# THE DEVELOPMENT OF AN EXPERT SYSTEM FOR SWALLOWING DISORDER SCREENING IN STROKE PATIENTS

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Thesis
entitled

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THE DEVELOPMENT OF AN EXPERT SYSTEM FOR SWALLOWING DISORDER SCREENING IN STROKE PATIENTS

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ABSTRACT

This thesis describes an expert system for swallowing disorder screening in stroke patients. The knowledge was acquired from experts and textbooks to construct the knowledge base. If- then rules were used as the knowledge representation technique. The inference mechanism included backward chaining. The expert system was developed using Microsoft Visual Basic.NET 2005 program working on the Microsoft Windows XP operating system for personal computers. The objective of this research was to screen swallowing disorders in stroke patients that are as similar to a human as possible. The system was divided into two main parts. The first part was swallowing disorder screening and management. The second part was a general knowledge system about swallowing disorders.

This study can help improve the user assessment of swallowing disorders that affect the accuracy and consistency compared to a human expert evaluation. Results showed that users are satisfied with the system developed.

KEY WORDS: EXPERT SYSTEM / SWALLOWING DISORDER / DYSPHAGIA / SWALLOWING SCREENING / STROKE

108 pages

การพัฒนาระบบผู้เชี่ยวชาญเพื่อคัดกรองผู้ป่วยที่มีภาวะการกลืนผิดปกติอันเนื่องมาจากโรคหลอดเลือดสมอง

THE DEVELOPMENT OF AN EXPERT SYSTEM FOR SWALLOWING DISORDER SCREENING IN STROKE PATIENTS

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บทคัดย่อ

วิทยานิพนธ์ฉบับนี้ได้อธิบายถึงการออกแบบและพัฒนาระบบผู้เชี่ยวชาญ เพื่อคัดกรองผู้ป่วยที่มีภาวะการกลืนผิดปกติอันเนื่องมาจากโรคหลอดเลือดสมอง โดยนำความรู้จากผู้เชี่ยวชาญและตำราเอกสารความรู้ด้านการกลืนต่างๆ มาสร้างเป็นฐานความรู้ ซึ่งการประเมินการกลืนของระบบใช้เทคนิคการแสดงความรู้แบบกฎ (If-then rules) ส่วนกลไกการอนุมานใช้เทคนิคการอนุมานแบบย้อนกลับ(Backward chaining) ระบบผู้เชี่ยวชาญนี้ถูกพัฒนาขึ้นโดยใช้โปรแกรม Microsoft Visual Basic.NET 2005 ทำงานบนเครื่องคอมพิวเตอร์ส่วนบุคคล ภายใต้ระบบปฏิบัติการ Microsoft Windows XP มีจุดประสงค์เพื่อช่วยในการประเมินภาวะการกลืนที่ผิดปกติในผู้ป่วยโรคหลอดเลือดสมองให้ได้ใกล้เคียงกับผู้เชี่ยวชาญที่เป็นมนุษย์ให้มากที่สุด ระบบจะแบ่งออกเป็นสองส่วน ส่วนแรกเป็นส่วนของการประเมินหาการกลืนที่ผิดปกติและให้คำแนะนำในการดูแลรักษา ส่วนที่สองเป็นส่วนความรู้ทั่วไปเกี่ยวกับภาวะการกลืนผิดปกติ

ผลของการศึกษาพบว่า ระบบสามารถช่วยให้ผู้ใช้ประเมินภาวะการกลืนที่ผิดปกติได้ผลถูกต้องและสอดคล้องเมื่อเปรียบเทียบกับการประเมินโดยผู้เชี่ยวชาญที่เป็นมนุษย์ ผลการใช้งานพบว่าผู้ใช้มีความพึงพอใจต่อระบบที่พัฒนาขึ้น

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# CHAPTER I
# INTRODUCTION

## 1.1 Background and Problem Statement

Stroke, also known as a cerebrovascular accident (CVA) or a brain attack is a form of cardiovascular disease. The incidence of stroke increases every year and still a serious health problem. Stroke is the third most common cause of death in the UK (Department of Health, 2007). In Thailand, stroke is the fourth cause of mortality rate (Ministry of Public Health, 2009). It is not only the leading cause of death but also the major cause of serious long-term disability (Poungvarin, 2001). The majority of stroke patients may have hemiplegia or other neurological symptoms such as cognitive impairment and memory problems, communication disorder, and chewing and swallowing problems (Suwanno, 1997).

Swallowing disorders or dysphagia is the abnormality or difficulty in swallowing due to swallowing process abnormality (Noll, Bender & Nelson, 1996). It is an important problem of stroke. The incidence rates are reported between 51-73% in acute and rehabilitation stroke patients (Han,et al., 2001). The swallowing process involves the proper functioning of many muscles and nerves. When a stroke causes dysfunction to these muscles or nerves, swallowing problems can develop. If not identified and managed, it can lead to aspiration pneumonia, poor nutrition, and increased hospital admission as well as an increased re-admission rate (Smithard, 1996). Evidence supports the importance of identifying and managing dysphagia in stroke survivors as a strategy to reduce these complications (Martino R, et al.2000). If stroke patients have access to a rapid and timely comprehensive dysphagia assessment by dysphagia experts, they will receive appropriate individualized and nutritional management.

The American Heart Association and the American Stroke Association currently recommend that stroke patients be screened for dysphagia before they receive food, liquid, or medication. Nurse is the first person who is able to screen the

dysphagia problem by making the swallowing assessment, noticing signs and symptoms in swallowing process abnormality during eating. The pre-oral feed dysphagia assessment is therefore important. Nurse should have knowledge and skill in dysphagia assessment correctly and precisely (Hubmann, et al., 2004).

However, many hospitals lack of dysphagia experts. The staff that care for patients with dysphagia still lack of experience and skill in accurate assessment and management of the patients. So this research is to use Expert System (ES) extracting the knowledge and solve problems by computers for screening swallowing problem and management in stroke patients. The expected benefit might be helping nurses, public health personnel or relevant person for screening swallowing problem and management. It is to reduce life threatening complications and to promote safe swallowing among stroke patients with dysphagia.

## 1.2 Objective of Work

To develop and build an expert system for swallowing disorder screening in stroke patients.

## 1.3 Scopes of Work

The scopes of this study are as follows:

1. To focus on screening swallowing disorder after stroke.

2. Develop the expert system that can screen swallowing disorder in stroke patients in Department of Rehabilitation Medicine, Siriraj Hospital.

3. A result of swallowing disorder screening is preliminary screening not final diagnosis.

4. Microsoft Visual Basic.NET 2005, Microsoft office program and microcomputer will be used as expert system tool.

5. The knowledge was acquired from both human experts and documents; a rule-base technique was used as the knowledge base representation.

## 1.4 Expected Results

The expected outcome of this study is summarized as:

1. Differentiate stroke patients according to the degree of swallowing disorder.

2. Advice management of swallowing problem in stroke patients.

3. A learning tool for teaching students or those concerned.

4. Initiate further researches.

# CHAPTER II
# LITERATURE REVIEW

This chapter has reviewed previous researches. It is divided into three sections as follow:

2.1 Swallowing problems after stroke (Dysphagia)

2.2 Expert System

2.3 Related Research

## 2.1 Swallowing problems after stroke (Dysphagia)

### 2.1.1 Definition

Dysphagia, or swallowing disorder, is a general term used to describe the inability to move food from the mouth to the stomach. Dysphagia should be differentiated from disorders that prevent transfer of food to the mouth or beyond the stomach but that are not characterized by difficulty swallowing. For example, feeding disorder, which is the inability to get food to the mouth, and gastric outlet obstruction, which is the inability of food to pass from the stomach into the small intestine, are not types of dysphagia.

Frequent causes of dysphagia include the following:

- Stroke or traumatic brain injury (TBI)
- Motor neuron disease (eg, amyotrophic lateral sclerosis [ALS])
- Parkinson disease and other degenerative disorders (apraxia) (Pitts T, et al., 2008)
- Poliomyelitis
- Multiple sclerosis
- Myasthenia gravis

- Myopathy (dermatomyositis, myotonic dystrophy)
- Laryngectomy
- Pharyngectomy, esophagectomy reconstructed by gastric pull-up
- Head and neck surgery (Greven KM, et al., 2008)
- Cervical brace, cervical spondylosis
- Ventilator dependency
- Age (elderly patients)
- Cerebral palsy and other movement disorders (mental retardation, developmental delay)
- Disorders in the cervical esophageal aspect of deglutition (esophageal-pharyngeal backflow, tracheoesophageal fistula, Zenker diverticulum, reflux)

Dysphagia, which can be classified as neurologic or nonneurologic, has been reported in several types of disorders. Although dysphagia introduces many confounding variables, it also exerts a large influence on the outcome of rehabilitation (eg, length of hospital stay, mortality/morbidity of the patient).

Neurologic swallowing disorders are encountered more frequently in rehabilitation medicine than in most other medical specialties. Stroke is the leading cause of neurologic dysphagia. Approximately 51-73% of patients with stroke have dysphagia, which is the most significant risk factor for the development of pneumonia; this can also delay the patient's functional recovery. According to the US National Medicare database, incidence of poststroke dysphagia is higher in Asians and other minority groups than in whites, suggesting racial disparities in the development of dysphagia after stroke (Bussell SA, et al., 2011).

### 2.1.2 Normal Swallowing Physiology

Deglutition is the act of swallowing, which allows a food or liquid bolus to be transported from the mouth to the pharynx and esophagus, through which it enters the stomach. Normal deglutition is a smooth, coordinated process that involves a complex series of voluntary and involuntary neuromuscular contractions and typically is divided into distinct phases: oral, pharyngeal, and esophageal. Each stage facilitates

a specific function; if the stages are impaired by a pathologic condition, specific symptoms may result.

1) Oral phase

The oral preparatory phase refers to the processing of the bolus to render it swallowable; the oral propulsive phase refers to the propelling of food from the oral cavity into the oropharynx. The process begins with contractions of the tongue and striated muscles of mastication. The muscles work in a coordinated fashion to mix the food bolus with saliva and then propel the food from the anterior oral cavity into the oropharynx, where the involuntary swallowing reflex is triggered.

The cerebellum controls output for the motor nuclei of cranial nerves V (trigeminal), VII (facial), and XII (hypoglossal).

With single swallows of liquid, the entire sequence lasts about 1 second. For swallows of solid foods, a delay of 5-10 seconds may elapse while the bolus accumulates in the oropharynx.

2) Pharyngeal phase

The pharyngeal phase is of particular importance, because without intact laryngeal protective mechanisms, aspiration is most likely to occur during this phase. This phase involves a rapid sequence of overlapping events. The soft palate rises, the hyoid bone and larynx move upward and forward, the vocal folds move to the midline, the epiglottis folds backward to protect the airway, and the tongue pushes backward and downward into the pharynx to propel the bolus downward (Paik NJ, et al., 2008).

The tongue is assisted by the pharyngeal walls, which move inward with a progressive wave of contraction from top to bottom.

The upper esophageal sphincter relaxes during the pharyngeal phase of swallowing and is pulled open by the forward movement of the hyoid bone and larynx. This sphincter closes after passage of the food, and the pharyngeal structures then return to the reference position.

The pharyngeal phase of swallowing is involuntary and totally reflexive, so no pharyngeal activity occurs until the swallow reflex is triggered.

This swallowing reflex lasts approximately 1 second and involves the motor and sensory tracts from cranial nerves IX (glossopharyngeal) and X (vagus).

3) Esophageal phase

In the esophageal phase, the bolus is propelled downward by a peristaltic movement. The lower esophageal sphincter relaxes at initiation of the swallow, and this relaxation persists until the food bolus has been propelled into the stomach. Unlike the upper esophageal sphincter, the lower sphincter is not pulled open by extrinsic musculature. Rather, it closes after the bolus enters the stomach, thereby preventing gastroesophageal reflux.

The medulla controls this involuntary swallowing reflex, although voluntary swallowing may be initiated by the cerebral cortex.

An interval of 8-20 seconds may be required for contractions to drive the bolus into the stomach.

### 2.1.3 Swallowing-Phase Disorders

Disorders of swallowing may be categorized according to the swallowing phase affected. A number of dysphagic problems can be identified during each phase of deglutition.

1) Oral-phase disorders

Oral-phase disorders affecting the oral preparatory and oral propulsive phases usually result from impaired control of the tongue. Patients may have difficulty chewing solid food and initiating swallows. When drinking a liquid, patients may find it difficult to contain the liquid in the oral cavity before swallowing. As a result, liquid spills prematurely into the unprepared pharynx, often resulting in aspiration.

Oral-phase swallowing symptoms and disorders (Logemann JA, 1993):

- Cannot hold food in the mouth anteriorly due to reduced lip closure

- Cannot form a bolus or residue on the floor of the mouth due to reduced range of tongue motion or coordination

- Cannot hold a bolus due to reduced tongue shaping and coordination

- Unable to align teeth due to reduced mandibular movement

- Entry of food material into the anterior sulcus or the presence of residue in the anterior sulcus due to reduced labial tension or tone

- Entry of food material into the lateral sulcus or the presence of residue in the lateral sulcus due to reduced buccal tension or tone

- Abnormal hold position or material falls to the floor of the mouth due to tongue thrust or reduced tongue control

- Delayed oral onset of swallow due to apraxia of swallow or reduced oral sensation

- Searching motion or inability to organize tongue movements due to apraxia of swallow

- Forward tongue movement to start the swallow due to tongue thrust

- Residue of food on the tongue due to reduced tongue range of movement or strength

- Disturbed lingual contraction (peristalsis) due to lingual discoordination

- Incomplete tongue-to-palate contact due to reduced tongue elevation

- Unable to mash material due to reduced tongue elevation

- Adherence of food to hard palate due to reduced tongue elevation or reduced lingual strength

- Reduced anterior-posterior lingual action due to reduced lingual coordination

- Repetitive lingual rolling in Parkinson disease (Pitts T, et al., 2008)

- Uncontrolled bolus or premature loss of liquid or pudding consistency into the pharynx due to reduced tongue control or linguavelar seal

- Piecemeal deglutition
- Delayed oral transit time

2) Pharyngeal-phase disorders

If pharyngeal clearance is severely impaired, a patient may be unable to ingest sufficient amounts of food and drink to sustain life. In people without dysphasia, small amounts of food commonly are retained in the valleculae or pyriform sinus after swallowing. If there is weakness in or a lack of coordination of the pharyngeal muscles or if there is a poor opening of the upper esophageal sphincter, patients may retain excessive amounts of food in the pharynx and experience overflow aspiration after swallowing.

Pharyngeal-phase swallowing symptoms and disorders (Logemann JA, 1993):

- Delayed pharyngeal swallow
- Nasal penetration during swallow due to reduced velopharyngeal closure
- Pseudoepiglottis (after total laryngectomy): fold of mucosa at the base of the tongue
- Cervical osteophytes
- Coating of pharyngeal walls after the swallow due to bilateral reduction of pharyngeal contraction
- Vallecular residue due to reduced posterior movement of the tongue base
- Coating in a depression on the pharyngeal wall due to scar tissue or pharyngeal pouch
- Residue at top of airway due to reduced laryngeal elevation
- Laryngeal penetration and aspiration due to reduced closure of the airway entrance (arytenoid to base of epiglottis)
- Aspiration during swallow due to reduced laryngeal closure
- Stasis of residue in pyriform sinuses due to reduced anterior laryngeal pressure

- Delayed pharyngeal transit time

3) Esophageal-phase disorders

Impaired esophageal function can result in retention of food and liquid in the esophagus after swallowing. This retention may result from a mechanical obstruction, a motility disorder, or an impairment of the opening of the lower esophageal sphincter.

Swallowing symptoms and disorders of the esophageal phase (Logemann JA, 1993):

- Esophageal-to-pharyngeal backflow due to esophageal abnormality
- Tracheoesophageal fistula
- Zenker diverticulum
- Reflux

### 2.1.4 Pathophysiology of dysphagia post stroke

Dysphagia is a dysfunction or difficulty in eating due to swallowing dysfunction. The cause of swallowing dysfunction in stroke patient is neurological disorder especially swallowing control related brain disorder. Dysphagia problem depends on position of lesion (Harnphadungkit, K., 2004) which can be divided into central nervous system and peripheral nervous system.

Pathology of brain that affect to swallowing and eating are (Russell & Hill, 1992):

1) Left hemisphere (dominant) lesion: The patients will usually show contralateral reductions in lip and tongue strength, rate and range of movement, and sensation, a delayed swallow reflex and contralateral reductions in pharyngeal peristalsis.

2) Right hemisphere (non-dominant) lesion: There may be contralateral reductions in lip and tongue strength, rate and range of movement and sensation, a delayed swallow reflex may occur. There may be contralateral reductions in pharyngeal peristalsis

3) Bilateral hemisphere lesions: The patients show reduced tongue and lip strength, rate and range of movement, and sensation. The swallow

reflex is delayed. Reduced pharyngeal peristalsis and chronic aspiration is a continuing hazard.

4) Brainstem lesion: Lip and tongue movements are reduced in rate, range and strength, and there may be associated sensory impairment. The swallow reflex is absent or delayed. Pharyngeal peristalsis is reduced.

The studied of Meng and colleagues (2000) found that of the patients who had a lesion at the brainstem 81 % had dysphagia at the time of initial clinical swallowing evaluation, which was performed 10-75 days after the onset of stroke. And 79 % of the dysphagic individuals depended on tube feeding at the initial evaluation and 22% of all individuals could not resume oral intake at discharge.

### 2.1.5 Complications of dysphagia

1) Aspiration

Aspiration occurs when food or liquid enters the trachea. Signs of aspiration include coughing, shortness of breath, difficulty breathing and respiratory complications. Malnourished individuals have a higher risk of aspiration, because muscles are weakened, reducing the strength of respiration, throat clearing and coughing. Silent aspiration, a concern in individuals with reduced laryngeal sensation, occurs when a bolus enters the trachea without producing coughing, throat clearing or changes in vocal quality. Silent aspiration may go undetected unless a videofluoroscopic swallowing study (VFSS) is performed or respiratory complications consistent with aspiration develop or use $O_2$ saturation due to swallowing.

Dysphagia is strongly associated with aspiration pneumonia, a pulmonary infection caused by the entry of foreign substances and/or bacteria into the lungs. This common respiratory complication following stroke is associated with repeated entry of food or liquid into the lungs due to abnormal swallowing physiology. Not everyone who aspirates develops aspiration pneumonia. Factors affecting the likelihood of aspiration pneumonia include stroke severity, level of consciousness, premorbid pulmonary function, ability to cough, mobility, posture, cognition, acidity of the aspirate, immune competence, oral hygiene and amount and frequency of aspiration. Other risk factors include dependency on others for oral care or feeding,

dental caries, tube feeding and medical conditions, such as COPD, cancer, malnutrition, cardiac disease, diabetes mellitus and multiple strokes.

2) Malnutrition

Patients who have had a stroke are likely to decrease their dietary intake, which increases their risk of malnutrition or exacerbates existing malnourishment. In an investigation of the nutritional status of patients with stroke who were admitted to a rehabilitation service, 49% had malnutrition, and 65% of those with dysphagia were malnourished (Finestone HM, et al., 1995)

In another study, no differences were found in the nutritional parameters of patients admitted for stroke with or without dysphagia on admission. However, after 1 week, 48.3% of the patients with dysphagia were malnourished, but only 13.6% of those without dysphagia were malnourished.

Malnutrition is a risk factor for pneumonia because it renders the person susceptible to altered colonization in the oropharynx and reduced resistance to infection by depressing the immune system. Malnutrition may also lead to lethargy, weakness, and reduced alertness, all of which may increase the probability of aspiration. In addition, malnutrition may reduce the strength of cough and mechanical clearance in the lungs.

3) Dehydration

Dehydration is a water and electrolyte disturbance resulting from either water loss or depletion of sodium with accompanying water loss. Dehydration can develop when metabolic water needs and losses exceed intake, such as occur with vomiting and diarrhea. Dysphagia is a risk factor for dehydration because it is associated with an inability to manage liquids safely, impaired cognition, dependency on others for oral intake and intolerance of thickened fluids with consequent voluntary restriction of fluid intake. Dehydration is an important predisposing factor in stroke reoccurrence.

### 2.1.5 Dysphagia examination and findings

The examining physician should determine how the swallowing process is impaired and what stage is involved by means of careful clinical assessment or bedside evaluation.

Patients who have dysphagia may present with a variety of signs and symptoms. They usually report coughing or choking or the abnormal sensation of food sticking in the back of the throat or upper chest when they are trying to swallow; however, some of these presentations can be quite subtle or even absent (eg, in those with silent aspiration) (Logemann JA, 1998; Palmer JB, et al., 2000; Spieker MR, 2000).

Signs and symptoms of oral or pharyngeal dysphagia include the following:

- Coughing or choking with swallowing
- Difficulty initiating swallowing
- Food sticking in the throat
- Sialorrhea
- Unexplained weight loss
- Change in dietary habits
- Recurrent pneumonia
- Change in voice or speech (wet voice)
- Nasal regurgitation

Signs and symptoms of esophageal dysphagia include the following:

- Sensation of food sticking in the chest or throat
- Oral or pharyngeal regurgitation
- Change in dietary habits
- Recurrent pneumonia

2.1.5.1 Physical examination

Look for oral-motor and laryngeal mechanisms; testing of cranial nerves V and VII-XII is essential for determining whether physical evidence of oropharyngeal dysphagia exists. Direct observation of lip closure, jaw closure, chewing and mastication, tongue mobility and strength, palatal and laryngeal elevation, salivation, and oral sensitivity is necessary.

Check the patient's level of alertness and cognitive status, because they can impact the safety of swallowing and the ability to learn

compensatory measures. Dysphonia and dysarthria are signs of motor dysfunction of the structures involved in oral and pharyngeal swallowing.

Inspect the oral cavity and pharynx for mucosal integrity and dentition, and examine the soft palate for position and symmetry during phonation and at rest.

Evaluate pharyngeal elevation by placing 2 fingers on the larynx and assessing movement during a volitional swallow; this technique helps to identify the presence or absence of key laryngeal protective mechanisms.

The gag reflex is elicited by stroking the pharyngeal mucosa with a tongue depressor. Testing for the gag reflex is helpful, but the absence of a gag reflex does not necessarily indicate that a patient is unable to swallow safely; many people with no gag reflex have normal swallowing abilities, and some patients with dysphagia have a normal gag reflex. Pulling of the palate to one side during testing of the gag reflex indicates weakness of the muscles of the contralateral palate and suggests unilateral bulbar pathology.

Cervical auscultation becomes part of the clinical evaluation of dysphagic patients; assess sound strength and clarity, timing of apneic episode, and speed of swallowing. Also assess respiratory function; if the respiratory force of a cough or clearing of the throat is inadequate, the risk of aspiration is increased.

The final step in the physical examination is direct observation of the act of swallowing; at a minimum, watch the patient while he/she drinks a few ounces of water. If possible, assess the patient's eating of various food textures. Sialorrhea, delayed swallow initiation, coughing, or a wet or hoarse voice quality may indicate a problem. After the swallow, observe the patient for 1 minute or more to see if a delayed cough response is present. DePippo and colleagues suggested a swallow test with 3 oz of water; in their investigation, the test helped them to identify 80% of patients with stroke who, during a subsequent videofluoroscopic study, were found to be aspirating (DePippo KL, et al., 1992).

2.1.5.2 Differential Diagnosis

Specific questions about the onset, duration, and severity of dysphagia and about a variety of associated symptoms may help to narrow the

differential diagnosis. Review the patient's general health information, including long-term illnesses and current prescription medications.

The patient's history is often useful in identifying esophageal dysphagia. The history also should be directed at eliciting information about symptoms related to gastroesophageal reflux disease (GERD), including heartburn, belching, sour regurgitation, and water brash.

The differential diagnosis may include the following:

- Cerebrovascular accident
- Parkinson disease (Pitts T, et al., 2008)
- Brainstem tumors
- Degenerative diseases, such as ALS, multiple sclerosis (MS), and Huntington disease
- Poliomyelitis
- Syphilis
- Peripheral neuropathy
- Myasthenia gravis
- Polymyositis, dermatomyositis, muscular dystrophy (myotonic dystrophy, oculopharyngeal dystrophy)
- Cricopharyngeal achalasia
- Obstructive lesions, such as tumors, inflammatory masses, Zenker diverticulum, esophageal webs, extrinsic structural lesions, anterior mediastinal masses, and cervical spondylosis
- Achalasia
- Spastic motor disorders, such as diffuse esophageal spasm, hypertensive lower esophageal sphincter, and nutcracker esophagus
- Scleroderma
- Obstructive lesions, such as tumors, strictures, lower esophageal rings (Schatzki rings), esophageal webs, foreign bodies, vascular compression, and mediastinal masses

2.1.5.3 Imaging Studies

Chest radiography is a simple assessment for pneumonia. The image below shows aspiration of liquid barium into the distal bronchus.

Ultrasonography depicts only the region of the tongue posterior to the hyoid and may aid in the evaluation of submucosal and extramural lesions of the esophagus.

Computed tomography (CT) scanning and magnetic resonance imaging (MRI) provide excellent definition of structural abnormalities, particularly when they are used to evaluate patients with suspected CNS causes of dysphagia.

2.1.5.4 Videofluoroscopy

The terms videofluoroscopic swallowing study (VFSS) and modified barium swallow (MBS) often are used interchangeably. Athough some clinical researchers believe that it is possible to identify patients with the potential to develop pneumonia by interpreting findings of bedside tests, most agree that discrepancies exist between findings of bedside tests and videofluoroscopy. Videofluoroscopy is the standard for identifying patients who have the potential to develop pneumonia and for diagnosing aspiration and swallowing problems (Splaingard ML, et al., 1988).

Splaingard and colleagues reported that only 42% of patients who had aspiration on videofluoroscopy were identified as having abnormalities in bedside tests (Splaingard ML, et al., 1988).

This finding indicates that bedside results are not sufficient for evaluating the frequency of aspiration. In general, 40-70% of patients with stroke have silent aspiration, which does not manifest specific symptoms. In a study of tetraplegia patients, sensitivity and specificity of the besdside test were higher than in stroke patients (Shem KL, et al., 2012).

Videofluoroscopy is designed to study the anatomy and physiology of the oral, pharyngeal, and esophageal stages of deglutition and to define treatment strategies to improve swallowing safety or efficiency in patients with dysphagia.

If aspiration occurs or if food is retained after the patient swallows, the next step is to evaluate the quantity of retained food, the mechanism of

retention or aspiration, and the patient's response. In general, various food consistencies, volumes, postural techniques, and swallowing maneuvers to enhance swallowing efficiency or safety are tested during the study, and clinical decisions (eg, changing food viscosity, finding appropriate swallowing postures or maneuvers) are made. This study is expensive because of the special expertise, equipment, and facilities required.

2.1.5.5 Fiberoptic Endoscopic Examination

A transnasal laryngoscope is used to assess pharyngeal swallowing. The procedure is a sensitive technique for detecting premature bolus loss, laryngeal penetration, tracheal aspiration, and pharyngeal residue. Because pharyngeal contraction obstructs the lumen, the fiberoptic endoscopic examination of swallowing (FEES) does not demonstrate the motion of essential food pathway structures or show the food bolus during the swallow.

Swallowing is directly evaluated by using measured quantities of food colored with blue liquid dye. FEES may be helpful when VFSS is not feasible (eg, in critically ill patients unable to tolerate any risk of aspiration, patients in intensive care units who cannot be transferred to the fluoroscopy room, or patients who require prompt evaluation).

2.1.5.6 Reflex Cough Test

For the reflex cough test, a 20% solution of L-tartaric acid is dissolved in 2 mL of sterile normal saline. Using a nasal nebulizer, the patient inhales the solution, which stimulates cough receptors in the vestibule of the larynx and initiates the laryngeal cough reflex.

The laryngeal cough reflex protects the laryngeal aditus from significant aspiration and reduces the risk of respiratory complications (eg, pneumonia). An impaired laryngeal cough reflex may permit laryngeal penetration and increase the risk of aspiration pneumonia. An acute cerebrovascular accident often appears to affect the protective cough reflex.

Using a reflex cough test, Addington and colleagues were able to identify which patients with stroke were unlikely to subsequently develop aspiration pneumonia (specificity, 100%) (Addington WR, et al., 1999).

2.1.5.7 Swallowing Electromyography

Mechanical upward-downward movement of the larynx is detected by using a piezoelectric sensor while submental integrated electromyography (EMG) activity is recorded during dry and wet swallowing. EMG activity of the cricopharyngeal muscle of the upper esophageal sphincter also can be recorded (Ertekin C, et al., 1998).

In patients with muscular disorders, laryngeal elevators are involved, whereas the cricopharyngeal sphincter is intact. In patients with clinical signs of involvement of the corticobulbar fiber (eg, patients with ALS and pseudobulbar palsy), discoordination between paretic laryngeal elevators and the hyperreflexic cricopharyngeal sphincter is present.

EMG can be used for muscle selection and for performing injections of botulinum toxin in patients with dysphagia caused by cricopharyngeal muscle spasm or hypertonicity.

2.1.5.8 Additional Tests for Evaluation

1) Gastroesophageal endoscopy

Gastroesophageal endoscopy enables the best assessment of the esophageal mucosa. Endoscopy has the added benefits of permitting the detection of infection and erosions and of enabling biopsy.

2) Esophageal pH monitoring

Esophageal pH monitoring is the criterion standard for diagnosing reflux disease. A nasogastric probe is inserted into the patient's esophagus to record pH levels. These levels are compared with the patient's record of symptoms over 24 hours to determine whether acid reflux contributes to the patient’s symptoms.

3) Manometry

Manometry is performed to assess motor function of the esophagus. A catheter with several electronic pressure probes is passed into the stomach to measure esophageal contractions and to define upper and lower esophageal responses to swallowing. Manometry reveals definitive abnormalities in only 25% of patients with nonobstructive lesions; therefore, its clinical use in oropharyngeal dysphagia is limited.

4) Laryngeal electromyography

Laryngeal EMG can help the clinician to diagnose oropharyngeal dysphagia of peripheral nerve origin (eg, recurrent laryngeal or superior laryngeal nerve injury).

5) Scintigraphy

Scintigraphy has limited value in evaluating pharyngeal swallowing disorders. This test is useful in quantitative and qualitative evaluation of subglottic aspiration, esophageal motility disorders, and gastroesophageal reflux (Holt S, et al., 1990).

6) Oropharyngeal transit time can be measured through time-activity curves constructed from a specific region of interest (ROI) of the mouth, pharynx, and esophagus. Peaks and nadirs of the first derivative curve correspond to peak emptying or filling rates of the respective regions.

### 2.1.6 Treatment of dysphagia

Various treatments have been suggested for the treatment of oropharyngeal dysphagia in adults. Direct and indirect strategies for treating dysphagia have been described. Direct strategy usually refers to treatment that involves food, whereas indirect strategy refers to an exercise regimen performed without a food bolus. Direct techniques include modifications of food consistency; indirect techniques include stimulation of the oropharyngeal structures and the adoption of behavioral techniques, such as those involving postural changes or the swallow maneuver (Noll SF, et al., 1996; Paik NJ, Han TR, 2002).

Our understanding of swallowing physiology and of the effect of swallowing maneuvers and exercises on the underlying physiology has noticeably improved. The literature shows a trend leading from simple descriptive articles to scientific articles, which include the measurement of treatment efficacy.

The Dietetics in Physical Medicine and Rehabilitation dietetic practice group conceived the National Dysphagia Diet project in 1996. Growing frustration regarding a lack of standardization for solid-food textures, liquid consistencies, and nomenclature led to the formation of a task force to study the issue and to formulate a new diet based on scientific food properties and clinical swallowing problems.

2.1.6.1 Dietary Modification

Dietary modification is the key component in the general treatment program of dysphagia. A diet of pureed foods is recommended for patients who have difficulties with the oral preparatory phase of swallowing, who pocket food in the buccal recesses, or who have significant pharyngeal retention of chewed solid foods.

As patients' swallowing function improves, their dysphagic diet may be advanced to the next level of soft and semisolid foods with regular consistencies. Recommend to patients that they alternate bites with sips, bite or sip size, and the number of swallows per size.

Viscosity and texture

If oral feedings are determined to be appropriate, the viscosity and texture of the food should be considered, because patients vary in their ability to swallow thin and thick liquids. Liquids can be thickened with various thickening agents. Many commercially available, starch-based food thickeners are used to increase the consistency of food, and prethickened water, juice, coffee, and other products are available.

Food viscosity is defined as frictional resistance to shear. Viscosity of the diet for dysphagia is frequently described in a nonobjective manner. For example, tomato juice, nectar, honey, and pudding have been referred to as fluids. Viscosity can be objectively determined by using a device called a viscometer.

A uniform and viscous bolus of food or beverage enables a patient with a delayed swallow reflex to control mastication and transport. It also allows the individual to swallow with less risk of aspirating residue material, because there is a reduced tendency for the material to fall over the base of the tongue before the swallow mechanism is triggered. Viscosity also influences the swallowing reflex and peristaltic activity. Another objective method is a line-spread test (Mann LL, Wong K., 1996; Paik NJ, et al., 2004). Diluted mix is placed on a circle marked on a glass plate and is allowed to stream for 5 minutes. Lengths of the 4 stream directions are measured, and their mean is determined.

Food texture is defined as the group of physical properties derived from the structure of the food that can be sensed by touch. Touch usually is

performed by elements of the oral and pharyngeal cavities. Food and liquid textures play important roles in the care of patients with dysphagia.

Sample dysphagia diet according to viscosity

The dysphagia diet can be classified according to viscosity, as follows:

- level I: pudding, crushed potato, and ground meat
- level II: curd-type yogurt, orange juice (3% thickener mixed), cream soup, and thin soup with starch
- level III: tomato juice, fluid-type yogurt, and thick, fluid rice
- level IV: water and orange juice

2.1.6.2 Nutritional Supply

The effect of dysphagia on the patient's nutritional status is profound. As the patient's ability to swallow becomes impaired, adequate dietary intake becomes a challenge, and vice versa. Therefore, early detection and management of dysphagia are critical to halting malnutrition.

Malnutrition is a risk factor for pneumonia, because it renders patients susceptible to altered colonization in the oropharynx and because it reduces resistance to infection by depressing the immune system. It may also lead to lethargy, weakness, and reduced alertness, all of which may increase the probability of aspiration. Malnutrition may reduce the strength of cough and the mechanical clearance of the lungs. It also contributes to overall functional decline, muscle breakdown, osteoporosis, osteopenia, iron-deficiency anemia, skin breakdown, and poor wound healing.

Therefore, in addition to dysphagia screening, formal nutritional assessment is necessary in high-risk patients. Nutritional needs are determined by means of thorough body composition analysis, clinical examination, and biochemical assessment. Energy, protein, and fluid requirements must also be assessed.

In an investigation of the nutritional status of patients admitted to a rehabilitation service, 49% of all patients admitted for stroke were malnourished, and 65% of persons admitted for stroke with dysphagia were malnourished.

Many commercial products are available to provide nutritional support. A patient's protein and calorie intake can be enhanced not only with thickening agents but also with prethickened beverages, prepacked puree molds, oral liquid supplements, and modular components. When oral nutrition is inadequate, enteral nutrition is indicated.

2.1.6.3 Hydration

Because fluid intake is restricted in most patients with dysphagia, these individuals are at risk of dehydration. Therefore, the patient's hydration status must be closely monitored. Conversely, dehydration may also be a risk factor for pneumonia, because it decreases salivary flow (thus promoting altered colonization of the oropharynx) and may lead to lethargy, mental confusion, and increased aspiration. In addition, dehydration depresses the immune system, making the patient susceptible to infection.

The hydration state of a patient can be assessed by using input and output records, laboratory values (eg, serum osmolality), and physical indicators (eg, dry mucous membranes, poor skin turgor, darkened urine).

Adequate fluid intake can be achieved through simple interventions, such as systematically offering patients preferred liquids or foods with high fluid content (eg, pureed fruits and vegetables, hot cereals, custards, puddings) and having an adequate number of supervised staff to help patients drink while properly positioned. Intravenous fluids or water boluses given via a feeding tube may be necessary if hydration cannot be maintained.

2.1.6.4 Oral Hygiene and Dental Care

Oral hygiene and dental care are important. Dried secretions that accumulate on the tongue and palate reduce oral sensitivity and promote bacterial growth. The elderly have an increased incidence of oropharyngeal colonization with respiratory pathogens, a well-known risk factor for pneumonia. Changes in the oral milieu may occur secondary to decreased salivary production and abnormalities in swallowing. These abnormalities may result in the impaired clearance of organisms, allowing for pathogenic colonization. A dependence on oral care is associated with poor oral health, subsequent weight loss and malnutrition, and altered colonization of the oropharynx.

The provision of oral care is extremely important when working to prevent pneumonia. Lemon glycerin swabs or a damp washcloth can be used to remove the secretions.

2.1.6.5 Exercise and Facilitation Techniques

Two types of exercise can be recommended to the patient with dysphagia: indirect (eg, exercises to strengthen swallowing muscles) and direct (eg, exercises to be performed while swallowing). Exercises designed to facilitate oral motor strength, range of motion (ROM), and coordination usually are performed 5-10 times per day.

1) Exercises

1.1) Lip exercises can facilitate the patient's ability to prevent food or liquid from leaking out of the oral cavity. Tongue exercises are used to facilitate manipulation of the bolus and its propulsion through the oral cavity or to facilitate retraction of the tongue base. Passive ROM and active-assistive ROM exercise concepts also can be applied in this technique. Tongue-holding maneuvers facilitate compensatory anterior movement of the posterior pharyngeal wall.

1.2) Jaw exercises help facilitate the rotatory movements of mastication. Respiratory exercises (eg, resistive straw sucking, coughing, and incentive spirometer) are recommended to improve respiratory strength. Vocal cord adduction exercises can promote strengthening of weak vocal cords.

1.3) Head-lift exercises increase anterior movement of the hyolaryngeal complex and opening of the upper esophageal sphincter. Patients lie flat and are instructed to keep their shoulders on the floor as they raise their head high enough to see their toes, maintaining this position for 1 minute. They repeat this activity 3 times, followed by 30 consecutive repetitions of the same action. Patients should perform this exercise 3 times per day for several weeks.

2) Facilitation techniques

2.1) Electrical stimulation can be applied for dysphagia. Electrical stimulation is administered by using a modified, handheld, battery-powered electrical stimulator connected to a pair of electrodes

positioned on the neck. This technique is comparable to neuromuscular stimulation or functional electrical stimulation applied to the limb.

2.2) Somatosensory input influences motor function, and oral sensory deficit is associated with increased tendency toward aspiration. Somatosensory stimulation in the form of an electrical current applied to the pharynx can change the excitability of the corticobulbar projection and induce cortical reorganization in patients with poststroke dysphagia (Fraser C, et al., 2002; Freed ML, et al., 2001; Leelamanit V, et al., 2002).

2.3) Deep pharyngeal neuromuscular stimulation (DPNS) is a therapeutic program that uses the afferent-efferent cycle (ie, sensory stimulation-motor response) to improve pharyngeal swallow. DPNS focuses on stimulating 3 reflex sites with frozen lemon-glycerin swabs. The first site—the bitter taste buds and tongue base—is used to improve tongue-base retraction. The second site is the soft palate, which is stimulated to improve palatal elevation. The therapy is applied to the third site, the superior and medial pharyngeal constrictor, to improve pharyngeal peristalsis and cricopharyngeal opening.

2.4) Tactile-thermal stimulation (TTS) can be used to increase the speed of swallow. TTS involves the application of cold by rubbing the bilateral anterior facial arch with a laryngeal mirror that has been placed in ice. The purpose is to sensitize the area of the oral cavity where the swallow is triggered.

2.5) The bite reflex can be inhibited by applying sustained pressure to the tongue with a rubber seizure stick, in the chin-tuck position. A hypoactive gag reflex can be facilitated by applying a tongue depressor or a quick tap to the arch of the soft palate. A hyperactive gag can be desensitized by using firm pressure with a tongue depressor, which is advanced farther back in the mouth.

2.1.6.6 Compensatory Techniques

Maintaining oral feeding often requires compensatory techniques to reduce aspiration or improve pharyngeal clearance.

1) Chin-tuck position

The chin-tuck position decreases the space between the base of the tongue and the posterior pharyngeal wall, creating increased pharyngeal pressure to move the bolus through the pharyngeal region. The chin-tuck often is helpful for patients with delayed swallow reflex, because it narrows the airway entrance and increases the vallecular space, increasing the probability that the bolus remains in the vallecular before triggering of the pharyngeal swallow. In this way, the risk of aspiration is decreased.

2) Rotation of the head to the affected side

This technique closes the pyriform sinus on the affected side and directs food down the opposite or stronger side. This posture also adds external pressure on the damaged vocal cord and moves it toward the midline, improving airway closure.

3) Tilting the head to the strong side

By tilting the head to the strong side, the bolus tends to be directed down the stronger side in the oral cavity and in the pharynx. The head-tilt is also effective for patients who have unilateral tongue dysfunction or a unilateral pharyngeal disorder.

4) Lying on one's side or back during swallowing

This measure sometimes prevents aspiration after the swallow. Using this posture often helps patients who, because of residue in the pharynx, aspirate after swallowing. They aspirate because gravity drops the residual food into the airway when they inhale after the swallow.

5) Supraglottic swallow

The supraglottic swallow is a technique designed to close the airway voluntarily before and during the swallow, protecting the trachea from aspiration. This technique can be useful for patients who have reduced laryngeal closure. Most patients can master this technique. Advise the patient to practice the following steps (Schultheiss C, et al., 2011):

- Take a deep breath and hold your breath

- Keep holding your breath and lightly cover your tracheostomy tube, if applicable

- Keep holding your breath while you swallow

- Cough immediately after the swallow

The extended supraglottic swallow is helpful for patients with severe reductions in tongue mobility or severely reduced tongue bulk due to surgical procedures for oral cancer, because these persons essentially have little or no oral transit. Advise these patients to learn the following technique:

- Hold your breath firmly

- Put the entire 5-10 mL of liquid in your mouth

- Continue to hold your breath and toss your head back, thus dumping the liquid into the pharynx as a whole

- Swallow 2-3 times or as many times as needed to clear the majority of the liquid while continuing to hold your breath

- Cough to clear any residue from the pharynx

The supersupraglottic swallow incorporates the supraglottic swallow with a Valsalva effect. This technique is designed to close the airway entrance voluntarily by tilting the arytenoid cartilage anteriorly to the base of the epiglottis before and during swallow. This strategy is used in patients with reduced closure of the airway entrance, particularly those who have undergone supraglottic laryngectomy.

6) Bolus-clearing maneuvers

The effortful swallow is designed to improve posterior tongue-base movement and thus to improve clearance of the bolus from the valleculae. Patients are instructed to swallow hard.

The Mendelson maneuver is used to improve laryngeal elevation and the cricopharyngeal opening during the swallow. Patients are instructed to swallow, to hold the swallow for 2-3 seconds, and then to complete the swallow and relax when the pharynx is in the uppermost stage. Repeated swallow and

washing food through the pharynx may be helpful to patients who have excessive residue in the pharynx after the swallow.

2.1.6.7 Enteral Feeding

In some patients, enteral feeding may be necessary in order to bypass the oral cavity and pharynx. In general, enteral feeding is indicated in any patient who is unable to achieve adequate alimentation and hydration by mouth. Patients with an impaired level of consciousness, massive aspiration, silent aspiration, esophageal obstruction, or recurrent respiratory infections fall into this category. There has been some controversy regarding the most appropriate mode and method of administering enteral feeding (e.g., continuous or intermittent, intestinal or gastric).

1) Nasogastric tube feeding

Nasogastric tube (NGT) feeding is a commonly used method of enteral feeding. In patients with a short-term life expectancy, nasogastric feeding is a more appropriate route for enteral nutrition. Insertion of a nasogastric tube is an easy, quick, relatively noninvasive procedure; it requires little training; and it is associated with negligible mortality. However, many patients find the nasogastric tube uncomfortable and repeatedly pull the tube out, which results in interrupted feeding and potential malnutrition. Its prolonged use can lead to complications such as lesions to the nasal wing, chronic sinusitis, gastroesophageal reflux, and aspiration pneumonia.

2) Percutaneous endoscopic gastrostomy

Percutaneous endoscopic gastrostomy (PEG) has several advantages over surgical gastrostomy, including reduced procedure time, cost, and recovery time, as well as the fact that it requires no general anesthesia. However, PEG also requires the invasive insertion of the feeding tube through the anterior abdominal wall, which can be complicated by bleeding, peritonitis or perforation of other abdominal organs; chest infections; local infection around the insertion site; and the tubes being pulled out (Park RH, et al., 1992).

Relative contraindications for PEG are aspiration pneumonia due to gastroesophageal reflux, significant ascites, and morbid obesity. Prospective, randomized trials have shown increased compliance, convenience, and continuity of feeding with PEG tubes compared with nasogastric intubation.

In one meta-analysis comparing effectiveness and safety between NGT and PEG, PEG was more effective and safer than NGT. Intervention failure occurred in 19 of 156 patients in the PEG group and 63 of 158 patients in the NGT group in favour of PEG. However, complications, mortality rates, and pneumonia rates were comparable between NGT and PEG (Gomes CA Jr, et al., 2012).

3) Oroesophageal tube feeding

Campbell-Taylor and colleagues introduced oroesophageal tube feeding, as shown below, in 1988 (Campbell-Taylor I, et al., 1988).

Patients who refuse nasogastric or gastrostomy tubes can use this method. The patient is taught to insert the 14F urethral tube into the mouth and past the side of the tongue, pushing slowly until the catheter end reaches the lips. Food supplements and liquid are administered by means of a 500-mL syringe at a rate of approximately 50 mL/min.

The absence of a gag reflex indicates the possible need for oroesophageal tube feeding. The patient must be cooperative and alert but need not be completely cognitively intact. This method is relatively contraindicated in patients with a hyperexaggerated gag reflex, esophagitis, Zenker diverticulum, or anteriorly directed cervical osteophytes.

This method has several advantages. First, oroesophageal tube feeding may prevent the harmful effects of continuous nasogastric tube feeding. Second, the speed of pouring liquids can be faster than with nasogastric tube feedings. Third, oroesophageal tube feeding provides training for facilitating the swallowing reflex.

A couple of disadvantages should be noted. First, performance of this procedure requires skillful technique. Second, the need for frequent manipulation (6 times per day) may be troublesome for the assistant.

2.1.6.8 Cricopharyngeal Myotomy

Cricopharyngeal myotomy (CPM) is a procedure designed to decrease pressure on the pharyngoesophageal sphincter (PES) by incising the main muscular component of the PES. However, no means of precisely determining the

underlying PES dysfunction exists. For this reason, no rational guidelines have been compiled for recommending CPM.

Even less certain is the advisability of performing a CPM in patients with neurogenic dysphagia, such as patients with stroke. The fact that neurogenic causes of dysphagia usually involve a lack of coordination of the swallow rather than any intrinsic or extrinsic muscle dysfunction probably explains this consideration. The injection of botulinum toxin injection into the PES has been introduced as a replacement for CPM.

2.1.6.9 Surgery for Chronic Aspiration

Surgery for chronic aspiration may involve tracheostomy, medialization, laryngeal suspension, laryngeal closure, and/or laryngotracheal separation-diversion.

A tracheostomy tube worsens dysphagia by tethering the trachea to the skin and decreasing laryngeal elevation over time. Medialization helps restore glottic closure and subglottic pressure during the swallow. With laryngeal suspension, the larynx is in a relatively protected position under the tongue base. Laryngeal closure may be performed to close the glottis off, in this way protecting the airway at the expense of phonation.

Laryngotracheal separation-diversion may be done to separate the airway from the alimentary tract. In the acute setting, when the need to decrease the aspiration of secretions is urgent, a tracheostomy is a simple and effective choice. However, in a chronic situation in which the patient has no likelihood of recovering a safe swallow and voice, laryngectomy is the most effective choice. In patients for whom recovery of voice and swallowing function is uncertain but aspiration of secretions is life threatening, temporary laryngeal closure by a diversion procedure can be used.

2.1.6.10 Other Maneuvers and Techniques

The Shaker exercise is a head lift designed to increase anterior movement of the hyolaryngeal complex and opening of the upper esophageal sphincter.

The Heimlich maneuver is used to dislodge food that the patient cannot cough out of the airway. The maneuver consists of wrapping one's arms

around the upper abdomen of the victim from behind and squeezing mightily and quickly in a brief, fervent hug.

Biofeedback can be useful for oral motor and facial exercises. The patient also receives feedback on the actual swallow.

Adaptive equipment for patients who have difficulty with the motor or perceptual components of feeding compensates for decreased upper extremity functions, accommodating limited grasp, incoordination, decreased ROM, and hemiparesis. Rocker knives, swivel utensils, built-up handles on utensils, scoop dishes, nonskid mats, and large-handled cups are examples.

Surgical placement of a gastrostomy tube requires a laparotomy under general or local anesthesia. This procedure is more expensive and is associated with greater morbidity than is PEG.

## 2.2 Expert Systems

### 2.2.1 Expert System Definition

An expert system is a computer program that represents and reasons with knowledge of some specialist subject with a view to solving problems or giving advice that human experts use to solve such problems (David B. & Charles J., 2003; David, 1988; Tuban E & Aron JE., 1998).

### 2.2.2 Expert System Concept

Expert systems have presented the three major components that appear in every expert system: the knowledge base, inference engine and user interface that show in Figure 2.1

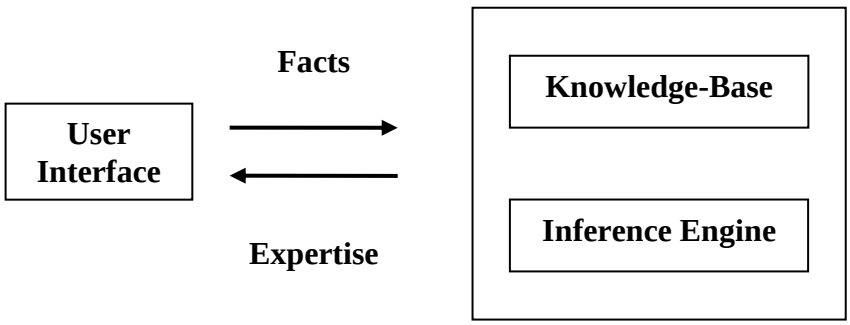


**Figure 2.1** Major components of expert systems

Development of an expert system had excluded knowledge-base from knowledge engineer. This system is expert system shell or expert system building tool that show in Figure 2.2

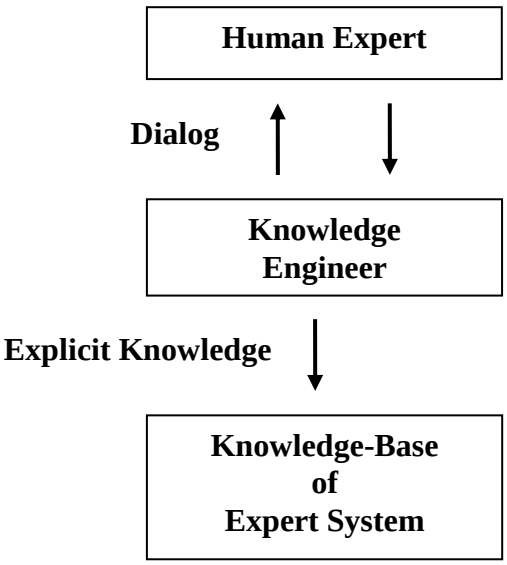


**Figure 2.2** Development of an Expert System

Expert system structure had many pattern of structure. Until, Feigenbaum and Mecorduek suggested the basic structure of expert system that is shown in Figure 2.3

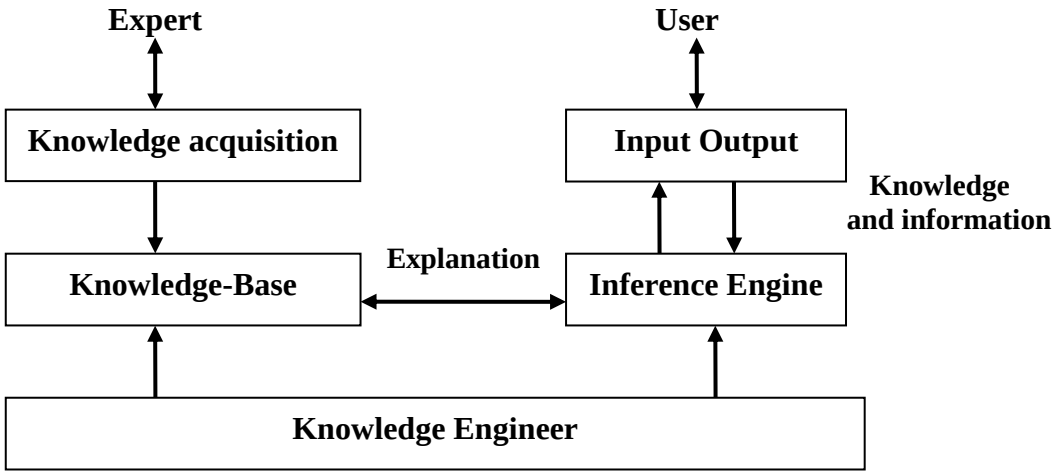


**Figure 2.3** Knowledge base

2.2.2.1 Knowledge Base

The knowledge base contains the knowledge necessary for understanding, formulating, and solving problems. It includes two basic elements: facts, such as the problem situation and theory of the problem areas; and special heuristics, or the rules that direct the use of knowledge to solve specific problems in a particular domain. The heuristics express the informal judgmental knowledge in an application area.

2.2.2.2 Inference Engine

The inference engine is the software system that locates knowledge and infers new knowledge from the base knowledge. The engine's inference paradigm is the search strategy that is used to develop required knowledge. Many different paradigms are used in an ES, but most are based on one of two fundamental concepts: *backward chaining*, which is a top-down reasoning process that starts from the desired goals and works backward toward requisite conditions, or *forward chaining*, which is a bottom-up reasoning process that starts with known conditions and works toward the desired goal.

2.2.2.3 User Interface

The user interface assists users in consulting the expert system, prompting them for information required to solve their problem, displaying the program’s conclusions and explaining its reasoning. Many contain a language processor.

### 2.2.3 Expert System Development Tools

The most common tools for building expert systems fall into two broad categories.

2.2.3.1 Programming languages for expert systems:

Almost every high level programming language and many lower languages have been used to develop AI and ES applications. The most common seems to be: LISP, Prolog, C/C++ followed by Java. The advantage is the flexibility of solving a wider variety of problems. However, they are difficult to apply for knowledge representation and inference engine designing.

2.2.3.2 Expert system shell:

A shell is an expert system without a knowledge base. A shell furnishes the ES developer with the inference engine, user interface, and the explanation and knowledge acquisition facilities. All of this makes it unnecessary to rebuild the components for each new expert system. Examples of shells are EXSYS, Level5 Object, INSIGHT, M.1 etc. The advantages of using ES shells to write expert system are that it generally greatly reduces the cost and time of development. Also, the level of programming skill needed to produce the finished system is much lower than it would be if the system was programmed from scratch using a language. The drawback is the flexibility problem. If the shell is a poor match for the type of knowledge in the domain concerned, it is liable to produce a system which simply does not correspond to the expertise of the original domain expert. Therefore, choosing a suitable ES shell to match the requirements of the problem is a very important step for develop an expert system.

## 2.3 Related Research

Expert systems have been implemented and used successfully in many areas of health care.

**(Kasemsumran, P., 2008):** An Expert System for Diagnosis of Respiratory Diseases is developed for help to diagnose respiratory diseases problems. The system has been developed by using Clips Shell expert which is the tool used for developing the system and works on Microsoft Windows operating system. The knowledge base is represented by using of production rules. Knowledge base contains 31 groups of respiratory diseases. A forward chaining method is applied as an inference engine mechanism for the searching solutions. The outcome of the study shows that the expert system is able to diagnose efficiently respiratory diseases problem. The system is able to support the user in finding the cause of such problem within the time frame close to when the activity is done by human being. It has proved that the well-developed expert system can provide good suggestions for user. Moreover, the system can be applied for training and knowledge review.

**(Lekcharoen, K., 2001):** An expert system for causality assessment of adverse events: drug-induced acute liver injuries (CADIALI-expert) were developed by using a high-level programming language, Microsoft Visual Basic 6.0 enterprise edition and Microsoft Access 97 as a database management system. The knowledge representation model uses production rules and frames. There are 144 rules and 800 items of drug data in the drug knowledge base. Knowledge, which is represented by frames, can be updated by the user. The inference strategy uses forward chaining in searching for the causality assessment result of suspected drugs. The explanation of reasons used to produce the answer is displayed to users at the end of each step of assessment. CADIALI-expert was validated by drugs of 14 case reports of drug-induced liver injuries that were collected from medical journals. CADIALI-expert limitation was due to the inability to assess the course of the reaction of some cases that required more liver function tests data at the stop date of the drug.

**(Sriprapaipongshal, S., 1997):** An expert system in First Aids is developed for helping the first aid human expert and giving the knowledge about first aids to novice users. The system was implemented by using an expert system shell known as LEVEL5. The knowledge was elicited by the interviewing of real experts and extraction from textbooks. Production rules were used as the knowledge representation technique. The inference mechanisms are forward and backward chaining. The limitation of system is that knowledge is not updateable and unable to dealing with uncertainty. The developer solving the limitation of the shell that has no explanation and justification by adding dynamic knowledge base of explanation and reason of the results into the expert system

**(Pruetleelar, K., 1994):** Toxic Plant Expert System (TPEX) is developed to assist doctors, pharmacists, nurses and paramedical personnel in diagnosis and treatment of the toxic symptoms of poisonous plants. The knowledge base is represented by using of production rules. Knowledge base contains 30 groups of 94 poisonous plants commonly found in Thailand providing 202 rules and 417 facts. A backward chaining method is applied as an inference engine mechanism for the searching solutions. TPEX is developed by a high-level programming language, Visual Prolog 4.0 professional version. The expert system works on Microsoft Windows operating system. TPEX needs more development such as knowledge acquisition facility, diagnosis results of old case, printing result and needs more verification before implementing in hospital, clinic, and health stations.

# CHAPTER III
# RESEARCH METHODOLOGY

This chapter shows about details of research methodology for each step and including tools of research.

## 3.1 Step of Research Methodology

In this research, the steps and research methodology was based on the Expert System Development Life Cycle: ESDLC (Liebowitz J, 1998) that consists of the following steps: shown in Figure 3.1

### 3.1.1 Collect Related Information

In this step, related information will be collected from generate research document. Information collected includes.

- Swallowing problems after stroke (Dysphagia)
- Expert System
- Related Research

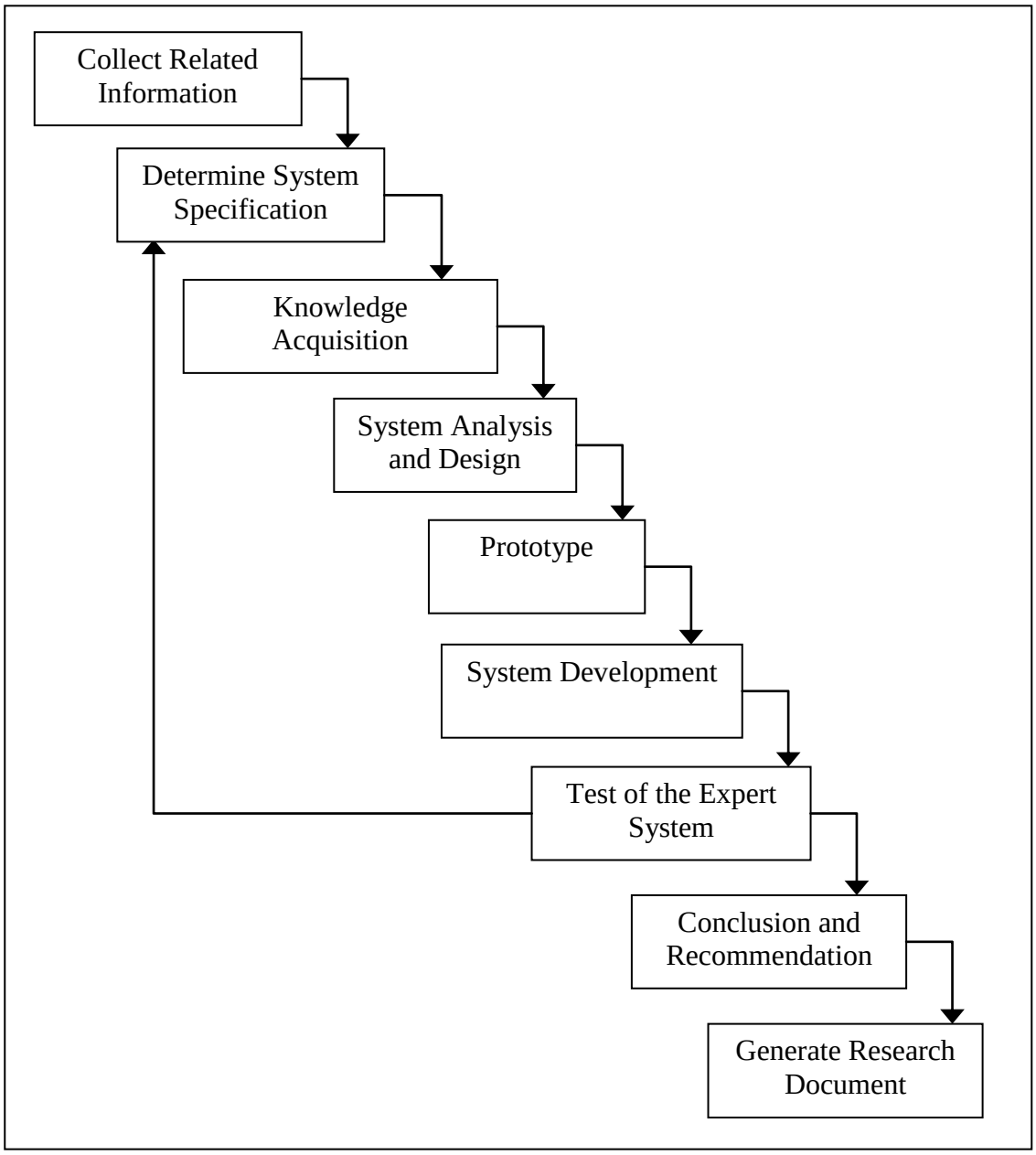


**Figure 3.1** Steps and research methodology

### 3.1.2 Determine the Expert System Specifications

Specification of expert system for swallowing disorders screening are classified into operations as follow:

3.1.2.1 Input Module of Swallowing screening

Get the information of patient's assessment and symptoms from user for screening. There are two parts in the input module for the swallowing screening as the following:

1) Pre-swallowing screening

1.1) Clinical assessment

These assessment forms patients clinical observe in 48 hours are presented as follow:

- Vital sign assessment data such as T (Body temperature), P (Pulse), RR (Respiratory), BP (Blood pressure).

1.2) Neurologic assessment: Record change of Level of consciousness using Glasgow Coma Scale (GCS) which record the score of eye opening, verbal response and motor response.

2) Swallowing assessment

This assessment form consisted of items to assess:

- The ability to control the head in an upright position
- The ability to follow two steps command
- The ability to lip closure, tongue movement and present gag reflex
- To coughing sharply on command
- The ability to have some control of their own saliva
- Water swallowing test

3.1.2.2 Results Module

The module show the results of problem and some advices management put into the expert system.

3.1.2.3 General knowledge Module

This module contains general knowledge of swallowing disorder that helps the user to search information of swallowing disorder management.

### 3.1.3 Knowledge Acquisition

This step involves the acquisition of knowledge about swallowing disorder screening and management from both experts and documents. This includes gathering of relevant resources.

### 3.1.4 Analyze and Design the System

3.1.4.1 Knowledge Base

In this research, the knowledge of swallowing screening will be reformed by flow diagram and then represent them in Ruled-Base System (IF-THEN Rules or Production Rules) as knowledge representation.

3.1.4.2 Inference Engine

In this step, the inference mechanism is analyzed and designed to search the created knowledge for solving the problem. The structure of inference engine is dependent of the knowledge base. This research will use backward chaining in searching result.

3.1.4.3 User Interface

This step is to design a user interface information input module, expert system advising module, and explanation feature to provide the means of communication between a user wishing to solve a problem and the application.

### 3.1.5 Prototype

This step, a small-scale system was created to represent the knowledge captured in a manner that allows a user to understand the rules of inference. The major component of expert system was created on the rudimentary basis.

### 3.1.6 System Development

In this step, the knowledge base, inference engine, user interface, and modules of system will be developed by Microsoft Visual Basic.NET 2005.

### 3.1.7 Testing an Expert System

There are two part of testing as the following:

3.1.7.1 System Verification

Bottom-up testing is used for test the working of the functions and sub functions in the system. When an error occurs, it will be corrected before going to the next step. Verification is composed of a unit test and an integration test.

3.1.7.2 System Validation

The testing in this step is following into two parts:

- System Result Testing

This testing is occurred when the system is finished. Swallowing disorder and management the expected results were defined. The prepared data will be entered into the system. Results from the system will be validated by comparing them with the expected results that have been prepared earlier. If both prepared results and system results are not similar, the system will be modified.

- System Evaluation

It will be tested by human experts and general users have tested the system. Clinical data of the tested cases were provided to the testers in order to use the system. After that, the testers will fill in a questionnaire after they have tested the system.

### 3.1.8 Conclusion and Recommendation

Both of system implementation and testing were finally concluded. Recommendations for further study will be given.

### 3.1.9 Generate Research Document

Finally step, generating a complete research documents and include the result of program testing.

## 3.2 Research Tools

This step is about the research tool. There are three parts as the following:

### 3.2.1 Hardware

Microcomputer

| | | |
|---|---|---|
| CPU | : | Intel Pentium Compatible |
| RAM | : | 512 MB or more |
| Hard Disk | : | at least 100 MB |

| | | |
|---|---|---|
| Monitor | : | Super VGA Monitor or better |
| Peripherals | : | Keyboard, Mouse, Printer |

### 3.2.2 Software

| | | |
|---|---|---|
| Operating system | : | Microsoft Windows XP |
| Application tools | : | Microsoft Visual Basic.NET 2005, Microsoft Access 2007 |
| Documentation | : | Microsoft Word 2007 |
| Other tools | : | Microsoft Excel 2007, Ulead Video Studio11, Paint |

### 3.2.2 Questionnaire

The questionnaire is used to evaluate the system after the users have tasted the system.

# CHAPTER IV
# RESULTS

This chapter will describe the results of this research. The development issues of an expert system include system analysis and design, user interfaces and system prototype as well as system testing and evaluation will also be presented.

## 4.1 Analysis and Design Knowledge Base

The knowledge of swallowing screening to acquired from both human experts and documents. This knowledge will be reformulated to the flow diagram and then represented in production rules (If-then rules). The diagnosis diagram that show in Appendix A.

According to acquired data, the step for swallowing screening are shown in Figure 4.1

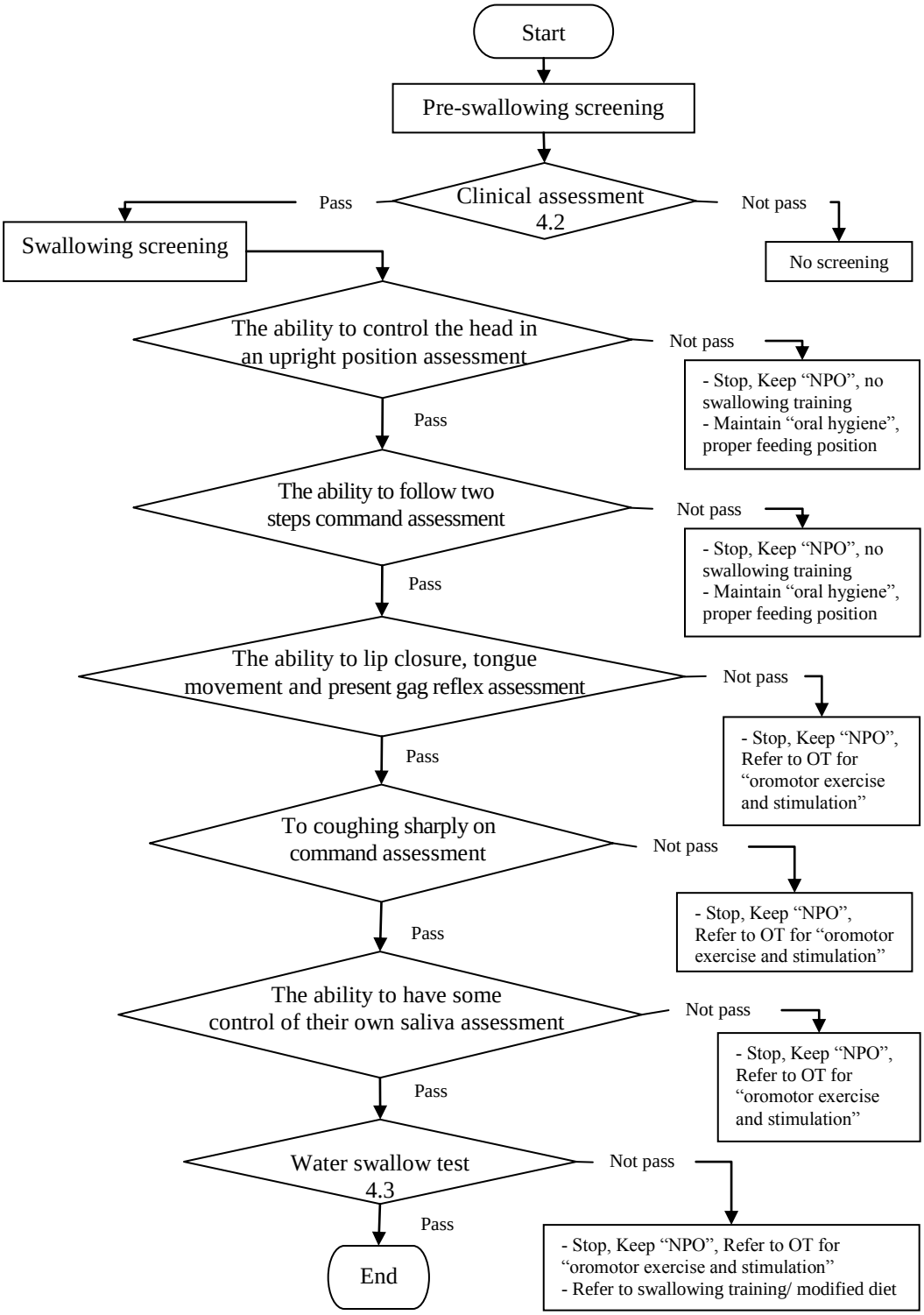


**Figure 4.1** Step of Swallowing screening

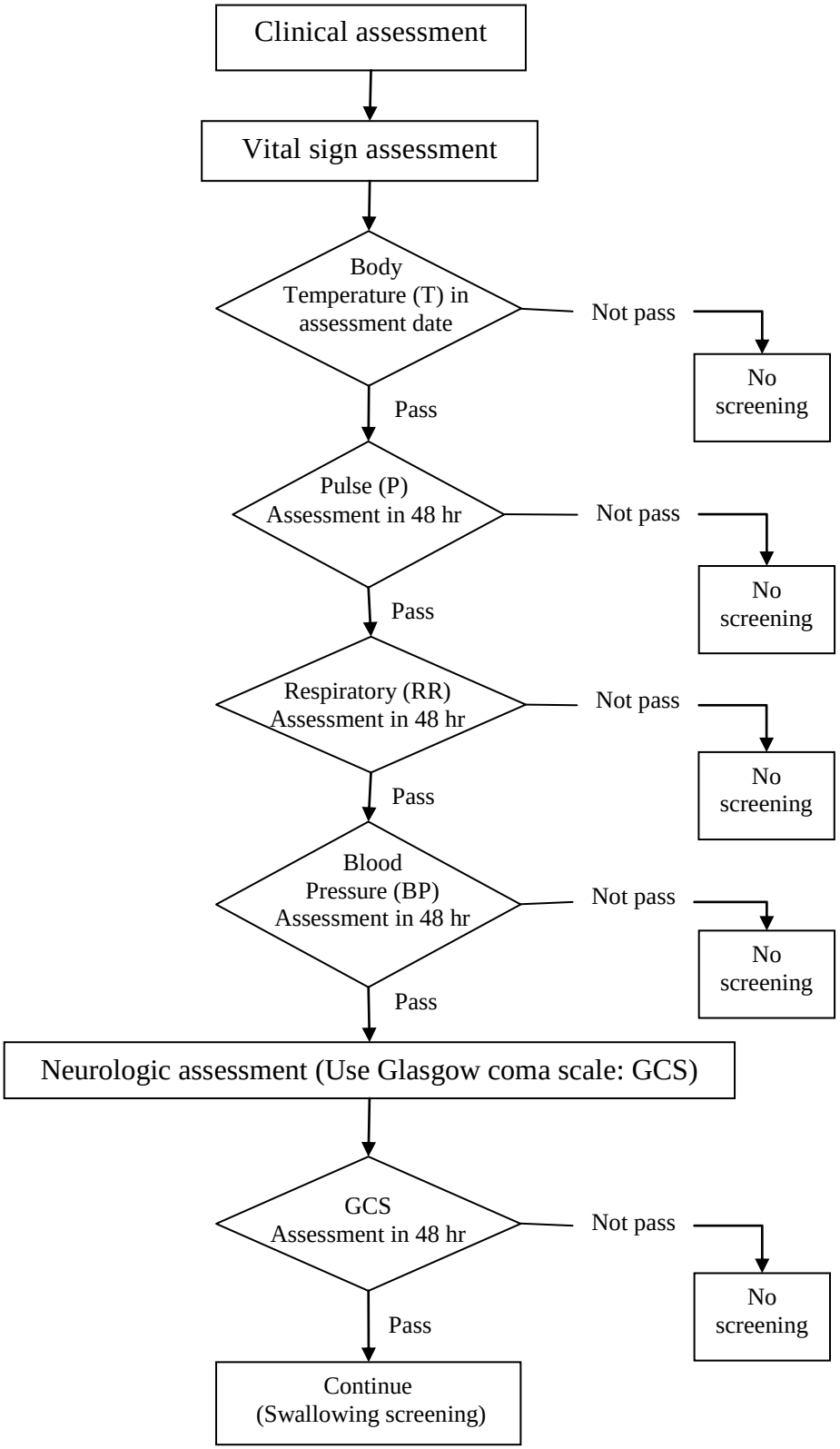


**Figure 4.2** Steps for Clinical assessment of Pre-swallowing screening

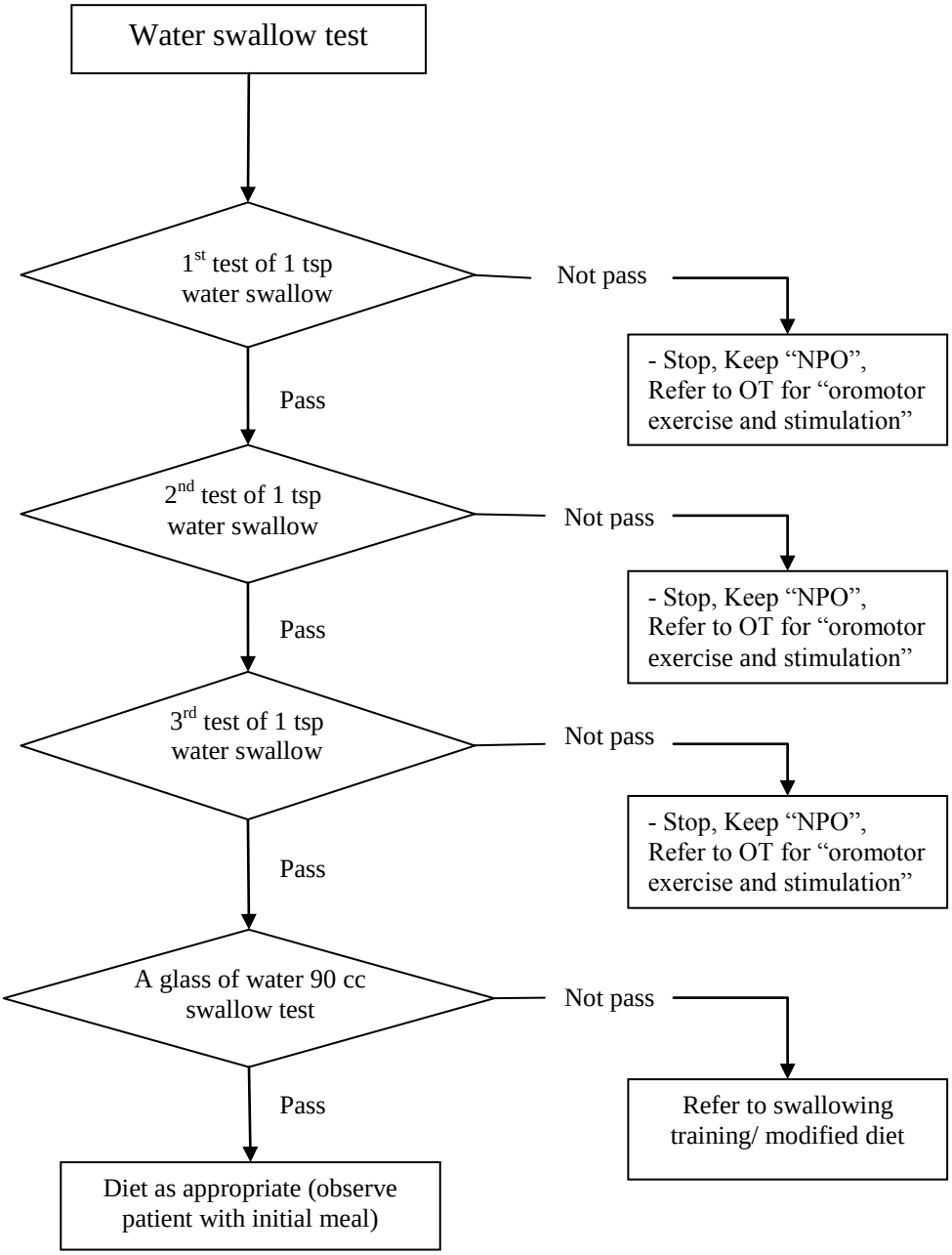


**Figure 4.3** Steps for Water swallow test of Swallowing screening

Rules for swallowing screening are creating form flow diagram. For example, flow diagram of Body temperature (T) in assessment date assessment can follow by Figure 4.4 (see in Thai version in appendix A).

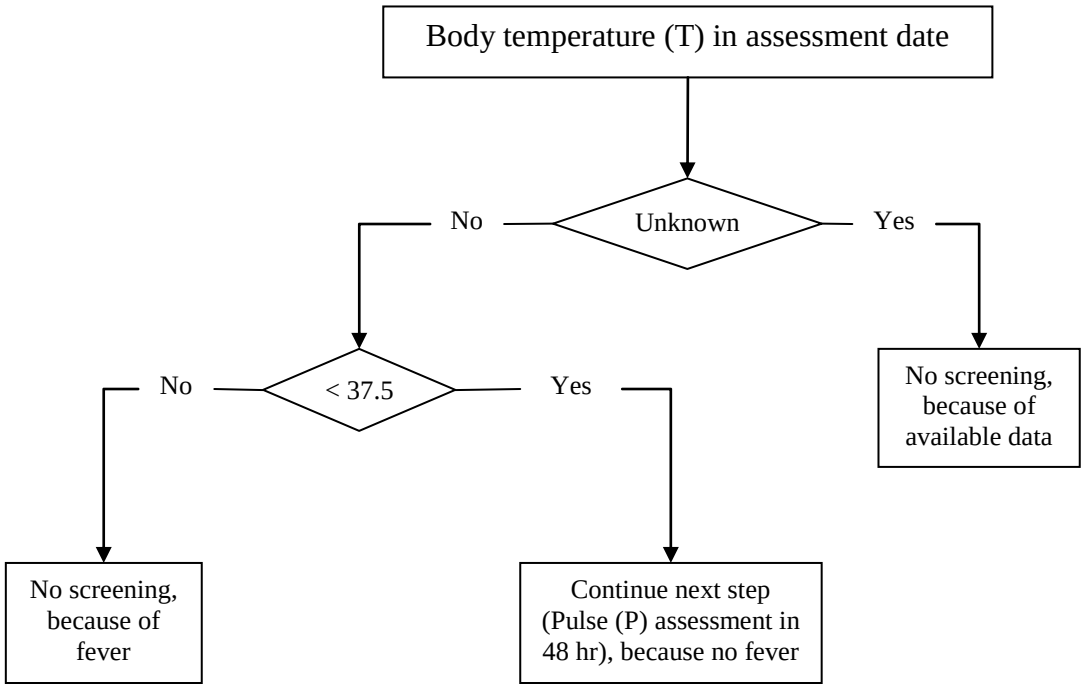


**Figure 4.4** Flow diagram for Body temperature (T) in assessment date assessment of Clinical assessment

Examples of rules from the flow diagram are shown in Table 4.1.

**Table 4.1** Rules for swallowing screening

| RULE | ASSESSMENT | RESULTS | SUMMARY |
|---|---|---|---|
| 1 | Body temperature (T) in assessment date | - If "Unknown"<br>- If "< 37.5$^{o}$C"<br>- If "≥37.5$^{o}$C" | - No screening, because of available data<br>- Go to 2$^{nd}$ rule<br>- No screening, because of fever |
| 2 | Pulse assessment in 48 hr Pulse (P) | - If "Unknown"<br>- If "pulse in yesterday and in assessment date <60"<br>- If "pulse in yesterday <60 and in assessment date =60-100" | - No screening, because of available data<br>- No screening, because of low pulse<br>- No screening, because of unstable pulse |
| ⋮ | ⋮ | ⋮ | ⋮ |

## 4.2 Analysis and Design Inference Engine

In this research, backward chaining is used as the inference mechanism. The process begins with a known goal or outcome and searches backward for the rule or facts that will achieve that goal. For example, in body temperature in assessment date assessment, the goal of this step is to find out if body temperature the patient has fever or not. The expert system will inference all related rules in knowledge base that satisfied the goal. After inferencing the expert system will know that all related rules are depending on the values of body temperature and normal range of body temperature of the patient. The system will ask the user for required data. If the data input to expert system can make all related rules to be true, the goal is proved to be true. The system will consider next goal and do the some process as the above to find suitable goal to answer for the user. If that goal is proved false, the system will answer the user and also give are explanation.

## 4.3 Analysis and Design User Interface

The user interface design phase focused on user's comfort in using and easy to understand the output. Expert system consists of three main functional parts such as Swallowing screening, User manual and General Knowledge. The main screen as shown in Figure 4.5

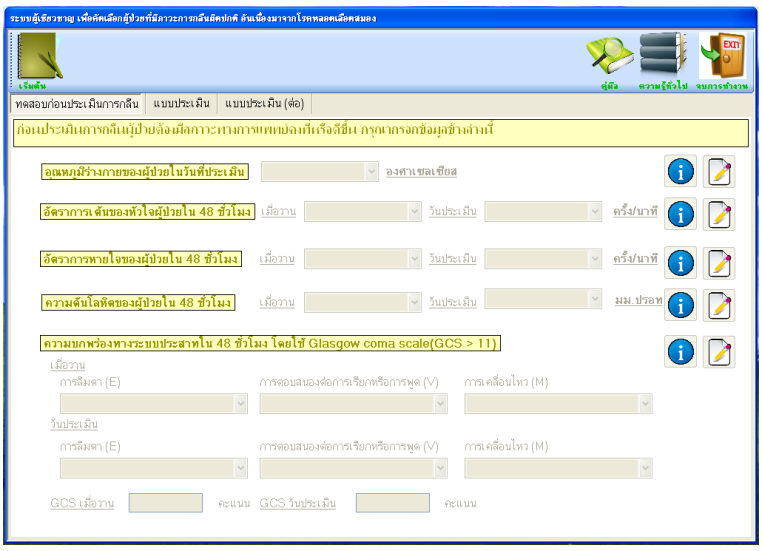


**Figure 4.5** Main screen

### 4.3.1 Swallowing screening Model

This is a main part of the expert system to screen swallowing disorder from stroke. In this model, the user can answer the question by selection the answer that has the same criteria or symptoms as user's patient. Swallowing screening Model are shown in Figure 4.6

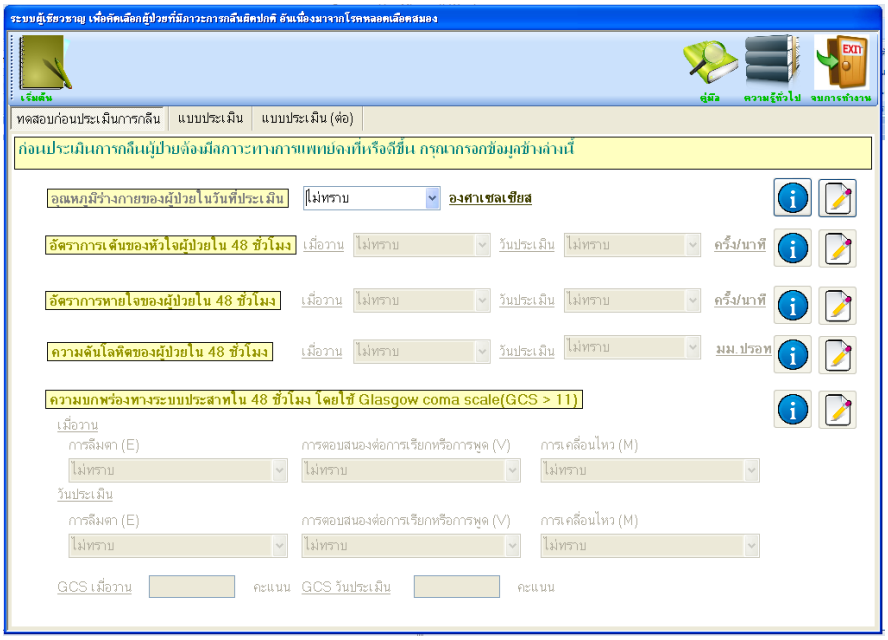


**Figure 4.6** Swallowing screening Model

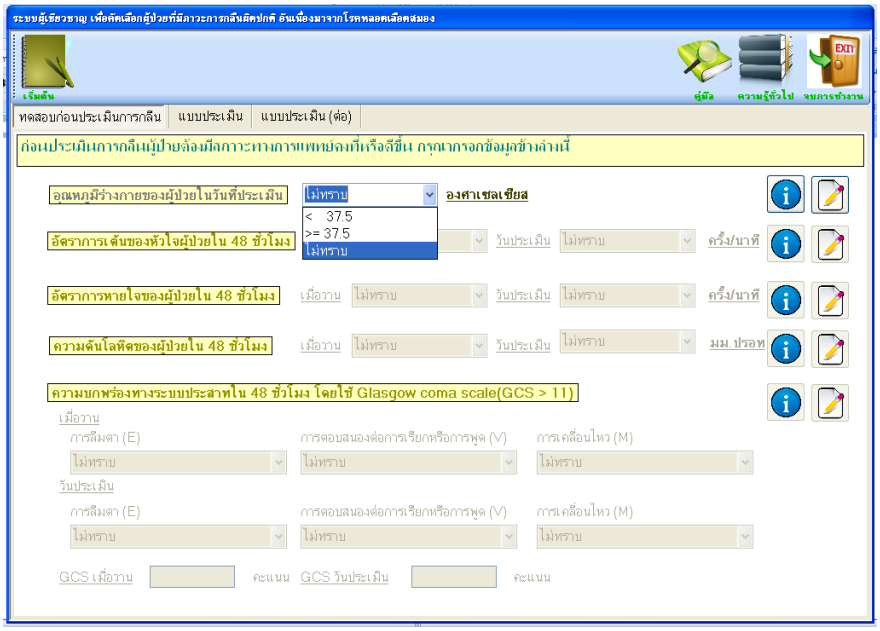


**Figure 4.7** Add patient's body temperature in assessment date (Step I)

After the user replied the previous assessment questions then click the assessment evaluate button. The system will display the swallowing assessment result and advice management. Screen of the swallowing assessment result are shown in Figure 4.8 – 4.9.

The user can go back to Swallowing screening by click close or exit button.

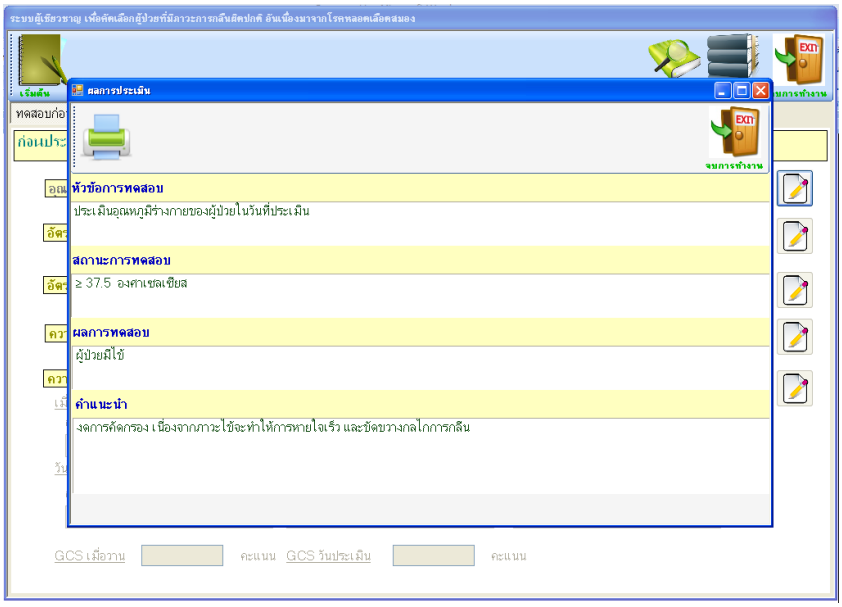


**Figure 4.8** Screen of the swallowing assessment result (Step II)

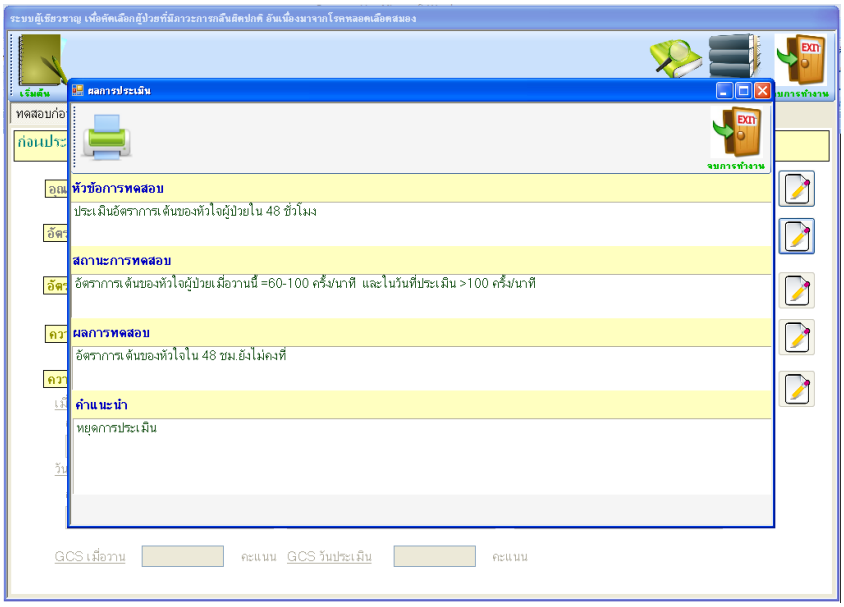


**Figure 4.9** Screen of the swallowing assessment result (Step II) (cont.)

Screen of the swallowing assessment result. The user can choose to print report that is a summary of the swallowing assessment result by click the print button. The system will display print layout of the swallowing assessment result are shown in Figure 4.10.

The user can go back to Swallowing screening by click close button.

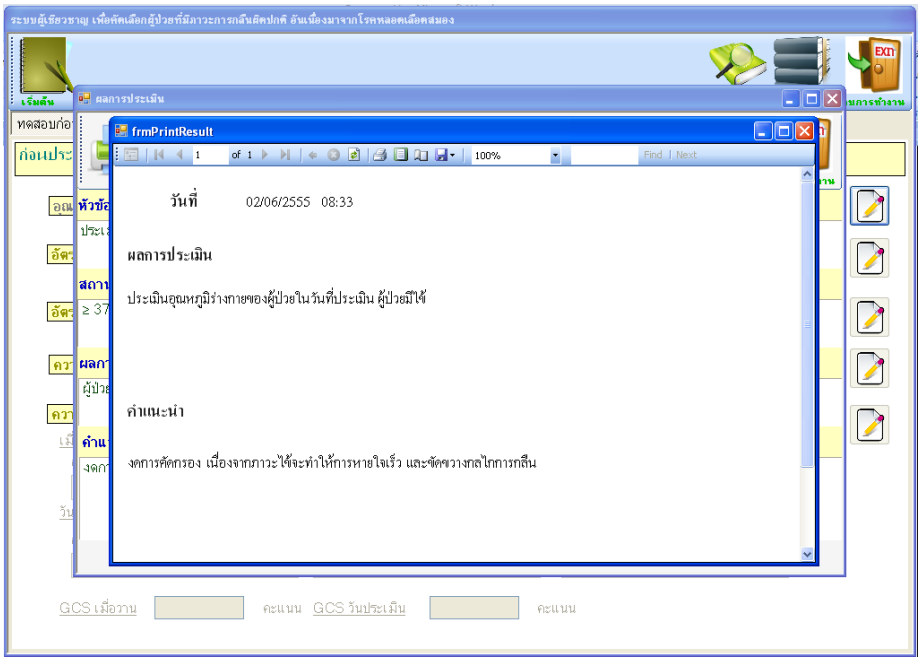


**Figure 4.10** Screen of print layout of results assessment

In Swallowing screening, the system will consider next step of Swallowing screening. If the data input to expert system can make all related rules to be true. The step of Swallowing screening are shown in Figure 4.11 – 4.19.

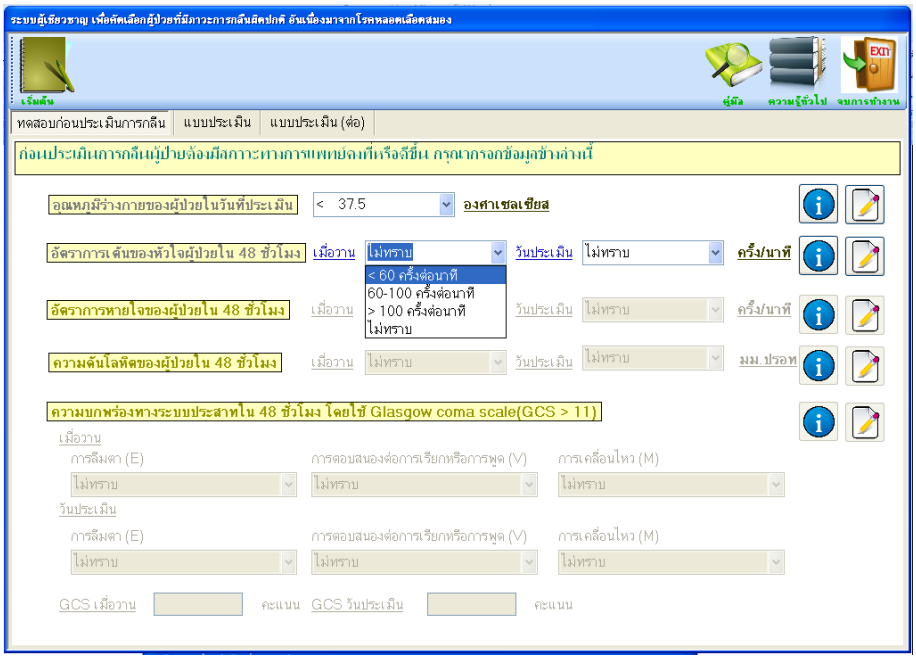


**Figure 4.11** Screen of pulse assessment in 48 hr

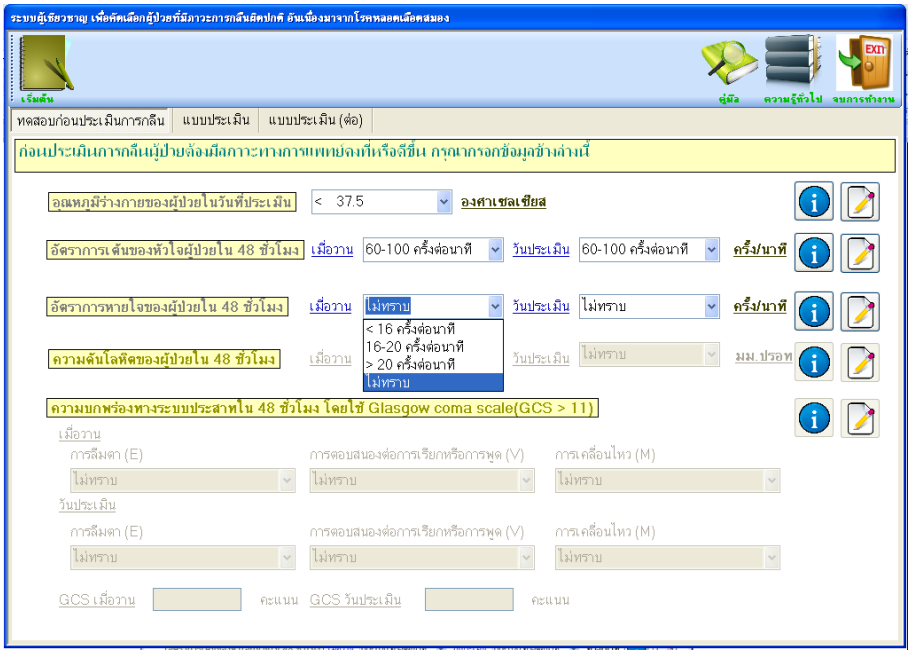


**Figure 4.12** Screen of respiratory pulse assessment in 48 hr

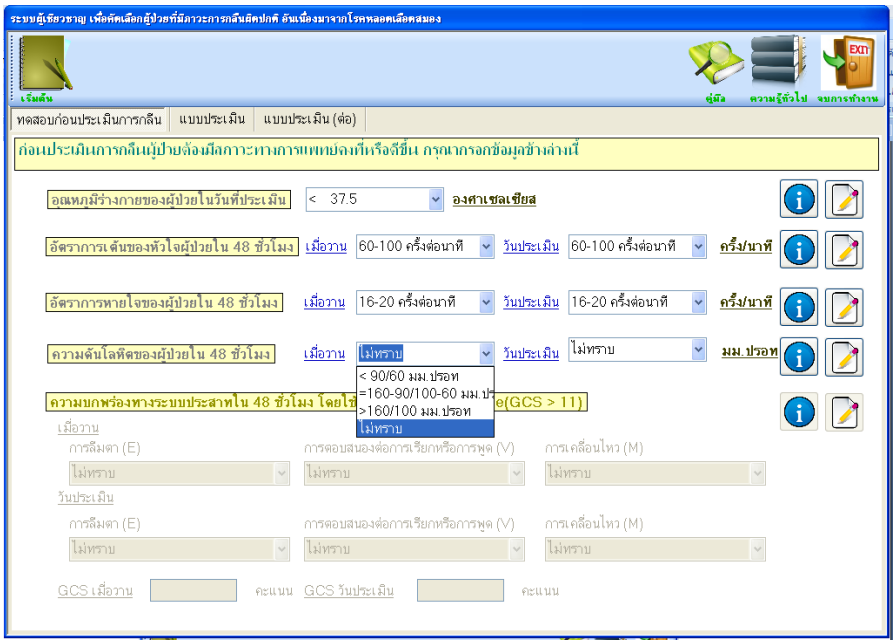


**Figure 4.13** Screen of blood pressure assessment in 48 hr

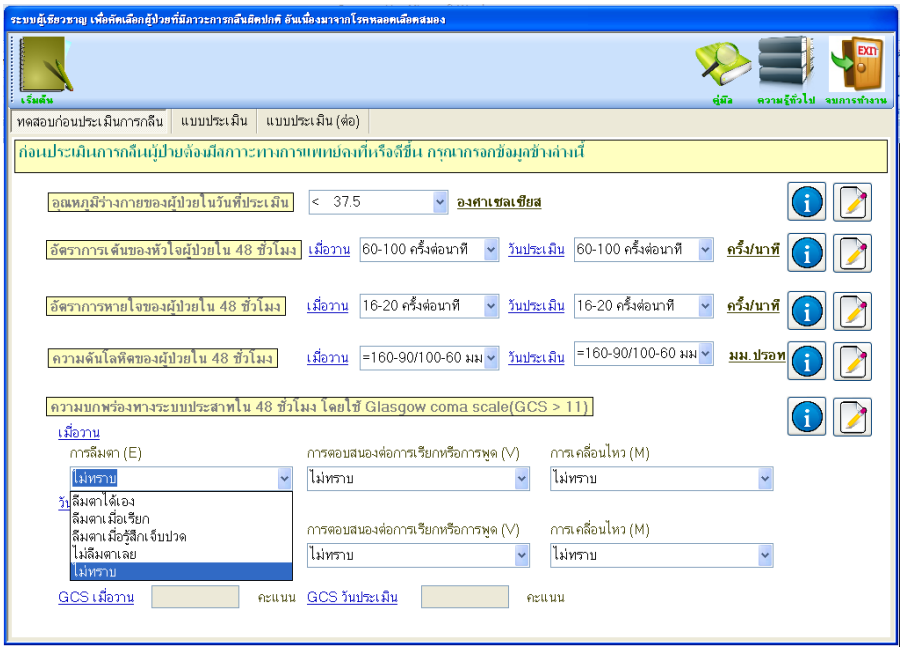


**Figure 4.14** Screen of GCS assessment in 48 hr (Step I)

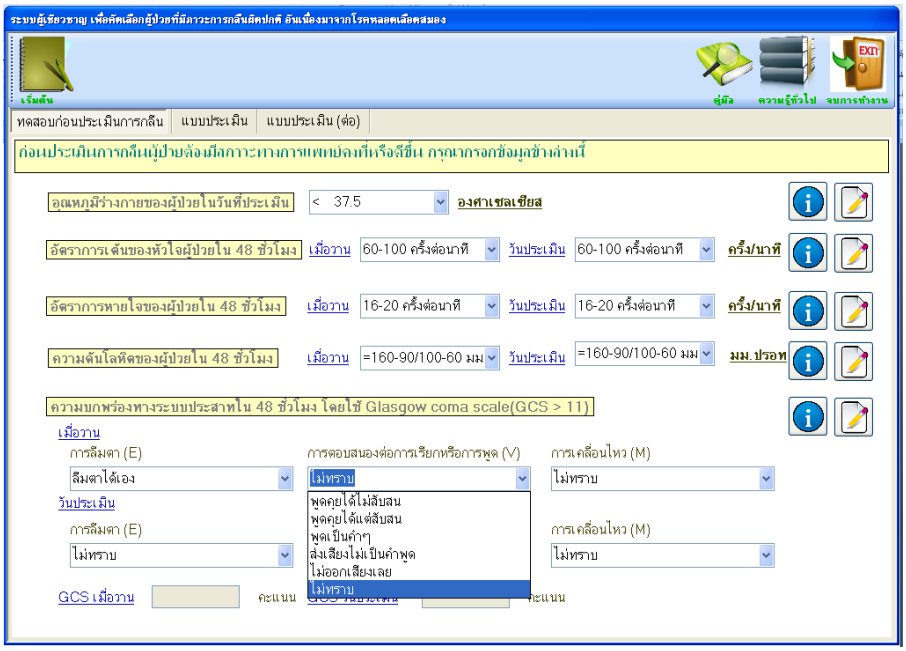


**Figure 4.15** Screen of GCS assessment in 48 hr (Step II)

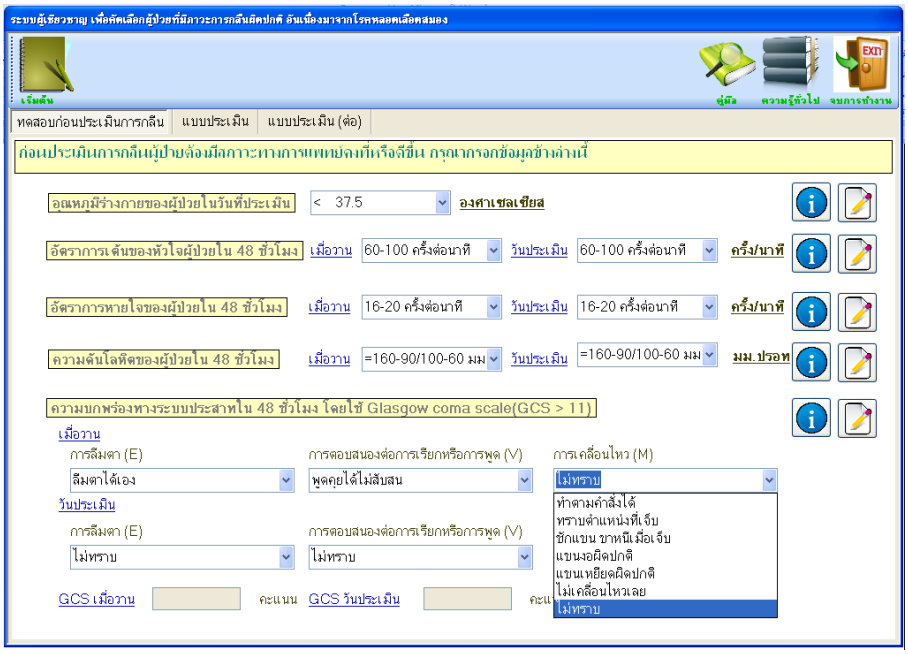


**Figure 4.16** Screen of GCS assessment in 48 hr (Step III)

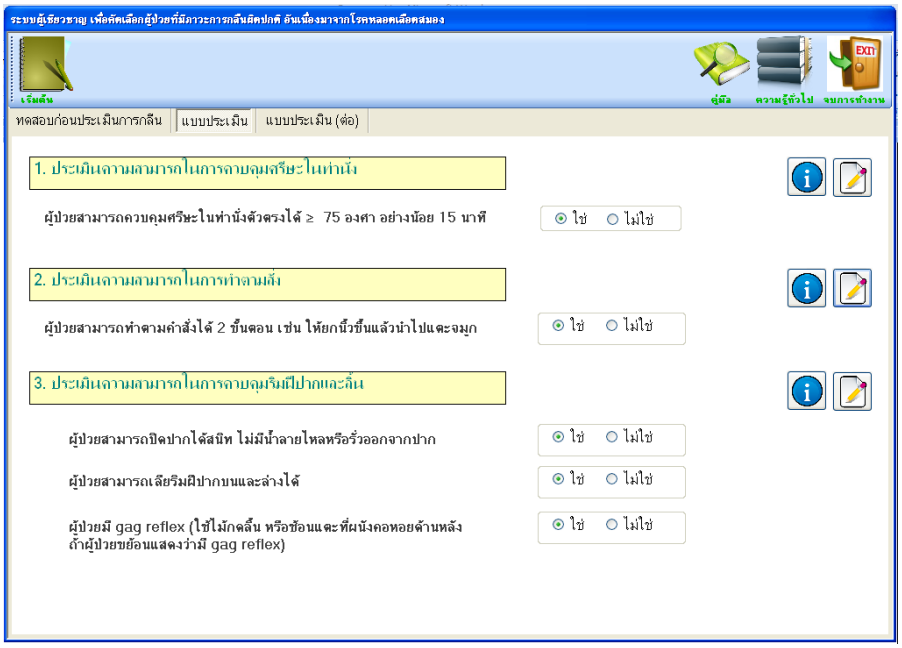


**Figure 4.17** Screen of Swallowing assessment

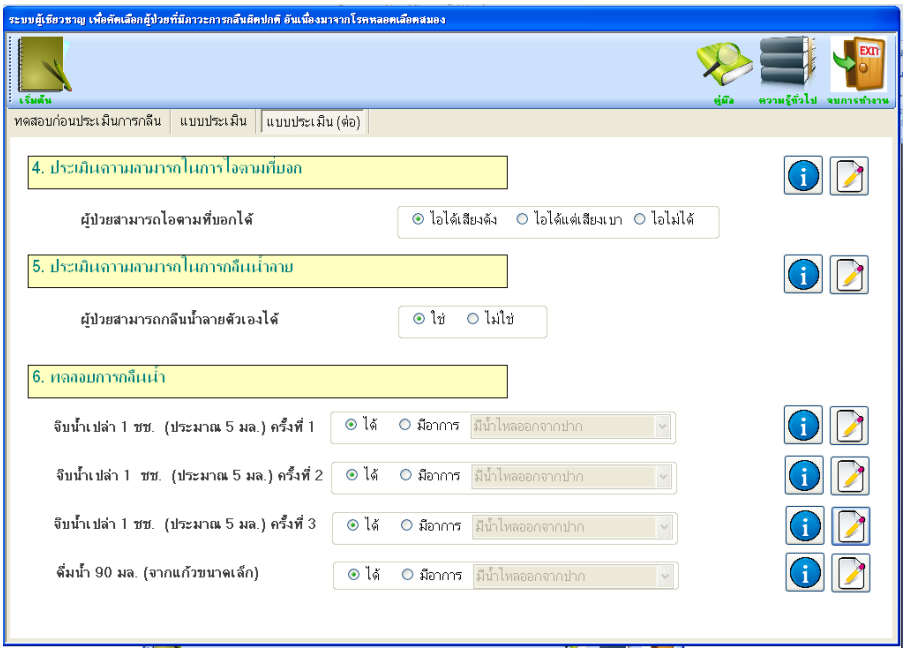


**Figure 4.18** Screen of Swallowing assessment (cont.)

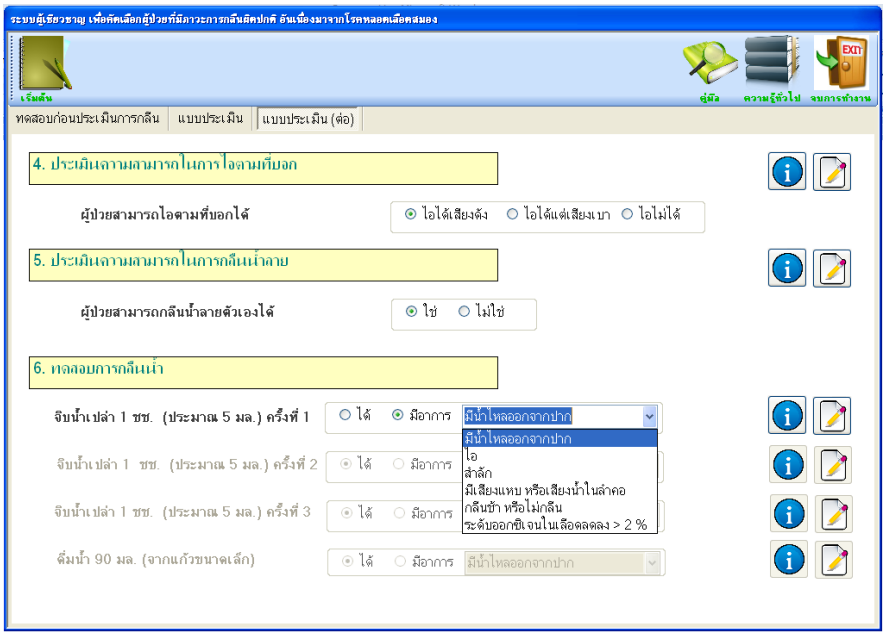


**Figure 4.19** Screen of Water swallow test

In screen of swallowing assessment, it has the button for explain of assessment information. The user can choose the button of swallowing assessment information. The system will display information are shown in Figure 4.20 - 4.21.

The user can go back to Swallowing screening by click close or exit button.

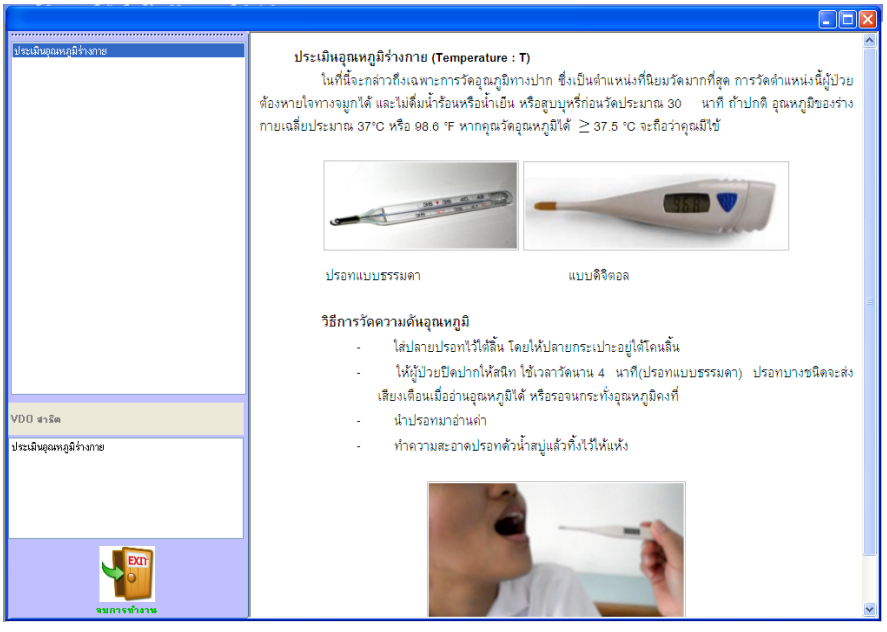


**Figure 4.20** Screen for explain of assessment information

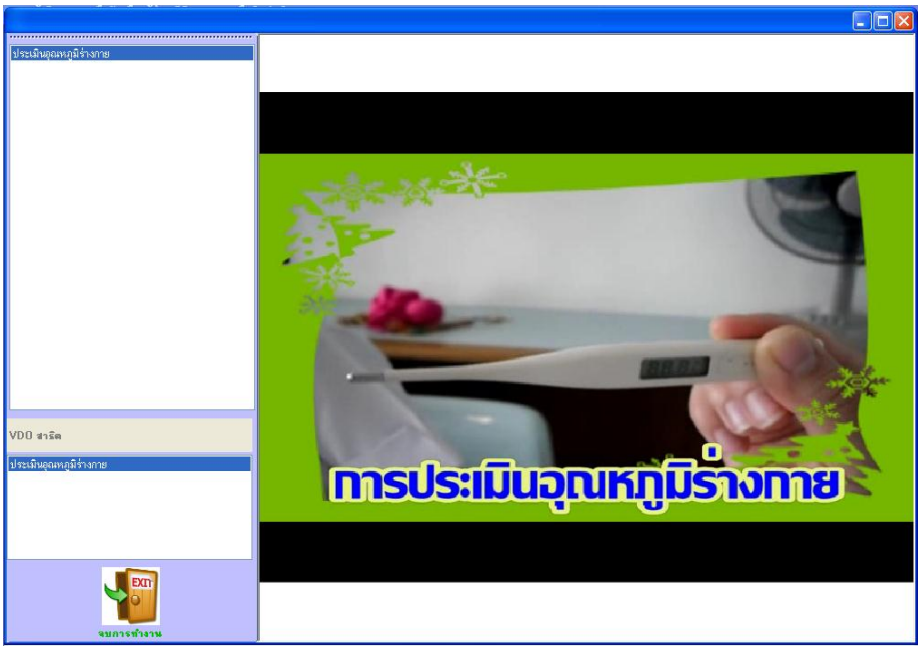


**Figure 4.21** Screen for explain of assessment information by video demonstration

### 4.3.2 User manual Model

This module helps the user use the expert system. The User manual screen was show in Figure 4.22

The user can go back to Main menu screen by click close or exit button.

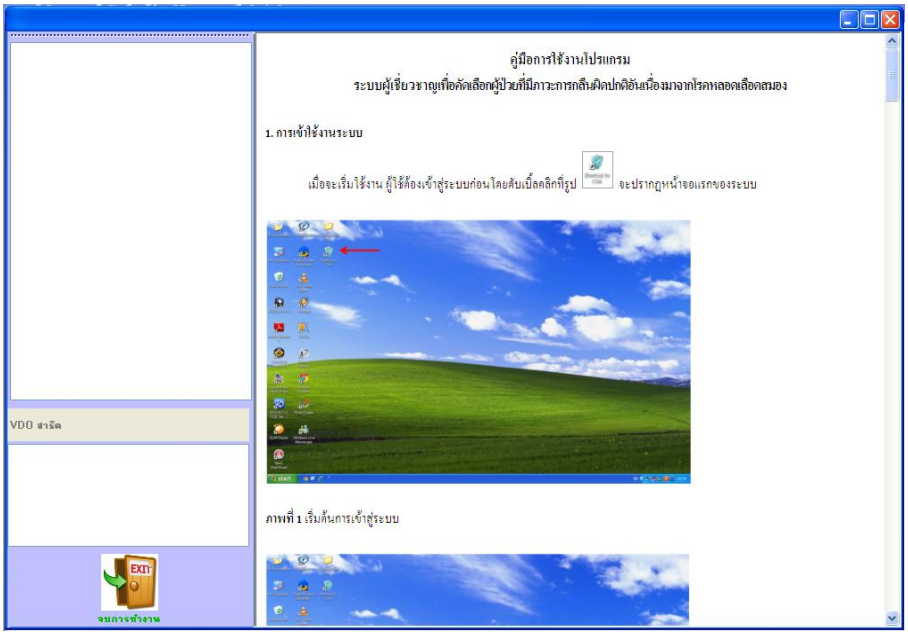


**Figure 4.22** Screen of User manual

### 4.3.3 General knowledge Model

This module contains general knowledge of swallowing disorder that helps the user to search information of swallowing disorder management. It has 13 items swallowing disorder knowledge: general knowledge of swallowing disorder (definition, symptom, cause, and treatment), oral hygiene care, oromoter stimulation and oromoter exercise, etc. Screen of this model is divided into two parts. The first one is chosen the list of items swallowing disorder knowledge will present in top of the left-hand side. The second is the lists of video demonstrate in below of the left-hand side. After select items in the list the knowledge will display in the right-hand side as shown in Figure 4.23 - 4.27.

The user can go back to Main menu screen by click close or exit button.

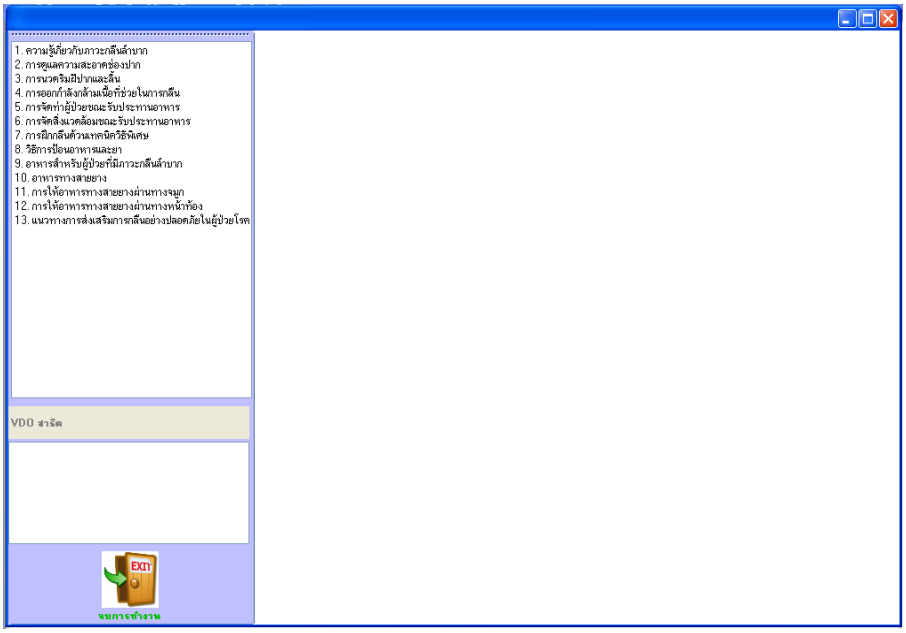


**Figure 4.23** Main screen of general knowledge of swallowing disorder

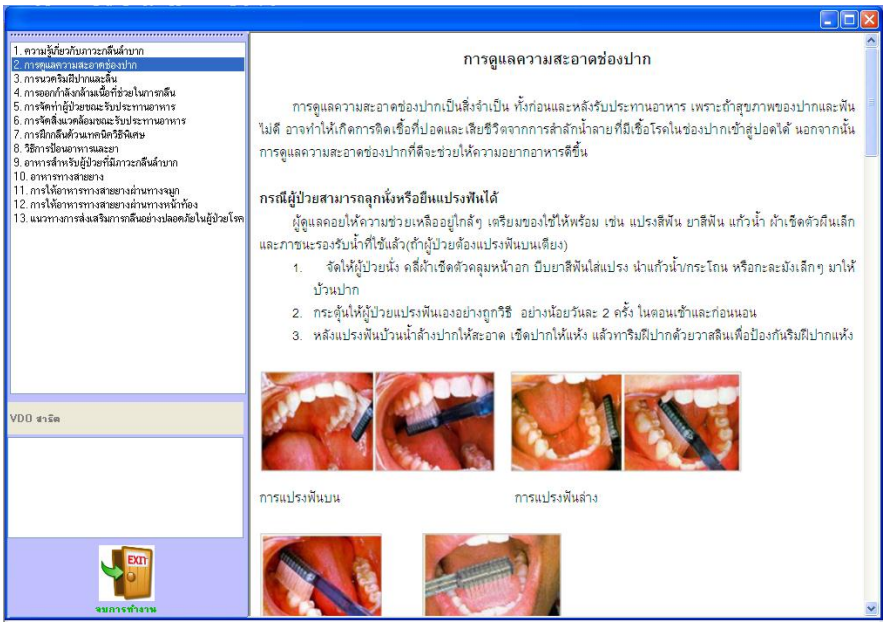


**Figure 4.24** Screen of knowledge of oral hygiene care

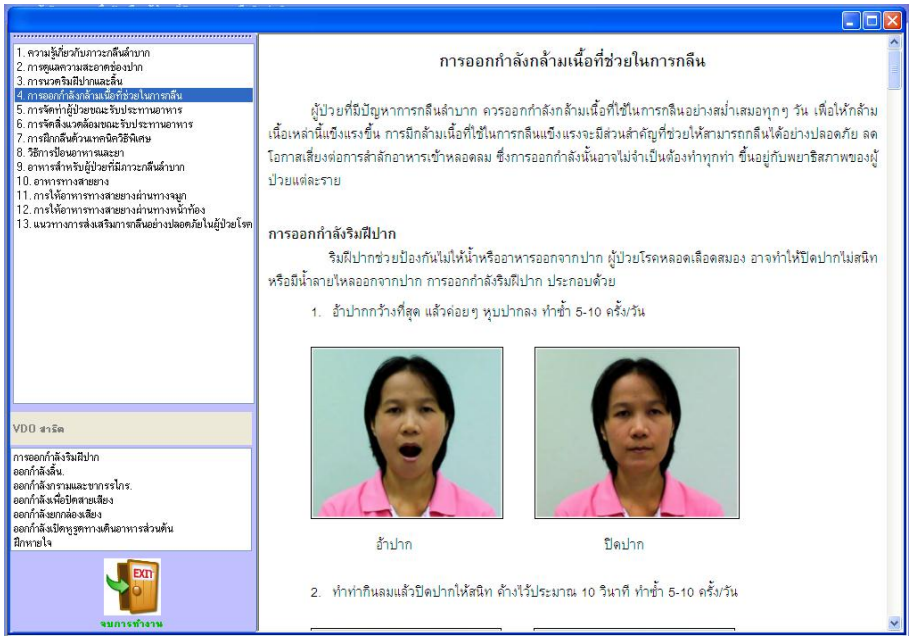


**Figure 4.25** Screen of knowledge of oromoter exercise

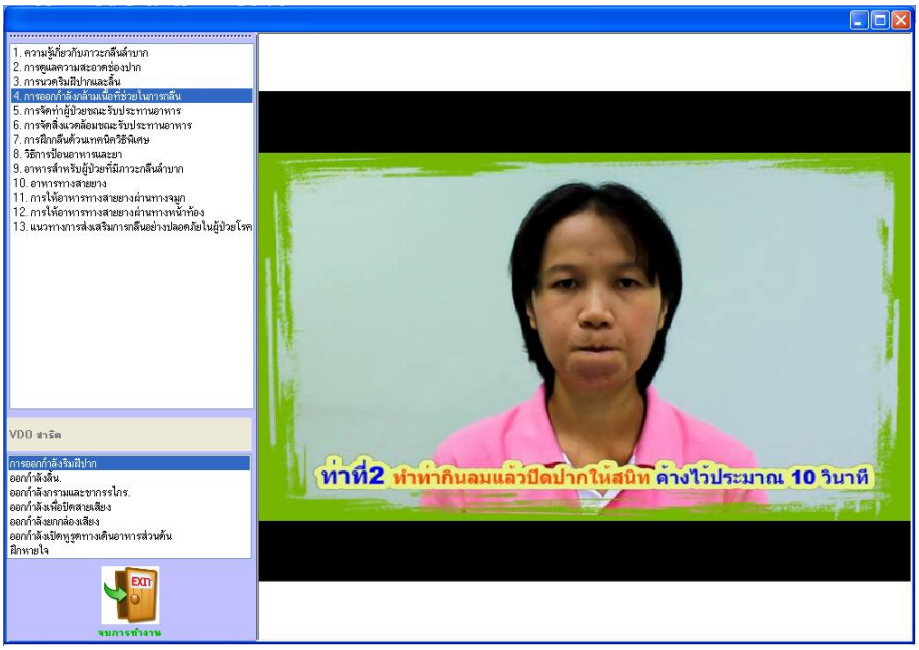


**Figure 4.26** Screen of video demonstration of oromoter exercise

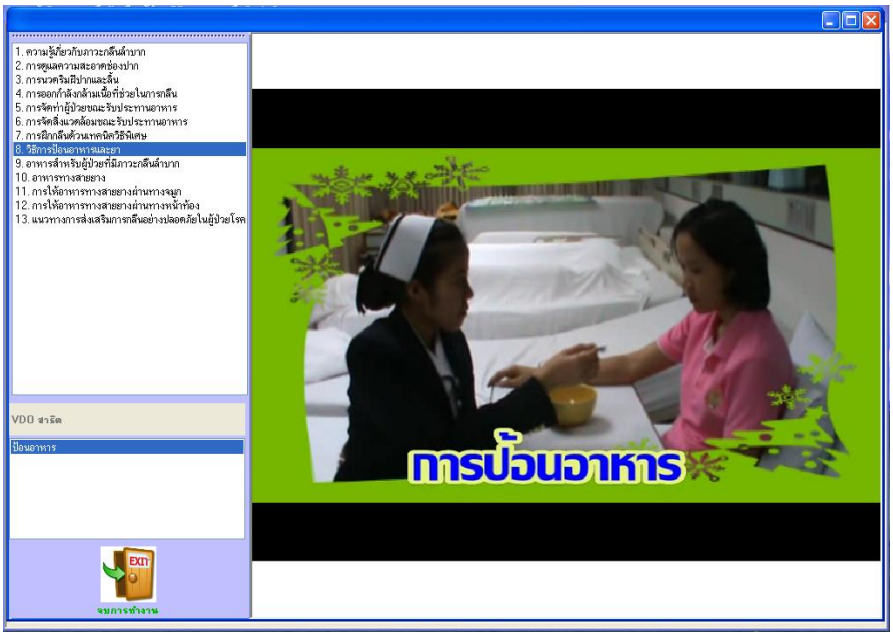


**Figure 4.27** Screen of video demonstration of feeding technique

## 4.4 Result of Testing Expert System

### 4.4.1 System Verification

Bottom-up testing is used for testing effectiveness of each function and sub function in the system. After identified, all errors are corrected.

### 4.4.2 System result testing

After the expert system has been operated as designed, samples of patient as the test cases are being tested. The result is that the program can work as efficiently, quickly and accuracy as it has done before.

### 4.4.3 System evaluation

The system was tested by group of nurses in Siriraj Hospital. They were use the system to swallowing screening of the test cases. After that, the testers will fill in a questionnaire after they have tested the system (see the example questionnaire in the Appendix D). Finally, the developer considers the results of testing, and then rectifies the defects according to the user recommendation to improve the efficiency and effectiveness of the system.

The testers are divided in to two groups as the following:

Group 1: the nurses in Chalermphrakiet $11^{th}$ ward who have knowledge of stroke disease and swallowing disorder 10 persons (Expert users)

Group 2: the nurses in other ward 10 persons (General users)

**Table 4.2** The decoding criteria value for evaluation

| Domain Value | Meaning |
|---|---|
| 4.50-5.00 | Satisfaction with the system is Excellent |
| 3.50-4.49 | Satisfaction with the system is Good |
| 2.50-3.49 | Satisfaction with the system is Medium |
| 1.50-2.49 | Satisfaction with the system is Fair |
| 1.00-1.49 | Satisfaction with the system is Poor |

The evaluation of the expert system is divided in to four parts as the following:

- System response
- User interface
- Data processing
- User manual

The result of the system evaluation by Group 1 is shown in Table 4.3 – 4.6 and can be summarized as below.

**Table 4.3** Evaluation result of system response from expert users

| Assessment Topics | Mean | Satisfied Values |
|---|---|---|
| - Rapidness of response time | 4.80 | Excellent |
| - Correctness of information on demand | 4.80 | Excellent |
| - Convenience and rapidness of screen presentation | 4.70 | Excellent |
| - Convenience and rapidness of search equipment data | 4.80 | Excellent |
| Total | 4.78 | Excellent |

**Table 4.4** Evaluation result of user interface from expert users

| Assessment Topics | Mean | Satisfied Values |
|---|---|---|
| - Format of screen presentation are easy | 4.80 | Excellent |
| - Appropriate menu position/buttons of screen presentation | 4.70 | Excellent |
| - Correctness of information | 4.90 | Excellent |
| - Clearness of document presentation | 4.90 | Excellent |
| - Appropriate of overall system | 4.80 | Excellent |
| Total | 4.82 | Excellent |

**Table 4.5** Evaluation result of data processing from expert users

| Assessment Topics | Mean | Satisfied Values |
|---|---|---|
| - Rapidness of processing | 4.70 | Excellent |
| - Consistency of processing in swallowing assessment when compared to the experts | 4.60 | Excellent |
| - Rapidness and correctness of data searching | 4.70 | Excellent |
| - Rapidness and correctness of information | 4.90 | Excellent |
| Total | 4.73 | Excellent |

**Table 4.6** Evaluation result of user manual from expert users

| Assessment Topics | Mean | Satisfied Values |
|---|---|---|
| - Appropriate and completely of step explain | 4.60 | Excellent |
| - Appropriate of wording and easy | 4.60 | Excellent |
| Total | 4.60 | Excellent |

From above testing, the result of system evaluate Group 1 has average scores of 4.78, 4.82, 4.73 and 4.60. That mean the expert users satisfy on this system and level of satisfaction is excellent. About recommendation part, some suggested that improved the colors of character so beautiful and good for read, in the part of water swallow test should be input data more than one answer and cannot input answer in the system.

The result of the system evaluation by Group 2 is shown in Table 4.7 – 4.10 and can be summarized as below.

**Table 4.7** Evaluation result of system response from general users

| Assessment Topics | Mean | Satisfied Values |
|---|---|---|
| - Rapidness of response time | 4.40 | Good |
| - Correctness of information on demand | 4.30 | Good |
| - Convenience and rapidness of screen presentation | 4.30 | Good |
| - Convenience and rapidness of search equipment data | 4.30 | Good |
| Total | 4.33 | Good |

**Table 4.8** Evaluation result of user interface from general users

| Assessment Topics | Mean | Satisfied Values |
|---|---|---|
| - Format of screen presentation are easy | 4.60 | Excellent |
| - Appropriate menu position/buttons of screen presentation | 4.50 | Excellent |
| - Correctness of information | 4.00 | Good |
| - Clearness of document presentation | 4.10 | Good |
| - Appropriate of overall system | 4.30 | Good |
| Total | 4.30 | Good |

**Table 4.9** Evaluation result of data processing from general users

| Assessment Topics | Mean | Satisfied Values |
|---|---|---|
| - Rapidness of processing | 4.50 | Excellent |
| - Consistency of processing in swallowing assessment when compared to the experts | 4.10 | Good |
| - Rapidness and correctness of data searching | 4.30 | Good |
| - Rapidness and correctness of information | 4.30 | Good |
| Total | 4.30 | Good |

**Table 4.10** Evaluation result of user manual from general users

| Assessment Topics | Mean | Satisfied Values |
|---|---|---|
| - Appropriate and completely of step explain | 4.40 | Good |
| - Appropriate of wording and easy | 4.40 | Good |
| Total | 4.40 | Good |

From above testing, the result about system evaluate Group 2 has average scores of 4.33, 4.30, 4.30 and 4.40. That mean the general users satisfy on this system and level of satisfaction is good. About recommendation part, some suggested that improved the colors of user interface for easy to find, in part of BP assessment should be divided into systolic and diastolic box, should be have reference and criteria of assessment for evaluation it made the system more reliable.

The summary of the system evaluation is shown in Table 4.11.

**Table 4.11** The summary of the system evaluation from users

| Assessment Topics | Group 1 (expert users) | | Group 2 (general users) | |
|---|---|---|---|---|
| | Mean | Satisfied Values | Mean | Satisfied Values |
| - System response | 4.78 | Excellent | 4.33 | Good |
| - User interface | 4.82 | Excellent | 4.30 | Good |
| - Data processing | 4.73 | Excellent | 4.30 | Good |
| - User manual | 4.60 | Excellent | 4.40 | Good |
| Total | 4.73 | Excellent | 4.33 | Good |

In summary, the average scores of testing by users in four parts of the system evaluation. Group 1 has average scores of 4.73 and Group 2 has average scores of 4.33. That mean all the system is good for user and the users are accept it.

# CHAPTER V
# DISCUSSION AND CONCLUSION

This chapter provides discussion, conclusion and recommendation of using the expert system for swallowing disorder screening in stroke patients.

## 5.1 Discussion

The expert system for swallowing disorder screening in stroke patients was evaluated by the group of nurses in Siriraj Hospital. The testers are divided in to two groups as the following:

Group 1: 10 persons with experience in knowledge of stroke disease and swallowing disorder

Group 2: 10 persons not have experience in knowledge of stroke disease and swallowing disorder

Everyone use the system to swallowing screening of the test cases. After that, the testers will fill in a questionnaire after they have tested the system (see the example questionnaire in the Appendix D).

The evaluation of the expert system is divided in to four sections: system response, user interface, data processing and user manual. All experts evaluated all factors as excellent or good. The expert users satisfy on this system.

During the study of the expert system for swallowing disorder screening in stroke patients, there are many problems as follow:

- The knowledge of swallowing disorder and swallowing screening technique are specially and has less of book or image, so it takes a long time to study and consulting the experts about swallowing disorder.
- The knowledge base is un-flexibility. If the user input data that difference from a knowledge base the system cannot find an answer.

- During the development of the expert system, the errors were found for all swallowing screening. Hence, the developer has to re-create production-rules.

- The knowledge elicitation from experts and documents is cause of error or conflict knowledge.

The advantages of the system are following:

- The system helps users to swallowing screening and to advice management for user.

- The system has information about swallowing screening and general knowledge of swallowing disorder for user.

- The display of photographs and videos in swallowing screening will facilitate the user to understand the screening method.

- Thai language was used in this system, so it comforts for the user to understand.

- The system can precisely provide screening and result of swallowing disorder.

- The system can run the general knowledge of swallowing disorder faster than books.

However, there are some disadvantages of the expert system as follow:

- The system can screen swallowing disorder and to advice management only stroke patients.

- The system has information only swallowing screening and general knowledge of stroke disease.

- Production-rules and knowledge base must be edited and updated by developer or knowledge engineer.

## 5.2 Conclusion and Recommendation

### 5.2.1 Conclusion

The objective of this research is an expert system for swallowing disorder screening in stroke patients. Comparing to the

The evaluation of the expert system is divided in to four sections: system response, user interface, data processing and user manual. All experts evaluated all factors as excellent or good. The expert users satisfy on this system.

The expert system was developed by Microsoft Visual Basic.NET 2005 as user interfaces and coding program. It works on a stand-alone personal computer with Microsoft Windows XP or higher as an operating system. Production rules (if-then rules) are used as the knowledge representation model. Inferencing strategy uses backward chaining in searching for swallowing disorder results of swallowing screening. The explanation of reasons is display to users at the end of each step of assessment.

The system was distinguished into three modules, the first one is "Swallowing screening" that is a main part of the system use to swallowing disorder screening. There are two parts in the input module for the swallowing screening such as: Pre-swallowing screening and Swallowing assessment. The second one is "User manual" that module helps for use the expert system. The last one is "General knowledge" that supports 13 items swallowing disorder knowledge.

The working of this expert to screen is asking the user some questions to screen and then reply the user with the swallowing disorder and display a management of that swallowing disorder.

### 5.2.2 Recommendation

For this study, the main aim is to develop an application software, which use expert system technology for swallowing screening. The recommendations for further development are as follows:

- To develop more knowledge base about swallowing disorder and management, including other details and images for attractive user interface.

- To create more production-rules that can provide more diagnosis and treatment of swallowing disorder with any patient.

- Add a database about patient's data in the system for to learn about development and progressive of the patient.

- Finding the strengths of system that different or more efficiently than assessment in the paper.

- This study can guide the development of other expert system in the further.

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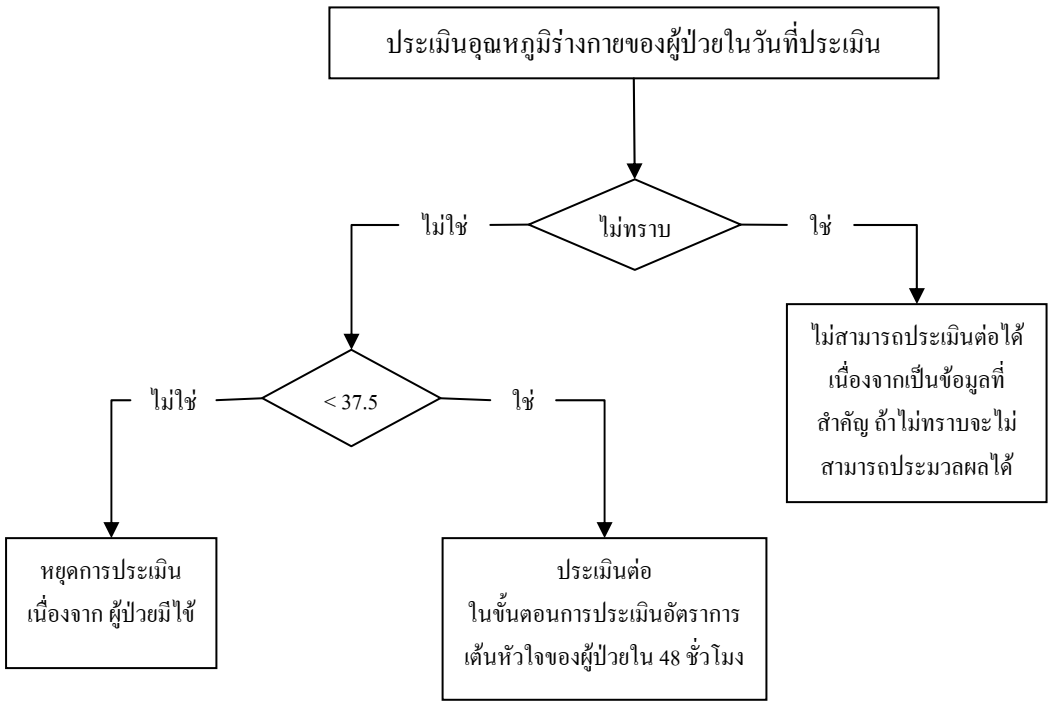
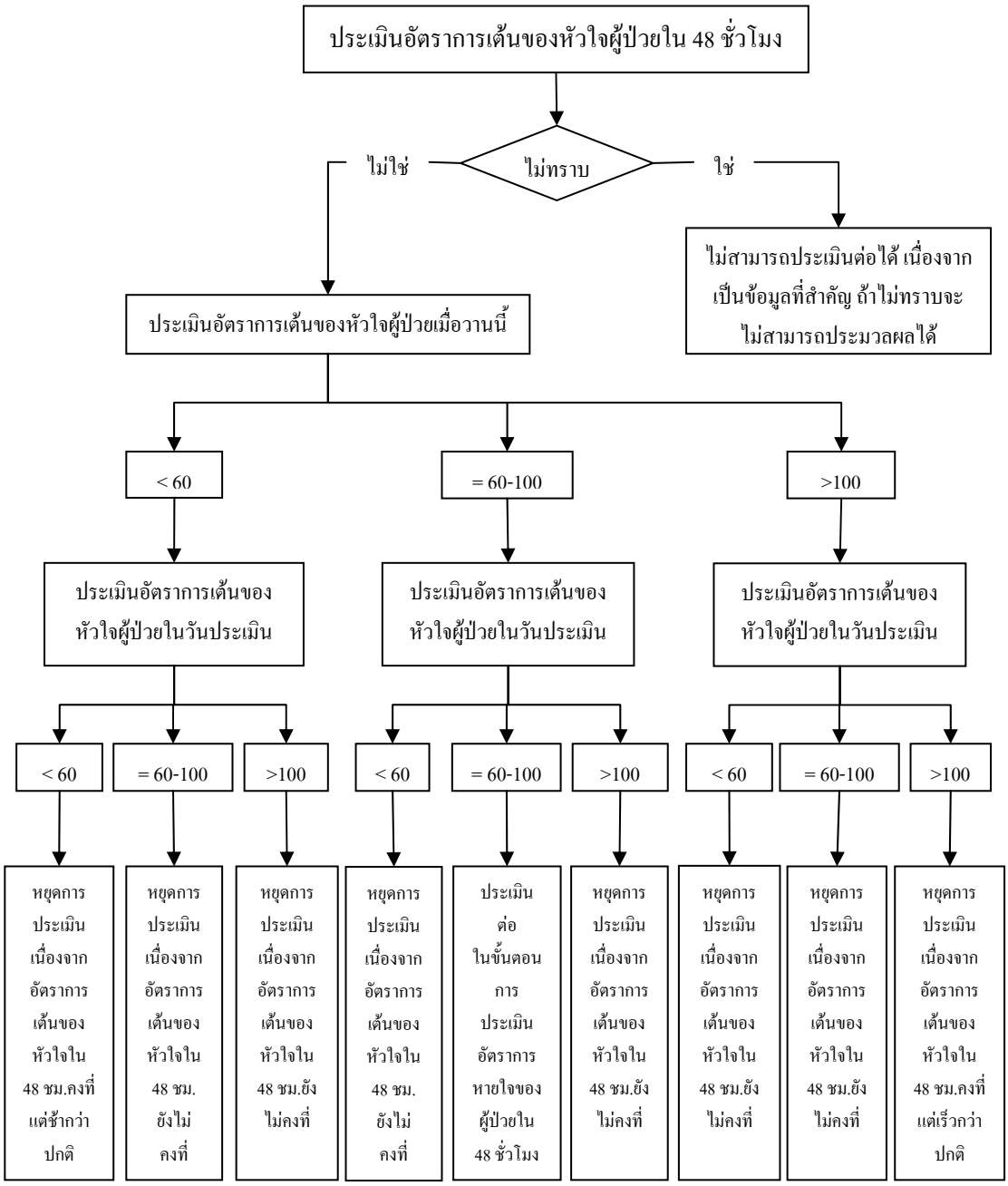
# APPENDICES

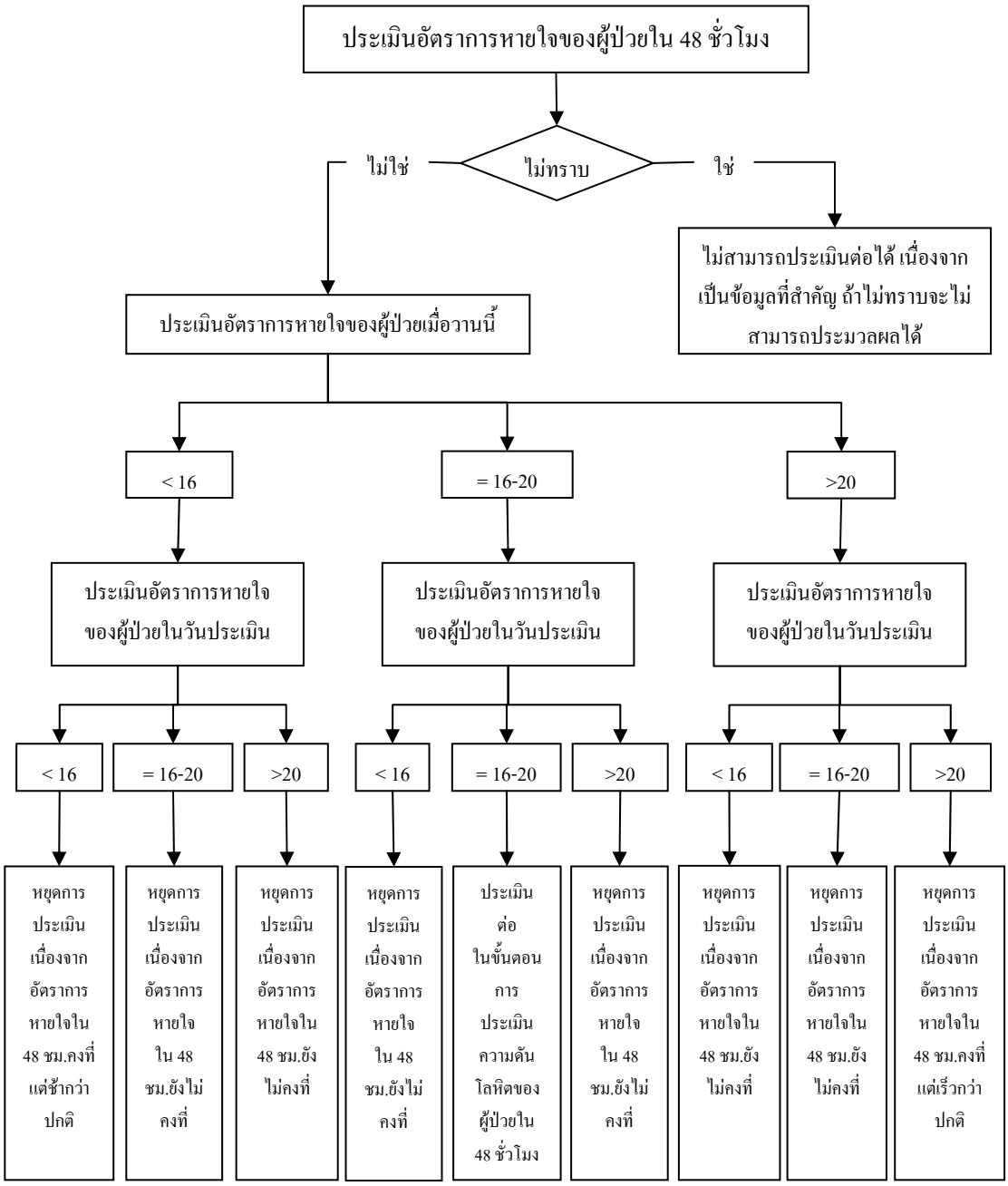
# APPENDIX A
# FLOW DIAGRAM FOR SWALLOWING SCREENING



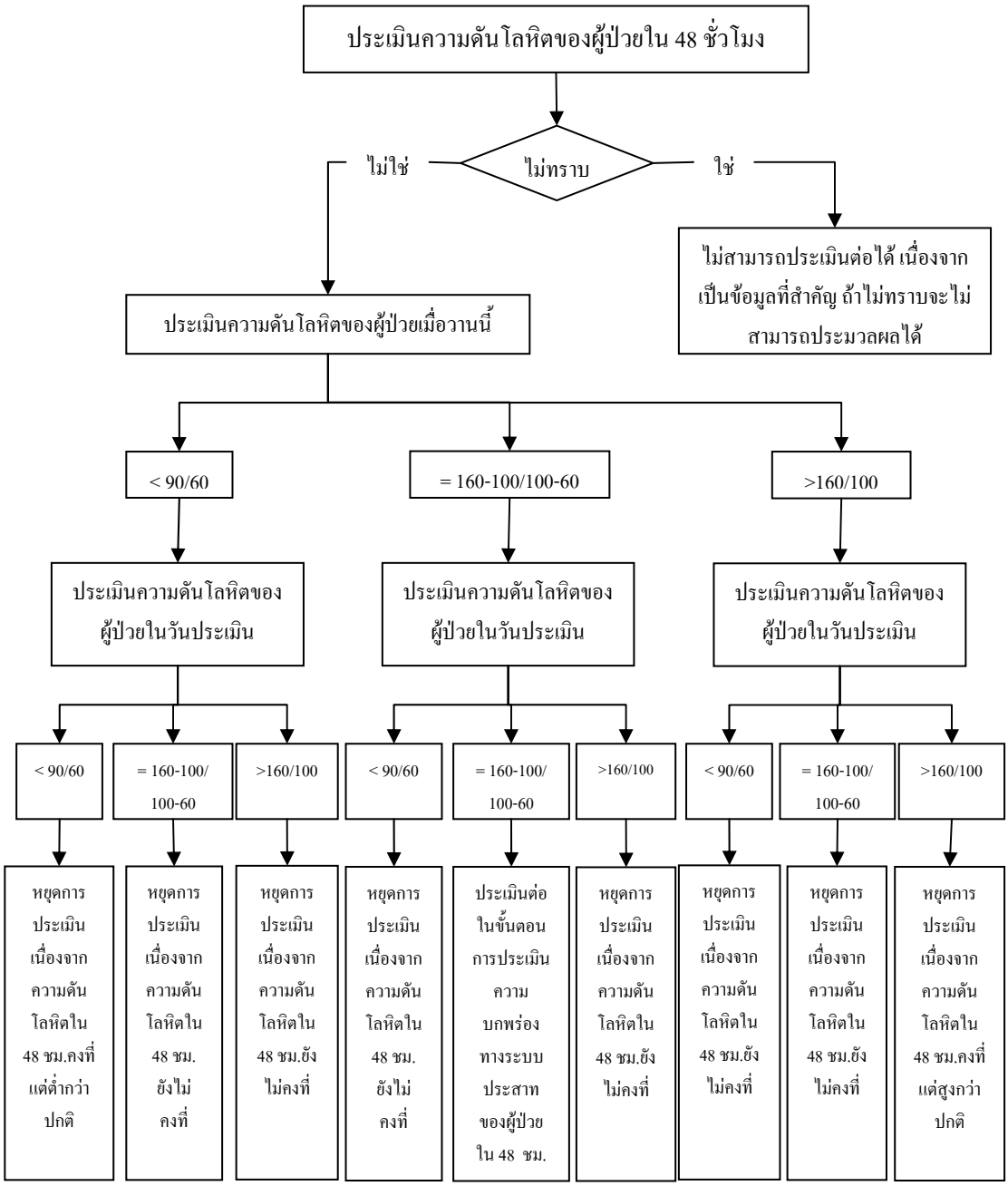

**รูปที่ A-1** แผนผังแสดง การประเมินอุณหภูมิร่างกายของผู้ป่วยในวันที่ประเมิน



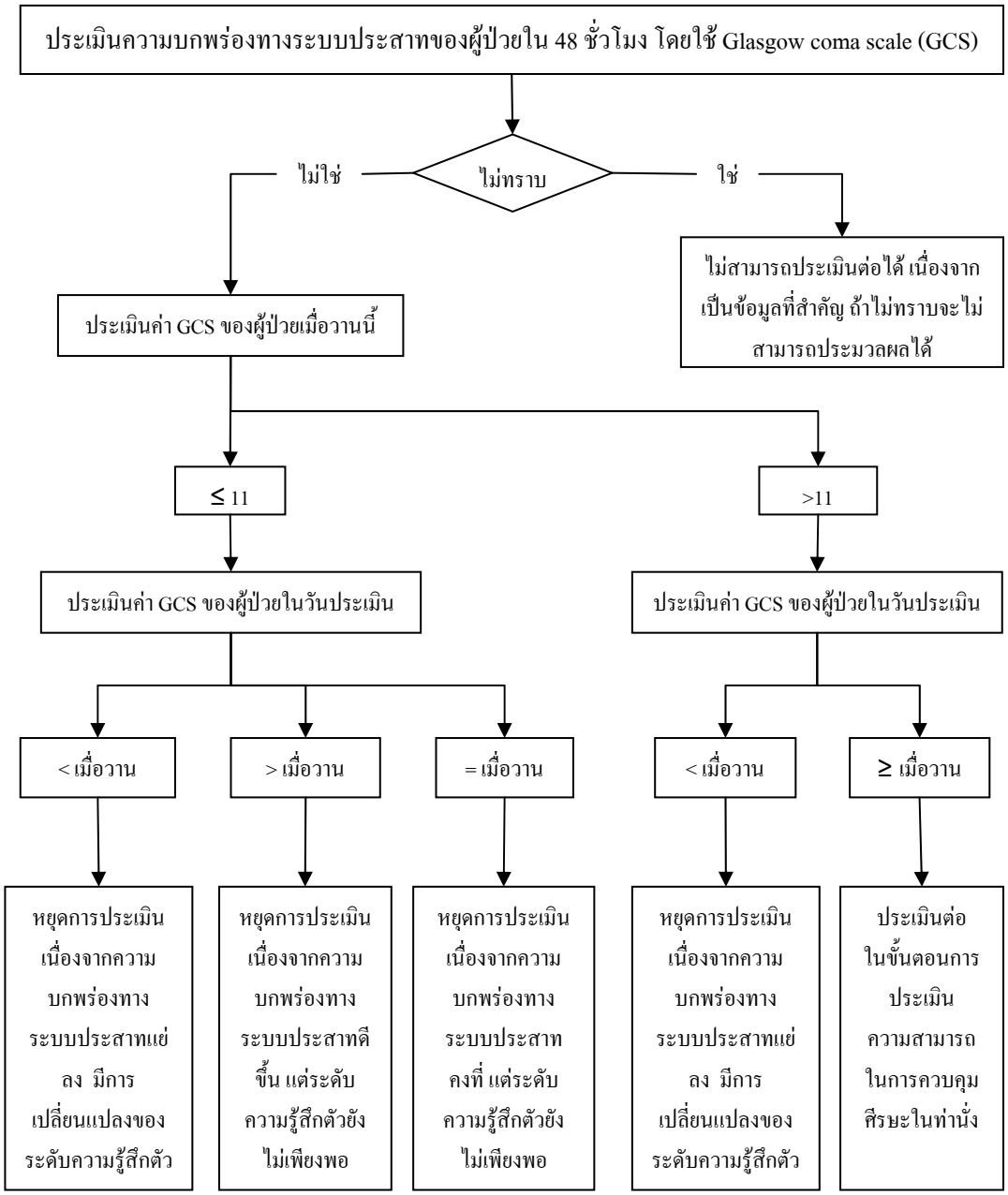

**รูปที่ A-2** แผนผังแสดง การประเมินอัตราการเต้นของหัวใจผู้ป่วยใน 48 ชั่วโมง



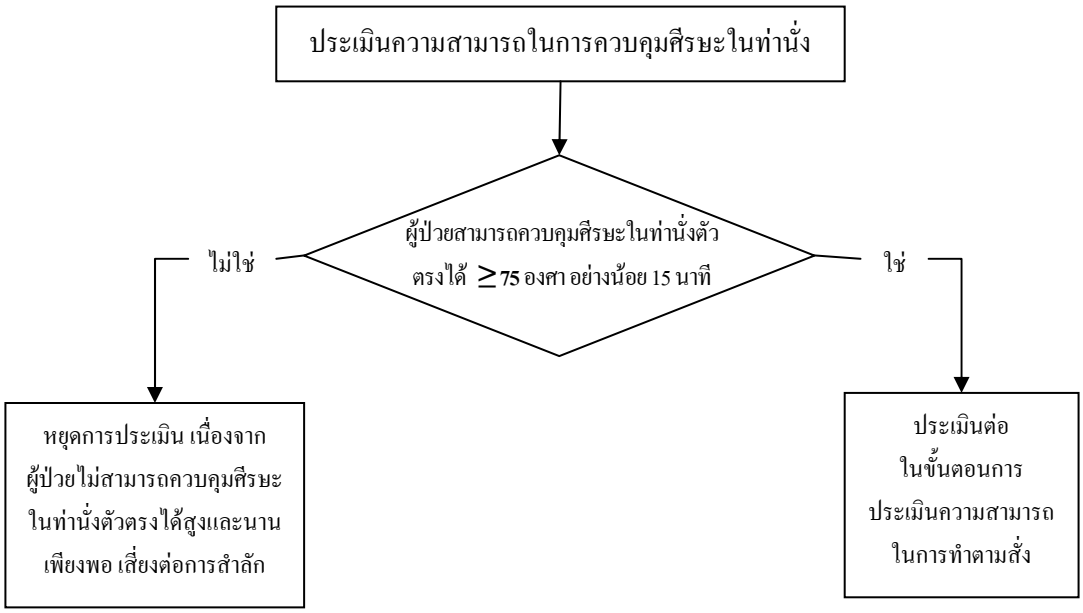

**รูปที่ A-3** แผนผังแสดง การประเมินอัตราการหายใจของผู้ป่วยใน 48 ชั่วโมง



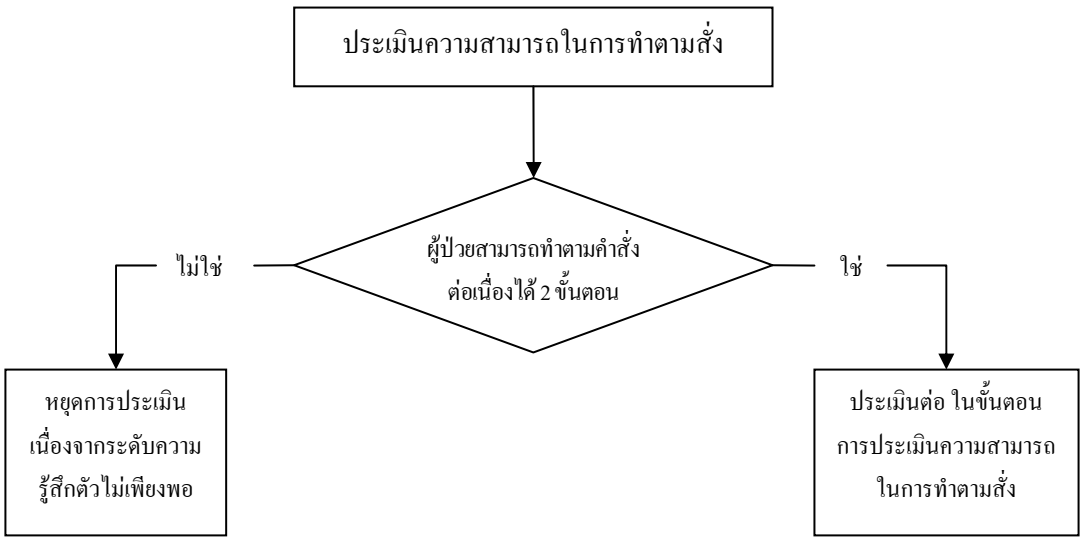

**รูปที่ A-4** แผนผังแสดง การประเมินความดันโลหิตของผู้ป่วยใน 48 ชั่วโมง



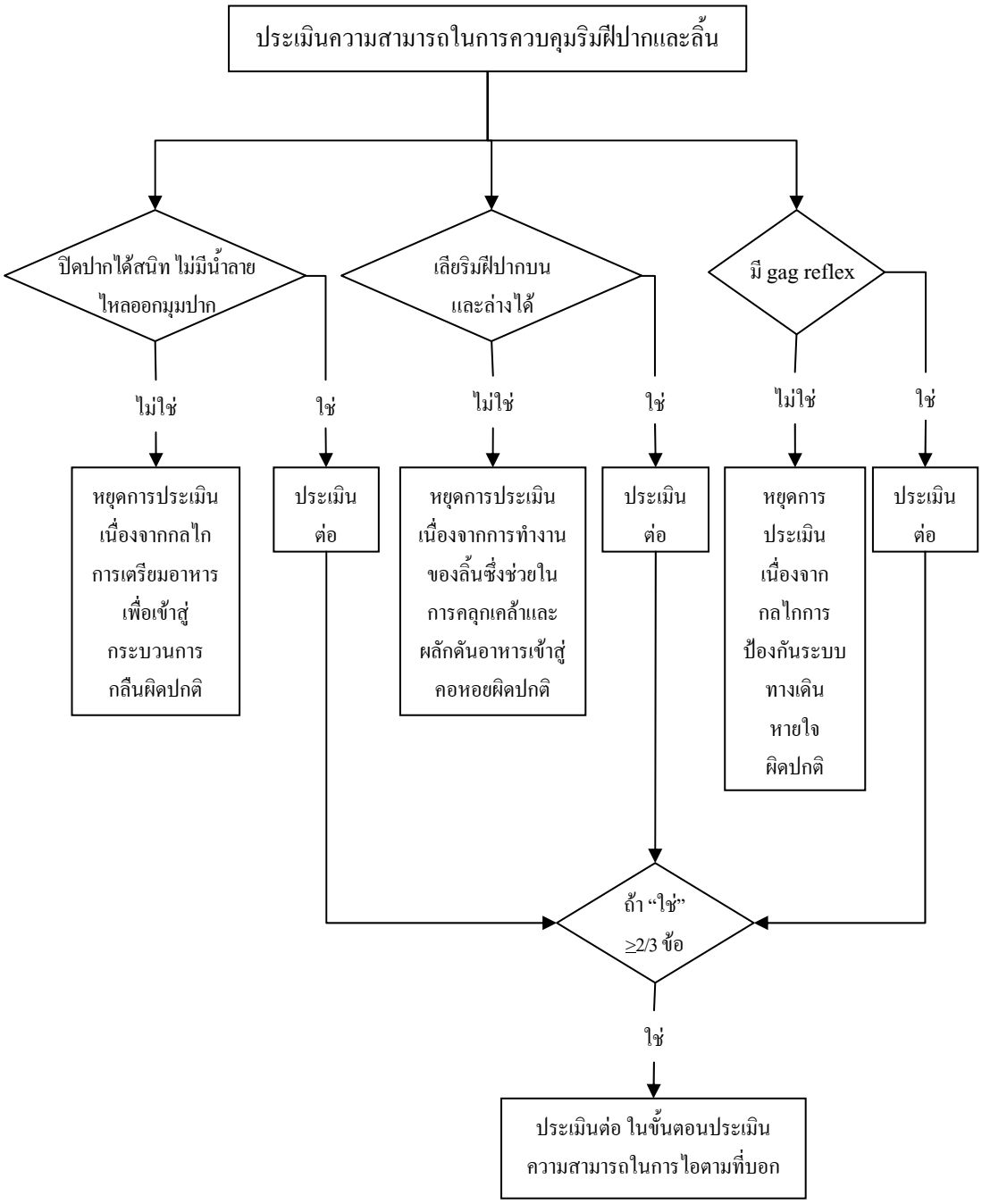

**รูปที่ A-5** แผนผังแสดง การประเมินความบกพร่องทางระบบประสาทของผู้ป่วยใน 48 ชั่วโมง



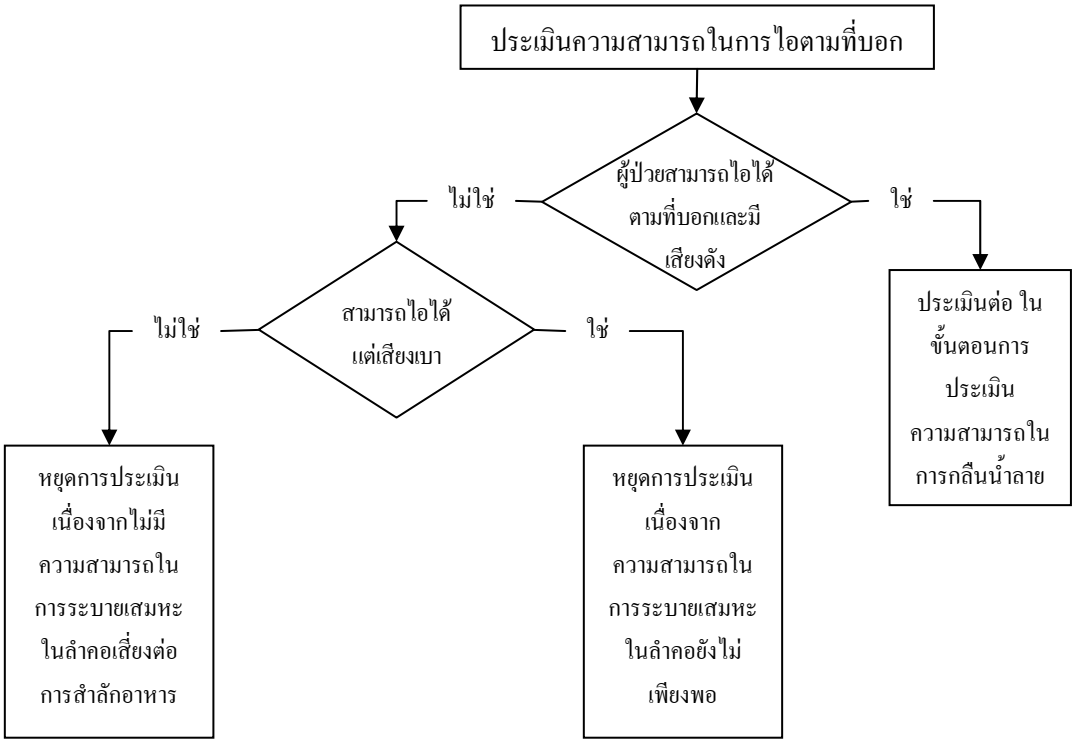

**รูปที่ A-6** แผนผังแสดง การประเมินความสามารถในการควบคุมศีรษะในท่านั่ง



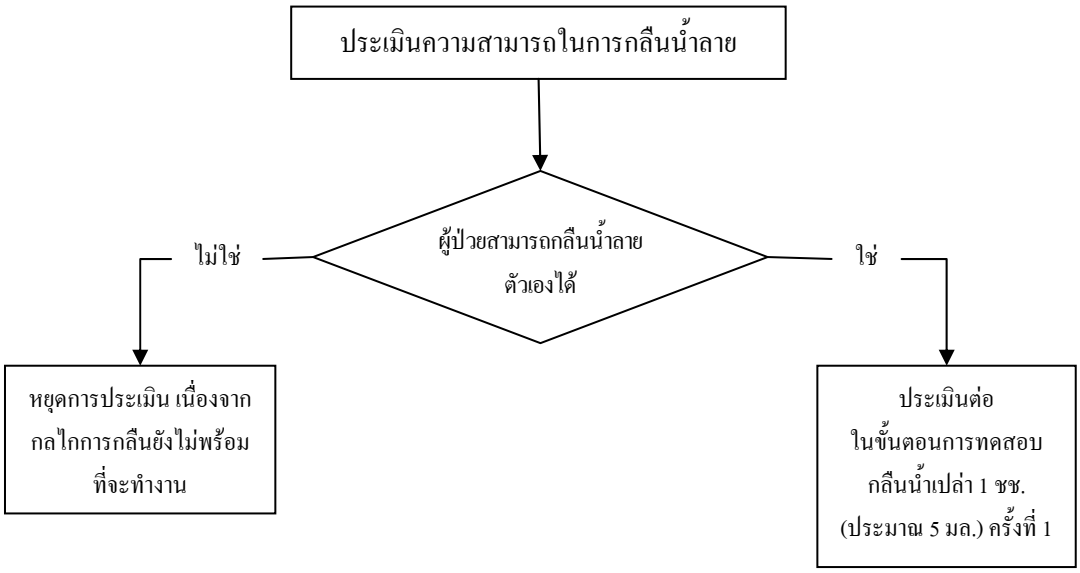

**รูปที่ A-7** แผนผังแสดง การประเมินความสามารถในการทำตามสั่ง



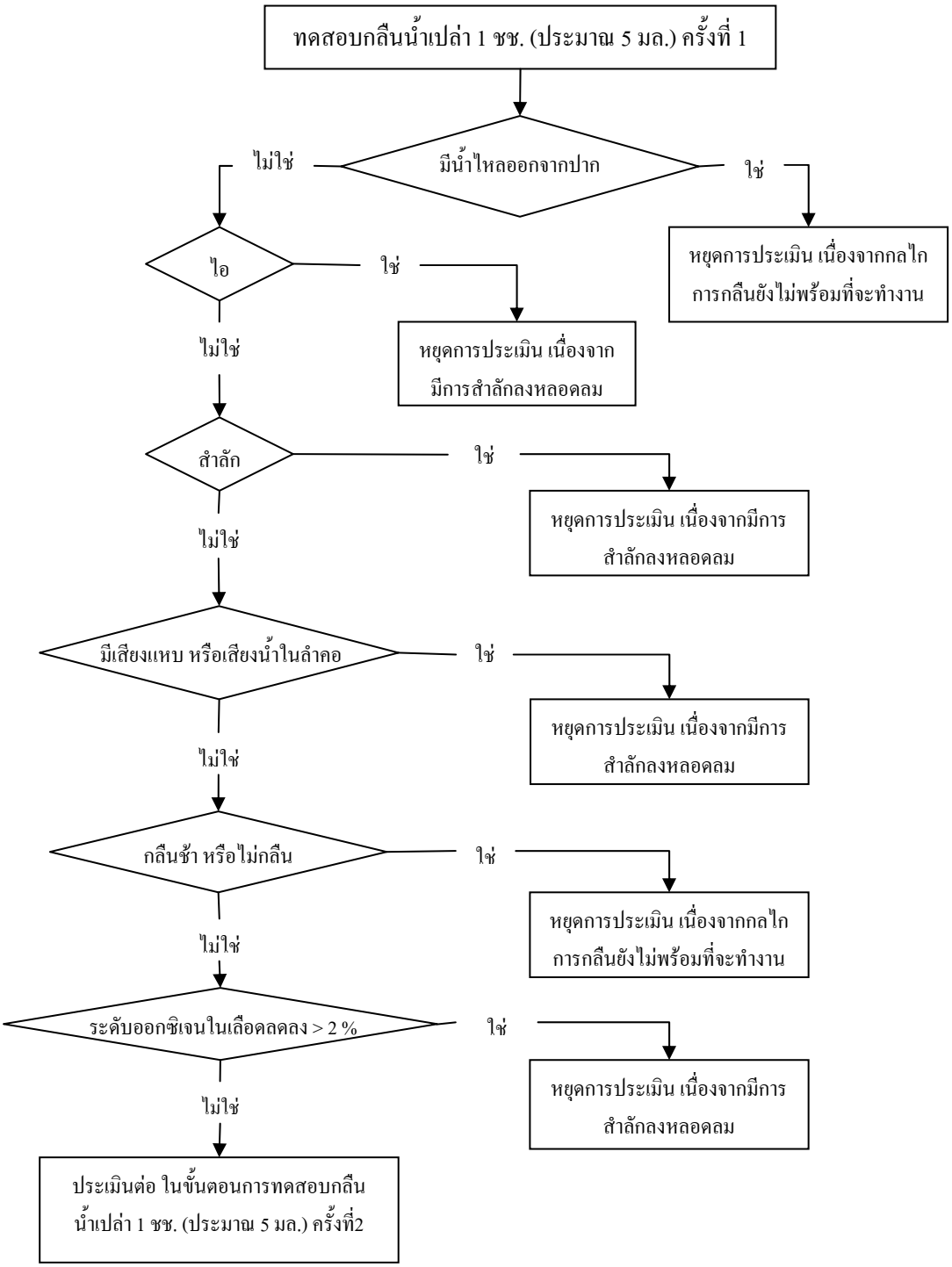

**รูปที่ A-8** แผนผังแสดง การประเมินความสามารถในการควบคุมริมฝีปากและลิ้น



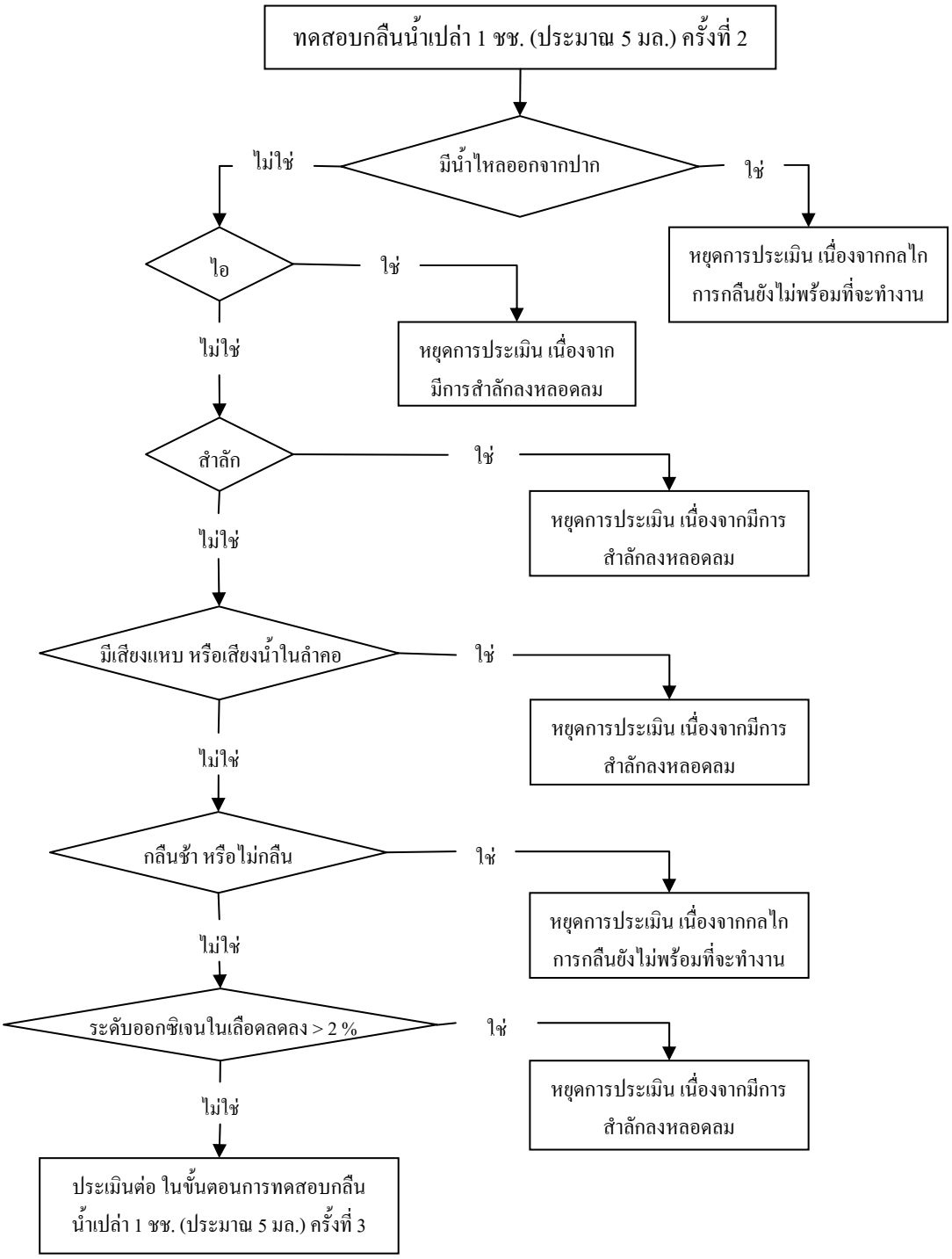

**รูปที่ A-9** แผนผังแสดง การประเมินความสามารถในการไอตามที่บอก



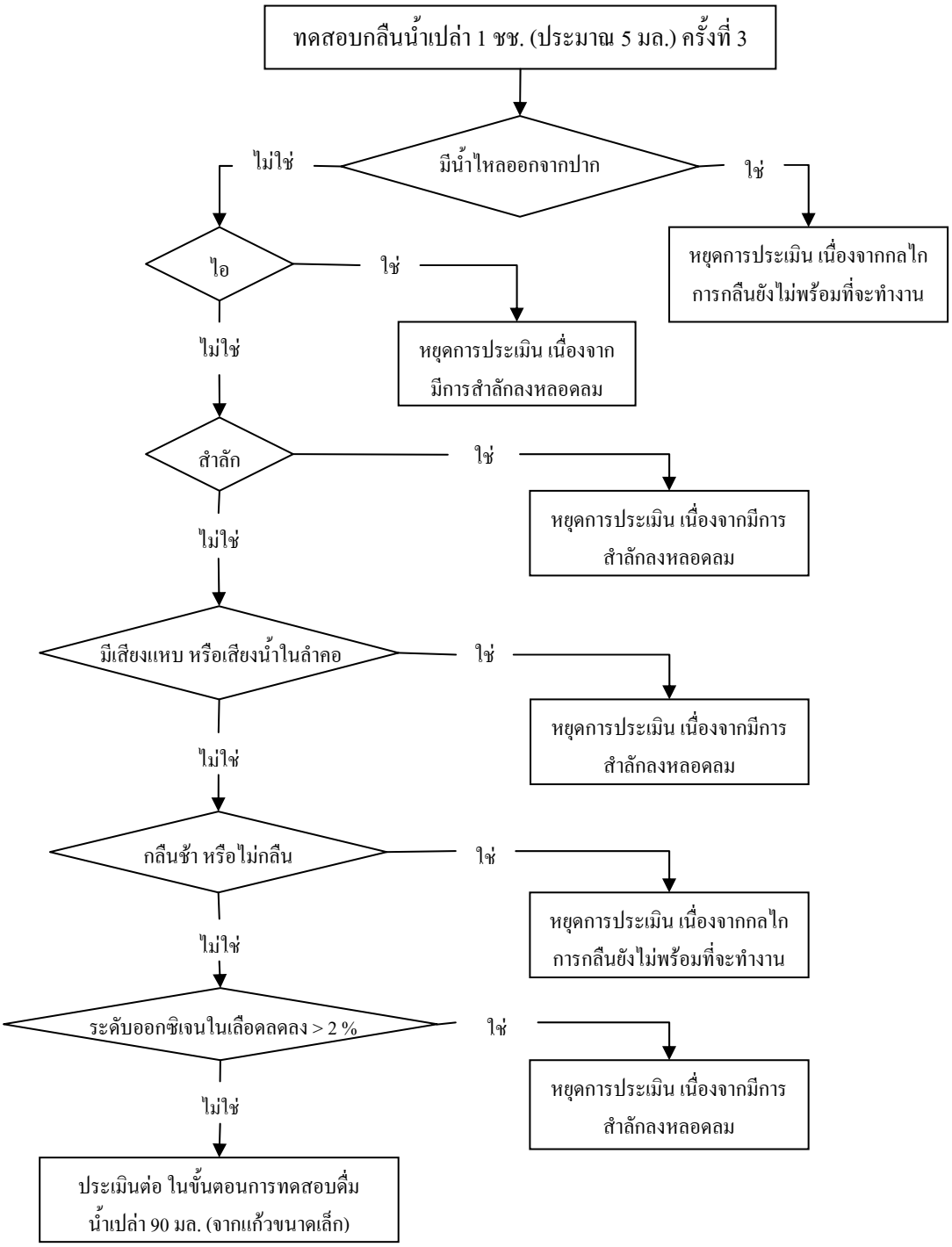

**รูปที่ A-10** แผนผังแสดง การประเมินความสามารถในการกลืนน้ำลาย



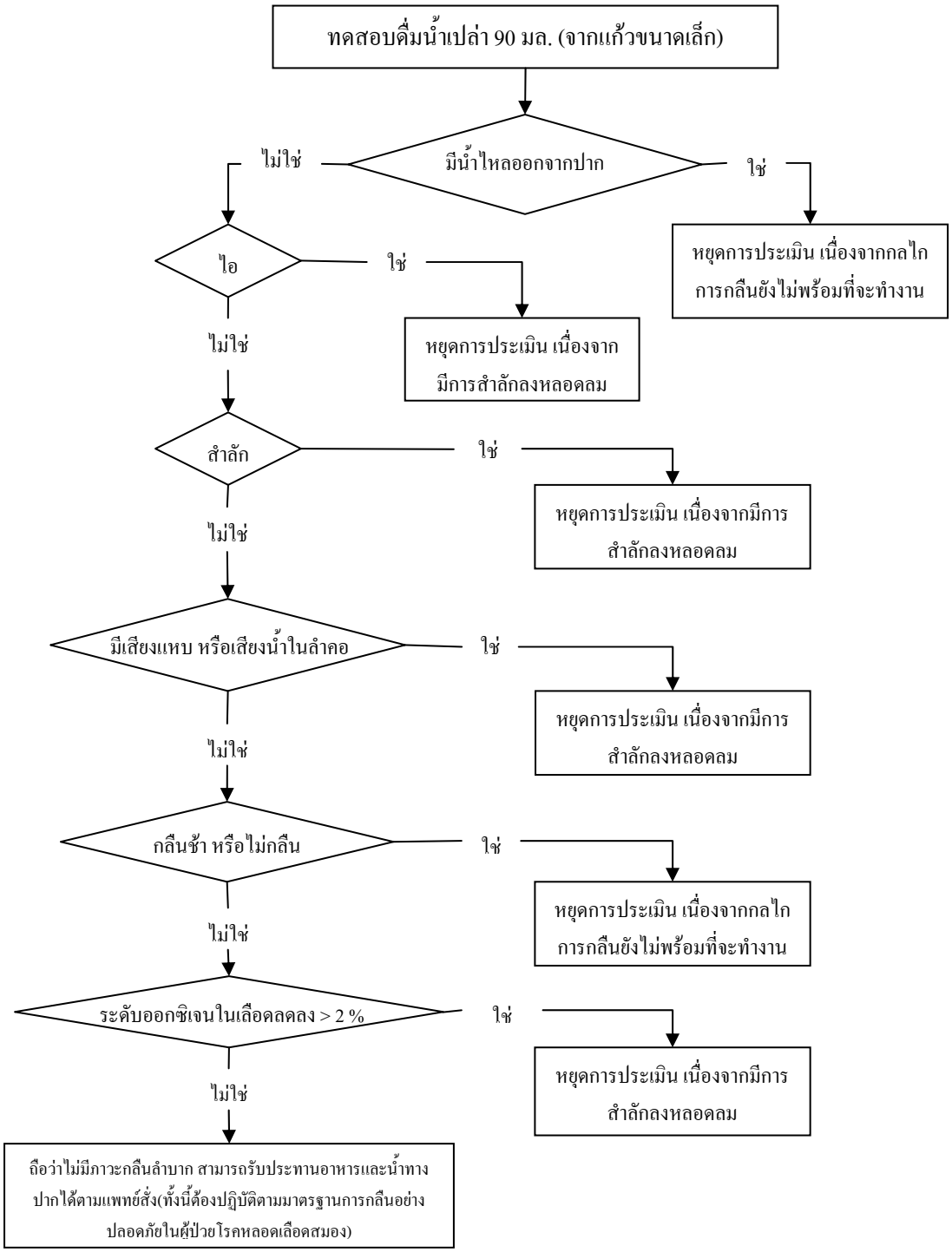

**รูปที่ A-11** แผนผังแสดง การทดสอบกลืนน้ำเปล่า 1 ชช. (ประมาณ 5 มล.) ครั้งที่ 1




**รูปที่ A-12** แผนผังแสดง การทดสอบกลืนน้ำเปล่า 1 ชช. (ประมาณ 5 มล.) ครั้งที่2




**รูปที่ A-13** แผนผังแสดง การทดสอบกลืนน้ำเปล่า 1 ชช. (ประมาณ 5 มล.) ครั้งที่3




**รูปที่ A-14** แผนผังแสดง การทดสอบดื่มน้ำเปล่า 90 มล. (จากแก้วขนาดเล็ก)

# APPENDIX B
# LIST OF EXPERTS

There are tree expert who have validated of the swallowing screening from in expert system for swallowing disorder screening in stroke patients. There are:

1. Phakamas Tanvijit, M.D.
   Lecturer
   Department of Rehabilitation Medicine
   Faculty of Medicine,
   Mahidol University

2. Ratcharin Kongkasuwan, M.D.
   Lecturer
   Department of Rehabilitation Medicine
   Faculty of Medicine,
   Mahidol University

3. Saowaluk Jantharakasamjit, M.Sc.
   Occupational therapy (OT)
   Department of Rehabilitation Medicine
   Faculty of Medicine,
   Mahidol University

# APPENDIX C

# CERTIFICATE OF APPROVAL

# MAHIDOL UNIVERSITY INSTITUTION REVIEW BOARD (MU-IRB)

COA. No. MU-IRB 2012/066.0304

Certificate of Approval
Mahidol University Institutional Review Board (MU-IRB)

**Title of Project:** Development of an Expert System for Swallowing Disorder Screening in Stroke Patients: System Satisfied Assessment
(Thesis for Master Degree)

**Principal Investigator:** Miss Kanjana Rawainok

**Name of Institution:** Faculty of Engineering

**Approval includes:** 1) MU-IRB Submission form version received date 3 April 2012
2) Participant Information Sheet for Questionnaire version date 3 April 2012
3) Questionnaire version received date 28 March 2012

Mahidol University Institutional Review Board is in full compliance with International Guidelines for Human Research Protection such as Declaration of Helsinki, The Belmont Report, CIOMS Guidelines and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP)

**Date of Approval:** 3 April 2012

**Date of Expiration:** 2 April 2013

**Signature of Chair:** .....
(Professor Shusee Visalyaputra)

**Signature of Head of the Institute:** .....
(Professor Prasit Palittapongarnpim)
Vice President for Research

Office of the President, Mahidol University, 999 Phuttamonthon 4 Rd., Salaya, Phuttamonthon District, Nakhon Pathom 73170. Tel. (662) 8496223-5 Fax. (662) 8496223

# APPENDIX D
# QUESTIONNAIRE FOR EVALUATE THE EXPERT SYSTEM

## แบบสอบถามความคิดเห็นสำหรับผู้ใช้งานระบบผู้เชี่ยวชาญ เพื่อคัดกรองผู้ป่วยที่มีภาวะการกลืนผิดปกติอันเนื่องมาจากโรคหลอดเลือดสมอง

**<u>คำชี้แจง</u>:**

แบบประเมินนี้ เป็นแบบประเมินผลความคิดเห็นของผู้ใช้ระบบว่ามีความคิดเห็นเป็นอย่างไร มีวัตถุประสงค์ เพื่อประเมินหาความพึงพอใจของโปรแกรมระบบผู้เชี่ยวชาญที่พัฒนาขึ้น เพื่อใช้เป็นข้อมูลพื้นฐานในการปรับปรุงและพัฒนาระบบให้มีประสิทธิภาพต่อไป ขอให้ท่านทำแบบประเมินชุดนี้ตามความเป็นจริง คำตอบของท่านจะเป็นประโยชน์อย่างยิ่ง และการประเมินนี้จะไม่กระทบต่องานและสิทธิส่วนบุคคลของท่านแต่อย่างใด

**<u>ส่วนที่ 1</u>: ข้อมูลของผู้ตอบแบบสอบถาม**

1. เพศ ☐ ชาย ☐ หญิง
2. อายุ.....ปี
3. วุฒิสูงสุดทางการศึกษา ☐ ปริญญาตรี ☐ ปริญญาโท ☐ ปริญญาเอก
4. ประสบการณ์ทำงานกับผู้ป่วยโรคหลอดเลือดสมอง.....ปี
5. ท่านเคยได้รับการอบรมความรู้ด้านการกลืนมาก่อนหรือไม่ ☐ เคย ☐ ไม่เคย

**<u>ส่วนที่ 2</u>: ความคิดเห็นจากการใช้งานระบบผู้เชี่ยวชาญเพื่อคัดกรองผู้ป่วยที่มีภาวะการกลืนผิดปกติอันเนื่องมาจากโรคหลอดเลือดสมอง**

**คำชี้แจง :** โปรดทำเครื่องหมาย ✓ ลงในช่องที่ตรงกับความคิดเห็นของท่านมากที่สุด

5 หมายถึง การทำงานของระบบอยู่ในระดับดีมาก
4 หมายถึง การทำงานของระบบอยู่ในระดับดี
3 หมายถึง การทำงานของระบบอยู่ในระดับปานกลาง
2 หมายถึง การทำงานของระบบอยู่ในระดับพอใช้
1 หมายถึง การทำงานของระบบอยู่ในระดับต้องปรับปรุง

| รายการประเมิน | ระดับคะแนนในการประเมิน | | | | |
|---|---|---|---|---|---|
| | ดีมาก (5) | ดี (4) | ปานกลาง (3) | พอใช้ (2) | ปรับปรุง (1) |
| <u>ด้านความสามารถในการตอบสนองโปรแกรม</u><br>- ระยะเวลาในการตอบสนองรวดเร็ว | | | | | |
| - สามารถทำงานได้ถูกต้องตรงตามความต้องการ | | | | | |
| - มีความสะดวกรวดเร็วในการติดต่อสื่อสาร | | | | | |
| - สามารถทำการค้นหาข้อมูลที่ต้องการได้รวดเร็วและถูกต้อง | | | | | |
| <u>ด้านการติดต่อกับผู้ใช้โปรแกรม</u><br>- การจัดรูปแบบในหน้าจอง่ายต่อการใช้งาน | | | | | |
| - ความเหมาะสมของตำแหน่งจัดวางเมนู/ปุ่ม ที่ปรากฏบนหน้าจอ | | | | | |
| - ความถูกต้องของข้อมูล | | | | | |
| - ความชัดเจนของข้อความที่แสดงผล | | | | | |
| - ความเหมาะสมโดยรวมของระบบ | | | | | |
| <u>ด้านการประมวลผลข้อมูลของโปรแกรม</u><br>- ความเร็วในการประมวลผล | | | | | |
| - ความสอดคล้องในการประมวลผลการประเมินการกลืนจากระบบเมื่อเทียบกับผู้เชี่ยวชาญ | | | | | |
| - สามารถทำการค้นหาข้อมูลที่ต้องการได้รวดเร็วและถูกต้อง | | | | | |
| - สามารถแสดงข้อมูลที่เกี่ยวข้องได้อย่างรวดเร็วและถูกต้อง | | | | | |
| <u>ด้านเอกสารคู่มือการใช้งาน</u><br>- มีลำดับขั้นตอนการอธิบายย่างเหมาะสมและครบถ้วน | | | | | |
| - มีการใช้สำนวนภาษาเหมาะสมและเข้าใจง่าย | | | | | |

**<u>ส่วนที่3</u>: ข้อคิดเห็นและข้อเสนอแนะเพิ่มเติมของผู้ใช้ระบบ**

.....

.....

.....

ขอขอบคุณที่ให้ความร่วมมือในการตอบแบบสอบถาม

# APPENDIX E
# SWALLOWING SCREENING

## แบบประเมินการกลืน(Swallowing screening)

แบบประเมินการกลืนในผู้ป่วยโรคหลอดเลือดสมองสำหรับงานวิจัยนี้ ใช้ประเมินผู้ป่วยโรคหลอดเลือดสมองภายใน 24 ชั่วโมงแรก หรือก่อนเริ่มรับประทานอาหารมื้อแรก โดยอิงตามแบบประเมิน PM&R Siriraj Swallowing Screening ของภาคภาควิชาเวชศาสตร์ฟื้นฟู โรงพยาบาลศิริราช ซึ่งปฏิบัติโดยแพทย์เวชศาสตร์ฟื้นฟู ซึ่งมีการประเมิน ดังนี้

## ทดสอบก่อนประเมินการกลืน

**ประเมินสภาวะทางการแพทย์ของผู้ป่วย**

**อุณหภูมิร่างกายของผู้ป่วยในวันที่ประเมิน.....องศาเซลเซียส**

**อัตราการเต้นของหัวใจผู้ป่วยใน 48 ชั่วโมง**

เมื่อวาน…….. วันประเมิน……..ครั้ง/นาที

**อัตราการหายใจของผู้ป่วย ใน 48 ชั่วโมง**

เมื่อวาน…….. วันประเมิน……..ครั้ง/นาที

**ความความดันโลหิตของผู้ป่วย ใน 48 ชั่วโมง**

เมื่อวาน…….. วันประเมิน……..มม.ปรอท

**ความบกพร่องทางระบบประสาทของผู้ป่วย ใน 48 ชั่วโมง โดยใช้ Glasgow coma scale (GCS > 11)**

<u>เมื่อวาน</u>

การลืมตา(E).....การตอบสนองต่อการเรียกหรือพูด(V).....การเคลื่อนไหว(M).....

<u>วันประเมิน</u>

การลืมตา(E).....การตอบสนองต่อการเรียกหรือพูด(V).....การเคลื่อนไหว(M).....

GCS เมื่อวาน.....คะแนน GCS วันประเมิน.....คะแนน

## ประเมินการกลืน

1. **ประเมินความสามารถในการควบคุมศีรษะในท่านั่ง**

- ผู้ป่วยสามารถควบคุมศีรษะในท่านั่งตัวตรงได้ $\geq$ 75 องศา อย่างน้อย 15 นาที

☐ ใช่ ☐ ไม่ใช่

2. **ประเมินความสามารถในการทำตามสั่ง**

- ผู้ป่วยสามารถทำตามคำสั่งได้ 2 ขั้นตอน เช่น ให้ยกนิ้วขึ้นแล้วนำไปแตะจมูก

☐ ใช่ ☐ ไม่ใช่

ถ้าตอบ “ใช่” ทั้ง 2 ข้อ ให้ประเมินต่อ แต่ถ้า “ไม่ใช่” อย่างน้อย 1 ข้อ ให้หยุดประเมิน แสดงว่าผู้ป่วยไม่พร้อมในการกลืน ให้งดการรับประทานอาหารทางปาก งดการฝึกกลืน ส่งปรึกษาแพทย์เพื่อดูแลเรื่องการได้รับอาหารและน้ำทางสายยางหรือสารอาหารทางหลอดเลือด ดูแลความสะอาดปากฟัน และการจัดท่าที่เหมาะสมในการให้อาหารทางสายยาง

3. **ประเมินความสามารถในการควบคุมริมฝีปากและลิ้น**

- ผู้ป่วยสามารถปิดปากได้สนิท ไม่มีน้ำลายไหลหรือรั่วออกจากปาก

☐ ใช่ ☐ ไม่ใช่

- ผู้ป่วยสามารถเลียริมฝีปากบนและล่างได้

☐ ใช่ ☐ ไม่ใช่

- ผู้ป่วยมี gag reflex (ใช้ไม้กดลิ้น หรือช้อนแตะที่ผนังคอหอยด้านหลัง ถ้าผู้ป่วยขย้อน แสดงว่ามี gag reflex)

☐ ใช่ ☐ ไม่ใช่

ทั้ง 3 หัวข้อ ถ้าตอบ “ใช่” $\geq$ 2/3 ข้อ ให้ประเมินในขั้นตอนถัดไป ถ้า “ใช่” $\leq$ 2/3 ข้อ ให้หยุดการประเมิน

4. **ประเมินความสามารถในการไอตามที่บอก**

-ผู้ป่วยสามารถไอตามที่บอกได้

☐ ไอได้เสียงดัง ☐ ไอได้ แต่เสียงเบา ☐ ไอไม่ได้

**5. ประเมินความสามารถในการกลืนน้ำลาย**

-ผู้ป่วยสามารถกลืนน้ำลายตนเองได้

□ ใช่ □ ไม่ใช่

ถ้า “สามารถทำได้” หรือตอบ “ใช่” ให้ดำเนินการประเมินต่อ และถ้าตอบ “ไม่ได้” หรือ “ไม่ใช่” อย่างน้อย 1 ข้อ ให้งดการรับประทานอาหารทางปาก และส่งต่อนักกิจกรรมบำบัด (OT: Occupational therapy) เพื่อกระตุ้นและฝึกบริหารกล้ามเนื้อปากและใบหน้า (Oromotor exercise and stimulation)

**6. ทดสอบการกลืนน้ำ**

- จิบน้ำเปล่า 1 ช้อนชา (ประมาณ 5 มล.) ครั้งที่ 1

□ ได้ □ มีอาการ.....

- จิบน้ำเปล่า 1 ช้อนชา (ประมาณ 5 มล.) ครั้งที่ 2

□ ได้ □ มีอาการ.....

- จิบน้ำเปล่า 1 ช้อนชา (ประมาณ 5 มล.) ครั้งที่ 3

□ ได้ □ มีอาการ.....

ทั้ง 3 หัวข้อ ถ้าตอบ “ได้” ทั้ง 3 ข้อ ให้ประเมินในขั้นตอนถัดไป ถ้ามีอาการ น้ำไหลรั่วจากมุมปาก ไอ สำลัก มีเสียงแหบหรือเสียงน้ำในลำคอ กลืนช้า หรือไม่กลืน และระดับออกซิเจนในเลือดลดลง > 2 % ให้หยุดการประเมิน งดให้อาหารและน้ำทางปาก และส่งต่อนักกิจกรรมบำบัด (OT) เพื่อกระตุ้นกล้ามเนื้อปากและใบหน้า (Oromotor exercise and stimulation) แต่ถ้าไม่มีปัญหาให้ทดสอบต่อ ช้อนที่ 2 และ 3

- ดื่มน้ำ 90 มล. (จากแก้วขนาดเล็ก)

□ ได้ □ มีอาการ.....

ถ้าตอบ “ได้” ถือว่าไม่มีภาวะกลืนลำบาก สามารถรับประทานอาหารและน้ำทางปากได้ตามแพทย์สั่ง(ทั้งนี้ต้องปฏิบัติตามมาตรฐานการกลืนอย่างปลอดภัยในผู้ป่วยโรคหลอดเลือดสมอง) ถ้ามีอาการ น้ำไหลรั่วจากมุมปาก ไอ สำลัก มีเสียงแหบหรือเสียงน้ำในลำคอ กลืนช้า หรือไม่กลืน และระดับออกซิเจนในเลือดลดลง > 2 % ให้ส่งต่อนักกิจกรรมบำบัด (OT) อาจต้องใช้เทคนิคพิเศษช่วยในการฝึกกลืนก่อนกลืนโดยใช้การปรับอาหาร

# APPENDIX F
# USER MANUAL

## 1. การติดตั้งเครื่องมือ

ในการติดตั้งระบบผู้เชี่ยวชาญเพื่อคัดเลือกผู้ป่วยที่มีภาวะการกลืนผิดปกติอันเนื่องมาจากโรคหลอดเลือดสมอง จะต้องทำความเข้าใจกับส่วนต่างๆที่สำคัญในการติดตั้ง เพื่อที่จะสามารถใช้งานโปรแกรมได้อย่างมีประสิทธิภาพ และเมื่อเกิดปัญหาในการติดตั้งจะสามารถแก้ปัญหาได้ด้วยตัวเอง ส่วนสำคัญต่างๆ มีดังนี้

### ความต้องการด้านฮาร์ดแวร์

ก่อนที่จะติดตั้ง จะต้องตรวจสอบเครื่องคอมพิวเตอร์ให้พร้อมด้วยส่วนประกอบด้านฮาร์ดแวร์ ดังต่อไปนี้

1. เครื่องคอมพิวเตอร์รุ่น Intel Pentium Compatible ขึ้นไป
2. หน่วยความจำตั้งแต่ 512 เมกะไบต์ขึ้นไป
3. เนื้อที่ว่างในฮาร์ดดิสก์ประมาณ 100 เมกะไบต์ขึ้นไป

### ความต้องการด้านซอฟต์แวร์

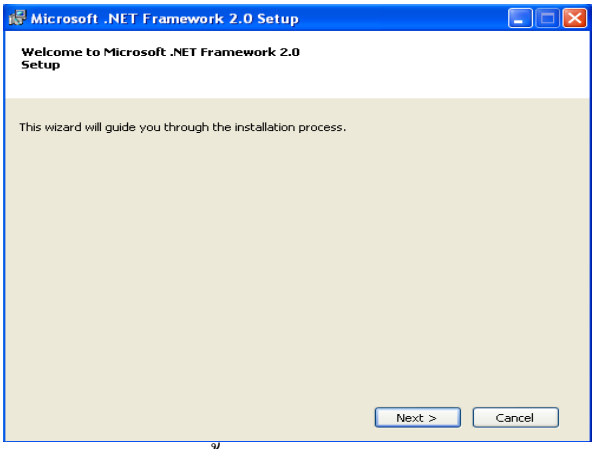
จะต้องติดตั้งระบบปฏิบัติการ Windows XP ขึ้นไป

### ขั้นตอนการติดตั้งเครื่องมือก่อนการใช้งานระบบผู้เชี่ยวชาญ

ก่อนเริ่มใช้งานโปรแกรมระบบผู้เชี่ยวชาญ ต้องทำการติดตั้งโปรแกรม Microsoft .NET Framework Version 2.0 Redistributable Package (x86) และโปรแกรม ReportViewer ในเครื่องคอมพิวเตอร์นั้นๆ ก่อน จึงจะสามารถใช้งานโปรแกรมระบบผู้เชี่ยวชาญได้ ขั้นตอนการติดตั้งมีดังนี้

**ขั้นตอนที่ 1**

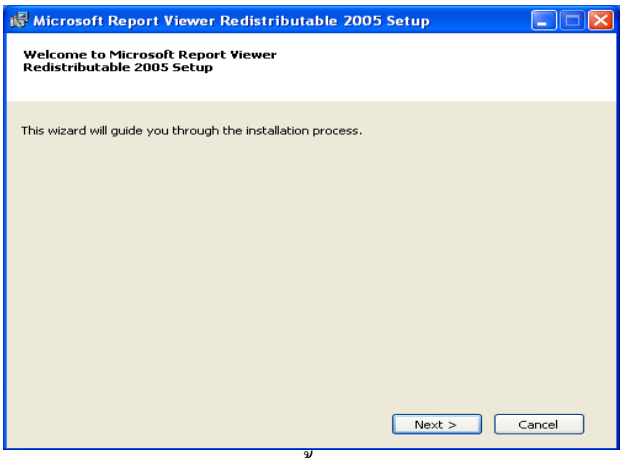
ติดตั้งโปรแกรม Microsoft.NET Framework Version 2.0 Redistributable Package (x86) ซึ่งสามารถดาวน์โหลดได้ฟรี โดยไม่เสียค่าใช้จ่าย จากเวบไซต์ http://www.microsoft.com/download/en/details.aspx?id=19 เมื่อดาวน์โหลดมาเรียบร้อยแล้ว ให้ทำการดับเบิ้ลคลิกเข้าไฟล์ที่ดาวน์โหลดมา จะปรากฏหน้าจอดังรูป จากนั้นคลิกที่ปุ่ม Next เพื่อดำเนินการต่อไป




หน้าจอการติดตั้ง Microsoft .NET Framework

**ขั้นตอนที่ 2**

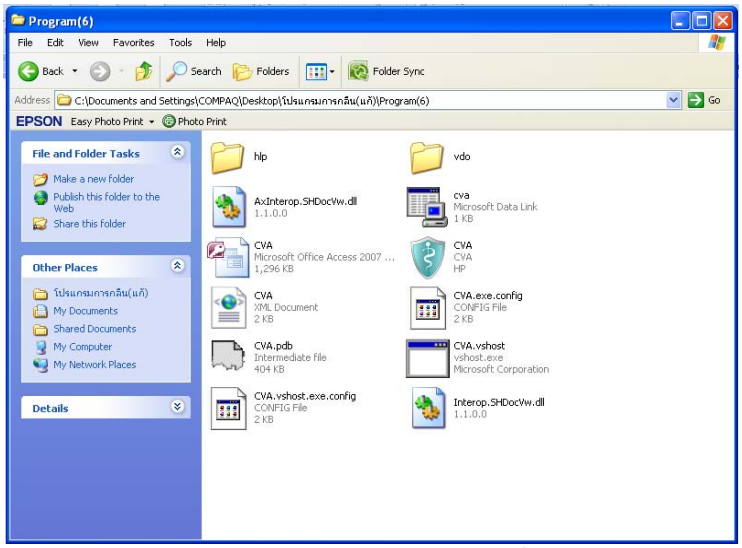
ติดตั้งโปรแกรม ReportViewer โดยสามารถดาวน์โหลดมาใช้โดยไม่เสียค่าใช้จ่าย จากเวบไซต์ http://www.microsoft.com/download/en/details.aspx?id=6576 เมื่อดาวน์โหลดมาเรียบร้อยแล้ว ให้ทำการดับเบิ้ลคลิกเข้าไฟล์ที่ดาวน์โหลดมา จะปรากฏหน้าจอดังรูป จากนั้นคลิกที่ปุ่ม Next เพื่อดำเนินการต่อไป




หน้าจอการติดตั้ง ReportViewer

**ขั้นตอนที่ 3**

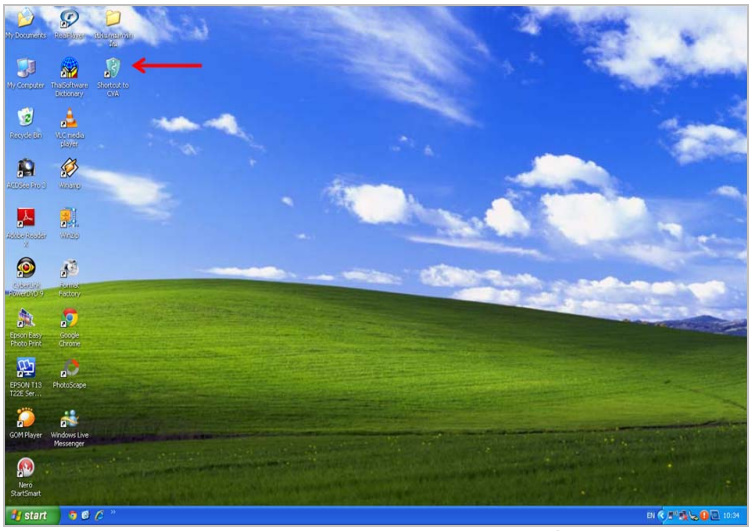
Copy โฟลเดอร์โปรแกรมระบบผู้เชี่ยวชาญเพื่อคัดเลือกผู้ป่วยที่มีภาวะการกลืนผิดปกติอันเนื่องมาจากโรคหลอดเลือดสมอง มาไว้ในเครื่องคอมพิวเตอร์ที่จะใช้งาน จากนั้นดับเบิ้ลคลิกที่โฟลเดอร์ จะปรากฏหน้าจอดังรูปด้านล่าง




หน้าจอโฟลเดอร์โปรแกรมระบบผู้เชี่ยวชาญฯ

หรือส่งไอคอน 

ไปเป็น Short cut  ที่หน้าจอคอมพิวเตอร์ ดังรูปด้านล่าง

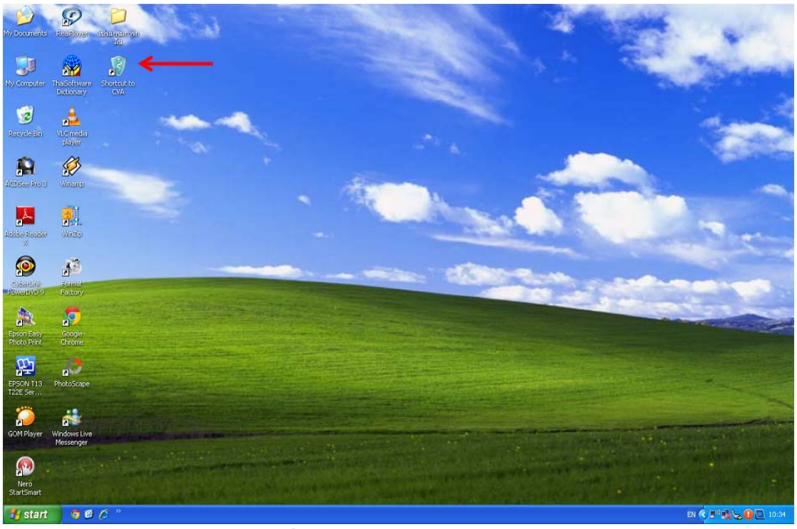


หน้าจอ Short cut ของโปรแกรมระบบผู้เชี่ยวชาญฯ

# 2. คู่มือการใช้งานโปรแกรม

## 2.1 การเข้าใช้งานระบบ

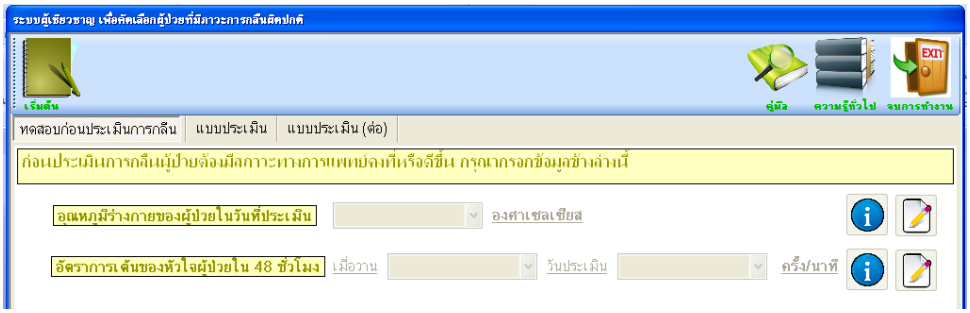
เมื่อจะเริ่มใช้งานระบบ ผู้ใช้ต้องเข้าสู่ระบบโดยดับเบิ้ลคลิกที่ไอคอน  จะปรากฏหน้าจอแรกของระบบแล้วคลิกที่รูป จะเข้าสู่หน้าจอการประเมินการกลืน



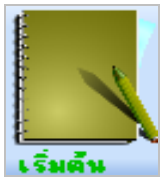
เริ่มต้นการเข้าสู่ระบบ

หน้าจอแรกของระบบ

ภายหลังเข้าสู่หน้าจอแรกของระบบแล้ว คลิกที่รูป  จะเข้าสู่หน้าจอประเมินการกลืน ซึ่งจะปรากฏเมนูการใช้งาน (Menu Bar) เพื่อเลือกเข้าไปในส่วนต่างๆ ดังนี้




หน้าจอเมนูการใช้งาน (Menu Bar)




เริ่มต้นการประเมินการกลืน

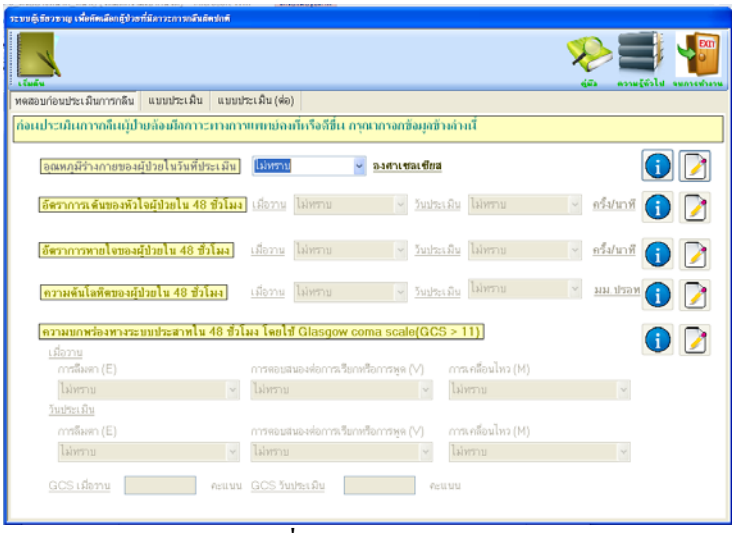

คู่มือการใช้งานโปรแกรม


ความรู้ทั่วไปเกี่ยวกับภาวะกลืนลำบาก


ออกจากการทำงานของโปรแกรม

## 2.2 การประเมินการกลืน

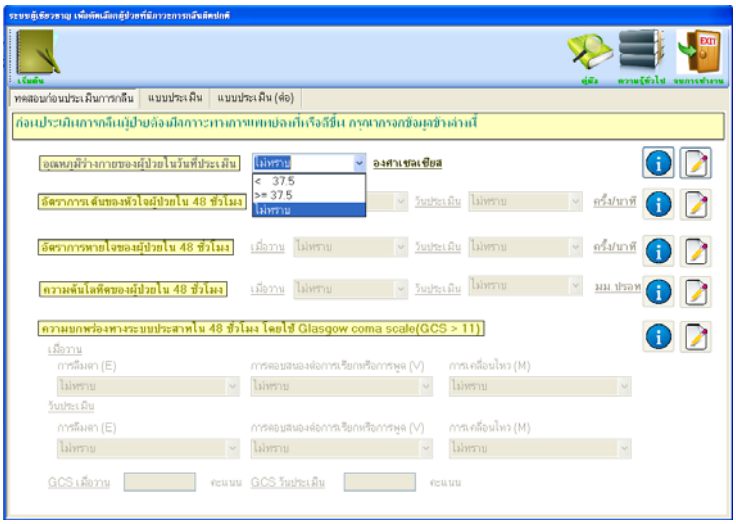
เมื่อคลิกเข้าสู่หน้าจอการประเมินการกลืน ผู้ใช้ต้องคลิกที่ไอคอน  เพื่อเริ่มต้นประเมินการกลืน



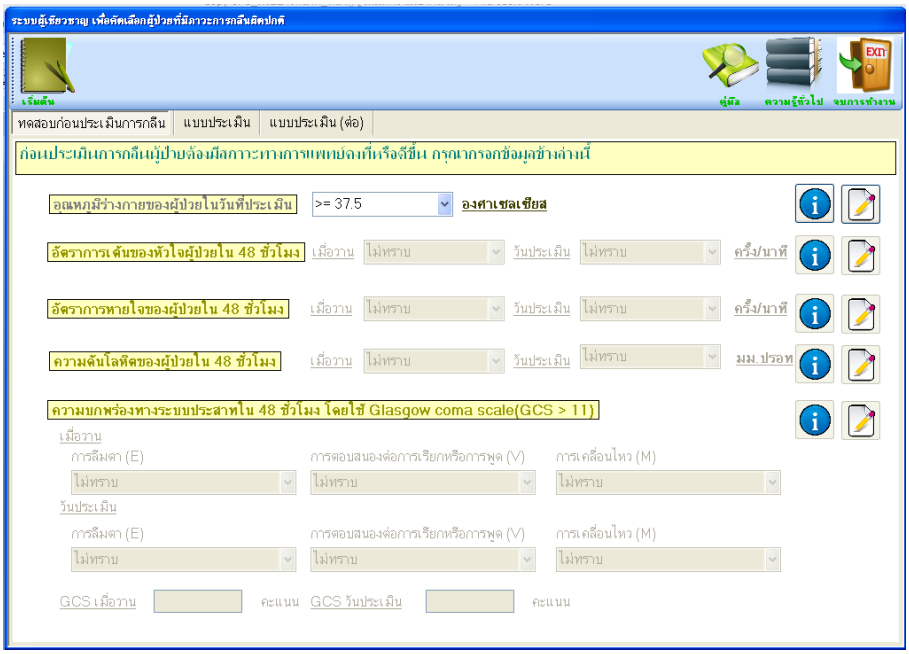
หน้าจอเริ่มต้นประเมินการกลืน

**โดยมีขั้นตอนการประเมินการกลืน ดังนี้**

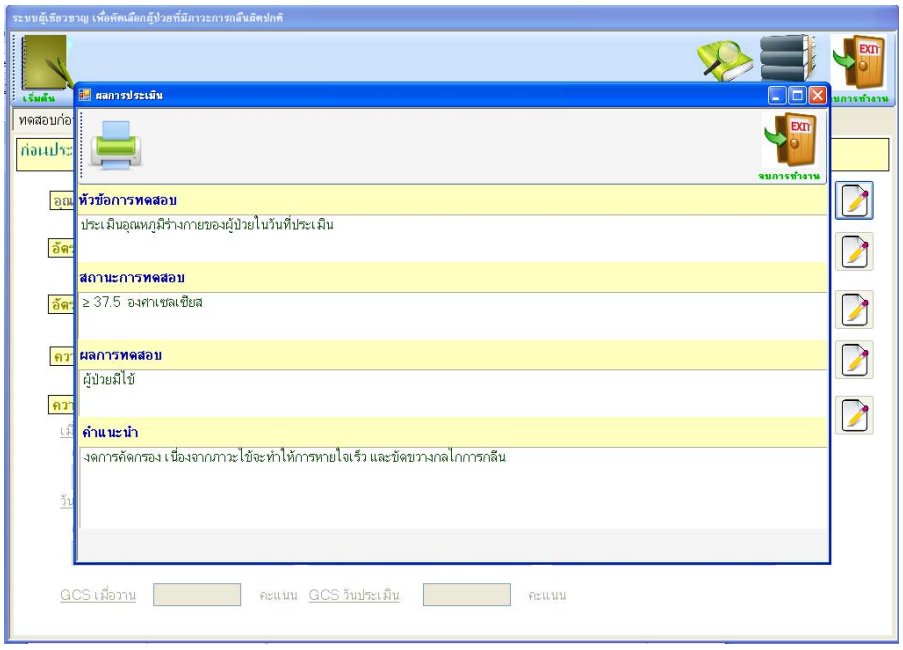
1) เลือกคำตอบที่ตรงตามข้อมูลในการตรวจประเมินของผู้ป่วย แล้วคลิกที่ปุ่ม  เพื่อประเมินผลและหากมีภาวะผิดปกติระบบจะแสดงผลการประเมินและคำแนะนำแก่ผู้ใช้ระบบให้ทราบดังรูป



หน้าจอแสดงการเลือกคำตอบในการประเมินการกลืน

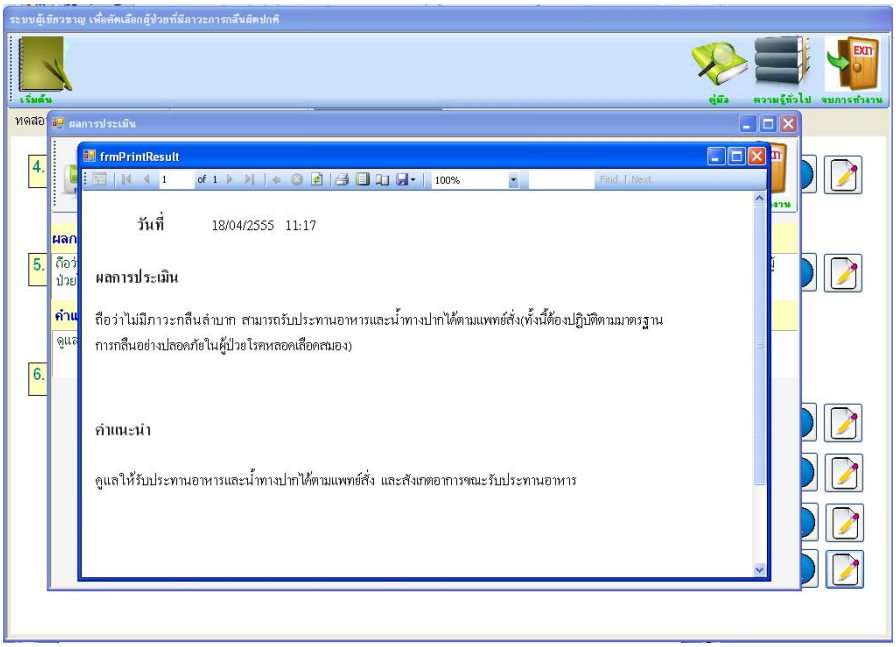



หน้าจอแสดงการเลือกคำตอบในการประเมินการกลืน



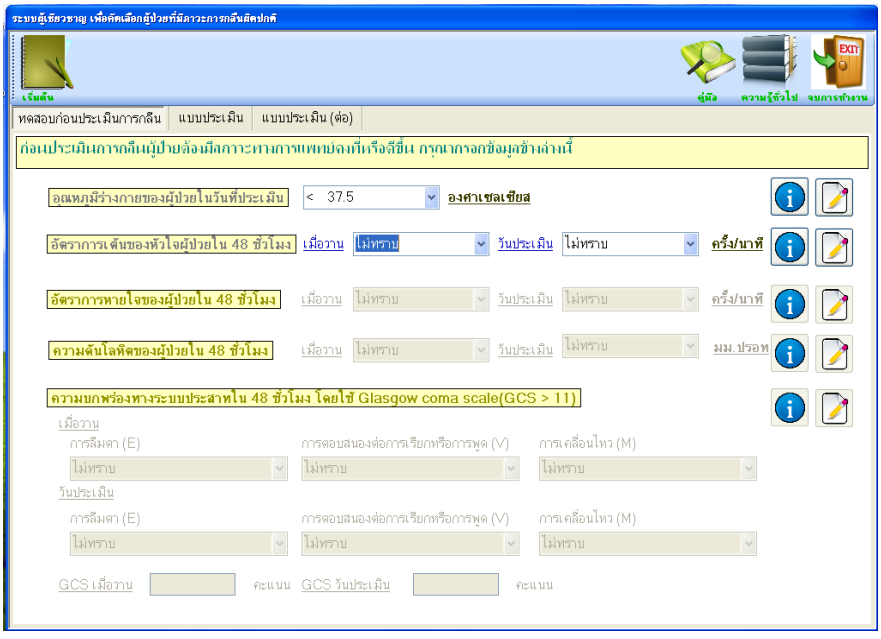

หน้าจอแสดงผลการประเมินการกลืนและคำแนะนำ

และหากต้องการพิมพ์ผลการประเมิน ให้คลิกที่ไอคอน  หน้าจอจะแสดง ดังรูปด้านล่าง แล้วกดที่ไอคอน 



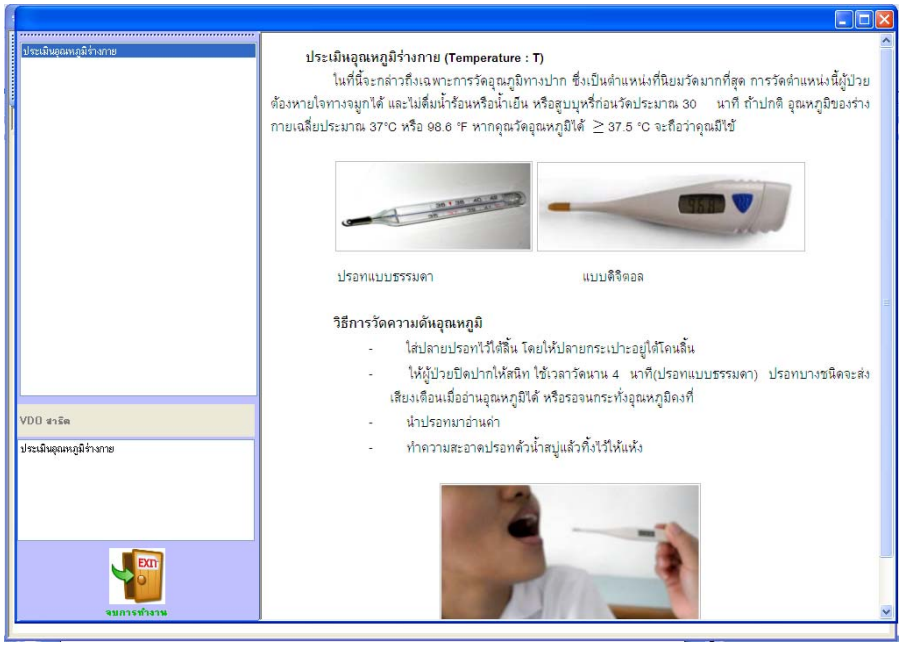

หน้าจอแสดงข้อมูลการพิมพ์ผลการประเมินการกลืนและคำแนะนำ

แต่ถ้าไม่พบความผิดปกติ ระบบจะแสดงให้ประเมินในหัวข้อต่อไป ดังรูป

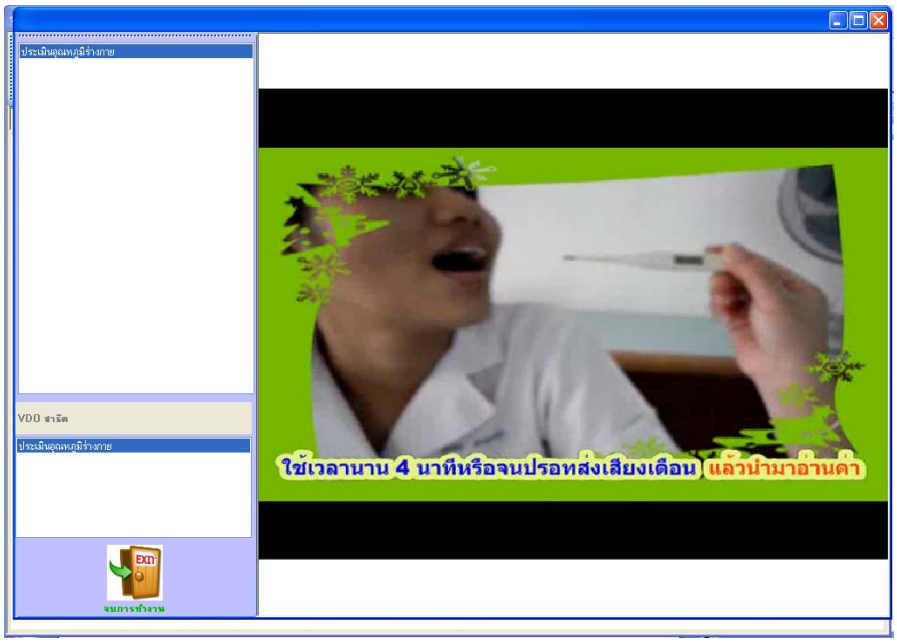



หน้าจอแสดงการประเมินการกลืน (ต่อ)

2) หากผู้ใช้ระบบต้องการทราบวิธีการประเมิน หรือรายละเอียดเพิ่มเติมเกี่ยวกับการประเมินในข้อนั้นๆ ให้คลิกที่ไอคอน  ก็จะเข้าสู่หน้าจอแสดงวิธีการประเมินในข้อนั้นๆ ดังรูป




หน้าจอแสดงรายละเอียดวิธีการประเมิน




หน้าจอแสดง VDO สาธิตวิธีการประเมิน

3) หากผู้ใช้ระบบต้องการลด - เพิ่มขนาดหน้าจอ หรือ ปิดหน้าจอแสดงรายละเอียดวิธีการประเมิน ให้ใช้คลิกที่ปุ่มมุมบนสุดด้านขวามือ  ซึ่งจะอธิบายการทำงานของแต่ละปุ่ม ดังนี้

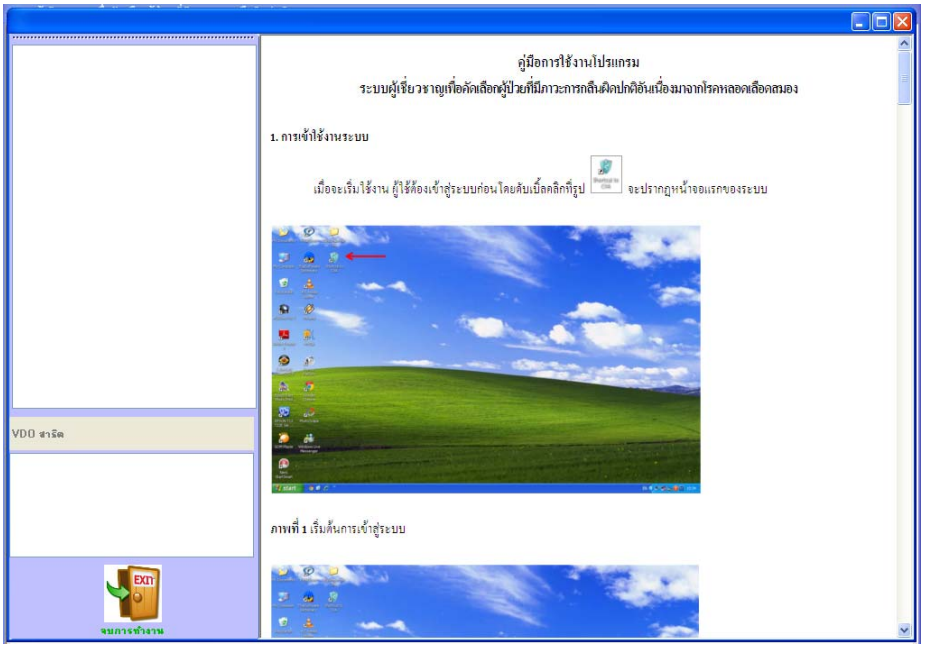
 Minimize -การทำหน้าต่างของฟอร์มให้เล็กลง

 Maximize -การทำหน้าต่างของฟอร์มให้ใหญ่ขึ้น

 Close –การปิดหน้าต่างของฟอร์มการทำงาน หรือ คลิกที่ไอคอน 


## 2.3 คู่มือการใช้งานโปรแกรม

เมนูคู่มือการใช้งานโปรแกรม เมื่อคลิกที่ไอคอน  จะแสดงคู่มือในการใช้งานโปรแกรม ดังรูป เพื่อการเข้าใจในการใช้งานโปรแกรมได้อย่างถูกต้อง ประกอบด้วยรายละเอียดหน้าที่ในแต่ละเมนู ส่วนประกอบของเมนูและวิธีการใช้งาน

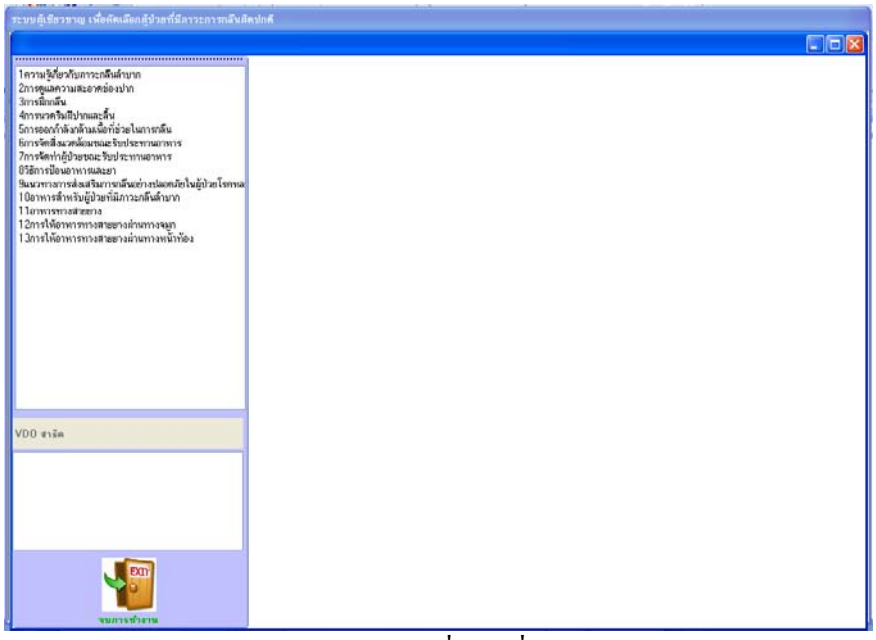



หน้าจอแสดงคู่มือการใช้งานโปรแกรม

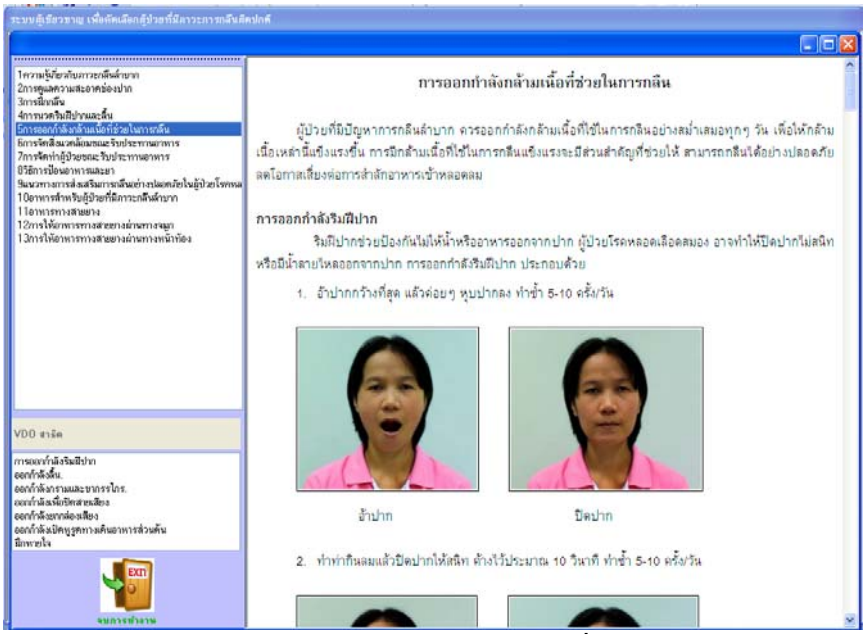
**2.4 ความรู้ทั่วไปเกี่ยวกับภาวะกลืนลำบาก**

เมื่อผู้ใช้ระบบ ต้องการทราบข้อมูล ความรู้ทั่วไปเกี่ยวกับภาวะกลืนลำบาก ให้กดที่ไอคอน 

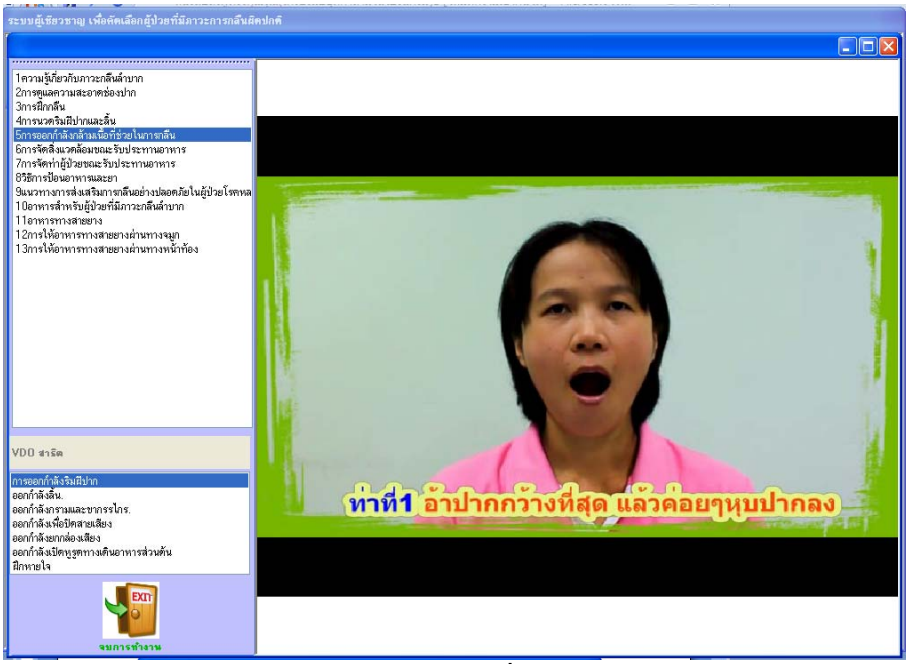
หน้าจอจะแสดงรายละเอียดและหัวข้อของความรู้ไว้ให้ผู้ใช้สามารถเลือกดูได้ทั้งที่เป็นรายละเอียดและ VDO ดังรูป



หน้าจอแสดงหัวข้อของความรู้ทั่วไปเกี่ยวกับภาวะกลืนลำบาก



หน้าจอแสดงรายละเอียดความรู้ตามหัวข้อที่ผู้ใช้ระบบเลือก

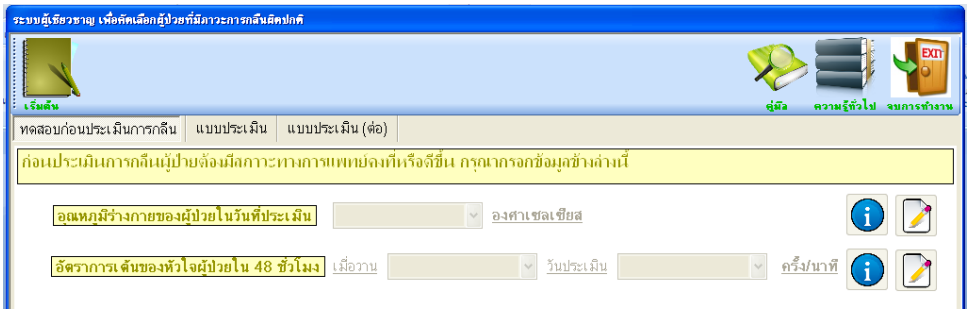



หน้าจอแสดงรายละเอียดความรู้ตามหัวข้อที่ผู้ใช้ระบบเลือก ในรูปแบบ VDO

**2.5 ออกจากการทำงานของโปรแกรม**

ผู้ใช้สามารถเข้าสู่เมนู จบการทำงาน เพื่อจบการทำงานและออกจากระบบ โดยคลิกที่ไอคอน 

ซึ่งอยู่บริเวณด้านมุมบนขวามือของหน้าเมนูการใช้งานหลัก




หน้าจอเมนูการใช้งาน (Menu Bar)

# BIOGRAPHY

| | |
|---|---|
| **NAME** | Miss Kanjana Rawainok |
| **DATE OF BIRTH** | 12 March 1976 |
| **PLACE OF BIRTH** | Buriram, Thailand |
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