Title of Proposal (Not to exceed 15 words)

Volume-dependent Water Swallow Activities Using a Doppler Ultrasonic Analysis in Older Adults

Abstract of Proposal (Not to exceed 60 words)

We utilized a neck-held doppler ultrasonic device to compare the duration of hyolaryngeal excursion(HLE) during 3mL and 9mL water swallow activities between 31 normal older adults and 18 stroke patients. The patient group manifested significantly shorter HLE duration than the normals only in 3mL(p=0.043). This finding may imply volume-dependent sensory and motor function during swallowing activities.

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Summary of Proposal (Not to exceed 1000 words)

Background and purpose: Numerous research has reported that swallowing activities vary depending upon bolus consistency and volume. Among the various measures, the extent and duration of hyolaryngeal excursion(HLE) can be indices of core pharyngeal symptoms of swallowing such as penetration and aspiration. Various instrumentations including a videofluoroscopic swallowing study(Regueiro et al., 2017) and area detector CT scan(Shibata et al., 2017) can be used to measure the pharyngeal swallowing dynamics. In this study, we utilized a neck-held doppler ultrasonic device to compare the duration of HLE during water swallow activities of 3mL and 9mL between stroke patients with dysphagia and normal older adults.

Methods: Participants included 31 community-dwelling older adults(76.42±6.25 years old) and 18 stroke patients(mean±sd age=71.17±6.21 years old) referred for swallowing consultation. Written consents were obtained from the participants before conducting the study(IRB no. PIRB-2018-E109, PSSH0475-201802-HR-002). They were instructed to swallow two different volumes of water, i.e., thin 3 mL and 9 mL. We used a doppler ultrasonic device to measure various characteristics of the hyolaryngeal excursion. The instrument is a wearable device with a sensor module consisting of seven doppler ultrasonic sensors (two transmitters and five receivers) to be located along the neck. The measured signals are wirelessly transmitted to a computer by a radio frequency communication module in the device. An analysis program plots and quantifies real-time data received from the doppler ultrasonic device. Algorithms of noise filtering and smoothing are applied to signals measured by the ultrasonic sensors, gyro sensor, and microphone. Five measures (peak amplitude, duration, number of peaks, peak-to-peak interval, and impulse) were extracted to quantify the characteristics of swallowing activity. Among them, time interval(in msec.) ('duration') between the onset and offset of the hyolaryngeal excursion was analyzed in this study. Statistical analyses were made between the two groups in both volumes using an independent *t*-test (IBM SPSS version 24).

Results: Mean(±SD) duration during 3 mL swallowing task for the stroke patient(486.67±235.52 sec.) was significantly shorter than that of the normal older adults(736.03±474.64 sec.)(p=0.043) groups. However, mean(±SD) duration during 9 mL for the stroke patient(551.64±177.77 sec.) was not significantly different from that of the normal(652.61±262.04)(p=0.140) groups.

Discussion: Measurement of the HLE duration is crucial in that a shorter duration usually results in negative swallowing consequences such as penetration and aspiration because it does not allow a sufficient time for the upper esophageal sphincter(UES) opening. In fact, reduced HLE duration(Kim et al., 2019) and subsequently shorter opening duration of the UES has often been observed in the stroke patients(Zhang et al., 2016). For this reason, Mendelsohn maneuver and effortful swallowing are frequently used as evidence-

based practices for improving the HLE for safe swallowing(Doeltgen et al., 2017; Molfenter et al., 2018). The therapeutic techniques require the individual to volitionally hold the hyolarynx as high as possible for as long as possible, while contracting submandibular hyolaryngeal muscles(Doeltgen et al., 2017; Molfenter et al., 2018; Watts & Kelly, 2015; Wheeler-Hegland et al., 2008). However, in this study, we found the group difference only in 3 mL water. Smaller amount of water may not trigger the pharyngeal stage of swallowing as efficiently as larger amount because it has been reported that "large volume of water would be capable of producing a stronger afferent discharge"(Leder et al., 2011). In fact, oral tactile sensitivity is often impaired in stroke patients(Schimmel et al., 2017) and lingual biomechanics involving posterior tongue movement influences on subsequent pharyngolaryngeal dynamics(Alvarez et al., 2018). This finding may imply sufficient amount of liquid to be used for swallowing intervention.

Conclusion: In conclusion, reduced HLE duration induces detrimental effects to pharyngeal stage of swallowing. The doppler ultrasonic device can be a useful tool not only for measuring the HLE duration but also as a non-invasive monitoring system during effortful swallowing and Mendelsohn maneuver. Further research is warranted to acquire the normative data of HLE duration on 'dry' swallow and more diverse water volume using the same tool.

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Keywords
Deglutition, Dysphagia, Hyolaryngeal excursion, Water swallow, Doppler ultrasonic analysis