

Adaptation, Compensation, and Decompensation of the Pharyngeal Swallow

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Abstract. Under normal circumstances, the act of swallowing adjusts to varying demands of different bolus characteristics and different head and neck postures. When the swallowing mechanism is impaired by disease, adjustment is essential to compensate for the impairment and allow swallowing. Evidence of adjustment can be demonstrated by cineradiography which provides important clues to the presence of underlying disease. When adjustment to disease is inadequate, swallowing decompensates. In this case, gross changes in swallowing performance are evident from clinical evaluation and cineradiography.

Key words: Swallowing disorders, cineradiography.

The pharyngeal swallow is constantly changing to achieve its purpose: to propel a properly sized bolus of food or drink into the esophagus without penetrating the nasopharynx or larynx. Each swallow is subject to variation in both the bolus and the swallowing apparatus.

We will discuss the specific coping mechanisms in both normal and impaired swallowing. In the case of normal swallowing, the adjustment to variability is referred to as *adaptation*. In the case of impaired swallowing, the process of coping with impairment is called *compensation*. When there is failure of compensation for swallow impairment, *decompensation* is said to occur.

Adaptation

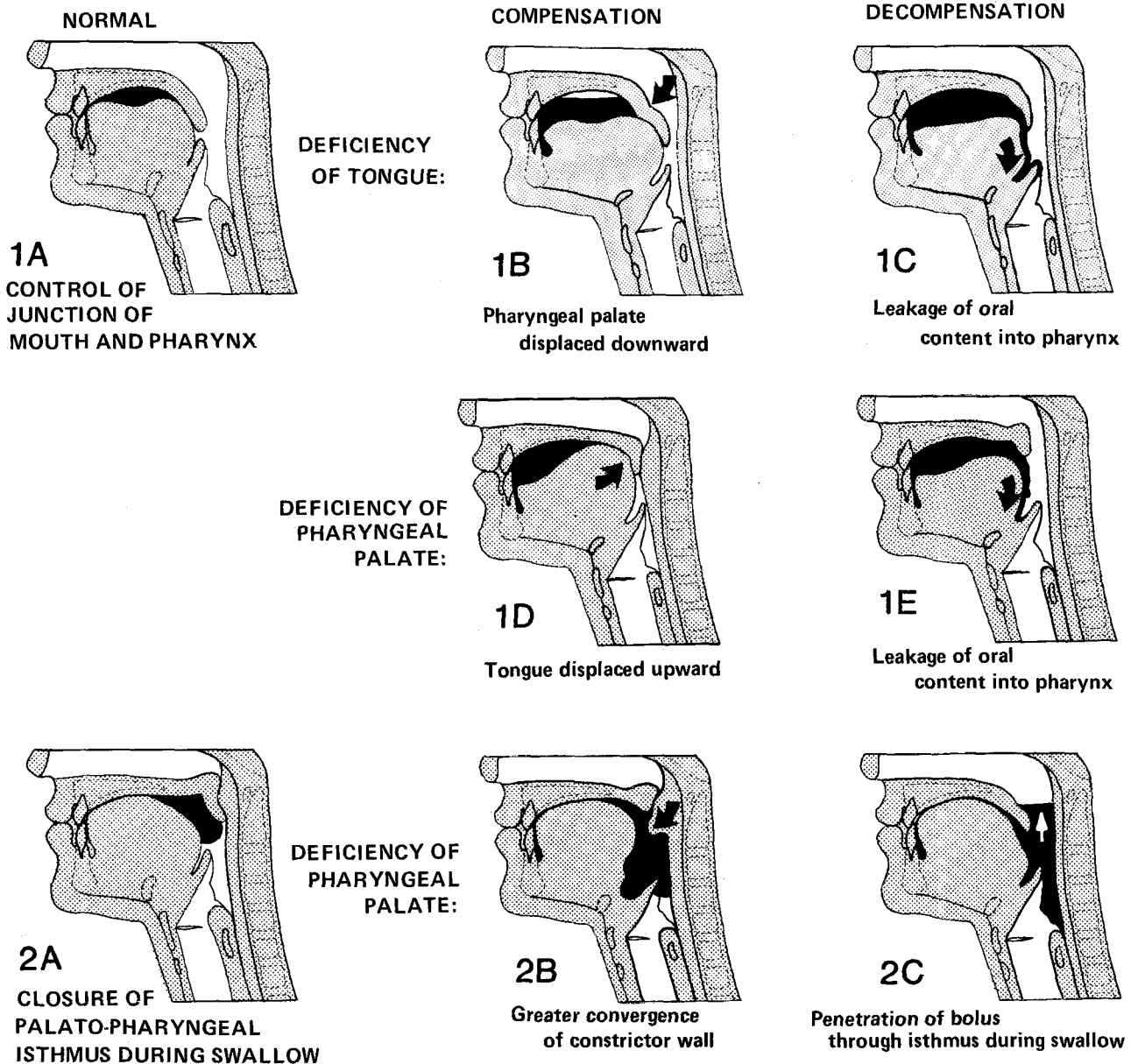
Swallowing is only 1 of 4 principal functions of the pharynx. The other 3 are maintenance of the

pharyngeal airway, participation in respiration, and speech. These 3 functions, like swallowing, normally undergo continual adaptation. As the orientation of the head and neck changes, the pharynx adjusts to ensure airway patency. During respiration the pharynx and laryngeal vestibule are expanded and contracted, respectively. Each different sound of speech requires a different configuration of the pharynx and its associated structures. Since our main concern is swallowing, we will not elaborate further on these other actions of the pharynx. Their dynamic nature, however, serves to emphasize the theme of constant adaptation of the swallow.

To what must the normal swallow adjust? First, to the bolus in the oral cavity. This varies in consistency, viscosity, elasticity, volume, mass, and temperature. It is a very different task to swallow a mouthful of water than a bolus of tough meat. Yet in each case the end result is the same: the entire bolus is transferred into the esophagus without penetrating the nasopharynx or larynx. It is thought that local sensory mechanisms in the oral cavity play a vital role in ascertaining the characteristics of a bolus so that the swallow can be adapted suitably.

Swallowing must also adapt to changes in head and neck postures which alter the anatomical relationships of the pharynx. As a mechanical device, the pharynx has certain positions of mechanical disadvantage, such as extension at the head and neck, which require that the pattern of muscular contraction in the pharynx be adapted so that the bolus can be effectively propelled. Orientation to gravity is also a factor. An extreme example is the considerable muscular effort which must be generated to achieve a successful swallow while standing on one's head, as shown by Bruhlmann [1]. The very fact that this can be accomplished emphasizes the great adaptive capability of normal swallowing.

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Figs. 1-5. Schematic presentation of the five steps of the pharyngeal swallowing in normal (A), compensated (B), and decompensated cases (C)

Over a longer time, swallowing also is altered by anatomical changes that occur with aging. An infant feeds by suckling, in accordance with the design of the infant mouth and pharynx. As pharyngeal anatomy changes with growth, the feeding process and swallowing adapt appropriately.

Pharyngeal swallowing can be described as a sequence of 5 steps, each of which is capable of adaptation:

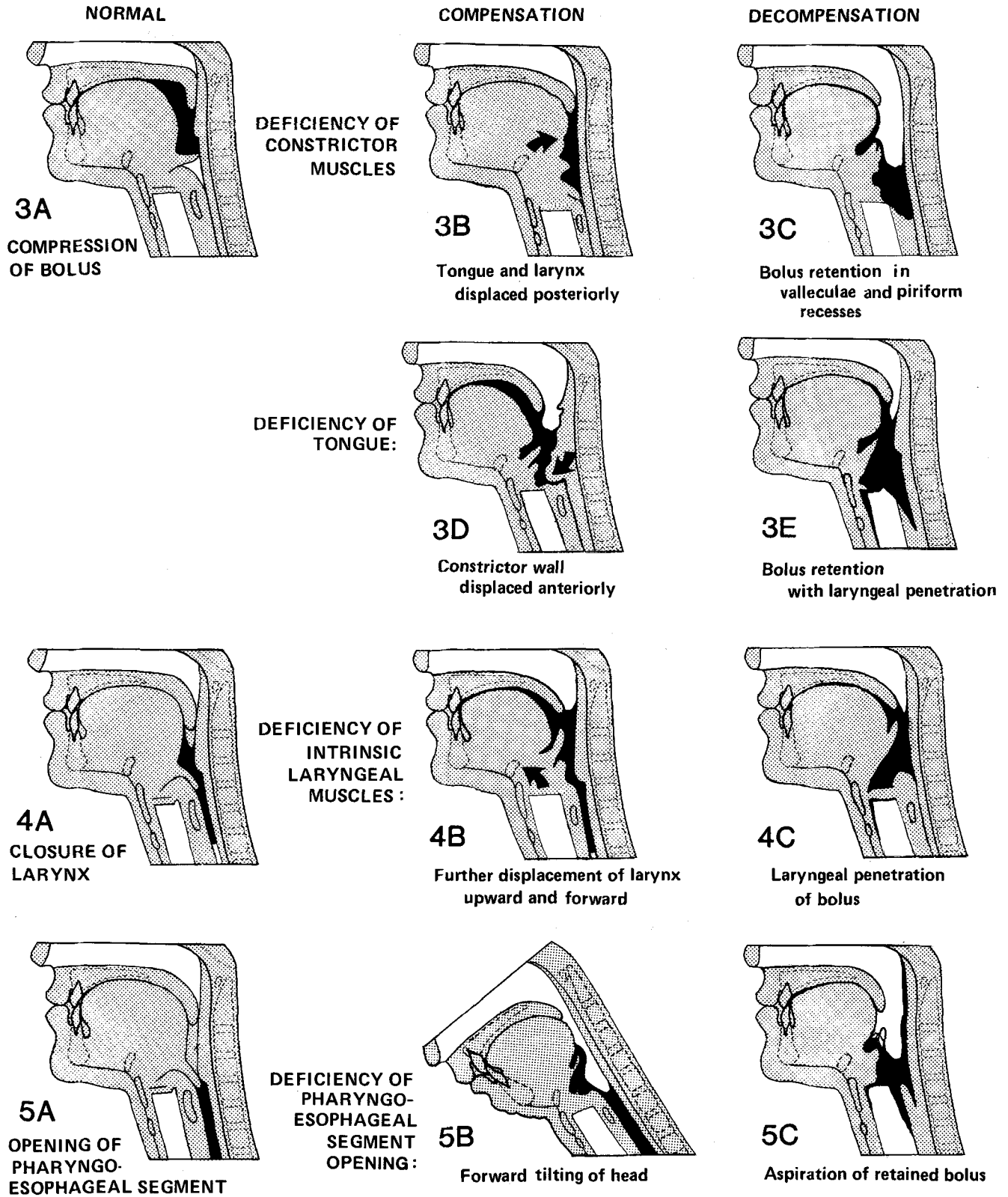
1. Control of the junction of mouth and pharynx is accomplished by combined action of the tongue and pharyngeal palate. This junction is closed during nasal respiration, except at the beginning of a swallow (Fig. 1 A);

2. Approximation of the pharyngeal palate and pharyngeal constrictor wall closes the palatopharyngeal isthmus during a swallow (Fig. 2 A);

3. The bolus is actively propelled through the pharynx by pharyngeal constrictor muscles, although coordinated activity of the palate, tongue, hyoid muscles, and larynx is required (Fig. 3 A);

4. The larynx is protected by downward tilting of the epiglottis and occlusion of the vestibule and glottis (Fig. 4 A);

5. The pharyngoesophageal segment is opened as the larynx is displaced upward and the cricopharyngeus muscle relaxes (Fig. 5 A).



Compensation

We have considered the ways in which normal swallowing is accomplished by adaptation to the varying demands of each swallow. Now we will extend this concept to the impaired swallow apparatus. In this situation, adequate swallowing is achieved as a result of compensation by part of the swallow apparatus for deficiency in another part. The result is that an effective swallow occurs: a properly sized bolus is delivered to the esophagus without penetration into the nasopharynx or larynx. However, the patient may be aware of alterations in the swallowing process, and cineradiography may demonstrate an abnormal pattern. The radiologist must recognize the swallowing abnormality and alert the clinician to the presence of a swallowing disorder.

Structural, motor, and sensory problems impair the swallow apparatus and result in compensation. Structural changes may be due to neoplasm, cervical spine disease, chronic inflammation, or surgery. Motor and/or sensory dysfunction indicates neurologic disease such as stroke, multiple sclerosis, amyotrophic lateral sclerosis, poliomyelitis, or myopathy. These diseases may initially present as dysphagia; a compensated pattern of swallowing without structural cause should prompt further neurologic investigation.

When swallowing is impaired but compensated, careful history-taking may provide important clues. A patient may report that feeding has become more arduous and time-consuming. Food may have to be specially prepared, either by vigorous chewing or mechanical blending, and certain foods may be avoided entirely. Frequent small meals make feeding easier, and the patient may reduce the individual bolus size. Swallowing a second time with each bolus helps to clear retained material from the pharynx. Certain postures such as tilting or flexing the head and neck may help a patient to swallow. Sometimes postural muscles of the head and neck are recruited to aid in swallowing, and in such a case the recumbent position may afford relief by allowing the postural muscles to be more available for swallowing. Even the basic method of feeding may be altered, as when sipping liquids through a straw becomes the predominant mode.

These are "voluntary" compensations for impaired swallowing of which the patient may be aware, so that history-taking is the primary tool of evaluation. However, compensation is also "involuntary," that is, it takes place through adjustments in the swallow apparatus itself. This form

of compensation is best evaluated by cineradiography, and each of the 5 steps of the pharyngeal swallow has a characteristic pattern of compensation:

1. Deficiency of the tongue (atrophy, weakness, incoordination, or postsurgical defect) may be compensated by downward displacement of the palate (Fig. 1 B) and, conversely, palatal deficiency is compensated by upward displacement of the tongue (Fig. 1 D);
2. Deficiency of the pharyngeal palate may be compensated by greater convergence of the pharyngeal constrictor muscles (Fig. 2 B);
3. Deficiency of the constrictor muscles may be compensated by exaggerated upward and posteriorward displacement of the tongue and larynx (Fig. 3 B). Deficiency of the tongue in bolus compression may be compensated by anterior displacement of the constrictor wall (Fig. 3 D);
4. Deficiency of epiglottic tilting or glottic closure may be compensated by increased upward and anteriorward displacement of the larynx (Fig. 4 B);
5. Deficiency of laryngeal displacement in contributing to opening of the pharyngoesophageal segment may be compensated by forward tilting of the head and forward thrusting of the jaw (Fig. 5 B).

In a sense, compensation is an extension of the normal process of adaptation applied to the abnormal situation of impaired swallowing. The important point about compensation is that it allows swallowing to proceed fairly effectively, that is, without grossly abnormal passage of the bolus. Compensation often causes subtle changes which are apparent only when specifically sought through history-taking and cineradiography.

However, the presence of compensation suggests an underlying impairment of the swallowing apparatus which should be evaluated further.

Decompensation

If compensation fails, decompensation occurs. In this case, swallowing is ineffective, so that the bolus is not delivered to the esophagus without retention in the hypopharynx or penetration into the nasopharynx or larynx.

Compensation may fail for a variety of reasons. The underlying disorder impairing the swallow apparatus may be too severe to be compensated, such as amyotrophic lateral sclerosis in an advanced stage of bulbar impairment. Also, the process of compensation itself may be rendered inadequate. This may result from extension of the underlying

disorder to involve the compensatory mechanism, such as in progressive neurologic disease.

Decompensation may arise when multiple causes of swallowing impairment coexist, even though each cause by itself could be effectively compensated for. Systemic factors such as fatigue, infection, stress, and medications can interfere with compensation. Such medications include local anesthetic agents applied to the pharynx and a variety of central nervous system depressants.

In addition, compensation may be effective with certain bolus characteristics and head and neck positions, but changes in these factors can cause swallowing to decompensate. Bolus preparation may be inadequate due to poor dentition, neurologic impairment of the mouth, or deficient salivation, and the bolus may be improperly sized by the tongue. Finally, aging may limit compensation for an impaired swallow. Degeneration of neural structures responsible for swallowing may occur with aging, although under normal circumstances this is inapparent. However, diminished neuromuscular "reserve" would increase the likelihood of decompensation in the event of an impairment in swallowing.

Symptoms of decompensation are often dramatic and include coughing and choking with feeding, aspiration pneumonia, and asphyxia due to a solid bolus obstructing the airway. Other symptoms are nasal regurgitation, frequent "throat-clearing" and "wet voice," retention of solid food particles in the pharynx, and delayed food passage. However, decompensation may occur without obvious symptoms, especially in the presence of pharyngeal and/or laryngeal sensory loss. This is "silent dysphagia," which may remain undetected for a prolonged time.

The radiologic features of decompensation are gross abnormalities, unlike the more subtle changes of compensation:

1. Decompensated deficiency of the tongue results in leakage of oral content prematurely into the pharynx (Fig. 1 C). Deficiency of the palate results in an overly large bolus entering the pharynx (Fig. 1 E);

2. Decompensated deficiency of the pharyngeal palate allows penetration of bolus through the palatopharyngeal isthmus when the bolus is compressed (Fig. 2 C);

3. Decompensated deficiency of pharyngeal constrictor muscles or the tongue in bolus compression results in retention of bolus in the valleculae and piriform recesses (Fig. 3 C, E);

4. Decompensated deficiency of epiglottic tilting or laryngeal closure results in penetration of bolus through the larynx (Fig. 4 C);

5. Decompensated deficiency of pharyngoesophageal segment opening results in retention of bolus in the piriform recesses and possibly aspiration into the larynx (Fig. 5 C).

The known effects of certain factors in causing a compensated swallow to decompensate can be useful in radiologic evaluation. "Provocative" maneuvers may be useful when a compensated pattern of swallowing is seen in order to demonstrate the abnormality more clearly. These maneuvers include alteration of bolus characteristics (liquid vs. paste vs. solid) and head and neck extension. Obviously, extreme caution must be exercised.

In summary, normal swallowing is accomplished by adaptation of each swallow to bolus characteristics and head and neck position. Impaired swallowing is compensated by voluntary and involuntary mechanisms which have specific features in the patient's history and specific findings on radiography. The presence of compensation should prompt further investigation into the cause of swallowing impairment. Decompensation, or failure of compensation, leads to ineffective swallowing which usually is grossly evident from the history and radiologic studies. Decompensation arises due to a variety of factors, some of which may be manipulated for diagnostic and therapeutic purposes.

Reference

1. Bruhlmann W: *Die roentgenkinematographische Untersuchung von Störungen des Schluckaktes*. Zürich: Habilitationsschrift, 1982