

HAZOP for Swallowing Disorders**1) Preparation for HAZOP**

As shown in Chapter 1, the swallowing process is classified according to the function, and evaluation has been performed according to the swallowing phase. The main nodes and the subnodes according to the function for the swallowing process are shown in Table 3.1. HAZOP was carried out for every subnode listed below.

The HAZOP for dysphagia shown below is created according to the motion of bolus that is the foundations of swallowing process. In this chapter, the node of pharyngeal phase will be shown. In addition, examples of application are shown in chapter 4, which include surgical procedures, human factors, rehabilitation methods,

Table 3.1 Nodes and subnodes in swallowing process

| Node No. | Main node | subnodes |
|----------|-------------------|--|
| SW1 | Recognition Phase | Understand food and start ingestion |
| SW2 | Preparatory phase | Ingestion and mastication to form bolus |
| SW3 | Oral phase | Tongue moves bolus to oral canal Bolus contacts Wassilief area to start swallowing reflex Bolus end passes through oral canal |
| SW4 | Pharyngeal phase | SW4.1 : Soft palate attaches tightly to pharyngeal wall SW4.2 : Tongue and palate shut tightly to prevent from oral reflux SW4.3 : Larynx elevates SW4.4 : Epiglottis falls SW4.5 : Vocal cord closes SW4.6 : UES opens |
| SW5 | Esophageal phase | SW5.1 : UES closes tightly SW5.2 : Bolus moves with peristalsis SW5.3 : LES opens |

clinical pathway, in-home care, and medical research.

By illustrating to a matrix, understanding for the risk is obtained shown below.

- (1) There are risks with both harmful effect and high frequency in the matrix. These risks need to be corresponded immediately.
- (2) The effect of the risk becoming more harmful as deviation increases. There are two types of growth of the risk; the risk that increases gradually with deviation step by step, and the one which jumps to a high level of danger with a little deviation.
- (3) The incident whose effect increases gradually, can be observed and taken measures with a time to think over.
- (4) The risk increased abruptly with a little change of deviation, should be corresponded immediately, and checking system for the risk must be clarified.

When there is much amount of bolus, or when texture is unsuitable, inflow to the larynx and aspiration can occur. The following can be considered as a measure for dysphagia. The quantity which a patient puts into a mouth needs to be managed (with the explanation and the education to a patient and a family about proper quantity of bolus) for the case with suitable texture management in an inpatient's meal. The quantity which a patient puts into a mouth needs to be managed for the case who takes a between-meal snack.

2) Pharyngeal Phase

Pharyngeal phase can be divided into five more subnodes.

SW4-1: Bolus comes to tongue base and larynx begins to elevate. At the same time velum contacts posterior pharynx wall and closes nasopharynx to prevent bolus from reverse to nasal cavity.

SW4-2: When bolus passes, tongue base, the velum, tongue, and hard palate stick completely, and adverse current into mouth will be prevented.

SW4-3: Respiratory tract entrance is narrowed with laryngeal elevation.

SW4-4: Epiglottis falls.

SW4-5: Epiglottis closes.

HAZOP was carried out for every subnode listed above. Hereafter, the influence, cause, and frequency accompanying typical deviation are analyzed for every subnode.

3) Subnode 3 (SW4.3) in Pharyngeal Phase

Analysis with deviation guidewords are listed in Table 3.2 in Subnode 4.3 (SW4.3). Among them a deviation of LESS are described as “Since elevation of pharynx is inadequate, tracheal gill is not closed. There are clinical examples which exists in mostly elderly people.” Table 3.3 indicate results when Less deviation occur. The

Table 3.2 Deviation in SW4-3 (Laryngeal elevation)

| Code No. | Secondary guidewords | Contents of deviation |
|----------|----------------------|--|
| SW4.3-01 | None/No | Larynx does not elevate, and airway does not completely shut |
| SW4.3-11 | Less | Larynx does not elevate completely, and airway does not completely shut |
| SW4.3-28 | Delay | Larynx elevates with delay , and airway does not completely shut |
| SW4.3-41 | Slow | Larynx elevates slowly, and airway does not completely shut |
| SW4.3-51 | Delay & Slow | Larynx elevates with delay and slowly, and airway does not completely shut |
| SW4.3-61 | Less & Slow | Larynx elevates incompletely and slowly, and airway does not completely shut |
| SW4.3-71 | Less & Slow | Larynx elevates incompletely and with delay, and airway does not completely shut |

Table 3.3 Deviation of Less in SW4-3 (Laryngeal elevation) : analysis of effects and cause

| Code No. | Deviation | Effect 1 | Effect 2 | Effect 3 | Effect 4 | Cause | |
|----------|------------------------------------|-----------------------------|--|------------|------------------|---|-----------|
| SW4.3-11 | Larynx elevate incompletely (Less) | Bolus goes to lower pharynx | | | | Disease of cerebrum Disease of medulla or cranial nerves (IX, X, XI, XII) Disease of muscle Disuse Aging Oral or pharyngeal cancer | |
| SW4.3-12 | | | | | | | |
| SW4.3-13 | | | Remove bolus | | | | |
| SW4.3-14 | | | Bolus goes to laryngeal entrance (penetration) | | | | |
| SW4.3-15 | | | | Aspiration | Remove all | | |
| SW4.3-16 | | | | | Remove partially | | |
| SW4.3-17 | | | | | Remove partially | | Pneumonia |

influences, cause, influence level, and measure to take are entered in the HAZOP sheet. An evaluation result is also shown in these tables.

In the next step, each codes are evaluated by frequency and impact of the risk. As shown in Table 3.4, this deviation has many clinical examples, dysphagia occurs every day, and there is a case which results in pneumonia. It is important to recognize that dysphagia occurred frequently (everyday), and the risk of pneumonia increases when a part of aspirated material is not discharged.

Table 3.4 Deviation of Less in SW4-3 (Laryngeal elevation) : analysis of frequency and impact

| Code No. | contents | Results | Frequency | Impact |
|----------|--|-----------------------------|--------------------------------------|--------|
| SW4.3-11 | Bolus goes to lower pharinx | No harm | Frequent UH (several times in a day) | B |
| SW4.3-12 | Bolus goes to larynx | Check by exam. | Frequent UH (several times in a day) | C |
| SW4.3-13 | Bolus removed | Check by exam. | Frequent UH (several times in a day) | C |
| SW4.3-14 | Aspiration | Treatment | Frequent HH (once in a day) | C |
| SW4.3-15 | Remove all the bolus | Treatment | Frequent (several times in a year) | B |
| SW4.3-16 | Remove part of the bolus | Treatment | Frequent HH (once in a day) | C |
| SW4.3-17 | Remove part of the bolus ⇒ aspiration pneumonia | Treatment Intensive care | Frequent H (once in a month) | D/E |

4) Information from HAZOP Analysis

Risk rank distribution is shown in Table 3.5 for every evaluation scenario of the node of oral phase, pharyngeal phase, and esophageal phase in HAZOP. Although the evaluation result of all the scenarios is distributed over A or B ranks in oral and esophageal phase, distribution of C or more ranks appears in pharyngeal phase. In a deviation with elevation of larynx and closure of respiratory tract entrance, distribution of D and E ranks is also accepted. Although it was known that pharyngeal phase is critical for the swallowing function, HAZOP analysis revealed that the risk in the subnode of elevation of larynx and of closing of respiratory tract is high (Table 3.5).

HAZOP-SW-5.4-1
Risk Rank

Elevation of epiglottis and closure of air way

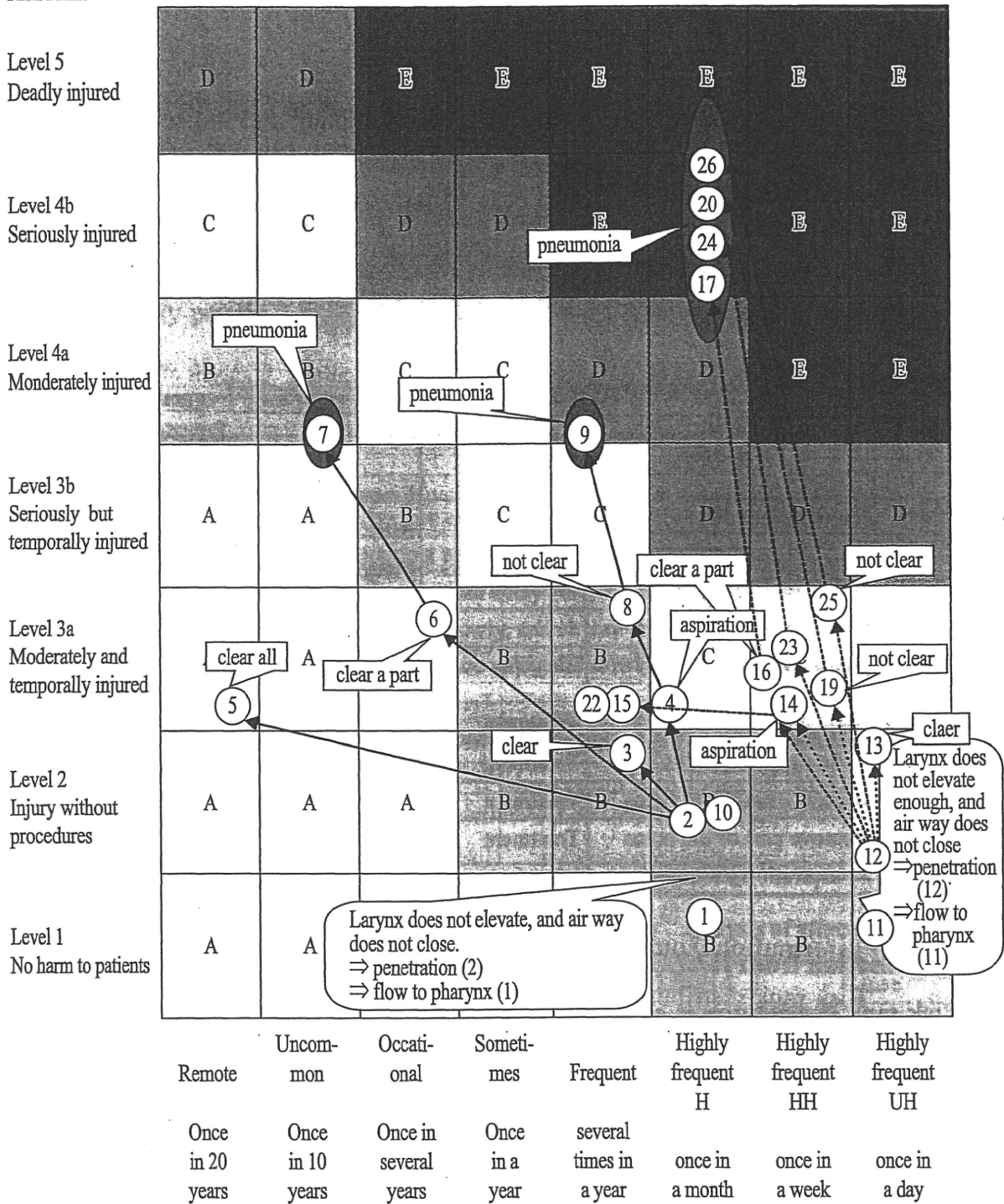


Figure 3.1 Risk Matrix in SW4.3-1

Table 3.5 Analysis of risk rank in each node

| Node No. | Main node | Contents of nodes and subnodes | Risk rank | | | |
|----------|------------------|---|-----------|-----|----|----|
| | | | A&B | C | D | E |
| SW3 | Oral phase | Tongue moves bolus to oral canal Bolus contacts Wassilief area to start swallowing reflex Bolus end passes through oral canal | 100% | 0 | 0 | 0 |
| SW4 | Pharyngeal phase | SW4.1: Soft palate attaches tightly to pharyngeal wall | 65% | 35% | 0 | 0 |
| | | SW4.2: Tongue and palate shut tightly to prevent from oral reflux | 92% | 8% | 0 | 0 |
| | | SW4.3: Larynx elevates | 55% | 31% | 7% | 7% |
| | | SW4.4: Epiglottis falls | 79% | 21% | 0 | 0 |
| | | SW4.5: Vocal cord closes | 100% | 0 | 0 | 0 |
| | | SW4.6: UES opens | 100% | 0 | 0 | 0 |
| SW5 | Esophageal phase | SW5.1: UES closes tightly | 100% | 0 | 0 | 0 |
| | | SW5.2: Bolus moves with peristalsis | 100% | 0 | 0 | 0 |
| | | SW5.3: LES opens | 100% | 0 | 0 | 0 |

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