometry. However, one of the possible problems that may take place when pharyngeal swallowing pressure is measured with a single-point sensor is that elevation of the larynx during swallowing sometimes causes unnatural spike-like increase of the pressure as a movement artifacts. To date, this has been one of the reasons to make it difficult to study the characteristics and detailed mechanisms of swallowing along the velopharynx and upper esophagus using a conventional manometer. This may be one of the reasons why the present results were different from those of Lazarus et al (7) done with a conventional manometer.

HRM has high population and density of pressure sensors with circumferential sensing ability, and is now being used not only for research but in clinical practice in the esophageal region (9). Using this devise, we have already reported the maximum value of dry and water swallowing pressures at the velopharynx, meso-hypopharynx, UES, and the distances from the nostril to each point, and obtained important anatomical and physiological information about normal swallowing along the velopharynx and upper esophagus (12). However there are few reports to observe the swallowing pattern with some rehabilitative maneuvers for patients with swallowing disorders in order to digitalize the effect of such maneuvers in normal individuals using this device. The present study revealed that the maximal pressure increased not at the meso-hypopharynx as shown in the previous study (7), but at the UES. This may indicate a higher ability of HRM to collect more precise and detailed data than the conventional manometer. Thus, we may expect to obtain much important information about the swallowing physiology and pathophysiology along the velopharynx and upper esophagus using HRM in the future.

Conclusion

These findings indicate that THM has a potential to facilitate compensatory swallowing power at the upper esophagus, but not at the pharynx. HRM will provide us with important information about the swallowing physiology and pathophysiology along the velopharynx and upper esophagus.

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Legends

Figure 1

Schematic drawing showing the tongue position and space of the pharynx at rest and during the tongue-holding maneuver (THM).

Figure 2

High-resolution manometer depicts swallowing pressure activity from the velopharynx to the upper esophagus in the spatiotemporal plot. Time is on the x-axis and distance from nostril is on the y-axis. Strength of the pressure is expressed by a series of colors from blue to purple as indicated on the left side color bar. When an examinee vocalizes “kakaka”, we can identify the location of the velopharyngeal muscle zone (A), meso-hypopharyngeal muscle zone (B), and upper esophageal sphincter (UES) muscle (C).

Figure 3

Using ManoView™ analysis software, the maximum value of the swallowing pressure in any arbitrarily selected area (white square, the velopharyngeal muscle zone in this figure) and the distance from the nostril to the upper and lower margins of the area are demonstrated in mmHg and in centimeters, respectively.

Table 1: Maximum Values of Velopharyngeal, Meso-hypopharyngeal and UES Pressures and Distances from Nostril to Each Point

	Velopharynx		Meso-hypopharynx		U E S		
	Maximum Pressure (mmHg)	Distance (cm)	Maximum Pressure (mmHg)	Distance (cm)	Maximum Pressure (mmHg)	Distance (cm)	
Without THM	135.2±67.3	9.77±1.1	188.8±67.6	13.8±1.6	196.0±89.9 *	17.1±1.7 *	
With THM	142.3±64.5	9.6±1.4	201.0±78.8	13.6±1.7	215.3±70.7	16.5±1.8	

* Asterisk indicates $P<0.05$. UES: Upper Esophageal Sphincter, THM: Tongue Holding Maneuver

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Author names: list corresponding author first, then all others	**Authorship: specific contribution to the manuscript or research process**	**Conflict of interest: potential conflicts or financial relation-ships in past 24 months***
Hiroshi Umeki	Main Writer, Study Design, Date Collection	None
Kenji Takasaki	Writer, Study Design, Date Collection	None
Kaori Enatsu	Date Collection	None
Fujinobu Tanaka	Date Collection	None
Hidetaka Kumagami	Date Collection	None
Haruo Takahashi	Writer, Study Design	None

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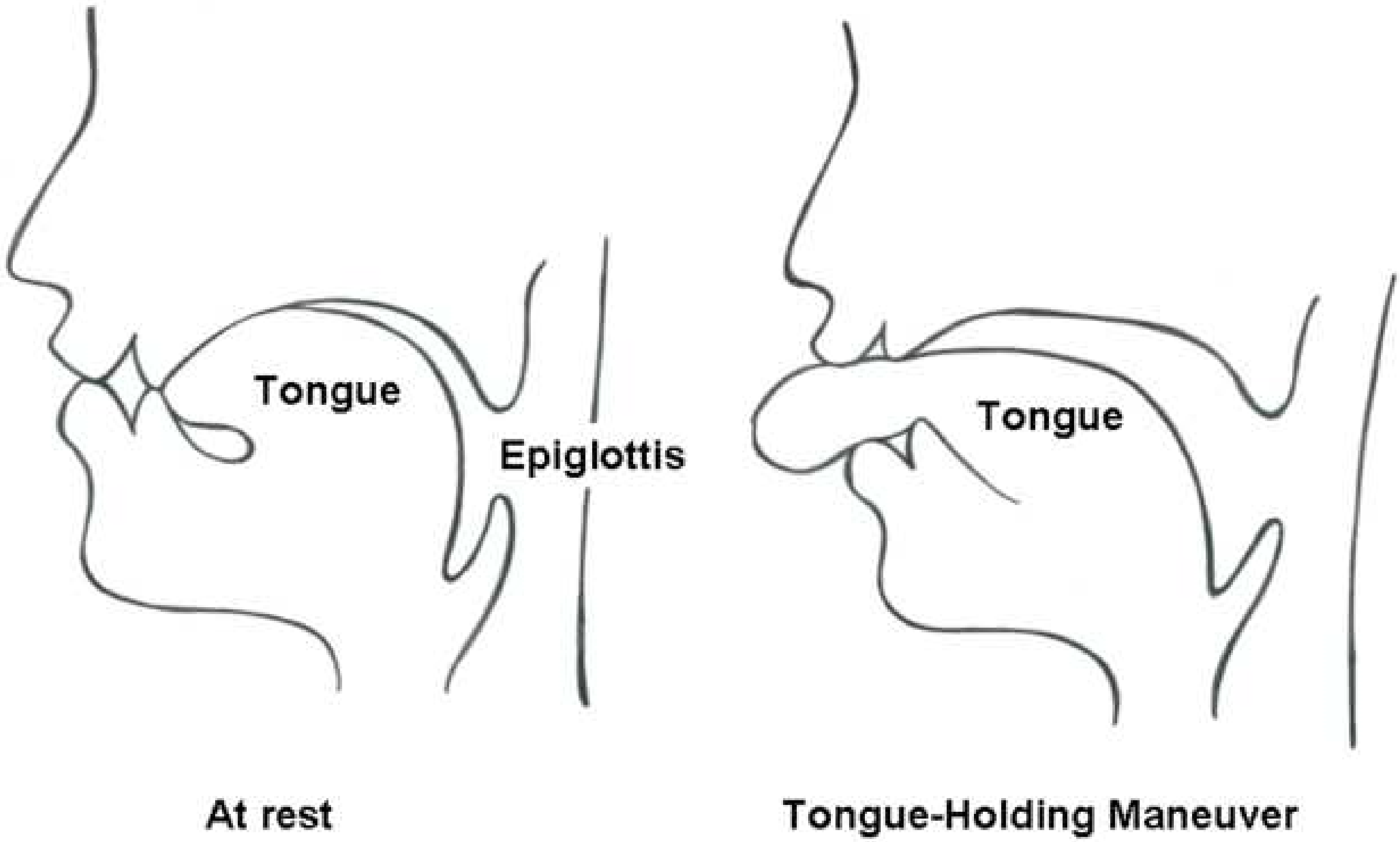

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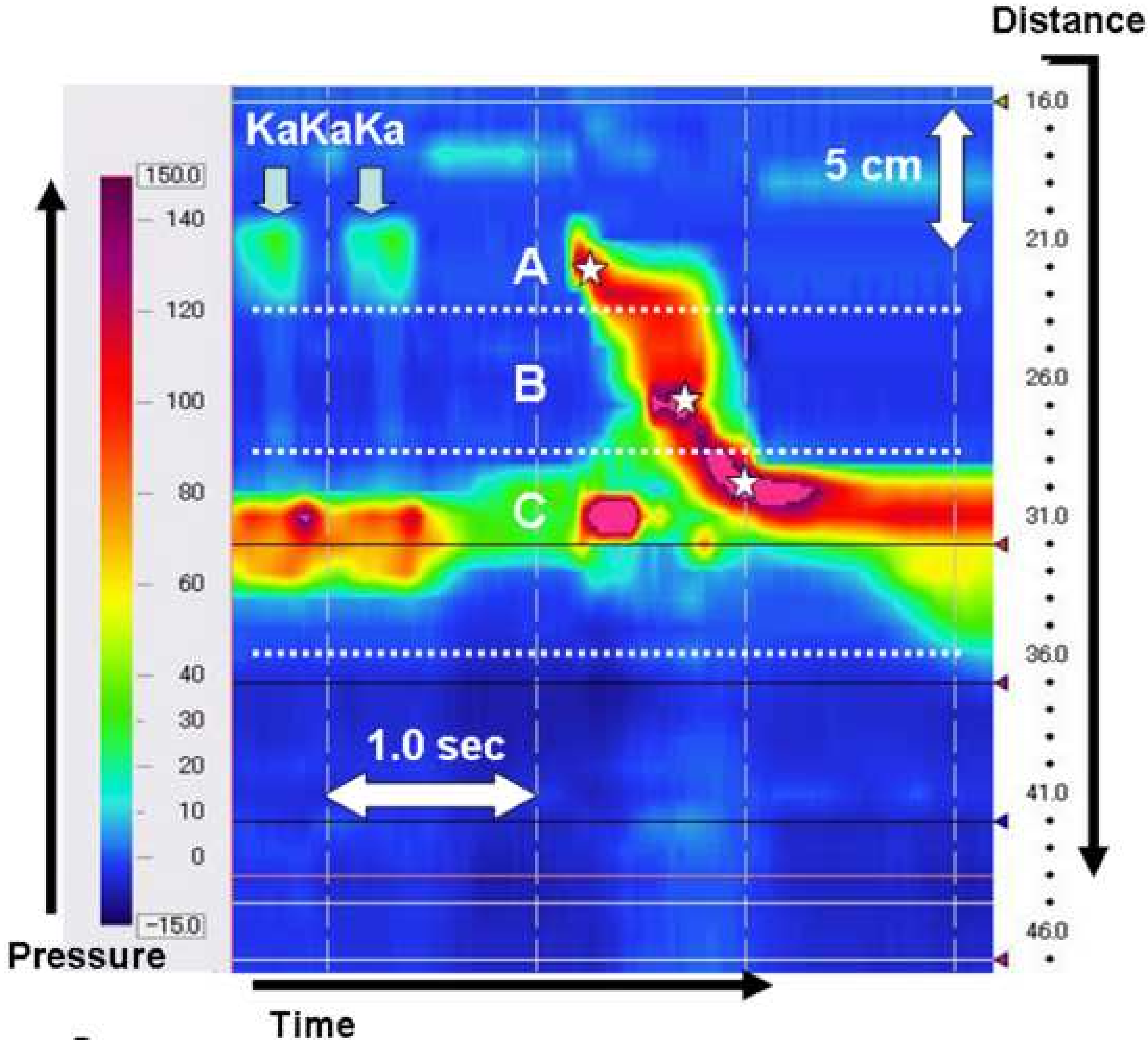

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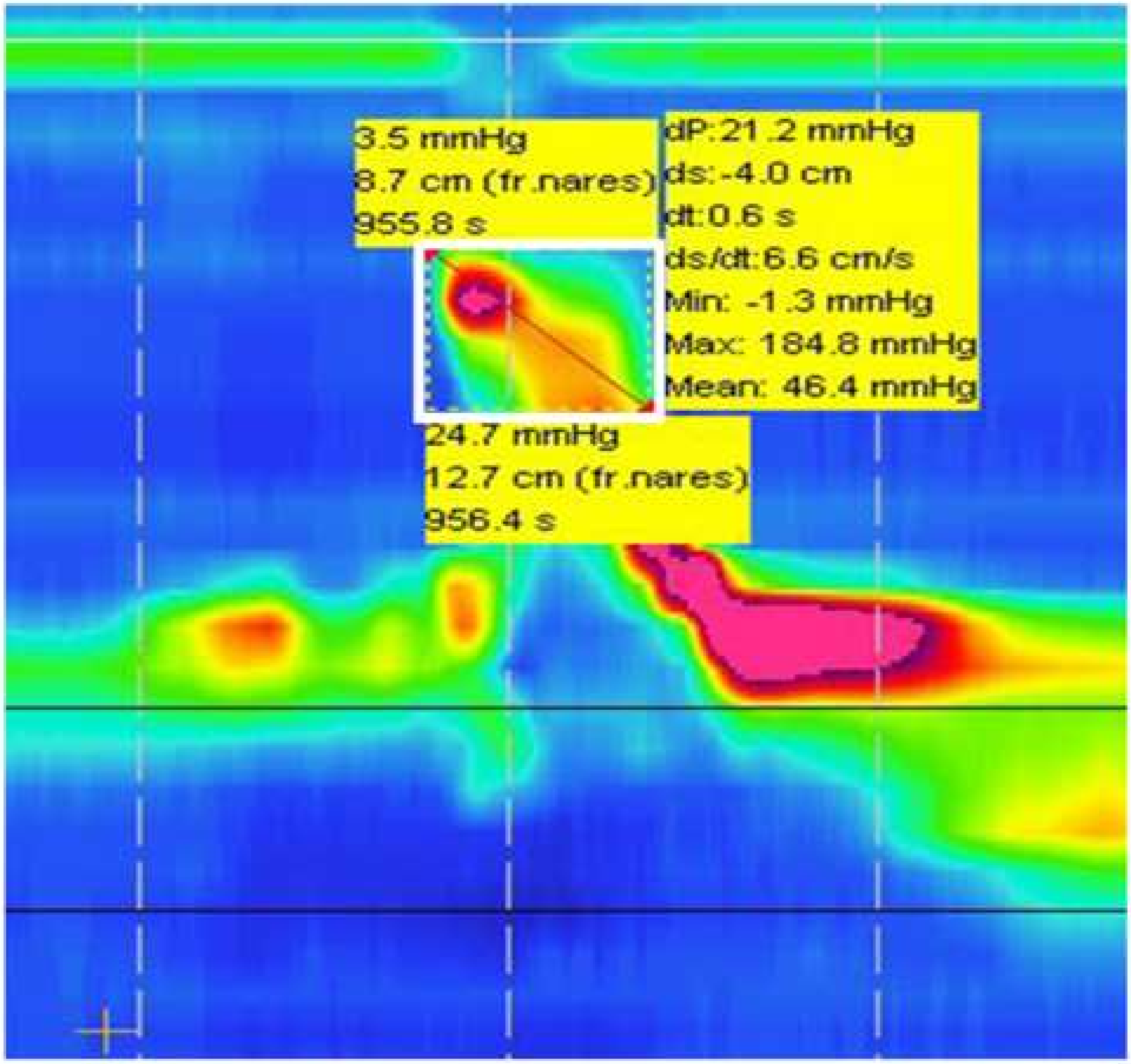

Figure 3.

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