行政院國家科學委員會專題研究計畫　成果報告

呼吸及喉部聲學信號之臨床吞嚥評估功用

計畫類別：個別型計畫
計畫編號：NSC91-2614-B-040-001-M47
執行期間：91 年 08 月 01 日至 92 年 07 月 31 日
執行單位：中山醫學大學語言治療與聽力學系

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報告類型：精簡報告

處理方式：本計畫可公開查詢

中　華　民　國 92 年 11 月 1 日

中英文摘要

本研究探討呼吸及喉部聲學信號在臨床吞嚥評估之用途。要確保有正常及安全的進食，呼吸及吞嚥功能的協調非常重要；如果兩者缺乏協調，極可能會產生吸入現象，嚴重的話會造成肺部疾病甚至危害生命安全。然而研究顯示，有百分之四十的吞嚥障礙病人在臨床吞嚥評估中無法察覺他們有吸入現象，所以引發研究者找尋不同的臨床吞嚥評估工具，以便更有效、正確及客觀地指出吞嚥吸入的現象。為了更加瞭解呼吸和吞嚥之間的協調及更容易測出吸入之臨床評估工具，此研究應用血氧機、聽診器和鼻套管來測量吞嚥障礙病患的進食、呼吸協調及吸入現象。

受測者為五十位吞嚥正常成人及五十位有吸入吞嚥障礙病患。血氧機、聽診器和鼻套管所蒐集的呼吸及喉部聲帶信號用來瞭解兩組受測者呼吸及吞嚥之間的協調。同時將病患的呼吸及喉部聲帶信號與電視螢光攝檢查時結果作比較。本研究將有助於瞭解呼吸跟吞嚥過程的關係，更重要的是瞭解呼吸及喉部聲帶信號在臨床探測吸入現象的功用，以便提高病患生活品質。

This study investigates the usage of respiratory and acoustic swallowing signals at bedside swallowing examination. For a normal and safely swallow, coordination of breathing and swallowing functions are crucial. Lack of this coordination may lead individual at risk for aspiration that may result in a variety of pulmonary complications and even death. Yet, studies have shown that about 40% of patients with swallowing disorders are silent aspirators who are not detected at bedside swallowing examination. In recent research, therefore, investigators have searched for alternate and additional bedside tools to increase the sensitivity and specificity of bedside swallow examination, especially in detecting aspiration. Hence, to advance our understanding of the coordination of respiration and swallowing, and thereby better bedside tools for swallowing examination, pulse oximetry, respiratory nasal cannula, and stethoscopic laryngeal microphone were incorporated in this study.

Fifty normal adult subjects and fifty patients with aspiration were recruited in this study. The respiratory signals from both the pulse oximetry and respiratory nasal cannula, and the acoustic swallowing signals from the stethoscopic laryngeal microphone were collected and analyzed. In addition, the respiratory and acoustic results from the patients with aspiration were compared with their videofluoroscopic evaluation. Results from this investigation will provide better understanding of the coordination of respiratory and swallowing, more specifically, 1.the role of respiratory and acoustic signals at bedside swallowing examination, 2, potential tools for detecting aspiration at bedside swallowing examination and consequently 3.increase the life quality of dysphagic patients.

關鍵詞(Keywords)：吞嚥障礙、吸入、臨床吞嚥評估、電視螢光攝、
swallowing disorders, aspiration, bedside swallowing examination、videofluoroscopic

Introduction (前言)

Coordination of breathing and swallowing functions are crucial for normal and safely swallow (Martain, Logemann, Shaker & Dodds, 1992; Perlman, Ettema, Barkmeier, 2000). Individuals who lack of this coordination are especially at risk for aspiration that may lead to a variety of pulmonary complication and even death. During bedside swallowing examination, speech language pathologist can detect patient at risk for aspiration via several clinical signs of aspiration (Daniels, McAdam, Brailey, & Foundas, 1997). Yet studies have shown that about 40% of patients who aspirated during bedside examination failed to be identified by experience speech language pathologists (Logemann, Lazarus, & Jenkins, 1982; Logemann, 1998).

Although instrumental assessment of swallowing such as videofluoroscopic swallowing study (VFSS) and fiberoptic endoscopic evaluation of swallow (FEES^{R}) does provide clear and objective assessment of swallowing functions (Logemann, 1986; Langmore, Schatz, & Olsen, 1988), it is significant and of priority that clinical dysphagia screening tools at bedside swallowing evaluation can provide objective criteria to warrant a VFSS or FEES^{R}. Therefore, in recent research, investigators are in search of clinical dysphagia screening tools to increase the sensitivity and specificity of bedside swallow examination (Exley, 2000).

Literature Review (文獻探討)

The two most widely investigated clinical tools as stated in the editorial section of *Age and Ageing* (2000) are the pulse oximetry and the cervical auscultation with stethoscope. Exley (2000) suggested that researchers are in favor of these two clinical tools because they are widely available in hospital, easy to use and non-invasive. In addition, clinicians and nurses are familiar with their usage.

Several studies have investigated the use of pulse oximetry in detecting aspiration by observing the oxygen desaturation during and immediately after swallowing (Collins & Bakheit, 1997; Colodny, 2000, 2001; Smith, Lee, O'Neill' & Connolly, 2000). Smith et al (2000) examined the predictive values of pulse oximetry at bedside swallowing assessment in detecting aspiration. The oxygen saturation levels for 53 patients with acute strokes were compared with the videfluoroscopy results. Their results show that screening of stroke patients by oxygen saturation assessment fails to detect only 14% of patient with aspiration or peneratation. In addition, Collins and Bakheit (1997) also suggested that pulse oximetry was reliable for detection of aspiration in stroke patients. However, Colodyn (2001) provided controversial results. Colodyn (2000, 2001) studied the oxygen saturation level of 104 dysphagia patients and 77 nondysphagic persons before, during and after oral feeling. Her findings suggested that individuals with dysphagia do not necessarily

desaturate while aspirating. Data indicated that oxygen saturation levels do not vary much during feeding for dysphagics and nondysphagics alike. Colodyn (2001) concluded that oxygen desaturated was more related to pulmonary deterioration than to dysphagia.

However, one major drawback in these oxygen saturation studies was the lack of information regarding respiratory statues of these subjects. In addition, the respiratory phases, including the inspiratory and the expiratory phases, were not monitored to provide details on how a disturbance on the respiratory cycle may cause a change in the oxygen saturation level. Our understanding of the change of oxygen saturation during aspiration will be more complete if respiratory tool such as a respiratory nasal cannula is also used with the pulse oximetry (Perlman, Ettema, Barkmeier, 2000).

Another investigated clinical tools is the use of cervical auscultation with stethoscope (Exley 2000). Cervical auscultation has been used at bedside swallowing evaluation to distinguish between normal and abnormal patterns of sound. In an attempt to enhance the clinical examination's ability to detect aspiration, Zenner, Losinski, and Mills (1995) incorporated the cervical auscultation with stethoscope in their study. They placed the cervical auscultation on the flat diaphragm of the stethoscope against the lateral side of the neck in the regions of the laryngeal of 50 subjects with suspected oral-pharyngeal dysphagia. Results show that tracheal aspiration was suspected when the flushing sound of material was heard prior to the initiation of the pharyngeal swallow or when breathe sound wetness, strider coughing, throat clearing, or voice distortion was heard after the swallow. They concluded that the use of cervical auscultation is a highly sensitive and specific method of dysphagia assessment in long-term care. However, no acoustic signals that can be objectively qualified for detecting aspiration via the cervical auscultation were mentioned and described in the Zenner, Losinski, and Mills' (1995) study.

Hence to advance our understanding for the coordination of respiration and swallowing and thereby better bedside tools for swallowing examination, respiratory and acoustic signals were collected and compared. More specifically, the respiratory signals from pulse oximetry and respiratory nasal cannula, and the acoustic signal from compute-aided stethoscopic laryngeal microphone were analyzed. Research questions include

1. What are the salient respiratory and acoustic signals in detecting aspiration via pulse oximetry, respiratory nasal cannula, and laryngeal microphone? and
2. Are these signals sensitive and specificity enough to detect aspiration at bedside swallowing examination?

Methods (研究方法)

Fifty adults with normal swallow and fifty patients with suspected aspiration were recruited in this study. All participants were asked to intake five different types of food consistencies: 5cc of thin liquid, 5cc of thick liquid, one tablespoon of puree, paste and solid. The Kay Digital Swallowing Workstation from Kay Elemetrics Corp (Martin-Harris, 2002) and the hand held pulse oximeter from Nonin Medical (Exley, 2000) were used to collect three sets of data, namely the respiratory signal, the acoustic swallowing signal, and the oxygen saturation level during swallowing of these food consistencies. The Kay Digital Swallowing Workstation is a computerized system that can provide a variety of feedback of physiologic signals including EMG, tongue pressure, respiratory phase, and swallowing acoustics (Martin-Harris, 2002). In this study, the participants' respiratory signals were collected from the Kay Digital Swallowing Workstation's respiratory nasal cannula and the acoustic swallowing signals from the Kay Digital Swallowing Workstation's stethoscopic laryngeal microphone. The participants' oxygen saturation levels during swallowing were recorded from the pulse oximeter. In addition, for patients with suspected aspiration, a bedside swallowing evaluation and a VFSS were also conducted to gather their oral and pharyngeal phases information during swallowing. The bedside swallowing evaluation included an oral-motor examination and a swallow function examination. Items in the oral-motor examination include the lip, tongue, velum, jaw and teeth oral structures, the structures' symmetry, strength, gross sensation, and range movement. As for the swallow function examination, the labial closure, mastication, oral control, oral transit time, residue, nasal regurgitation, laryngeal excursion, coughing, and vocal quality were examined. All data were analyzed with the MatLab 6.5 Software and the SPSS statistic package. For measuring the agreement between clinical swallowing signals and videofluoroscopic results of aspiration, the percent agreement, sensitivity, specificity, and kappa coefficient were used (Zenner et al. 1995)

Results (結果)

The three sets of swallowing data for the fifty normal adult subjects are reported here. For the respiratory signals, the majority of subjects demonstrate an interruption of the exhalatory phase of the respiratory cycle for all food consistencies during swallowing (Table 1).

Table 1. The percentage of swallow-respiratory coordination for five different types food consistencies

	Thin	Thick	Puree	Paste	Solid
Interruption of exhalatory	78%	86%	92%	82%	88%
Interruption of inhalatory	22%	14%	8%	18%	12%

The stethoscopic laryngeal microphone results show that two distinct acoustic components are detected for all subjects. In addition, no significant temporal difference is noted among the different types of food viscosities. A first burst sound is detected right after swallowing for all subjects. This burst sound indicates that there is no delay in the pharyngeal swallow for all subjects.

The oxygen saturation levels for thin liquid, thick liquid, puree, paste and solid foods are showed in Figure 1 to Figure 5. The average oxygen saturation for all subjects among all food consistencies are 98%, ranging from 96% to 100%.

Figure1. The oxygen saturation level for thin liquid for all fifty subjects.

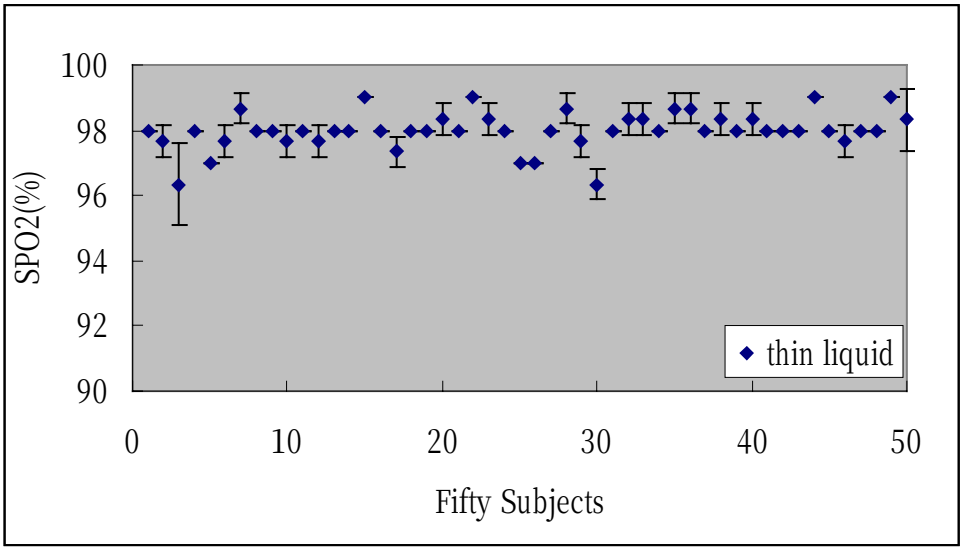


Figure2. The oxygen saturation level for thick liquid for all fifty subjects.

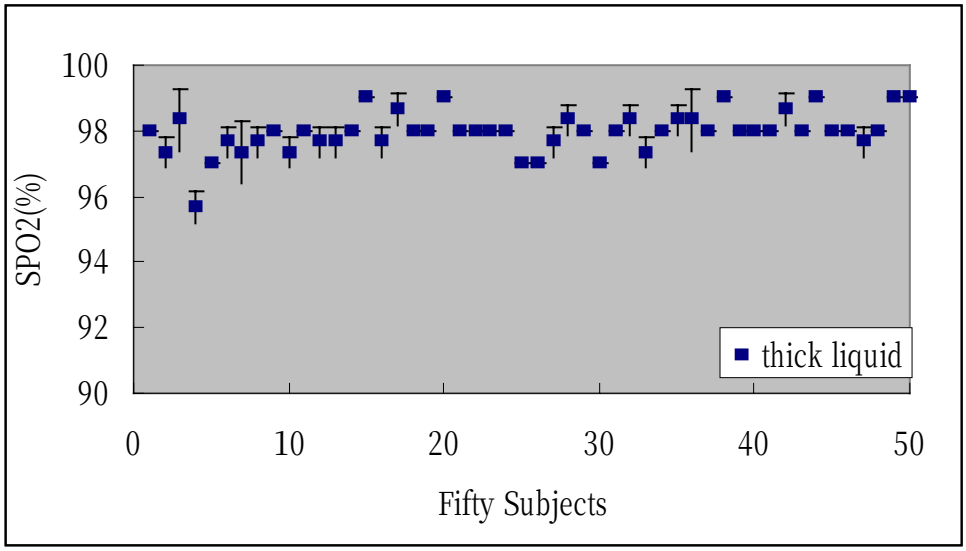


Figure3. The oxygen saturation level for puree consistency for all fifty subjects.

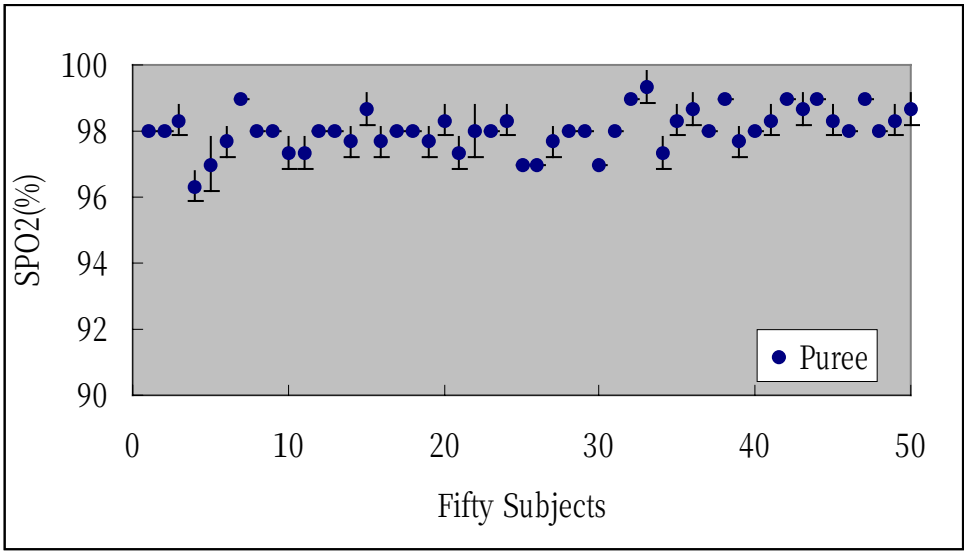


Figure4. The oxygen saturation level for paste consistency for all fifty subjects.

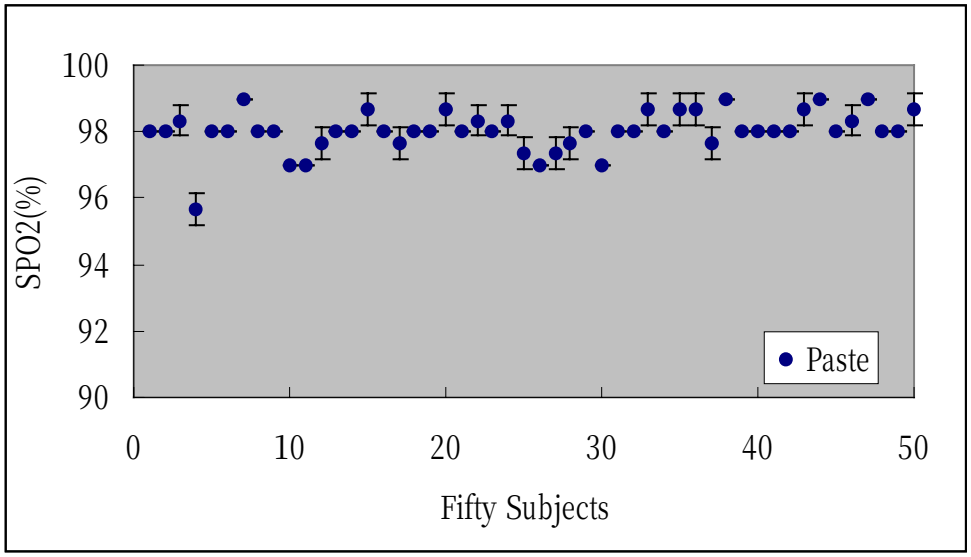
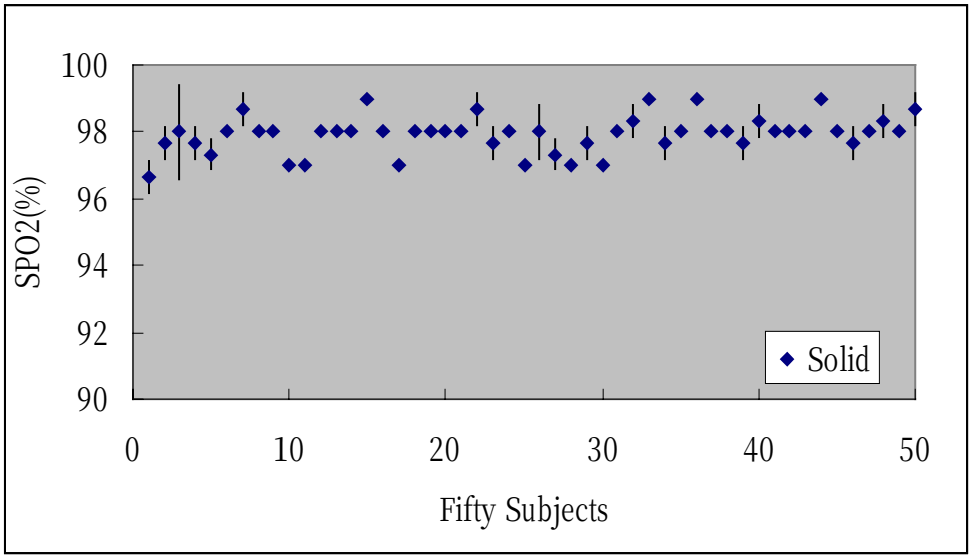


Figure5. The oxygen saturation level for solid consistency for all fifty subjects.



Discussion (討論)

This study investigates the usage of respiratory and acoustic swallowing signals at bedside swallowing examination. Results from adult normal subjects show that the respiratory patterns during swallowing are in agreement with Martin et al., (1994). Most subjects exhibit the safer pattern of swallow-respiratory coordination pattern as suggested by Logemann (1998). Results from the stethoscopic laryngeal microphone show that none of the normal subject demonstrate a delay in pharyngeal swallow. In addition, the stethoscopic laryngeal microphone results are in agreement with Zenner, et al., (1995). Acoustic swallowing signals are clear and unambiguous in detecting the triggering of pharyngeal swallowing reflex. These results may indicate that acoustic swallowing signals can be a good indicator for detecting delay pharyngeal swallowing during bedside swallowing evaluation. This indication will be important for individuals that are at risk for aspiration due to delay pharyngeal swallow (Murray, 1999). Results show that there is no significant difference in the oxygen saturation levels among different types of food consistencies for all subjects.

Results from this investigation will provide better understanding of the coordination of respiratory and swallowing. More specifically,

1. the role of respiratory and acoustic signals at bedside swallowing examination,
2. potential tools for detecting aspiration at bedside swallowing examination, and consequently,
3. increase the life quality of dysphagic patients.

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Self-evaluation (計畫成果自評)

This study investigates the usage of respiratory and acoustic swallowing signals at bedside swallowing examination. One major change had been done in this research as compared to the original planning. That is, an additional fifty adult normal subjects had been recruited and their data for respiratory-swallowing coordination had been collected and analyzed. This was done because no data had been reported among the respiratory signals, acoustic swallowing signals and oxygen saturation level for normal subjects. Such information will be of great important in understanding the respiration-swallowing coordination and thereby their values and functions in bedside swallowing examination. A minor change was that only five types of food consistencies were used instead of original six types of food consistencies. In this report , the normal data were reported. Part of the data for the patients with aspiration is still work in progress and will be reported in future conferences that are related to speech-language pathology and swallowing disorder.