Instruction Manual for
ASPEKT-C Method

Analysis of Swallowing Physiology:
Events, Kinematics & Timing for Use in Clinical Practice (ASPEKT-C)
Table of Contents

Table of Contents ..........................................................................................................................2
Acronyms.......................................................................................................................................2
Background and History of the ASPEKT Method.........................................................................3
Introduction to the ASPEKT-C Method .........................................................................................4
Before You Get Started................................................................................................................5
ASPEKT-C Method Worksheet - Overview ..................................................................................5
ASPEKT-C Method Worksheet - Section 1: Bolus Information ..................................................7
  1a. IDDSI Level and Bolus # ......................................................................................................7
  1b. Total Swallows Per Bolus ....................................................................................................8
ASPEKT-C Method Worksheet - Section 2: Swallowing Safety ................................................9
  2a. Penetration-Aspiration Scale Score ....................................................................................9
  2b. Laryngeal Vestibule Closure (LVC) Integrity ...................................................................10
  2c. PAS Timing ........................................................................................................................12
  2d. Time-to-LVC ......................................................................................................................13
  2e. PAS Evolution ....................................................................................................................14
ASPEKT-C Method Worksheet – Section 3: Swallowing Efficiency .........................................15
  3a. Total Pharyngeal Residue ..................................................................................................15
  3b. Pharyngeal Area at Maximum Pharyngeal Constriction (PhAMPC) .............................19
ASPEKT-C Method Scoring Sheet ..............................................................................................22
References .......................................................................................................................................24
Appendix A: Introduction to ImageJ Software ..............................................................................25

Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALS</td>
<td>Amyotrophic Lateral Sclerosis</td>
</tr>
<tr>
<td>ASPEKT</td>
<td>Analysis of Swallowing Physiology: Events, Kinematics and Timing</td>
</tr>
<tr>
<td>ASPEKT-C</td>
<td>Analysis of Swallowing Physiology: Events, Kinematics and Timing for use in Clinical Practice</td>
</tr>
<tr>
<td>COPD</td>
<td>Chronic Obstructive Pulmonary Disease</td>
</tr>
<tr>
<td>IDDSI</td>
<td>International Dysphagia Diet Standardisation Initiative</td>
</tr>
<tr>
<td>LVC</td>
<td>Laryngeal Vestibule Closure</td>
</tr>
<tr>
<td>ms</td>
<td>Milliseconds</td>
</tr>
<tr>
<td>PAS</td>
<td>Penetration Aspiration Scale</td>
</tr>
<tr>
<td>PD</td>
<td>Parkinson Disease</td>
</tr>
<tr>
<td>PhAMPC</td>
<td>Pharyngeal Area at Maximum Pharyngeal Constriction</td>
</tr>
<tr>
<td>SCI</td>
<td>Spinal Cord Injury</td>
</tr>
<tr>
<td>S-LP</td>
<td>Speech-Language Pathology</td>
</tr>
<tr>
<td>SOP</td>
<td>Standard Operating Procedure</td>
</tr>
<tr>
<td>SRRL</td>
<td>Swallowing Rehabilitation Research Lab</td>
</tr>
<tr>
<td>VFSS</td>
<td>Videofluoroscopic Swallow Study</td>
</tr>
<tr>
<td>WNL</td>
<td>Within Normal Limits</td>
</tr>
</tbody>
</table>
Background and History of the ASPEKT Method

The videofluoroscopic swallow study (VFSS) is an instrumental assessment that is widely considered the gold standard for evaluating swallowing function. At the Swallowing Rehabilitation Research Lab (SRRL), it is our belief that in order to effectively treat dysphagia, clinicians need to understand the underlying mechanisms of impairment. In order to identify the mechanisms of impairment that underlie a person’s swallowing difficulties, we first need to know what healthy swallowing looks like.

In April 2019, the article “Reference Values for Healthy Swallowing Across the Range from Thin to Extremely Thick Liquids” was published by Professor Catriona Steele and colleagues in the Journal of Speech, Language and Hearing Research. This article establish quantitative reference values for a large number of parameters describing swallowing physiology in healthy adult volunteers from thin liquids to extremely thick liquids (International Dysphagia Diet Standardization or IDDSI levels 0, 1, 2, 3, 4), as seen on the “drinks” side of the IDDSI pyramid in Figure 1. This article also included extensive detail on the foundation laid to rigorously collect this data including:

(a) The creation and use of a standardized protocol to collect VFSS data.
(b) The creation and use of a standard operating procedure (SOP) to analyze the swallowing mechanism, in an attempt to overcome the concern around poor inter-rater reliability (Ekberg et al., 1988; Ott, 1998).

The resultant SOP was entitled the ASPEKT Method, or the Analysis of Swallowing Physiology: Events, Kinematics and Timing (Steele, Peladeau-Pigeon et al., 2019). The ASPEKT Method, seen below in Figure 2, included standard definitions for all terminology and quantitative measurements developed with the purpose of conducting videofluoroscopic swallowing research. Please note that at this time, the ASPEKT Method does not cover the “foods” side of the pyramid.

**IMPORTANT NOTE:** This instruction manual only provides guidance on post-VFSS analysis. For evidence-based recommendations on VFSS setup and protocol, please see our VFSS Best Practice Recommendations document at [www.steeleswallowinglab.ca](http://www.steeleswallowinglab.ca).
Introduction to the ASPEKT-C Method

Recognizing that time constraints are likely to make it impractical for a clinician to complete an analysis of every swallow in a videofluoroscopy recording using the full ASPEKT Method, the SRRL undertook to develop a shorter process for regular use by clinicians, called the ASPEKT-C Method (ASPEKT for use in Clinical Practice) shown in Figure 3.

The goal of the ASPEKT-C Method is to assist clinicians in identifying the mechanisms underlying impaired swallowing safety and efficiency on VFSS. Swallowing safety is defined as the ability to protect the airway and swallowing efficiency as the ability to clear material through the pharynx.

The 8 key parameters of swallowing included in the ASPEKT-C Method have been chosen based on data suggesting that they are the parameters that most commonly explain penetration-aspiration and post-swallow residue in people with dysphagia. This conclusion was based on detailed analysis of several clinical datasets using the full ASPEKT Method: 1) a dataset of 305 individuals “at risk” for dysphagia (non-structural, non-congenital, non-oncologic); 2) cross-sectional studies in patient cohorts (Amyotrophic Lateral Sclerosis (ALS), Parkinson Disease (PD), traumatic Spinal Cord Injury (SCI), post-radiation oropharyngeal cancer, Chronic Obstructive Pulmonary Disease (COPD)); and 3) a growing set of other clinical cases.

The 8 key parameters can be compared to normative reference values from healthy volunteers (under age 60) published by Steele, Peladeau-Pigeon and colleagues (2019). It is important to understand how those healthy reference values were collected to determine if they can be applied to your individual clinical setting and patients. Reference values for the ASPEKT-C Method were collected under the conditions described below.

- Videofluoroscopy acquired at 30 unique images per second
- Protocol to begin with IDDSI Level 0 thin liquids
- Low concentration barium (20%w/v)
- Stimuli mixed to meet IDDSI levels 0, 1, 2, 3, 4
- Xanthan gum thickened liquids
- Self-administered comfortable sips of IDDSI levels 0, 1 and 2
- Non-cued, spontaneous swallows
- Self-administered teaspoons of IDDSI levels 3 and 4

If you collect your data under different conditions, the strict ASPEKT-C Method reference values may not apply. Assessing how modifications of the conditions listed above influence your ability to compare your patient’s values to the ASPEKT-C Method reference values is difficult. While there is some information in the literature that can guide how to interpret these changes, in many cases it is simply unknown.

CAUTION: References values may not be generalizable to other situations.
The reference values published by Steele, Peladeau-Pigeon et al. (2019) were collected using barium prepared to IDDSI levels 0, 1, 2, 3, 4 (Figure 1). The ASPEKT-C reference values provided for IDDSI level 3 moderately thick are also generalizable to “liquidised”, on the “Foods” side of the framework. Similarly, IDDSI level 4 extremely thick reference values are generalizable to “pured”, on the “Foods” side of the framework. While reference values are included for IDDSI levels 0, 1, 2, 3 and 4, you may not need to test them all as part of your VFSS. Based on the research, thin liquid boluses are the most likely to reveal problems with swallowing safety. Therefore, it makes the most sense, to begin the exam with thin liquids in order to identify penetration-aspiration problems. For swallowing efficiency, the SRRL prefers to use discrete sips of mildly thick liquid. Other consistencies represent interventions that can be explored for their effectiveness in addressing safety and/or efficiency concerns.

Before You Get Started
Please ensure you have the following items available:

- Print out a copy of the **VFSS Best Practice Recommendations** (found at www.steeleswallowinglab.ca). This document contains evidence-based recommendations for VFSS. Read and consider each recommendation and how it applies to current VFSS practices within your institution.

- Print out a copy of the **ASPEKT-C Method Worksheet** (found at www.steeleswallowinglab.ca). This worksheet will guide you through the process of calculating quantitative measures based on your patient’s VFSS. You will need a new worksheet every time you analyze a new VFSS.

- Print out a copy of the **ASPEKT-C Method Scoring Sheet** (found at www.steeleswallowinglab.ca). This scoring sheet provides instructions on how to carry over values from the **ASPEKT-C Method Worksheet** into a chart for comparison against healthy references.

- Download ImageJ software (found at https://imagej.nih.gov/ij/) or another frame-by-frame and pixel based measurement software. If you are unfamiliar with ImageJ, please find supplemental information under Appendix A of this Instruction Manual.

**CAUTION:** This manual provides step-by-step instructions using the ImageJ software ONLY.

ASPEKT-C Method Worksheet - Overview
Ensure that you have your **ASPEKT-C Method Worksheet** in front of you. This worksheet is divided into three sections which have been colour-coded for ease of use and clarity (as shown in Figure 4):

- **Section 1: Bolus Information**
- **Section 2: Swallowing Safety**
- **Section 3: Swallowing Efficiency**

![Figure 4: ASPEKT-C Method Worksheet](image)
As you move through the process, you will complete 1 row of the ASPEKT-C Method Worksheet for each bolus administered. If you have 6 boluses, you’ll go through the ASPEKT-C Method 6 times, 1 bolus per row. It is important to analyze each bolus, and not collapse boluses of the same volume or consistency together, because we know that they may present differently within a single VFSS exam. For instance, patients who have impaired swallowing safety do not show penetration-aspiration on every swallow (Steele, Mukherjee, et al., 2019). It can be helpful to think of the ASPEKT-C Method as a “choose your own adventure” critical thinking pathway that we apply to each bolus. Not all 8 parameters of the ASPEKT-C Method may need to be completed for every bolus. This will be dictated by the patient’s performance with that individual bolus and determined through a series of questions.

We will now explain each section of the ASPEKT-C Method Worksheet in detail with step-by-step instructions. You may wish to print out a hard copy of this instruction manual in colour so that you can quickly flip to sections of interest, particularly as you become more familiar with this document’s content.

The information on each column or parameter of the ASPEKT-C Method Worksheet will be presented in the following format. Symbols have been incorporated to allow you to quickly locate information of interest.

- **“Not Applicable”:** Indicates if and/or when a parameter does NOT need to be completed. This information has intentionally been placed at the beginning of each section to prevent you from assessing a parameter, only to realize later that it is not required. Please note, this information is also available in the columns describing each parameter in the ASPEKT-C Method Worksheet.

- **“Background”:** Explains the history behind a given ASPEKT-C Method parameter, its purpose, and why it was included in the ASPEKT-C Method. It may also include standardized definitions.

- **“How To”:** Describes how to analyze the parameter in question for the field and generate quantitative values where applicable.

- **“Next Step”:** Based on the results of the parameter you have just analyzed, this lets you know your next step.

- **“Example”:** This includes the ASPEKT-C Method Worksheet with sample values. This information will be surrounded by a black box.
ASPEKT-C Method Worksheet - Section 1: Bolus Information

1a. IDDSI Level and Bolus #

Always complete this column for every bolus.

**Background:** The purpose of this column is to help keep track of exactly which bolus you are measuring, particularly since there can be multiple boluses of the same consistency and volume, each with unique ASPEKT-C Method measurement outcomes.

**How to:** Use this column to record the IDDSI level/consistency information and the bolus sequence or repetition number.

**Next Step:** Continue to the next column “1b. Total Swallows per Bolus” on the ASPEKT-C Method Worksheet.

---

**Example:** If you administered 2 boluses of IDDSI level 0 thin, you would fill out thin 1 and thin 2 down the length of this column.

<table>
<thead>
<tr>
<th>1. BOLUS INFORMATION</th>
<th>2. SWALLOWING SAFETY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. IDDSI Level</td>
<td>2a. PAS Score</td>
</tr>
<tr>
<td>and Bolus # (e.g., 3)</td>
<td>For the initial</td>
</tr>
<tr>
<td>1b. Total swallows</td>
<td>swallow of the bolus,</td>
</tr>
<tr>
<td>per bolus</td>
<td>what is the</td>
</tr>
<tr>
<td>(e.g., 3)</td>
<td>PAS score?</td>
</tr>
<tr>
<td></td>
<td>(1-8)</td>
</tr>
<tr>
<td></td>
<td>If PAS 1, 2 or</td>
</tr>
<tr>
<td></td>
<td>4, skip to 2c, else</td>
</tr>
<tr>
<td></td>
<td>continue to 2b.</td>
</tr>
<tr>
<td></td>
<td>2b. LVC Integrity</td>
</tr>
<tr>
<td></td>
<td>If the answer to</td>
</tr>
<tr>
<td></td>
<td>2b. was Y, did PAS</td>
</tr>
<tr>
<td></td>
<td>occur before or after</td>
</tr>
<tr>
<td></td>
<td>LVC?</td>
</tr>
<tr>
<td></td>
<td>If before, continue</td>
</tr>
<tr>
<td></td>
<td>2c. If Y, continue</td>
</tr>
<tr>
<td></td>
<td>2d. LVC Timing</td>
</tr>
</tbody>
</table>
|                      | 2e. PAS Evolution    | For the answer to 2c.
|                      |                      | was before LVC,      |
|                      |                      | calculate time-to-LVC|
|                      |                      | (in frames).         |
|                      |                      | Hyoid burst frame to |
|                      |                      | first frame where    |
|                      |                      | laryngeal vestibule  |
|                      |                      | is most closed.      |
|                      |                      | Continue to 2e.      |
|                      |                      | Continue to 3a.      |
| Thin 1               | Is there evidence of   |
|                      | a different PAS      |
|                      | score for the        |
|                      | bolus? If yes,       |
|                      | include PAS score     |
|                      | (1-8), if no, enter  |
|                      | “no change”.         |
| Thin 2               |                      |

Figure 5: ASPEKT-C Method Worksheet with column “1a. IDDSI Level and Bolus #” completed
**1b. Total Swallows Per Bolus**

Always complete this column for every bolus.

**Background:** One indicator of swallowing efficiency is the total number of swallows taken to clear the bolus. The purpose of this column is to tally the number of swallows taken. A swallow is defined as UES opening plus at least one of the following:

1. pharyngeal constriction,
2. laryngeal elevation and/or
3. hyoid excursion.

Do NOT include swallow attempts (e.g., hyoid and laryngeal excursion in the absence of UES opening). You may wish to differentiate between spontaneous and clinician-cued swallows in your notes here as it may provide information about the patient’s sensation or awareness of residue.

**How To:** Indicate the total number of swallows taken to clear the bolus that were captured before the fluoroscopy was turned off.

**Next Step:** Continue to the blue section entitled “2. Swallowing Safety”, more specifically the next column “2a. PAS Score” on the **ASPEKT-C Method Worksheet**.

---

**Example:** If you witness a patient swallow 4 times to clear their first single cup sip of thin liquids, enter the number 4 in the first row of this column.

<table>
<thead>
<tr>
<th>1. BOLUS INFORMATION</th>
<th>2. SWALLOWING SAFETY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. IDDSI Level and Bolus #</td>
<td>2a. PAS Score</td>
</tr>
<tr>
<td>1b. Total swallows per bolus (e.g., 3)</td>
<td>For the initial swallow of the bolus, what is the PAS score? (1-8) If PAS 1, 2 or 4, skip to 2e; else continue to 2b.</td>
</tr>
<tr>
<td>Thin 1</td>
<td>If PAS 2c. If Y, continue 2c. If N, skip to 2e</td>
</tr>
<tr>
<td></td>
<td>2b. LVC Integrity</td>
</tr>
<tr>
<td></td>
<td>If Y, continue 2c. If N, skip to 2e</td>
</tr>
<tr>
<td></td>
<td>2c. PAS Timing</td>
</tr>
<tr>
<td></td>
<td>If the answer to 2b was Y, did PAS occur before or after LVC?</td>
</tr>
<tr>
<td></td>
<td>If before, continue to 2d. If after, skip to 2e.</td>
</tr>
<tr>
<td></td>
<td>2d. LVC Timing</td>
</tr>
<tr>
<td></td>
<td>If the answer to 2c was before LVC, calculate time-to-LVC (in frames).</td>
</tr>
<tr>
<td></td>
<td>Hyoid burst frame to first frame where laryngeal vestibule is most closed.</td>
</tr>
<tr>
<td></td>
<td>Continue to 2e.</td>
</tr>
<tr>
<td></td>
<td>2e. PAS Evolution</td>
</tr>
<tr>
<td></td>
<td>Is there evidence of a different PAS score for the bolus? If yes, include PAS score (1-8). If no, enter “no change”.</td>
</tr>
<tr>
<td></td>
<td>Continue to 3a.</td>
</tr>
</tbody>
</table>

Figure 6: **ASPEKT-C Method Worksheet** with column “2a. Total Swallows per Bolus” completed
**2a. Penetration-Aspiration Scale Score**

Always complete this column for every bolus.

**Background:** The 8-point Penetration Aspiration Scale (PAS) (Rosenbek et al., 1996) (Figure 7A) has become the standard way of describing the severity of airway invasion. The scale can be broken down into different levels. Steele and Grace-Martin slightly adapted this scale in 2017. They proposed a modified scale where a PAS score of 4, describing material that contacts the vocal fold but is ejected from the airway, reflects normal function. For our purpose in ASPEKT-C, the scale can be broken down into two categories (Figure 7B). PAS scores of 1, 2 and 4 are considered Within Normal Limits (WNL) as no material is left within the airway. PAS scores of 3, 5 and higher fall into the impaired range, as whenever material enters the supraglottic space and stays there, it is at risk for eventual aspiration.

![Figure 7: A) Penetration Aspiration Scale (Rosenbek et al, 1996); B) Dichotomized Penetration-Aspiration Scale for use in the ASPEKT-C Method](image)

**How To:** For the initial swallow of the bolus, identify the PAS score.

**Next Step:**

<table>
<thead>
<tr>
<th>What is your PAS score on the first swallow of this bolus?</th>
<th>PAS of 1, 2, 4</th>
<th>PAS of 3, 5, 6, 7, 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>These scores are considered WNL.</td>
<td>These scores are considered impaired.</td>
<td></td>
</tr>
<tr>
<td>Skip ahead to “2e. PAS Evolution” on the <strong>ASPEKT-C Method Worksheet</strong>.</td>
<td>Continue to “2b. LVC Integrity” on the <strong>ASPEKT-C Method Worksheet</strong> to investigate possible contributors.</td>
<td></td>
</tr>
</tbody>
</table>
### 2b. Laryngeal Vestibule Closure (LVC) Integrity

**Not Applicable:** Do not complete this column if the “2a. PAS score” was WNL (i.e., 1, 2, or 4).

**Background:** If the PAS score is impaired (i.e., scores of 3, 5, 6, 7 or 8), examine Laryngeal Vestibule Closure (LVC) integrity. LVC is one of the most critical parameters associated with airway protection. Complete LVC is defined as a complete seal between epiglottis and arytenoids leaving no visible airspace or contrast in the laryngeal vestibule (see Figure 8 A). Incomplete closure includes any amount of air or contrast in the laryngeal vestibule. This can include a wide gap with minimal to no closure (see Figure 8 B) or partial tissue contact between the arytenoids and laryngeal surface of the epiglottis (see Figure 8 C).

![Figure 8: Sample images showing complete LVC (A) and incomplete closure (B) & (C).](image)

**How To:** For the initial swallow of the bolus, determine if complete LVC occurred. “Yes” indicates complete closure and “No” indicates incomplete or partial closure.

**Next Step:**

<table>
<thead>
<tr>
<th>Did complete LVC occur?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yes – Complete LVC</strong></td>
<td><strong>No – Incomplete or Partial LVC</strong></td>
</tr>
<tr>
<td>This is considered WNL and suggests that it is not the integrity of LVC but rather the timing that may be impaired leading to a PAS event.</td>
<td>This is considered impaired. PAS event may be occurring due to inability to achieve complete airway closure during the swallow.</td>
</tr>
<tr>
<td>Continue to “2c. PAS Timing” on the ASPEKT-C Method Worksheet to try to understand the timing between the PAS event and LVC.</td>
<td>Skip ahead to “2e. PAS Evolution” on the ASPEKT-C Method Worksheet.</td>
</tr>
</tbody>
</table>
Example: This sample figure below demonstrates that you must have an impaired PAS score in order to move on to “2b. LVC Integrity”. It also demonstrates that there are two potential responses to column “2b. LVC Integrity”, yes (“Y”) or no (“N”).

<table>
<thead>
<tr>
<th>1. BOLUS INFORMATION</th>
<th>2. SWALLOWING SAFETY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. IDDSI Level and Bolus #</td>
<td>2a. PAS Score</td>
</tr>
<tr>
<td>1b. Total swallows per bolus (e.g., 3)</td>
<td></td>
</tr>
</tbody>
</table>

For the initial swallow of the bolus, what is the PAS score? (1-8)
If PAS 1, 2 or 4, skip to 2e, else continue to 2b.

If PAS 3, 5, 6, 7, 8, continue to 2b.

If the answer to 2b. was “Y”, did PAS occur before or after LVC?
If before, continue to 2d.
If after, skip to 2e.

If the answer to 2c. was before LVC, calculate time-to-LVC (in frames).
Hyoid burst frame to first frame where laryngeal vestibule is most closed.
Continue to 2e.

Is there evidence of a different PAS score for the bolus? If yes, include PAS score (1-8). If no, enter “no change”.

MUST be: 3, 5, 6, 7, 8

Y

MUST be: 3, 5, 6, 7, 8

N

Figure 9: ASPEKT-C Method Worksheet with column “2b. LVC Integrity” completed for two separate boluses
2c. PAS Timing

**Not Applicable:** Do not complete this column if “2a. PAS Score” was WNL (i.e., 1, 2, or 4). Do not complete this column if “2b. LVC Integrity” was incomplete (i.e., response was “N”).

**Background:** Once you have established that complete LVC closure was achieved under “2b. LVC Integrity” (response was “Y”), we want to know more about why the PAS event occurred. The first step is to look at timing and ask when the PAS event occurred.

**How To:** For the PAS event observed on the initial swallow of the bolus, determine if it occurred before or after LVC.

**Next Step:**

<table>
<thead>
<tr>
<th>Did PAS occur before or after LVC?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>When the PAS event occurs before LVC, it is possible the system did not react quickly enough to the incoming bolus.</td>
<td>When the PAS event occurs after LVC, it is possible that the patient is penetrating or aspirating residue from a previous bolus on which they displayed impaired swallowing efficiency.</td>
</tr>
<tr>
<td>Continue to “2d. Time-to-LVC” on the ASPEKT-C Method Worksheet.</td>
<td>Skip ahead to “2e. PAS Evolution” on the ASPEKT-C Method Worksheet.</td>
</tr>
</tbody>
</table>

**Example:** This figure below demonstrates that you must have a “Yes” (i.e., complete LVC) under “2b. LVC Integrity” in order to move on to column “2c. PAS Timing”.

![Figure 10: ASPEKT-C Analysis Worksheet with column “2c. PAS Timing” completed for 2 separate boluses](image)
## 2d. Time-to-LVC

### Not Applicable:
Do not complete this column if “2a. PAS score” was WNL (i.e., 1, 2, or 4).
Do not complete this column if “2b. LVC Integrity” was “N” (incomplete).
Do not complete this column if “2b. LVC Integrity” was “Y” (complete) and the PAS event in “2c. PAS Timing” occurred “after” the swallow.

### Background:
Once we have established that the PAS event occurred before complete LVC, we need to look at how quickly the system responded to the incoming bolus. The system’s response is called “time-to-LVC” which represents the time from the “hyoid burst frame” to “LVC frame”. This parameter is sometimes referred to as Laryngeal Vestibule Closure reaction time (LVCrt) in the literature.

Hyoid burst frame: The first frame of the rapid anterior-superior movement of the hyoid associated with the first swallow. The moment where the hyoid appears to “take off” or “burst”. Small movements around the starting position that occur prior to this burst should not be counted.

LVC frame: The frame of maximum approximation of the arytenoids to the epiglottis during the first swallow.

### How To:
For the initial swallow of the bolus, calculate time-to-LVC (in frames). This is the difference between the hyoid burst frame number and the LVC frame number.

### Next Step:
Once “2d. Time-to-LVC” is calculated, continue to “2e. PAS Evolution” on the ASPEKT-C Method Worksheet.

### Example:
If the hyoid burst occurs at frame 1125 and LVC at frame 1150, this means time-to-LVC is 25 frames.

<table>
<thead>
<tr>
<th>1. BOLUS INFORMATION</th>
<th>2. SWALLOWING SAFETY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. IDSS! Level and bolus #</td>
<td>2a. PAS Score</td>
</tr>
<tr>
<td>1b. Total swallows per bolus (e.g., 3)</td>
<td>2b. LVC Integrity</td>
</tr>
<tr>
<td>For the initial swallow of the bolus, what is the PAS score? (1-8) If PAS 1, 2 or 4, skip to 2b. else continue to 2b.</td>
<td>For the initial swallow of the bolus, is LVC complete? (Y/N)</td>
</tr>
<tr>
<td>2c. PAS Timing</td>
<td>If the answer to 2b. was “Y”, did PAS occur before or after LVC?</td>
</tr>
<tr>
<td>2d. LVC Timing</td>
<td>2e. PAS Evolution</td>
</tr>
<tr>
<td>Is the answer to 2c. was before LVC, calculate time-to-LVC (in frames). Hyoid burst frame to first frame where laryngeal vestibule is most closed. Continue to 2e.</td>
<td>If there evidence of a different PAS score for the bolus? If yes, include PAS score (1-8). If no, enter “no change”.</td>
</tr>
</tbody>
</table>

**MUST be:** before 25 frames

**Figure 11:** ASPEKT-C Method Worksheet with column “2d. Time-to-LVC” completed
2e. PAS Evolution

Always complete this column for every bolus.

**Background:** Now we want to take a step back and look at all swallows involving this particular bolus; is there evidence of a different PAS score on any sub-swallows involving this bolus? For instance, a patient may perform 4 swallows for a single bolus and over that time, the PAS score may evolve. Evolution can improve (e.g., material being squeezed out/ejected during subsequent swallows) or worsen (e.g., penetration becomes aspiration or new material is aspirated on a later swallow of the same bolus). If the PAS score does not evolve across later swallows for the bolus and remains consistent with the initial value from “2a. PAS score”, enter “no change”.

**How To:** Is there evidence of a different (better or worse) PAS score for this bolus compared to the initial value in “2a. PAS Score”? If yes, include that PAS score. If no, enter “no change”.

**Next Step:** Continue to section “3. Swallowing Efficiency” on the **ASPEKT-C Method Worksheet**.

**Example:** You already completed column “2a. PAS Score” and indicated a PAS score of 2 on the initial swallow of the bolus. However, with subsequent swallows of this same bolus, the material that originally scored as a 2 falls below the true vocal folds and there is no cough response. This evolution to a score of 8, should be captured under column “2e. PAS Evolution”. As a second example, if you completed column “2a. PAS Score” and indicated a PAS score of 4 on the first and only swallow of the bolus, we would enter “no change” under column “2e. PAS Evolution”.

<table>
<thead>
<tr>
<th>1. BOLUS INFORMATION</th>
<th>2. SWALLOWING SAFETY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. IDDSI Level and Bolus #</td>
<td>2a. PAS Score</td>
</tr>
<tr>
<td>1b. Total swallows per bolus (e.g., 3)</td>
<td>For the initial swallow of the bolus, what is the PAS score? (1-8) If PAS 1, 2 or 4, skip to 2e, else continue to 2b.</td>
</tr>
<tr>
<td>2</td>
<td>no change</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

Figure 12: **ASPEKT-C Method Worksheet** with column “2e. PAS Evolution” completed for two separate boluses.
**ASPEKT-C Method Worksheet – Section 3: Swallowing Efficiency**

### 3a. Total Pharyngeal Residue

**Not Applicable:** If there is no pharyngeal residue at the end of the initial swallow of the bolus, you do not need to measure “3a. Total Pharyngeal Residue” or “3b. PhAMPC”. Move on to the next bolus in the VFSS by returning to “1a. IDDSI Level and Bolus #”.

**Background:** A second criterion to consider when determining whether swallowing impairments are present is swallowing efficiency. Efficiency is defined as the ability to clear material through the pharynx. The total pharyngeal residue includes any remaining bolus material in the valleculae, pyriform sinuses, and/or elsewhere in the pharynx. Note that in the ASPEKT-C Method, oral residue is not quantitatively calculated.

Scaling measurements to the length of the C2-C4 cervical spine controls for differences in the size of the system including sex-based or height based differences (Molfenter and Steele, 2014). By tailoring the residue measures to an individual’s anatomy, comparisons can be made between anatomically normalized measures within or across exams.

It is important to identify C2-4 correctly. C1-C3 cannot be substituted as it is significantly longer (Nagy et al., 2015). See Figure 13 for a sample tracing of C2-C4 moving from the anterior inferior corner of C2 to the anterior inferior corner of C4.

As part of the ASPEKT-C Method, residue severity is measured at the end of the initial swallow for the bolus. If there are 4 swallows associated with a single bolus, measure the residue remaining after the first swallow only. This is important, as subsequent swallows may be a compensatory measure that reduce residue and underestimate a patient’s level of impairment.

![Figure 13: Sample image of cervical spine](image-url)
How To: Is there pharyngeal residue at the end of the initial swallow of the bolus? If yes, measure the pharyngeal residue using the step-by-step instructions below.

Step 1: Identify the frame on which to measure residue

For the first swallow of the bolus, select the first frame showing the pyriform sinuses at their lowest position (relative to the spine) at the end of the swallow, prior to any hyoid burst or laryngeal elevation related to an ensuing sub-swallow (if any). The frame on which you want to measure may look very similar to the image of the pharynx taken at the beginning of the VFSS, in that the pharynx should be rested or relaxed. Use the forward and backwards arrow keys on your keyboard to move frame by frame, to locate the frame that meets this definition. Avoid frames that are “blurred” due to additional patient movement.

Step 2: Measure residue in the pharynx

Trace the residue remaining in each of the spaces (valleculae, pyriform sinuses and other), one at a time, using the following steps. If a particular space does not contain any residue, there is no need to trace – simply write ‘0’ in the designated field on the ASPEKT-C Method Worksheet.

i. Select the Freehand tool (Figure 15).

Figure 15: ImageJ Freehand tool

ii. Click and hold to trace a contour line around the area of interest. See sample images in Figure 16 for tracings of each space (valleculae in yellow, pyriform sinuses in green and other in blue). NOTE: The boundaries of the pharynx are defined to include all space:

- above the UES
- below the top of C2
- posterior to the arytenoids, base of tongue, and pharyngeal surface of the epiglottis
- anterior to the posterior pharyngeal wall

Figure 16: Sample tracings of remaining residue in A) valleculae, B) pyriform sinuses, C) other
QUICK TIP: To refine or adjust the residue area tracing, follow these steps:

- Right-click on the Oval tool and choose Selection Brush tool (Figure 17 left).
- Click and hold down to adjust the area tracing.
  - Double click on the Oval tool to change the size of the brush (Figure 17 right).
- Use this tool to nudge the contour line already created around the residue.

iii. Press Ctrl + M when you have completed the area tracing.
  - If this is your first measurement, a Results box will open automatically. Leave the Results box open as it will continue to add measurements taken.

iv. Enter the Area value in the designated field on the ASPEKT-C Method Worksheet.

v. Repeat these steps for each of these three spaces (valleculae, pyriform sinuses and other).

---

**Step 3: Measure the C2-C4 cervical spine length scalar**

i. Select the line tool (see Figure 19).

ii. Click (and hold) on the anterior inferior edge of C2 vertebral body.

iii. Hold the mouse button down and drag to draw a line to the anterior inferior edge of C4.
  - If you make a mistake, click anywhere on the image and the line will disappear.

iv. Press Ctrl + M. ImageJ will append this measurement to the Results table.

v. Enter the length value in the designated field on the ASPEKT-C Method Worksheet.
Step 4: Calculate total pharyngeal residue

Calculate the total pharyngeal residue as a percent of the C2-C4 squared space using the formula included in the “3a. Total Pharyngeal Residue” column on the ASPEKT-C Method Worksheet. The residue shown in Figure 20 can be calculated as follows. The red dashed square in Figure 20 shows the (C2-C4)^2 reference area (i.e., C2-C4 length squared) to which the area(s) of residue are compared. In this example, the total pharyngeal residue is equivalent to 20.1% of the red-dashed square.

Total Pharyngeal residue

\[
\frac{V \text{ res. area} + PS \text{ res. area} + Other \text{ res. area}}{(C2 - C4 \text{ length})^2} \times 100\%
\]

\[
= \frac{202 + 958 + 131}{(79.67)^2} \times 100\% = 20.1\%
\]

Next Step: Continue to “3b. PhAMPC” to measure Pharyngeal Area at Maximum Pharyngeal Constriction on the ASPEKT-C Method Worksheet.
3b. Pharyngeal Area at Maximum Pharyngeal Constriction (PhAMPC)

Not Applicable: If there is no pharyngeal residue identified in column “3a. Total Pharyngeal Residue”, there is no need to complete this section. Move on to score the next bolus in the VFSS by returning to “1a. IDDSI Level and Bolus #”.

Background: Once it has been determined that pharyngeal residue is present at the end of the first swallow, we want to examine the underlying mechanism leading to the efficiency impairment. In the ASPEKT-C Method, the next step is to look at Pharyngeal Area at Maximum Pharyngeal Constriction (PhAMPC). This is defined as the area of unobliterated visible airspace and/or bolus at maximum constriction during the first swallow of the bolus.

As mentioned in column “3a. Total Pharyngeal Residue”, the ASPEKT-C Method scales quantitative measurements such as total pharyngeal residue and PhAMPC to the length of the C2-C4 cervical spine to control for differences in the size of the system.

How To: For the initial swallow, measure pharyngeal area at maximum pharyngeal constriction (PhAMPC). You can measure PhAMPC using the step-by-step instructions below.

Step 1: Identify the frame on which to measure PhAMPC

For the first swallow of the bolus, select the earliest frame showing maximum obliteration or squeeze of the pharynx. This frame must occur before the upper pharynx begins to relax and before the tracheal air column begins to descend.

IMPORTANT NOTE: Upper boundary of the Pharynx

When tracing residue in the pharynx do not go higher than the top of the C2 vertebral body shown in Figure 23. While it is not necessary to draw a line as shown in Figure 23, it may be helpful to visualize a right angle tool that cuts across the top of the pharynx visually. While it is rare bolus will appear at that level on your PhAMPC frame, it may be possible particularly in cases when patients have escape of the bolus into the nasopharynx.
Step 2: Measure the remaining visible airspace or bolus in the pharyngeal area

i. Select the Freehand tool.

ii. Click and hold to trace a contour line around the area of visible air space and residue in the pharynx.
   • If there is no visible air space and/or residue, there is no need to trace. In this case, simply write “0” in the designated field on the ASPEKT-C Method Worksheet.

NOTE: The boundaries of the pharynx are defined to include all space:
   • above the UES
   • below the top of C2 (see “Caution” from Step 1 Figure 23)
   • posterior to the arytenoids, base of the tongue, and pharyngeal surface of the epiglottis
   • anterior to the posterior pharyngeal wall

QUICK TIP: To refine or adjust the residue area tracing, follow these steps:
   ▪ Right-click on the Oval tool and choose Selection Brush tool (Figure 24 left).
   ▪ Click and hold down to adjust the area tracing.
     o Double click on the Oval tool to change the size of the brush (Figure 24 right).
   ▪ Use this tool to nudge the contour line already created around the residue.

iii. Press Ctrl + M when you have completed the area tracing, a Results box will open automatically.

iv. Enter the Area value in the designated field in the ASPEKT-C Method Worksheet.

Figure 24: Selection Brush tool in ImageJ

Figure 25: Sample pharyngeal area measurement
Step 3: Measure the C2-C4 cervical spine length scalar

i. Select the line tool (Figure 26).

ii. Click (and hold) on the anterior inferior edge of C2 vertebrae.

iii. Hold the mouse button down and drag to draw a line to the anterior inferior edge of C4.
   - If you make a mistake, click anywhere on the image and the line will disappear.

iv. Press Ctrl + M. ImageJ will append this measurement to the Results table.

v. Enter the length value in the designated field on the ASPEKT-C Method Worksheet.

Step 4: Calculate PhAMPC

Calculate the PhAMPC as a percent of the C2-C4 squared space using the formula included in the “3b. PhAMPC” column on the ASPEKT-C Method Worksheet. The unobliterated area of the pharynx shown in Figure 28 can be calculated as follows. The red dashed square in Figure 28 shows the (C2-C4)² reference area (i.e., C2-C4 length squared) to which the measured area is compared. In this example, PhAMPC is 3.8% of the red-dashed square.

\[
\text{PhAMPC} = \frac{\text{pharyngeal area}}{(C2 - C4 \text{ length})^2} \times 100\%
\]

\[
= \frac{2776}{(271.36)^2} \times 100\%
\]

\[
= 3.8\%
\]

Next Step: Move on to score the next bolus in your VFSS, returning to “1a. IDDSI Level and Bolus #s”.

Figure 26: ImageJ line tool

Figure 27: Sample cervical spine length measurement

Figure 28: Sample image showing PhAMPC
ASPEKT-C Method Scoring Sheet

1. On the **ASPEKT-C Method Scoring Sheet**, complete the “My Patient Values” table (Figure 29) by transferring the worst value per parameter per consistency from your **ASPEKT-C Method Worksheet** into the “Value” column. The worst value is defined as the most impaired value (e.g., highest PAS score, longest time-to-LVC, largest total pharyngeal residue, largest PhAMPC).
   - These values may come from different boluses of the same consistency. This is ok because the point of the **ASPEKT-C Method Scoring Sheet** is to make clear to the clinician all the mechanisms at play contributing to the patient’s swallowing safety and efficiency profile so that they can be considered in treatment planning.

2. It is ok to have blank fields. This may indicate:
   - Consistencies were not tested (e.g., I did not test my patient with “slightly thick” in VFSS) **OR**
   - Parameters did not require calculation according to the ASPEKT-C Method pathway (e.g., if PAS is WNL for all thin liquid boluses, you would have no “2d. Time-to-LVC” value under IDDSI Level 0 thin).

3. Values under “2d. Time-to-LVC” must be converted from frames to milliseconds. To do this, divide your value (i.e., # of frames) over the recording frame rate (i.e., number of images captured per second) then multiply by 1000. If you are unsure about your recording frame rate, speak with your radiology department.
   - **Example**: Value = 20 frames, 20 frames/30 frames per second x 1000 = 667 milliseconds.

   ![Figure 29: “My Patient Values” table from the ASPEKT-C Method Scoring Sheet](image)

4. Use the “**ASPEKT-C Reference Values**” table (Figure 30) to compare and determine if your values fall within normal limits (WNL) or are impaired.

   ![Figure 30: “ASPEKT-C Reference Values” table from the ASPEKT-C Method Scoring Sheet](image)

ASPEKT-C Documentation Considerations

- As previously mentioned the **ASPEKT-C Method Worksheet** and the **ASPEKT-C Method Scoring Sheet** were created as “rough worksheets” to guide clinicians through process of VFSS analysis. They are not meant to be included as is into a patient’s paper chart or electronic patient record. Consider creating your own template to document your results, dictating them or incorporating them however meets the specific documentation requirements of your organization.
- The ASPEKT-C “My Patient Values” table only captures the patient’s worst performance, not the frequency with which that impairment occurs. If a particular parameter did not show impairment on all trials, it may be salient to capture this in the text of your report (e.g., a PAS of 5, resulting from a long time-to-LVC only occurred on 1 out of 4 thin liquid bolus trials).
- While the ASPEKT-C Method focuses solely swallowing physiology, it is important to still consider any structural impairments identified by radiology that could be co-occurring and contributing to your patient’s profile as part of your report.

**How Healthy Reference Values are Defined in the ASPEKT-C Method**

The ASPEKT-C Method and reference values are generated based on data from the first swallow of the bolus for all parameters except for “2e. PAS evolution”. Boundaries for healthy reference values were established based on the mean +/- 2 standard deviations for normally distributed parameters (“2d. Time-to-LVC”) as shown in Figure 31A and 95th %ile for positively skewed parameters (“3a. Total Pharyngeal Residue” and “3b. PhAMPC”) as shown in Figure 31B. These boundaries will distinguish parameters that are clearly impaired from those clearly falling within normal limits. Using a traffic light analogy, these would be cases that are clearly red or green.

![Example of normally distributed data](A)

![Example of positively skewed data](B)

**Next Step(s) if ASPEKT-C Method Did Not Identify Underlying Mechanism of Impairment**

The ASPEKT-C Method is a critical decision-making pathway made up of 8 parameters that the SRRL believes are the most common underlying mechanisms for dysphagia. However, dysphagia is a complex phenomenon and it is possible that the reason for your patient’s swallowing safety or efficiency impairment is not explained by the 8 parameters in the ASPEKT-C Method. If these parameters don’t explain your patient’s dysphagia mechanism, other variables to consider include:

- When swallowing safety is not explained by the ASPEKT-C Method (i.e., PAS is not explained by “2b. LVC Integrity” or “2d. Time-to-LVC”), consider the following:
  a. Impaired swallowing efficiency may be contributing to increased safety risk (e.g., patient is aspirating on pharyngeal residue).
  b. Consider consultation with a radiologist to see if there are structural abnormalities such as osteophytes that may direct the bolus into the airway.

- When swallowing efficiency is not explained by the ASPEKT-C Method (i.e., impaired total pharyngeal residue not explained by PhAMPC), consider consultation with a radiologist to see if there are structural abnormalities like osteophytes or Zenker’s diverticula preventing complete bolus movement via UES.

As a final consideration, if none of the parameters measured using the ASPEKT-C Method or outlined above seem to explain the impairments observed in your patient, then this would be a situation where other parameters might need to be explored using the full ASPEKT Method described by Steele, Peladeau-Pigeon et al. (2019).
References


Appendix A: Introduction to ImageJ Software

Frame-by-frame and pixel based measurement tools are required to apply the ASPEKT-C Method. The SRRL uses ImageJ software which is an image analysis program created at the National Institutes of Health (https://imagej.nih.gov/ij). It is public domain, available free of charge, and runs on a variety of operating systems. You may wish to speak with an in-house IT department before downloading it.

Opening a Video using ImageJ

Drag and drop your file into the ImageJ toolbar. If your video is not compatible, you will need to either convert your video into an appropriate format or use another frame-by-frame viewing software at your own risk. See ImageJ online documentation for more information about compatible video formats (https://imagej.nih.gov/ij/docs/menus/file.html).

Many AVI video files can be large and may be too large for your computer’s memory capacity. When opening an AVI file, you may wish to reduce the number of frames opened (Figure 32, red box) or select virtual stack option (Figure 32, orange box) when you open your video for ease of use. These memory options are unfortunately not available if you are opening a DICOM file.

The ASPEKT-C Method requires careful frame-by-frame viewing to identify penetration aspiration events, LVC integrity and PAS timing. Advance the video frame-by-frame by pressing the forward or backward arrow keys on your keyboard or using the arrows at the bottom of the video window (Figure 33, orange arrows). Frame numbers are located on the top left-hand corner of the video window (Figure 33, red box).