Swallowing Rehabilitation Research Lab

www.steeleswallowinglab.ca

Instruction Manual for ASPEKT-C Method using ImageJ

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

Table of Contents

Acronyms

ALS	Amyotrophic Lateral Sclerosis
ASPEKT	Analysis of Swallowing Physiology: Events, Kinematics and Timing
ASPEKT-C	Analysis of Swallowing Physiology: Events, Kinematics and Timing for use in Clinical Practice
COPD	Chronic Obstructive Pulmonary Disease
IDDSI	International Dysphagia Diet Standardisation Initiative
LVC	Laryngeal Vestibule Closure
ms	Milliseconds
PAS	Penetration Aspiration Scale
PD	Parkinson Disease
PhAMPC	Pharyngeal Area at Maximum Pharyngeal Constriction
SCI	Spinal Cord Injury
SOP	Standard Operating Procedure
SRRL	Swallowing Rehabilitation Research Lab
VFSS	Videofluoroscopic Swallow Study

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. A VFSS not only allows continuous dynamic visualization of the bolus as it moves through the oropharynx, but also enables the clinician to view structural movements. At the Swallowing Rehabilitation Research Lab (SRRL), we believe that in order to effectively treat dysphagia, clinicians need to understand the mechanisms that lie behind impairments in the two key functions of airway protection and bolus clearance. In order to recognize impairments in a person's swallowing physiology, we first need to know what healthy swallowing looks like.

In 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 was followed by a subsequent article in 2023, "***Reference Values for Videofluoroscopic Measures of Swallowing: An Update***". Together, these articles establish quantitative reference values for a comprehensive set of 17 parameters describing oropharyngeal swallowing physiology in healthy adult volunteers across the range from thin liquids to extremely thick liquids (International Dysphagia Diet Standardization Initiative or IDDSI levels 0, 1, 2, 3 and 4), as seen on the "drinks" side of the double-pyramid IDDSI pyramid in *Figure 1*.

Figure 1: IDDSI Framework

The appendices for these articles include extensive details about the rigorous methods used for collecting and analyzing these data, including creation and use of:

(a) A standardized protocol to collect VFSS data.

(b) A standard operating procedure (SOP) and clear operational definitions for VFSS rating and analysis.

A major objective in describing these methods in detail is to facilitate excellent inter-rater agreement across clinicians and researchers who are measuring these same parameters. The resulting SOP is entitled the ASPEKT Method, or the *Analysis of Swallowing Physiology: Events, Kinematics and Timing* and is illustrated in *Figure 2.* At this time, the ASPEKT Method does not cover the "foods" side of the IDDSI Framework. This instruction manual only provides guidance regarding post-VFSS analysis. For evidence-based recommendations on VFSS setup and protocol, please see ***our VFSS Best Practice Recommendations*** document at www.steeleswallowinglab.ca.

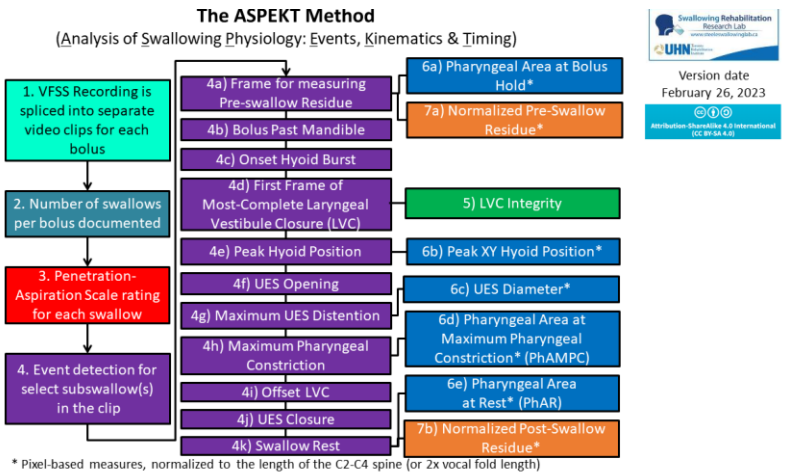


Figure 2: The ASPEKT Method

Introduction to the ASPEKT-C Method

We recognize that data collection protocols for research videofluoroscopies are often different than protocols used in everyday clinical practice, and also that time constraints are likely to make it impractical for a clinician to complete a full ASPEKT analysis on every swallow collected in a clinical videofluoroscopy. Therefore, we have developed a shorter version of the ASPEKT Method, intended for everyday clinical use called the ASPEKT-C Method (ASPEKT for use in Clinical Practice).

The ASPEKT-C Method involves a decision-making logic to help clinicians identify impairments in swallowing safety and swallowing efficiency, and then to determine mechanistic explanations for those impairments.

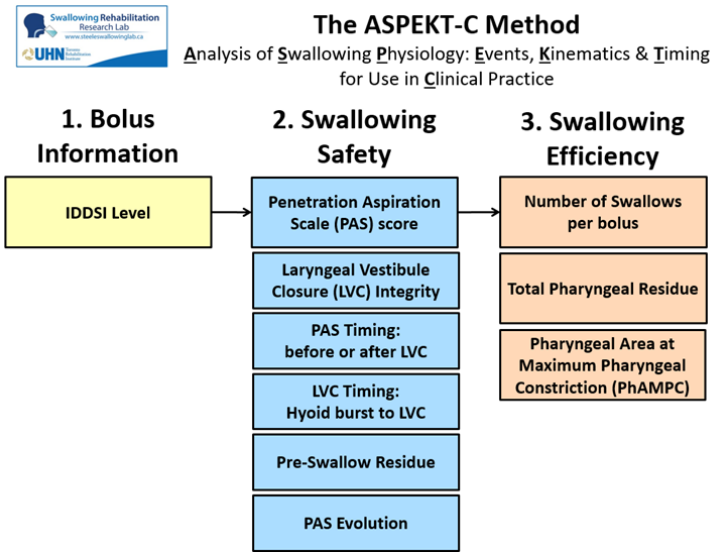


Figure 3: The ASPEKT-C Method

The 8 key parameters of swallowing that are considered in the ASPEKT-C Method (*Figure 3*) have been chosen based on evidence suggesting that these are the parameters that most commonly explain penetration-aspiration and post-swallow residue in people with dysphagia.

In the ASPEKT-C Method, a patient's values for these key parameters are classified as "typical" or "atypical" compared to consistency-specific reference values from healthy adults (Steele et al 2023). Identifying a parameter as "atypical" helps the clinician to recognize a specific feature of swallowing that may be targeted through compensatory or rehabilitative treatment techniques.

As mentioned above the ASPEKT-C Method involves comparing values from a patient to healthy reference values for key parameters. The reference values for the ASPEKT-C Method were collected under the conditions described below.

- Videofluoroscopy yielding at 30 unique images per second
- Low concentration thin liquid barium (20%w/v)
- Non-cued, spontaneous swallows
- Thin liquid barium mixed with a xanthan gum thickener to meet IDDSI levels 0, 1, 2, 3 and 4
- Self-administered comfortable sips of IDDSI levels 0, 1 and 2
- Self-administered teaspoons of IDDSI levels 3 and 4

If a clinical VFSS is performed under different conditions, the reference values used in the ASPEKT-C Method may not apply. In these situations, it is not straightforward to determine whether it is valid to compare your patient's values to the ASPEKT-C Method reference values

CAUTION: References values may not be generalizable to other situations.

Recommended ASPEKT-C Method VFSS Protocol

Strictly speaking, the ASPEKT-C Method can be used to analyze swallowing for any bolus from IDDSI level 0 (thin liquids) to level 4 (extremely thick liquids/pureed foods) collected under the conditions previously outlined. However, for clinical practice, we recommend the following videofluoroscopy protocol:

Part A) Diagnostic Portion of the Exam:
Still shot or 5cc bolus hold for positioning
Saliva swallow to see movement
Core tasks (no maneuvers)

- Sip of thin liquid barium
- Sip of thin liquid barium
- Sip of thin liquid barium*
- Sip of thin liquid barium*
- Sip of mildly thick barium
- Sip of mildly thick barium*

* These task repetitions may be omitted in the case of known safety or efficiency concerns on previous tasks of the same consistency

Part B) Therapeutic Portion of the Exam:
Up to 10 additional tasks, with the following goals:

- to "stress" the system and explore boundaries of safety (e.g. sequential swallowing of large thin liquid volume)
- to explore A-P view/esophageal phase
- to explore interventions:
  - different textures
  - changes in head position
  - volitional maneuvers

The selection of these tasks is based on previous research. Thin liquid boluses have been shown to be 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 (swallow safety). Our previous research suggests that penetration and aspiration may occur inconsistently across repeated sips of thin liquid (Steele, Mukherjee, et al., 2019) and that testing should continue to 4 sips in order to rule-out a problem with swallowing safety. By contrast, problems with bolus clearance (swallowing efficiency) are usually visible after the first presentation of a particular consistency. Sips (rather than teaspoon-sized boluses) of mildly-thick liquid have been shown to be highly sensitive to problems with bolus clearance, and are predictive of residue on thicker consistencies.

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 values.
- Print out a copy of the ***ASPEKT-C Treatment Planning Flowsheet*** (found at www.steeleswallowinglab.ca). This treatment sheet provides suggestions on how to address "atypical" mechanisms identified.
- 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

The ***ASPEKT-C Method 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

	2. SWALLOWING SAFETY						3. SWALLOWING EFFICIENCY							
1a. IDDSI Level and Bolus #	2a. PAS Score	2b. LVC Integrity	2c. PAS Timing	2d. LVC Timing	2e. Pre-swallow Residue	2f. PAS Evolution	3a. # of Swallows	3b. Total Pharyngeal Residue			3c. PhAMPC			
	For the initial swallow of the bolus, what is the PAS score? (1-8) *If PAS 1, 2 or 4, skip to 2f, else continue to 2b.*	For the initial swallow of the bolus, is LVC complete? (Y/N) *Continue to 2c.*	Did PAS occur before or after LVC? *If before, continue to 2d. If after, skip to 2f.*	If the answer to 2c. was before LVC, calculate time-to-LVC (frames & milliseconds)[a]. Hyoid burst frame to first frame where laryngeal vestibule is most closed. *Continue to 2e.*	Is there any residue present at the beginning of the clip (before any new bolus enters the oral cavity)? (Y/N) *Continue to 2f.*	Is there evidence of a worse PAS score for later swallows of this bolus? If yes, what is that PAS score (1-8)? If no, enter "N/A". *Continue to 3a.*	Number of swallows taken to clear the bolus (e.g., 3) *Continue to 3b.*	Is there pharyngeal residue[b] at the end of the initial swallow of the bolus? If no, move to next bolus (1a). If yes, measure. Total pharyngeal residue = (V res. area + PS res. area + Other res. area) / (C2-4 length)^2 x 100% *Compare to scoring sheet. If atypical, continue to 3c.*			For the initial swallow, measure Pharyngeal Area at Maximum Pharyngeal Constriction (PhAMPC). PhAMPC = pharyngeal area / (C2-4 length)^2 x 100% *Move to next bolus (1a).*		
Thin Cup #1				frames / milliseconds				Total Pharyngeal Residue / C2-4 length		calculation	Pharyngeal area / C2-4 length		calculation

Figure 4: ***ASPEKT-C Method Worksheet***

As you move through the process, you will complete 1 row of the ***ASPEKT-C Method Worksheet*** for each bolus administered. If you are completing the 6 boluses of part A of the diagnostic portion of the recommended VFSS protocol, you will enter data for each bolus on a new row. It is important to analyze each bolus, and not collapse boluses of the same volume or consistency together, because we know that swallowing may present differently across repeated boluses of the same consistency within a single VFSS exam. 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. You may not need to complete all 8 parameters of the ASPEKT-C Method for every bolus. This will be dictated by the individual patient's performance.

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 in 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 "2a. *PAS Score*" on the ***ASPEKT-C Method Worksheet***.

Example: If you administered 2 boluses of IDDSI level 0 thin, you would fill out the first two lines on the ***ASPEKT-C Method Worksheet***.

	2. SWALLOWING SAFETY					
1a. IDDSI Level and Bolus #	2a. PAS Score	2b. LVC Integrity	2c. PAS Timing	2d. LVC Timing	2e. Pre-swallow Residue	2f. PAS Evolution
	For the initial swallow of the bolus, what is the PAS score? (1-8) *If PAS 1, 2 or 4, skip to 2f, else continue to 2b.*	For the initial swallow of the bolus, is LVC complete? (Y/N) *Continue to 2c.*	Did PAS occur before or after LVC? *If before, continue to 2d. If after, skip to 2f.*	If the answer to 2c. was before LVC, calculate time-to-LVC (frames & milliseconds)*. Hyoid burst frame to first frame where laryngeal vestibule is most closed. *Continue to 2e.*	Is there any residue present at the beginning of *the clip (before any new bolus enters the oral cavity)? (Y/N) *Continue to 2f.*	Is there evidence of a worse PAS score for later swallows of this bolus? If yes, what is that PAS score (1-8)? If no, enter "N/A". *Continue to 3a.*
Thin Cup #1				frames / milliseconds		
Thin Cup #2				frames / milliseconds		

Figure 5: ***ASPEKT-C Method Worksheet*** with column "1a. *IDDSI Level and Bolus #*" completed for two separate boluses.

ASPEKT-C Method Worksheet - Section 2: Swallowing Safety

2a. Penetration-Aspiration Scale (PAS) Score

Always complete this column for every bolus.

Background: The 8-point Penetration Aspiration Scale (PAS) (Rosenbek et al., 1996) (*Figure 6 A*) 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 6 B*). PAS scores of 1, 2 and 4 are considered "typical" as no material is left within the airway. PAS scores of 3, 5 and higher fall into the "atypical" range, as whenever material enters the supraglottic space and stays there, it is at risk for eventual aspiration.

A

8-Point Penetration-Aspiration Scale
(Rosenbek et al., 1996)

1	Material does not enter the airway
2	Material enters the airway, remains above the vocal folds, and is ejected from the airway
3	Material enters the airway, remains above the vocal folds, and is NOT ejected from the airway
4	Material enters the airway, contacts the vocal folds, and is ejected from the airway
5	Material enters the airway, contacts the vocal folds, and is NOT ejected from the airway
6	Material enters the airway, passes below the vocal folds, and is ejected into the larynx or out of the airway
7	Material enters the airway, passes below the vocal folds, and is NOT ejected from the trachea despite effort
8	Material enters the airway, passes below the vocal folds, and no effort is made to eject

B

Dichotomized Penetration-Aspiration Scale
(for use in ASPEKT-C)

1	Material does not enter the airway	Typical
2	Material enters the airway, remains above the vocal folds, and is ejected from the airway	
4	Material enters the airway, contacts the vocal folds, and is ejected from the airway	
3	Material enters the airway, remains above the vocal folds, and is NOT ejected from the airway	Atypical
5	Material enters the airway, contacts the vocal folds, and is NOT ejected from the airway	
6	Material enters the airway, passes below the vocal folds and is ejected into the larynx or out of the airway	
7	Material enters the airway, passes below the vocal folds, and is NOT ejected from the trachea despite effort	
8	Material enters the airway, passes below the vocal folds, and no effort is made to eject	

Figure 6: A) 8-Point Penetration Aspiration Scale (Rosenbek et al, 1996);
B) Dichotomized Penetration-Aspiration Scale for use in the ASPEKT-C Method

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

Next Step:

What is your PAS score on the first swallow of this bolus?	
PAS of 1, 2, 4	**PAS of 3, 5, 6, 7, 8**
These scores are considered "typical".	These scores are considered "atypical".
Skip ahead to "*2f. PAS Evolution*" on the ***ASPEKT-C Method Worksheet*.**	Continue to "*2b. LVC Integrity*" on the ***ASPEKT-C Method Worksheet*** to investigate possible contributors.

2b. Laryngeal Vestibule Closure (LVC) Integrity

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

Background: If the PAS score is "atypical" (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 air space or contrast in the laryngeal vestibule (see *Figure 7 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 7 B*) or partial tissue contact between the arytenoids and laryngeal surface of the epiglottis (see *Figure 7 C*).

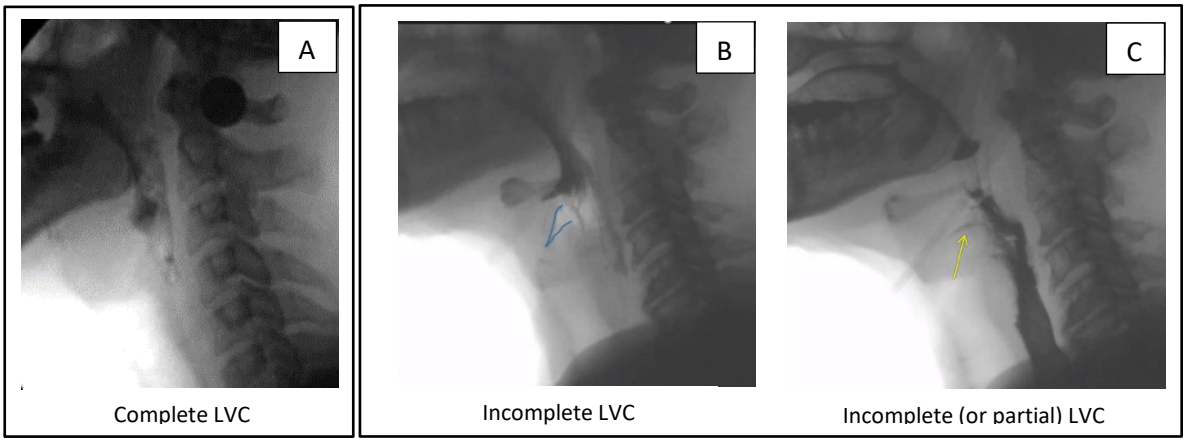


Figure 7: Sample images showing complete LVC (A) and incomplete closure (B) & (C).

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:

Did complete LVC occur?	
Yes – Complete LVC	**No – Incomplete or Partial LVC**
This is considered "typical". It suggests that it is not the integrity of LVC but rather the timing that may be impaired, leading to a PAS event.	This is considered "atypical". The PAS event may be occurring due to inability to achieve complete airway closure during the swallow. However, this may not be the only factor leading to the PAS event.
Continue to the next column "*2c. PAS Timing*" on the ***ASPEKT-C Method Worksheet*.**	

Example: This sample figure below demonstrates that you must have an "atypical" 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").

	2. SWALLOWING SAFETY					
1a. IDDSI Level and Bolus #	2a. PAS Score For the initial swallow of the bolus, what is the PAS score? (1-8) *If PAS 1, 2 or 4, skip to 2f, else continue to 2b.*	2b. LVC Integrity For the initial swallow of the bolus, is LVC complete? (Y/N) *Continue to 2c.*	2c. PAS Timing Did PAS occur before or after LVC? *If before, continue to 2d. If after, skip to 2f.*	2d. LVC Timing If the answer to 2c. was before LVC, calculate time-to-LVC (frames & milliseconds)[a]. Hyoid burst frame to first frame where laryngeal vestibule is most closed. *Continue to 2e.*	2e. Pre-swallow Residue Is there any residue present at the beginning of the clip (before any new bolus enters the oral cavity)? (Y/N) *Continue to 2f.*	2f. PAS Evolution Is there evidence of a worse PAS score for later swallows of this bolus? If yes, what is that PAS score (1-8)? If no, enter "N/A". *Continue to 3a.*
 Thin Cup #1	MUST be: 3, 5, 6, 7, 8	Y		frames / milliseconds		
 Thin Cup #2	MUST be: 3, 5, 6, 7, 8	N		frames / milliseconds		

Figure 8: ***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 "typical" (i.e., 1, 2, or 4).

Background: Regardless of whether the LVC closure was achieved under "*2b. LVC Integrity*", 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:

Did PAS occur before or after LVC?	
Before	**After**
When the PAS event occurs before LVC, it is possible the system did not react quickly enough to the incoming bolus.	When the PAS event occurs after LVC, it is possible that the patient is penetrating or aspirating residue on which they displayed impaired swallowing efficiency.
Continue to "*2d. LVC Timing*" on the ***ASPEKT-C Method Worksheet.***	Skip ahead to "*2f. PAS Evolution*" on the ***ASPEKT-C Method Worksheet***.

Example: This demonstrates that there are two potential responses to column *"2c. PAS Timing"*.

	2. SWALLOWING SAFETY					
1a. IDDSI Level and Bolus #	2a. PAS Score For the initial swallow of the bolus, what is the PAS score? (1-8) *If PAS 1, 2 or 4, skip to 2f, else continue to 2b.*	2b. LVC Integrity For the initial swallow of the bolus, is LVC complete? (Y/N) *Continue to 2c.*	2c. PAS Timing Did PAS occur before or after LVC? *If before, continue to 2d. If after, skip to 2f.*	2d. LVC Timing If the answer to 2c. was before LVC, calculate time-to-LVC (frames & milliseconds)*. Hyoid burst frame to first frame where laryngeal vestibule is most closed. *Continue to 2e.*	2e. Pre-swallow Residue Is there any residue present at the beginning of the clip (before any new bolus enters the oral cavity)? (Y/N) *Continue to 2f.*	2f. PAS Evolution Is there evidence of a worse PAS score for later swallows of this bolus? If yes, what is that PAS score (1-8)? If no, enter "N/A". *Continue to 3a.*
 Thin Cup #1			before	frames / milliseconds		
 Thin Cup #2			after	frames / milliseconds		

Figure 9: ***ASPEKT-C Analysis Worksheet*** with column "2c. *PAS Timing"* completed for 2 separate boluses

2d. LVC Timing

Not Applicable:
Do not complete this column if *"2a. PAS score"* was "typical" (i.e., 1, 2, or 4).
Do not complete this column if PAS event in "*2c. PAS Timing*" occurred "after" the swallow.

Background: Once we have established that the PAS event occurred before 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".

LVC frame: The frame of maximum approximation of the arytenoids to the epiglottis during the first swallow. In other words, the first frame when the laryngeal vestibule is the most closed.

NOTE: We are not aware of any data showing trends in time-to-LVC as a function of sex, age, sip-volume, cueing, or barium concentration.

How To: For the initial swallow of the bolus, calculate time-to-LVC.

The first step is to calculate the difference between the hyoid burst frame number and the LVC frame number.

The second step is to convert the value into milliseconds. To do this, divide your value in frames by 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.

See example in *Figure 10* for a demonstration of these two steps.

Next Step: Once *"2d. LVC Timing"* is calculated, continue to "*2e. Pre-swallow Residue"* on the ***ASPEKT-C Method Worksheet***.

Example: Step 1: hyoid burst frame=22, LVC frame=40, time-to-LVC = 18 frames
Step 2: 18 frames / (30 frames per second) x 1000 = 600 ms

	2. SWALLOWING SAFETY					
1a. IDDSI Level and Bolus #	2a. PAS Score	2b. LVC Integrity	2c. PAS Timing	2d. LVC Timing	2e. Pre-swallow Residue	2f. PAS Evolution
	For the initial swallow of the bolus, what is the PAS score? (1-8) *If PAS 1, 2 or 4, skip to 2f, else continue to 2b.*	For the initial swallow of the bolus, is LVC complete? (Y/N) *Continue to 2c.*	Did PAS occur before or after LVC? *If before, continue to 2d. If after, skip to 2f.*	If the answer to 2c. was before LVC, calculate time-to-LVC (frames & milliseconds)[a]. Hyoid burst frame to first frame where laryngeal vestibule is most closed. *Continue to 2e.*	Is there any residue present at the beginning of the clip (before any new bolus enters the oral cavity)? (Y/N) *Continue to 2f.*	Is there evidence of a worse PAS score for later swallows of this bolus? If yes, what is that PAS score (1-8)? If no, enter "N/A". *Continue to 3a.*
Thin Cup #1			MUST be: before	18 frames / 600 ms		

Figure 10: ***ASPEKT-C Method Worksheet*** with column "2d. *LVC Timing"* completed

2e. Pre-swallow residue

Always complete this column for every bolus.

Background: One indicator of swallowing safety is the presence of residue before any new bolus is administered. When compared to clean baseline swallows, swallows with pre-existing or pre-swallow residue exceeding a consistency specific threshold had double the odds of an "atypical" PAS score of ≥3 on that swallow (Steele et. al., 2020). The purpose of this column is to identify whether or not there is any residue present in the pharynx before any new bolus is administered.

How To: Indicate whether or not there is any residue present in the pharynx at the beginning of the video clip before any new bolus enters the pharynx.

Note: You may not be able to assess this parameter if the fluoro was turned on after the bolus entered the oral cavity or pharynx.

Next Step: Continue to "*2f. PAS Evolution*" on the ***ASPEKT-C Method Worksheet***.

Example: This demonstrates that there are two potential responses to column *"2e. Pre-swallow Residue".*

1a. IDDSI Level and Bolus #	2. SWALLOWING SAFETY					
	2a. PAS Score For the initial swallow of the bolus, what is the PAS score? (1-8) *If PAS 1, 2 or 4, skip to 2f, else continue to 2b.*	2b. LVC Integrity For the initial swallow of the bolus, is LVC complete? (Y/N) *Continue to 2c.*	2c. PAS Timing Did PAS occur before or after LVC? *If before, continue to 2d.* *If after, skip to 2f.*	2d. LVC Timing If the answer to 2c. was before LVC, calculate time-to-LVC (frames & milliseconds)[a]. Hyoid burst frame to first frame where laryngeal vestibule is most closed. *Continue to 2e.*	2e. Pre-swallow Residue Is there any residue present at the beginning of the clip (before any new bolus enters the oral cavity)? (Y/N) *Continue to 2f.*	2f. PAS Evolution Is there evidence of a worse PAS score for later swallows of this bolus? If yes, what is that PAS score (1-8)? If no, enter "N/A". *Continue to 3a.*
Thin Cup #1				frames / milliseconds	Y	
Thin Cup #2				frames / milliseconds	N	

Figure 11: ***ASPEKT-C Method Worksheet*** with column "2e. *Pre-swallow Residue*" completed for 2 separate boluses

2f. PAS Evolution

Always complete this column for every bolus.

Background: Now we want to take a step back and look at all the swallows of this particular bolus; is there evidence of a worse PAS score on any of the swallows involving this bolus? For instance, a patient may perform 4 swallows for a single bolus and over that time, the PAS score may 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 worsen across later swallows for the bolus and remains consistent with the initial value from "*2a. PAS score*", enter "N/A".

How To: Is there evidence of a worse PAS score for this bolus compared to the initial value in "*2a. PAS Score*"? If yes, include that PAS score. If no, enter "N/A".

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 first swallow of the bolus. However, with the second or third swallows of this same bolus, material falls below the true vocal folds and there is no cough response. This evolution to a score of *8*, should be captured under column "*2f. 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 "N/A" under column "*2f. PAS Evolution*".

	2. SWALLOWING SAFETY					
1a. IDDSI Level and Bolus #	2a. PAS Score For the initial swallow of the bolus, what is the PAS score? (1-8) *If PAS 1, 2 or 4, skip to 2f, else continue to 2b.*	2b. LVC Integrity For the initial swallow of the bolus, is LVC complete? (Y/N) *Continue to 2c.*	2c. PAS Timing Did PAS occur before or after LVC? *If before, continue to 2d. If after, skip to 2f.*	2d. LVC Timing If the answer to 2c. was before LVC, calculate time-to-LVC (frames & milliseconds)[a]. Hyoid burst frame to first frame where laryngeal vestibule is most closed. *Continue to 2e.*	2e. Pre-swallow Residue Is there any residue present at the beginning of the clip (before any new bolus enters the oral cavity)? (Y/N) *Continue to 2f.*	2f. PAS Evolution Is there evidence of a worse PAS score for later swallows of this bolus? If yes, what is that PAS score (1-8)? If no, enter "N/A". *Continue to 3a.*
Thin Cup #1	2			frames / milliseconds		8
Thin Cup #2	4			frames / milliseconds		N/A

Figure 12: ***ASPEKT-C Method Worksheet*** with column "2f. *PAS Evolution"* completed for two separate boluses

ASPEKT-C Method Worksheet – Section 3: Swallowing Efficiency

3a. Number of 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.

Two points of caution:

1) Do NOT include swallow attempts (e.g., hyoid and laryngeal excursion in the absence of UES opening) in the total number of swallows per bolus. For example, if on a given bolus there are 3 swallows and 1 swallow attempt, the total number of swallows is 3. On boluses where there is never any UES opening on any of the associated subswallows, and the patient is required to expectorate or suction out the entire bolus, do not use the ASPEKT-C Method to score this trial. The comments section on the ***ASPEKT-C Method Scoring Sheet*** may be used to document this important finding.
1) You may wish to differentiate between spontaneous and clinician-cued subswallows (e.g., did you ask the patient to swallow again or did they swallow/spontaneously/un-cued) 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 next column "*3b. Total Pharyngeal Residue*" 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.

3. SWALLOWING EFFICIENCY							
3a. # of Swallows	3b. Total Pharyngeal Residue			3c. PhAMPC			
Number of swallows taken to clear the bolus (e.g., 3) *Continue to 3b.*	Is there pharyngeal residue[b] at the end of the initial swallow of the bolus? If no, move to next bolus (1a). If yes, measure. Total pharyngeal residue = (V res. area + PS res. area + Other res. area) / (C2-4 length)² x 100% *Compare to scoring sheet. If atypical, continue to 3c.*			For the initial swallow, measure Pharyngeal Area at Maximum Pharyngeal Constriction (PhAMPC). PhAMPC = pharyngeal area / (C2-4 length)² x 100% *Move to next bolus (1a).*			
4	Total Pharyngeal Residue		calculation	Pharyngeal area		calculation	
	C2-4 length			C2-4 length			

Figure 13: ***ASPEKT-C Method Worksheet*** with column "*3a. # of Swallows*" completed

3b. 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 *"3b. Total Pharyngeal Residue"* or "*3c. 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. 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.

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.

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-C4 correctly. C1-C3 cannot be substituted as it is significantly longer (Nagy et al., 2015). See *Figure 14* for a sample tracing from the anterior inferior corner of C2 to the anterior inferior corner of C4.

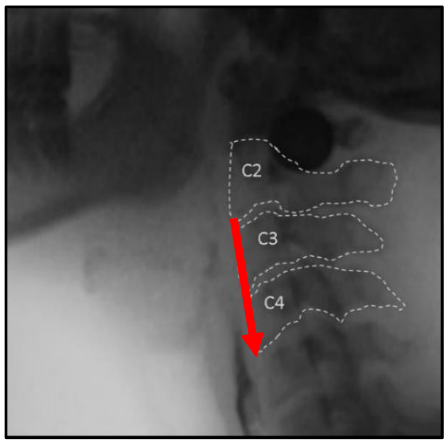


Figure 14: Sample image of cervical spine

Caution: When assessing the presence or absence of pharyngeal residue, there may be structural opacities overlying the pharynx, particularly in the region of the pyriform sinuses, which can act as confounding factors, potentially inflating residue severity. In these cases, comparing a positioning frame taken from the very beginning of the VFSS before any boluses were administered (see example in *Figure 15A*) to your frame of interest after the initial swallow of the bolus (see example in *Figure 15B*) may be helpful to minimize the risk of overestimating residue.

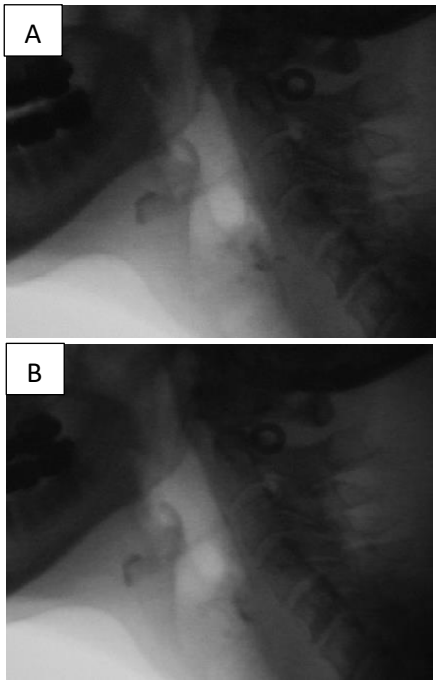


Figure 15: Sample images of (A) a positioning frame prior to administration of any boluses taken at the beginning of the VFSS showing darkness overlying the pyriform sinuses and (B) a frame after the patient swallowed a bolus of barium.

Note: Larger volume boluses are likely to leave greater residue. Higher barium concentrations (i.e. ≥ 60% w/v) are more likely to leave a coating on the walls of the pharynx, which may be difficult to distinguish from residue.

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.

Figure 16: Frame selected for total pharyngeal residue measurement showing rested or relaxed pharynx

Step 2: Measure the C2-C4 cervical spine length scalar

i. Select the *line* tool (see *Figure 17*).

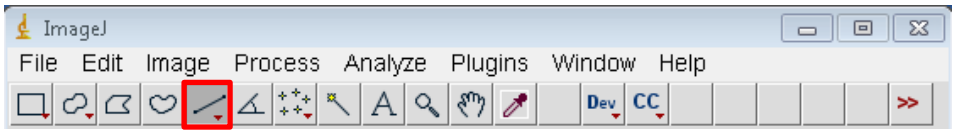


Figure 17: ImageJ line tool

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.
- 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.

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

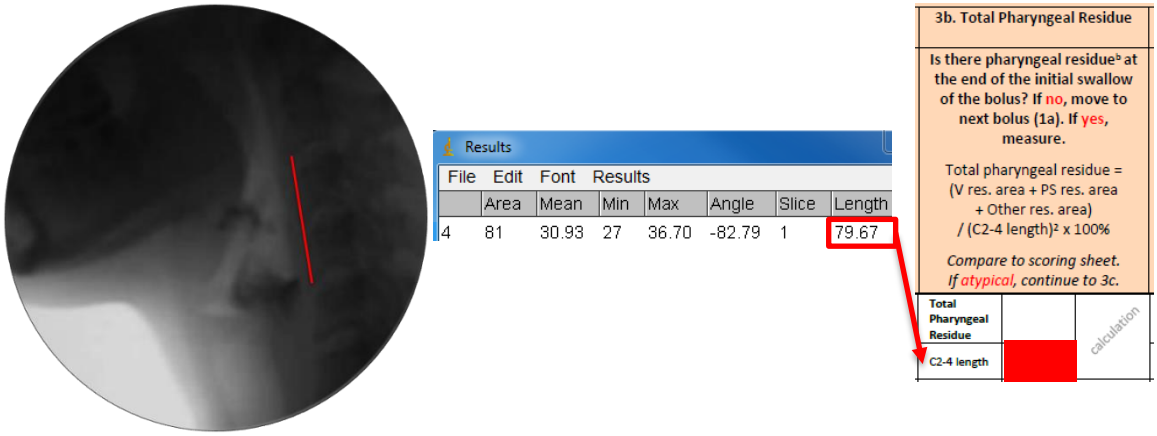


Figure 18: Sample cervical spine C2-C4 length measurement

Step 3: Measure residue in the pharynx

Trace the residue remaining in the pharynx using the following steps.

i. Select the *Freehand* tool (*Figure 19*, red box).

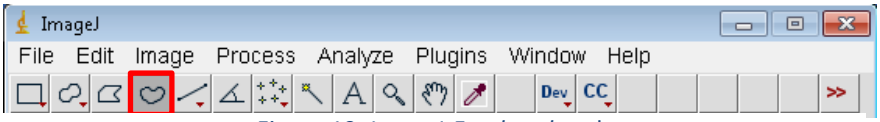


Figure 19: ImageJ *Freehand* tool

ii. Click and hold to trace a contour line around any residue areas of interest in the pharynx. 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

NOTE: Do not include penetrated or aspirated material in the laryngeal vestibule or material in the oral cavity.

QUICK TIP: To refine or adjust the residue area tracing, follow these steps:

a. Right-click on the *Oval* tool and choose *Selection Brush* tool (*Figure 20 left*).
b. Click and hold down to adjust the area tracing.
c. Double click on the *Oval* tool to change the size of the brush (*Figure 20 right*).
d. Use this tool to nudge the contour line already created around the residue.

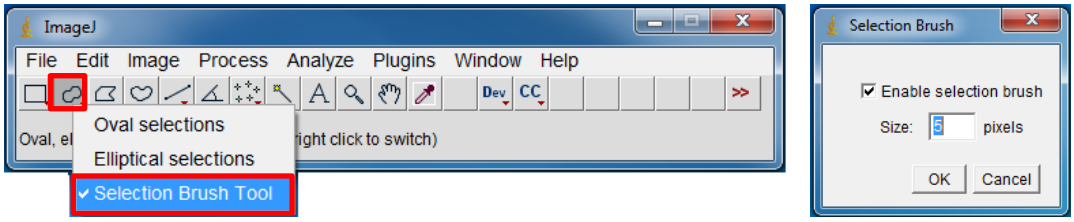


Figure 20: Selection Brush tool in ImageJ

iii. Press Ctrl + M when you have completed the area tracing.

iv. Repeat these steps for each residue area (if there are multiple) and enter the sum of those *Area* measures in the "Total Pharyngeal Residue" field on the ***ASPEKT-C Method Worksheet.***

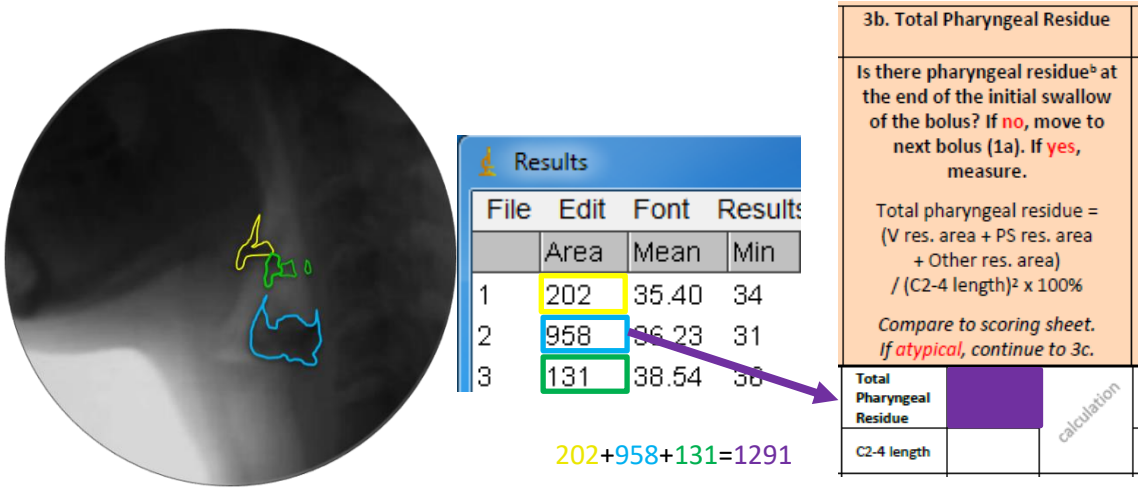
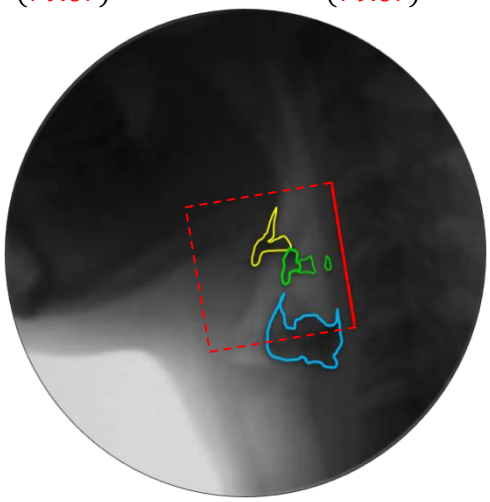


Figure 21: Sample total pharyngeal residue area measurement
(valleculae in yellow, pyriform sinuses in blue and other in green, total in purple)

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 "*3b. Total Pharyngeal Residue*" column on the ***ASPEKT-C Method Worksheet.*** The residue shown in *Figure 22* can be calculated as follows. The red dashed square in *Figure 22* shows the $(C2\text{-}C4)^2$ reference area (i.e., C2-C4 length squared) to which residue area(s) is compared. In this example, the total pharyngeal residue is equivalent to 20.1% of the red-dashed square.

$$Total\ Pharyngeal\ residue$$
$$= \frac{total\ pharyngeal\ residue}{(C2 - C4\ length)^2} x\ 100\%$$
$$= \frac{202 + 958 + 131}{(79.67)^2} x\ 100\% = \frac{1291}{(79.67)^2} x\ 100\% = 20.1\%$$



3b. Total Pharyngeal Residue		
Is there pharyngeal residue[b] at the end of the initial swallow of the bolus? If no, move to next bolus (1a). If yes, measure. Total pharyngeal residue = (V res. area + PS res. area + Other res. area) / (C2-4 length)² x 100% *Compare to scoring sheet. If atypical, continue to 3c.*		
Total Pharyngeal Residue	1291	20.1%
C2-4 length	79.67	

Figure 22: Sample total pharyngeal residue tracing and completed ***ASPEKT-C Method Worksheet***

Next Step:

Compare the total pharyngeal residue value to the *ASPEKT-C Method Scoring Sheet* to determine if it is "typical" or "atypical".	
"typical"	**"atypical"**
Move on to score the next bolus in your VFSS by returning to "*1a. IDDSI Level and Bolus #*".	Continue to "*3c. PhAMPC"* on the ***ASPEKT-C Method Worksheet***.

3c. Pharyngeal Area at Maximum Pharyngeal Constriction (PhAMPC)

Not Applicable: If there is no pharyngeal residue or a "typical" amount of residue identified in column "*3b. 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 "atypical" 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 air space and/or bolus at maximum constriction during the first swallow of the bolus.

As mentioned in column "*3b. 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.

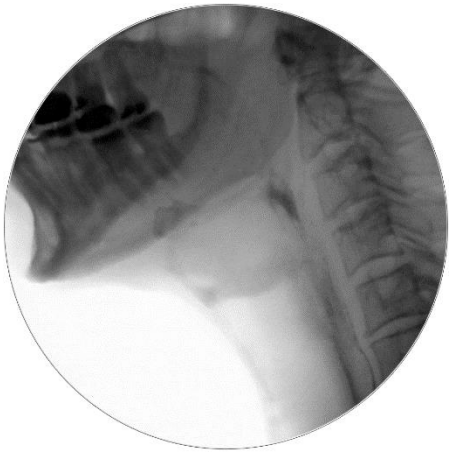


Figure 23: Frame selected for PhAMPC measurement

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 24*. While it is not necessary to draw a line as shown in *Figure 24,* it may be helpful to visualize a right angle tool that cuts across the top of the pharynx visually. While it is rare for bolus to 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.

Figure 24: Image showing upper boundary of pharynx

Step 2: Measure the C2-C4 cervical spine length scalar

i. Select the *line* tool (Figure 25).

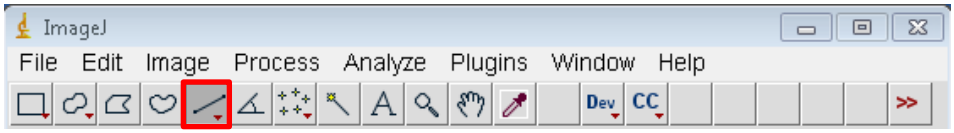


Figure 25: ImageJ *line* tool

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***.

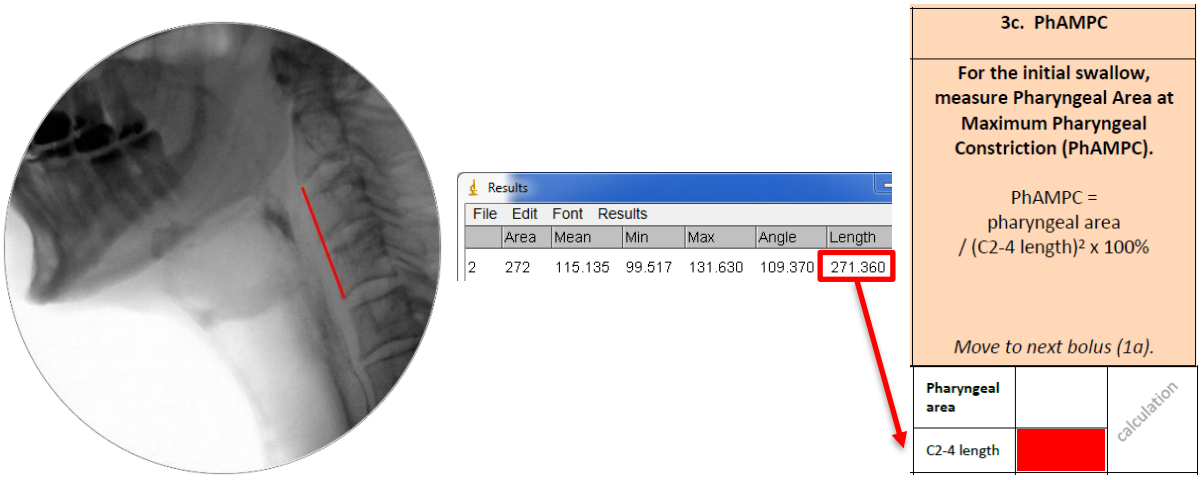


Figure 26: Sample cervical spine length measurement

Step 3: Measure the remaining visible air space and/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 "Important Note" from Step 1 *Figure 24*
- posterior to the arytenoids, base of the tongue, and pharyngeal surface of the epiglottis
- anterior to the posterior pharyngeal wall

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***.

NOTE: If there are two separate areas of bolus and/or airspace within the boundaries of the pharynx, trace each one separately. Enter the **sum** of those areas in the designated field on the ***ASPEKT-C Method Worksheet***.

QUICK TIP: To refine or adjust the area tracing, follow these steps: (previously described in *Figure 20*)

a. Right-click on the *Oval* tool and choose *Selection Brush* tool.
b. Click and hold down to adjust the area tracing.
c. Double click on the *Oval* tool to change the size of the brush.
d. Use this tool to nudge the contour line already created around the residue.

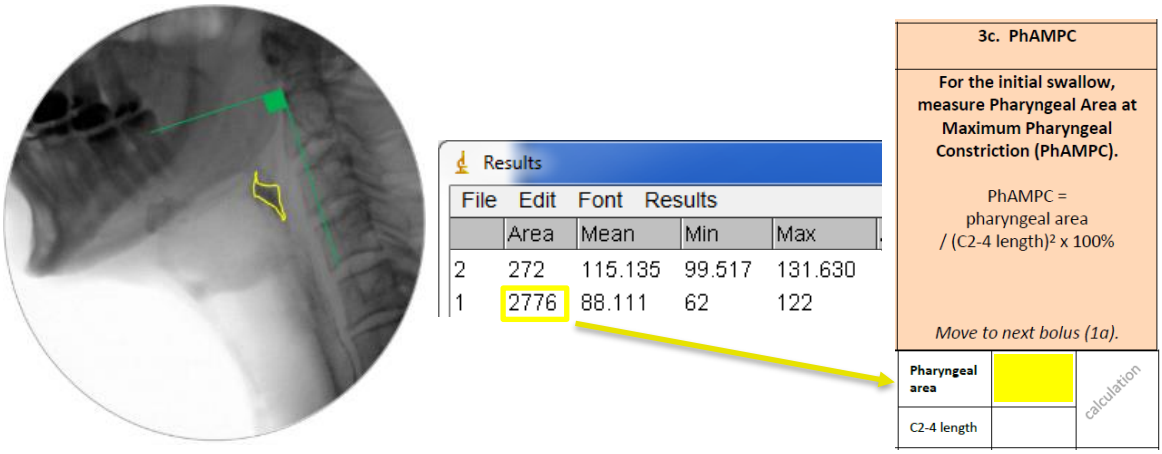


Figure 27: Sample pharyngeal area measurement

Step 4: Calculate PhAMPC

Calculate the PhAMPC as a percent of the C2-C4 squared space using the formula included in the "*3c. 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 $(C2\text{-}C4)^2$ 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.

$$PhAMPC = \frac{pharyngeal\ area}{(C2 - C4\ length)^2} x\ 100\% = \frac{2776}{(271.36)^2} x\ 100\% = 3.8\%$$

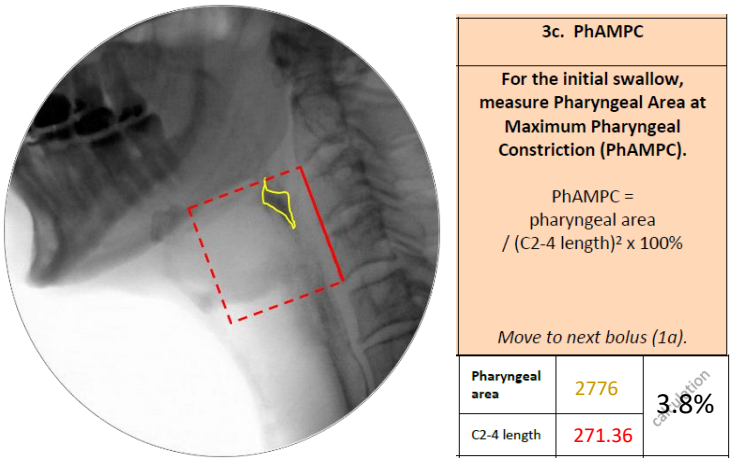


Figure 28: Sample image showing PhAMPC

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

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 blue and peach columns. 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 or tasks were omitted (e.g., did not administer IDDSI Level 2, study was aborted due to patient factors) **OR**
   - Parameters did not require calculation according to the ASPEKT-C Method pathway (e.g., if PAS is "typical" for all thin liquid boluses, you would have no "*2d. LVC Timing*" value under IDDSI Level 0 thin).
3. The frequency of how often an unsafe PAS event occurs is clinically relevant. Whether a patient aspirates on 1 of 4 trials versus 4 of 4 trials of thin liquids may portray a different profile of risk and should be included as part of documentation in the "My Patient Values" table.
4. Use the "*ASPEKT-C Typical Reference Values*" table (*Figure 29* to compare your patient values. If any of the safety values fall outside the typical reference range, their safety is "atypical". If any of the efficiency values fall outside the typical reference values, their efficiency is "atypical"

Core Protocol:

My Patient Values			Mechanism							Mechanism	
IDDSI Level		2a. & f. PAS Score & Evolution	2b. LVC Integrity	2d. Time-to-LVC	2e. Pre-swallow Residue	Safety (typical, atypical)	Frequency of Atypical PAS Events	3a. # of swallows	3b. Total Pharyngeal Residue %(C2-4)[2]	3c. PhAMPC %(C2-4)[2]	Efficiency (typical, atypical)
0	Thin										
2	Mildly Thick										

ASPEKT-C Typical Reference Values[a]		2a. & f. PAS Score & Evolution[b]	2b. LVC Integrity	2d. Time-to-LVC	2e. Pre-swallow Residue[c]	If any of the safety values fall outside the typical reference values, enter atypical.	Comment on the frequency of atypical PAS events (e.g.,1 of 4 trials)	3a. # of swallows	3b. Total Pharyngeal Residue %(C2-4)[2]	3c. PhAMPC %(C2-4)[2]	If any of the efficiency values fall outside the typical reference values, enter atypical.
IDDSI Level											
0	Thin	1, 2, 4	Complete	< 167 ms	N			1	< 1.7 %	< 2.7 %	
2	Mildly Thick	1, 2, 4	Complete	< 200 ms	N			1	< 2.2 %	< 3.3 %	

Figure 29: "My Patient Values" table from the ASPEKT-C Method Scoring Sheet

Other Observations

The ***ASPEKT-C Method Scoring Sheet*** includes a section for Other Observations (as shown in *Figure 30*). If you complete trials of IDDSI "drinks" outside the core protocol (e.g., moderately thick), you can use the "ASPEKT-C Typical Reference Values" table, *Figure 31*) to compare your patient values. ASPEKT-C Method typical reference values are not available for other views (e.g., AP), consistencies (e.g., IDDSI level 5 minced and moist), or with the use of interventions (e.g., effortful swallow), however you may wish to note those other observations under this section.

Other Observations

While there are no ASPEKT-C Method typical reference values available for other views (e.g., AP), consistencies (e.g., minced and moist), or with the use of interventions (e.g., effortful swallow), you may wish to note those other observations below.

IDDSI Level		Swallowing Safety	Swallowing Efficiency

Anterior/Posterior view? Yes/No Vallecular Sinus Residue Asymmetry? _____ Pyriform Sinus Residue Asymmetry? _____

Figure 30: "Other Observations" section of the ***ASPEKT-C Method Scoring Sheet***

ASPEKT-C Typical Reference Values[a]		2a. & f. PAS Score & Evolution[b]	2b. LVC Integrity	2d. Time-to-LVC	2e. Pre-swallow Residue[c]	If any of the safety values fall outside the typical reference values, enter atypical.	Comment on the frequency of atypical PAS events (e.g.,1 of 4 trials)	3a. # of swallows	3b. Total Pharyngeal Residue %(C2-4)[2]	3c. PhAMPC %(C2-4)[2]	If any of the efficiency values fall outside the typical reference values, enter atypical.
IDDSI Level											
0	Thin	1, 2, 4	Complete	< 167 ms	N			1	< 1.7 %	< 2.7 %	
1	Slightly Thick	1, 2, 4	Complete	< 234 ms	N			1	< 1.9 %	< 2.5 %	
2	Mildly Thick	1, 2, 4	Complete	< 200 ms	N			1	< 2.2 %	< 3.3 %	
3	Moderately Thick/Liquidised	1, 2, 4	Complete	< 200 ms	N			1	< 1.6 %	< 2.1 %	
4	Extremely Thick/Pureed	1, 2, 4	Complete	< 167 ms	N			1	< 1.5 %	< 1.4 %	

Figure 31: "ASPEKT-C Typical Reference Values" table form the ***ASPEKT-C Method Scoring Sheet***

ASPEKT-C Documentation Considerations

- As previously mentioned the ***ASPEKT-C Method Worksheet*** was created as a "rough worksheet" to guide clinicians through process of VFSS analysis. The Worksheet is not meant to be included as is into a patient's paper chart or electronic patient record. The ***ASPEKT-C Method Scoring Sheet*** contains a table where you may wish to use colour coding of red and green to quickly see which values were "typical" and "atypical". The "*My Patient Values*" table from the ***ASPEKT-C Method Scoring Sheet*** can be copied/pasted into a report and accompanied by an impression statement that qualifies the results within the context of your patient's unique situation and characteristics.
- 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 incomplete LVC integrity 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 typical reference values were established based on the 75% percentile values as shown in *Figure 32.* Given that healthy individuals typically swallow a bolus in a single swallow, these **reference values were calculated for the initial swallow of the bolus only** (except for "*2e. PAS evolution*")

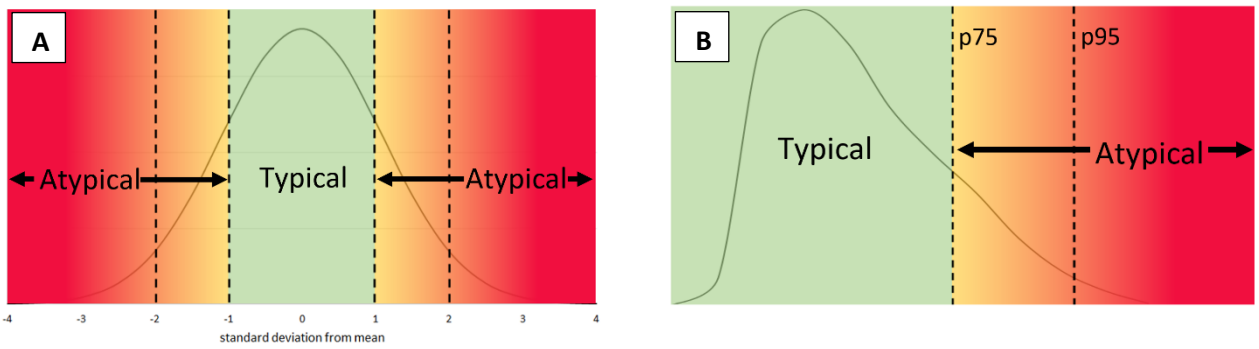


Figure 32: Examples of A) normally distributed data, and B) positively skewed data

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 do not 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).

It may be helpful to narrow down the list of additional parameters of interest by looking at the research associated your patient's suspected dysphagia etiology. Our team has published results of the ASPEKT Method in the following cohorts: healthy aging, Amyotrophic Lateral Sclerosis (ALS), Parkinson Disease (PD), Post-radiation oropharyngeal cancer and Chronic Obstructive Pulmonary Disease (COPD). See Appendix B for a complete list of publications.

It should be noted that patients are complex and can often have multiple comorbidities e.g., a patient with COPD that just had a stroke. In these cases, it is important to understand the profiles associated with each of these diagnoses as we determine the primary contributors to our patient's individual situation.

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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 as 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 33*, red box) or select *virtual stack* option (*Figure 33*, 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.

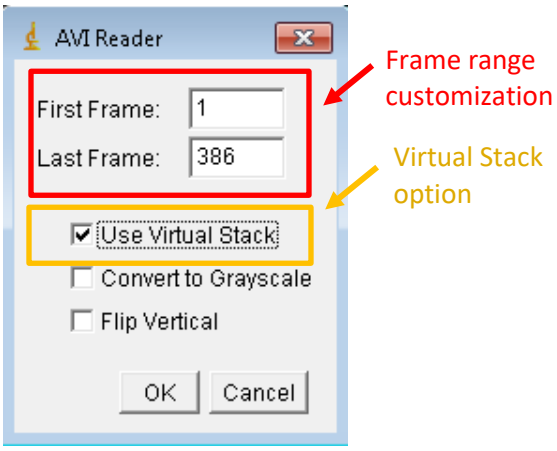

Figure 33: ImageJ's *AVI Reader* menu.

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 34*, orange arrows). Frame numbers are located on the top left-hand corner of the video window (*Figure 34*, red box).

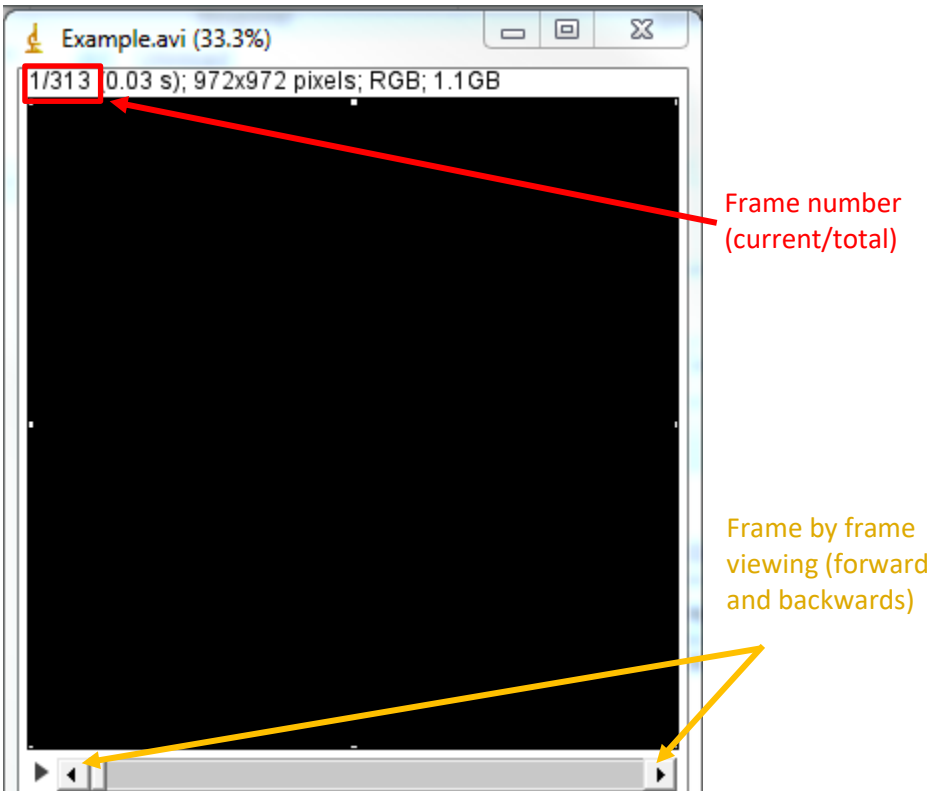

Figure 34: Sample video windows in ImageJ

Appendix B: Complete List of ASPEKT Method Publications

1. Steele, C. M., Mancopes, R., Barrett, E., Panes, V., Peladeau-Pigeon, M., Simmons, M. M. & Smaoui, S. (2024). Preliminary exploration of variations in measures of pharyngeal area during non-swallowing tasks. *Journal of Speech-Language Hearing Research.* https://doi.org/10.1044/2024_JSLHR-24-00418
2. Gandhi, P., Waito, A., Peladeau-Pigeon, M., Plowman, E. K. & Steele, C. M. (2024). Profiles of swallowing impairment in people with amyotrophic lateral sclerosis compared to age-matched controls. *Journal of Speech, Language and Hearing Research. https://doi.org/10.1044/2024_JSLHR-24-00106*
3. Gandhi, P., Barrett, E., Mancopes, R., Peladeau-Pigeon, M., Panes, V., Simmons, M. M. & Steele, C. M. (2024). Patterns and Duration of Vallecular Bolus Aggregation in Healthy Swallowing of Solid Food Boluses. *Journal of Speech-Language Hearing Research.* https://doi.org/10.1044/2024_JSLHR-24-00066
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17. Valenzano, T. J., Smaoui, S., Peladeau-Pigeon, M., Barbon, C. E. A., Craven, B. C. & Steele, C. M. (2023). Using reference values to identify profiles of swallowing impairment in individuals with traumatic spinal cord injury. *American Journal of Speech-Language Pathology.* https://doi.org/10.1044/2022_AJSLP-22-00298
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