Overview of Talk

- Review of the Anatomy and Physiology
- Basics of Acoustic Recording Assessment
- Assessment of the Respiratory System
- Treatment of the Respiratory System
- Case Discussion
- Feel free to ask questions throughout

Why Is Respiration Important?

- The respiratory system provides the support for the speech system - the drive for speech
- Without appropriate respiratory support, all other subsystems will be impaired
- Often the respiratory system is not assessed, leading to therapy targets which are inappropriate
ANATOMY AND PHYSIOLOGY REVIEW

Two Definitions

- End expiratory level (EEL):
  - Lung volume measured at the rest point of respiration – at the end of a tidal volume expiration

- Vital Capacity (VC):
  - The maximum amount of air in the lungs which can be exchanged
  - VC can be measured on a spirometer
  - Respiratory therapists often measure VC
  - Forced vital capacity (FVC) is similar except the patient is told to breathe out hard and fast

Demos

- End expiratory level (EEL):
  - Relax and breathe quietly
  - When you feel you are about to inhale (after exhaling), hold your breath
  - You are at your EEL

- Vital Capacity (VC):
  - Find your EEL again
  - Breathe in as much air as you can, and then blow it all out
  - The amount of air you expired from the top of your inspiration is your VC

Pleural Linkage

- The rib cage and the lungs are linked together via pleural linkage
- Pleura covers the inside of the rib cage (parietal pleura) and the outside of the lungs (visceral pleura)
- Pleural space – the space between the two pleura
- Intrapleural pressure is negative which sucks the lungs to the rib cage

Moore and Dalley (1999) pg. 95
Pleural Linkage

- Since the lungs are attached to the thorax via pleural pressure, forces exerted on the thorax will move the lungs
- We refer to the lungs and thorax, coupled by pleural pressure, as the lung-thorax unit
- Muscles of respiration work on the thorax and abdomen, causing the amount of air in the lungs (volume) to change

Recoil Pressures

- The lungs and the thorax are elastic (they resist being deformed from rest)
- They also exert a force to return to rest – elastic recoil force
- The rest position (at EEL) is at approximately 35-40% VC
- Alveolar (lung) pressure = atmospheric pressure

Passive Respiratory Forces

- When moved from rest, the lung-thorax unit exerts a force to return to rest
- The force used to return to rest generates recoil pressures
- The recoil pressures are pressures within the lung and are a source of power for the speech system

A Bit about Pressures

- Pressure: force/unit area
- Gas has pressure
- Respiratory Pressures:
  - Atmospheric pressure – pressure in the atmosphere
  - Alveolar pressure – pressure within the lungs
  - Pleural pressure – pressure within the pleural space

Image from Betts et al. (n.d.). Anatomy and Physiology. OpenStax; license: CC-by 4.0
Pressure Differentials

- Pressure differential: change in pressure across containers
- Atmospheric pressure is given value of 0
  - Pressure which is less than atmospheric pressure is called negative pressure
  - Pressure which is greater than atmospheric is called positive pressure

Recoil Pressures

- Above EEL, recoil pressures are positive (compressing) and lead to expiration
- Below EEL, recoil pressures are negative (expanding) and lead to inspiration
- The farther from EEL, the more positive or negative the recoil pressures become
  - It took more muscle force to reach a lung volume far from EEL
  - Recoil pressures are proportional to distorting forces

Demos

- Highly positive recoil force:
  - Breathe in as much air as you can and hold it
  - Can you feel how your system wants to expire (compress)?
- Highly negative recoil force:
  - Blow out as much air as you can and hold your breath
  - Can you feel how your system wants to inspire (expand)?
Net Pressure

- Active pressures: generated by the inspiratory and expiratory muscles
- Net pressure:
  - Active (muscular) pressures are superimposed on the recoil pressures
  - Simultaneous passive and active forces
  - Net force results in the change in lung volume (LV)

Inspiration and Expiration

- Inspiration Occurs When:
  - Dimensions of the rib cage are enlarged
  - Increased volume = decreased pressure in the lungs
  - Pressure in lungs is less than atmospheric (negative pressure)
  - Air flows into the lungs
  - From a region of higher pressure (outside the body) to lower pressure (in the lungs)
-Expiration Occurs When:
  - Dimensions of the rib cage are reduced
  - Decreased volume = increased pressure in the lungs
  - Pressure in lungs is more than atmospheric (positive pressure)
  - Air flows out of the lungs
  - From a region of higher pressure (in the lungs) to a region of lower pressure (outside the body)

Figure: Time Point 1

- Before inspiration:
  - Alveolar pressure is atmospheric
  - Pressure is ______
  - No pressure differential
  - Volume is not changing
  - Flow is ______
  - Lungs expand = increasing container size causing ________ to start

SMALL GROUP ACTIVITY
Clinical Assessment and Treatment of Respiration

Figure: Time Point 2

- During inhalation:
  - Alveolar pressure drops below atmospheric pressure
  - _______ alveolar pressure
  - Changes in airflow follow that of pressure
  - _______ pressure, leads to _______
  - Lung volume _______

Figure: Time Point 3

- End of inspiration:
  - Alveolar pressure = atmospheric pressure
  - $P_{alv} =$ _______
  - Airflow stops since there is no pressure differential
  - airflow = _______
  - Volume is at its maximum
  - Lungs compress – reducing container size, causing _______ to start

Figure: Time Point 4

- Expiration:
  - Alveolar pressure is above atmospheric pressure
  - _______ alveolar pressure
  - Changes in airflow follow pressure
  - _______ pressure, leads to _______
  - Lung volume is _______
Clinical Assessment and Treatment of Respiration

Diaphragm
- Main muscle of inspiration
- Attachments:
  - Central tendon
  - Xiphoid process of sternum
  - Ribs (7-12) and their costal cartilages
  - Lumbar vertebrae (1-3)

Diaphragm: Inferior View
- Sternum
- Vena Caval foramen
- Esophageal hiatus
- Aortic hiatus
- Lumbar vertebrae

Figure taken from: Agur and Lee (1999) Grant’s Atlas of Anatomy, p. 154

Diaphragm: Superior View
- Pericardial sac
- Diaphragm muscle
- Central tendon
- Esophagus

Figure taken from: Agur and Lee (1999) Grant’s Atlas of Anatomy, p. 45

Thoracic Expansion: Diaphragm

Video from Primal Pictures

Jessica E. Huber, Ph.D.; Purdue University
Crossroads Conference, Oct 2017
Diaphragm: Frontal View

- Esophagus
- When the diaphragm contracts and flattens, it pushes the abdominal contents down and outward
- Because of this, the abdominal wall moves outward during inspiration

Diaphragm: Innervation

- Motor: Phrenic nerve
- Composed of fibers from C3, C4, and C5

External Intercostal Muscles

- Origin: lower edge of one rib
- Insertion: upper edge of rib immediately below
- Function: inspiration

Internal Intercostal Muscles

- Origin: lower border of one rib
- Insertion: upper border of the rib immediately below
- Underneath the external intercostals
- Function: expiration
Clinical Assessment and Treatment of Respiration

Rib Cage Motion
- Diaphragm: superior/inferior
- Upper intercostals: anterior/posterior
- Lower intercostals: transverse

Internal and External Intercostals: Innervation
- Motor:
  - Intercostal nerves (T1-T11)
  - Spinal nerves at each vertebral level innervate the intercostal muscle at that vertebral level

Abdominal Muscles
- All abdominal muscles push abdominal viscera inward and upward
  - Reduce the superior-inferior dimensions of the rib cage and lungs
- All abdominal muscle also pull the sides of the lower rib cage in
  - Reduces the transverse dimensions of the rib cage and lungs
- Accessory muscles of expiration

Abdominal Muscles
- Contract during forced exhalation
  - Rectus Abdominis
  - External Oblique
  - Internal Oblique
  - Transverse Abdominis
Clinical Assessment and Treatment of Respiration

Rectus Abdominus and External Oblique: Frontal View

External oblique

Rectus abdominus

Internal Oblique & Transverse Abdominus: Frontal View

Internal oblique

Transverse abdominus

Linea alba

Accessory Muscles of Expiration: Innervation

- All: Thoracoabdominal nerves (T7-T11)
- Some:
  - Subcostal nerve (T12)
  - Iliohypogastric (L1)

Pressure Generation for Speech

- Main task of respiratory system: to provide pressure for speech production, commensurate with the task goals, efficiently and consistently
- During speech:
  - Decrease in lung volume
  - Subglottal pressure stays relatively constant
  - Flow stays relatively constant
  - Recoil pressures change
Pressure Generation for Speech
- Balance forces (active and passive) to maintain constant subglottal pressure across lung volume
  - Passive recoil pressure continually changing due to changes in lung volume
  - Use muscular forces to balance and add to passive recoil pressures

Muscular Forces
- Inspiration:
  - Actively initiated by contraction of the diaphragm and the external intercostals
- Expiration:
  - Rest breathing: passive forces cause expiration (return to rest position)
  - Speech: inspiratory and/or expiratory muscles are used to control and cause expiration

Muscular Forces: Inspiratory Muscles
- Cause inspiration
- Provide a checking action when lung volume is high to slow the descent of the rib cage
- Work against the recoil pressures

Muscular Forces: Expiratory Muscles
- Compress the abdominal contents, pushing the diaphragm up which
  - Decreases the lung volume and produces expiratory pressure
  - Place the diaphragm at its physiologic rest length
    - The length at which the diaphragm can contract most quickly and most strongly
- Compress the rib cage volume, compressing the lungs
  - Produces expiratory pressure
  - Abdominal muscles are active throughout breathing to support the respiratory system
    - Provide maximal advantage for movement of the rib cage, so expiration of the rib cage does not cause expansion of the abdomen (which would reduce the force of rib cage expiration)
Muscular Forces: Clinical Correlates
- Without inspiratory muscles, what can a person not do?
- Without expiratory muscles, what can a person not do?

Efficiency of Respiratory System
- Mid lung volume range used for speech at comfortable intensity level
  - 35-60% VC
  - Initiate speech at about 45-60% VC
  - Terminate at or slightly below EEL (35% VC)
- Women and children usually slightly below EEL
- Men usually at EEL
- Maximum efficiency with minimum effort

Why Is Mid Lung Volume Range Most Efficient?
- Mechanism takes advantage of recoil pressures – positive recoil pressures
- Little checking action required
- Expiratory passive force working in same direction as active force
- Lung-thorax unit wants to compress (expire) to move toward rest
- Older adults will breathe to higher lung volumes before speaking and stop talking at higher lung volumes
- Allows them to take advantage of higher recoil pressures available at higher lung volumes to support speech

Efficiency of Respiratory System
- Below EEL:
  - Recoil pressure are negative (lung-thorax unit wants to expand (inspire) to rest position)
  - Must use more muscular force to overcome the negative recoil forces
- At high LV:
  - More recoil pressure than needed for comfortable intensity speech
  - Must use more inspiratory muscular force to slow the compression of the lung-thorax unit
  - When we talk loudly, we breathe to higher lung volumes to take advantage of higher recoil pressures available to support the larger subglottal pressure required for higher intensity speech
BASICS OF ACOUSTIC RECORDING

Types of Microphones
- Dynamic:
  - Strong and sturdy
  - Good frequency response
  - Relatively less expensive and moderately sensitive
  - Good choices for general recording
- Condenser:
  - Delicate (will not tolerate abuse)
  - Expensive, but very precise measurements
  - Mostly used for research purposes

Microphone Frequency Response and Sensitivity
- Frequency response: the sensitivity of the microphone to various frequencies
- Want a microphone with flat response to a large range of speech frequencies
- Sensitivity: the sound intensity detectable by the microphone

Microphone Directionality
- Unidirectional (a.k.a. carotid): records sounds best which come from the direction in which the microphone is pointed, is fine to record from a seated patient
- Respond differently depending on the distance between the patient and the microphone. Information about this distance is available in the manufacturer instructions
- Omnidirectional: almost equally sensitive to sounds from all directions, will pick up extraneous sounds in the recording area more easily
- Respond equally well at all distances from the patient
Environmental Considerations

- Choose a setting that is as quiet as possible
- Consider your client
- Curtains/Carpeting in a room drastically reduce background noise
- A baseline noise level reading should be less than 50dB, and this level should be maintained throughout the recording session

Sound Level Meter

- Need a sound pressure meter and microphone
- Digital read-outs are nice for jotting down numbers as the patient speaks
- Set meter to “C-weighting”

Recording the Patient

- Keep a constant mouth-to-microphone distance
- If the microphone will be close to the patient (6 inches or less), place the microphone at a 45 degree angle to the mouth to reduce the recording of articulator noise
- Note the gain setting on the sound level meter and the mouth-to-microphone distance so if you collect data later, you can be sure you keep those the same

Making a Sound Recording

- Can use Praat and TF32 to record directly using the computer sound card
  - Just plug the microphone into the microphone input
  - Can control the sound card input loudness from the audio properties
  - Note these settings so you can keep them the same if you record the same patient again
  - Can also record into a digital recorder

http://www.proaudiosuperstore.com/Manzeno-PM670.html
Types of Speech Samples

- Sustained vowels
- Words containing specific consonants
- Reading
- Extemporaneous Speech
- A controlled, but generated, speech sample – like a map directions task

Software for Acoustic Analysis

- Praat (Boersma and Weenink)
  - http://www.fon.hum.uva.nl/praat/
- TF32 (Milenkovic)
  - http://userpages.chorus.net/cspeech/

Both are free downloads from the internet
Both are relatively user-friendly and allow the user to make a large number of acoustic measurements

Opening a Sound File in Praat

- Read – Read from file
- Navigate to “wav” file
- Click “open”

Practical Advice for Objective Measurements

- Select a technique appropriate to your patient population
- Invest time in learning the technique
- Then, use the technique on a regular basis
- Be consistent for: mouth-to-mic distance, speech samples and speech task
- After the first several uses, your time investment goes down, and you now have an easy way to add objective data to your assessment and treatment
ASSESSMENT OF RESPIRATION

Perceptual Assessment of Respiration
- Can use perceptual evaluation at the beginning to determine if a more in-depth assessment is warranted
- Listen to:
  - Loudness
  - Breath patterns
  - Phrasing
- Once you determine a more in-depth examination of respiratory support is required, you should use an instrumental evaluation

Perceptual Assessment of Loudness
- If loudness is appropriate, then respiratory support is likely to be ok
- Reduced loudness may or may not indicate a respiratory problem, but does indicate you should examine respiratory support further
- Monitor for fatigue, complaints of fatigue

Perceptual Assessment of Loudness
- Listen for the following:
  - Overall loudness
  - Consistency of loudness
  - Sudden changes in loudness
  - Reduction in loudness across utterance
  - Ability to increase and decrease loudness
  - Stress patterns
- To objectively assess loudness, you can measure sound pressure level
Clinical Assessment and Treatment of Respiration

Measuring Sound Pressure Level

- You can make notes of the sound pressure level every few seconds while the patient talks and take an average
- Be sure to get samples from multiple locations within the speech sample
- You can also measure vocal intensity from Praat or TF32
- To get sound pressure level, you will need to calibrate your system

Measuring Vocal Intensity in Praat

- You can make notes of the sound pressure level every few seconds while the patient talks and take an average
- Be sure to get samples from multiple locations within the speech sample
- You can also measure vocal intensity from Praat or TF32
- To get sound pressure level, you will need to calibrate your system

Measuring Sound Pressure Level in Praat

Will need to calibrate for sound pressure level using a calibration tone

Calibration in Praat

Collect your calibration tone using the same equipment and method and same gain as you will when collecting your speech sample
Clinical Assessment and Treatment of Respiration

Sound Pressure Level Norms

- Huber (2007, JSLHR) – Figure 1 shows average sound pressure level (SPL) for young adults in reading and extemporaneous speech, (comfortable and loud) used a 6 inch mouth-to-microphone distance
- Huber (2008, JSLHR) – Figure 2 shows average SPL for young and older adults in extemporaneous speech (comfortable and loud), used a 6 inch mouth-microphone distance
- Sadagopan & Huber (2007, Movement Disorders) – Figure 1 shows average SPL for older adults and individuals with Parkinson’s disease in reading (comfortable and loud), used a 6 inch mouth-to-microphone distance
- Huber, Stathopoulos, et al (1999, JASA) – Appendix 1A shows average SPL for children aged 4-18 years and young adults during a vowel (soft, comfortable, and loud), used a 6 cm mouth-to-microphone distance

Estimation of Subglottal Pressure

- To objectively assess a patient’s ability to generate pressure for speech, you can estimate subglottal pressure
- Subglottal pressure ($P_s$) is the pressure generated below the vocal folds during voicing
- Is related directly with loudness
- Normal $P_s = 4-8 \text{ cmH}_{2}\text{O at comfortable loudness}$
- Increase in $P_s$ with increased loudness

Estimation of Subglottal Pressure

- In research labs, usually estimate from oral pressure during production of a train of [pV] syllables.
  - Pressure in the oral cavity equals with the subglottal space since the vocal folds are open and the lips are closed during the [p].
  - Use pressure tube and low frequency pressure transducer
  - Have individual produce syllable train – “papapapapa” at a slower rate (1.5 syllables/sec) or a word like “papa”
  - Measure peak oral pressure during “p” and pharyngeal pressure during “a”
  - $\frac{(P_{o1} + P_{o2})}{2} - P_{ph}$

Estimate of Subglottal Pressure

- For norms see:
  - Stathopoulos & Sapienza (1997) – Appendix 1A lists mean subglottal pressure for children aged 4-14 and young adults during a syllable repetition task (soft, comfortable, and loud)
  - Baker et al. (2001) – Tables 2 & 3 list mean subglottal pressure for young and older adults during a syllable repetition task (soft, comfortable, and loud)
- If estimate of $P_s$ is low, check the following:
  - Good velopharyngeal closure (use nose clip if closure is poor)
  - Good lip closure
  - Low estimated $P_s$ may indicate a respiratory and/or a laryngeal problem

Phonatory Aerodynamic System (PAS) from KayPENTAX will also provide an estimate of subglottal pressure at http://www.kayelemetrics.com/Product%20Info/6600/6600.htm
Assessment of P_v
- Do not use maximum vowel phonation
- Reflects phonatory and respiratory function
- Reflects max capacity, not function for speech
- Can have them sustain a vowel for 4-5 second repeatedly to make the task more speech-like

Assessment of Breath Patterns
- Watch for:
  - Typical quick inspiration and long slow expiration
  - Initiation and termination of speech at an appropriate LV
  - Presence of preparatory inhalations
  - Abnormal timing of inspirations and expirations
  - A lag between inspiration and onset of phonation
  - A lack of pauses without inspiration (for emphasis)
  - Sudden inspirations or expirations
  - Exaggerated respiratory movements
  - Running out of air

Assessment of Respiratory Movement
- In research labs, Respitrace equipment is used to assess this
- In clinic, you can watch or use your hands
- For normative values, see:
  - Huber (2007) – Figure 3 shows lung volume initiation and termination for young adults producing a reading and extemporaneous speech task at comfortable and loud speech intensities
  - Huber (2008) – Figure 4 shows lung volume initiation and termination for young and older adults producing an extemporaneous speech task at comfortable and loud speech intensities

Assessment of Respiratory Movement
- Without equipment, look for the following:
  - Excessive movement of the shoulders or chest wall
  - Is speech produced at LV higher than EEL for the most part?
  - Initiation at very high or very low LV
  - Terminations at very low LV
  - Use of consistent LV
  - Do they breathe in before speaking?
  - Paradoxical movements
  - A lag time or exhalation between the end of inspiration and the onset of phonation
Assessment of Utterance Length

- Breath group: all of the words said on one breath
- Can have a patient read a paragraph and watch for breaths
  - Count the number of syllables/breath group
  - Can record the patient reading the paragraph into acoustic software
  - Measure the duration (seconds) of the breath group

Measuring Utterance Duration in Praat

Norms for Utterance Length

- Huber (2008) – Figure 3 shows the number of syllables and speech rate for four different utterance length groupings during extemporaneous speech (comfortable and loud) in young and older adults
- Hoit & Hixon (1987) – Tables 7 and 10 list number of syllables per breath group for reading and extemporaneous speech in young, middle-aged, and older men
- Hoit et al. (1989) – Tables 6 and 9 list number of syllables per breath group for reading and extemporaneous speech in young, middle-aged, and older women

Breath Pauses are Important to Consider

- Young adults generally take breaths at major syntactic locations
- Hammen and Yorkston (1994) found individuals with dysarthria (various types and causes) took a significant number of breath pauses at syntactically unimportant locations

- Why are they important?
  - Listeners use breath pauses to parse running speech into syntactic units
  - Taking breath pauses at unimportant syntactic locations makes speech less comprehensible
  - Can be particularly important when coupled with a degraded speech signal, as in Parkinson's disease

Grosjean & Collins, 1979; Hammen & Yorkston, 1994; Shah et al., 2006; Winkelworth et al., 1994, 1995
Example Sentences

- "Devoted to his family, especially his children, Papa worked night and day to provide for us. Although we never showed Papa our appreciation on a daily basis, I know that he felt our love, or so I hope."
Clinical Assessment and Treatment of Respiration

Speech Breath Pausing is Affected by PD

Norms for Breath Pausing

Assessment of Respiratory Muscle Function

Objective Assessment of Respiratory Muscle Function

• Can assess functionally during speech:
  • Individuals with paralyzed expiratory muscles will be unable to breathe below end expiratory level (the rest position of the lung-thorax unit)
  • May have reduced breath group lengths and/or take breaths in linguistically inappropriate locations as a result
  • Likely to have inconsistent vocal intensity – reduced as the utterance continues

• Can assess during non-speech using scales:
  • Hixon & Hoit (1998, 1999, 2000, and 2006) have published scales for assessing the function of the respiratory muscles (diaphragm, rib cage, and abdomen) using speech and nonspeech tasks
  • Observe the movement of the RC and AB to determine functioning of the muscles
  • Each paper describes the tasks, the indications of abnormal function for each task, and include a record form for doing the assessment

• Can use a meter to measure maximum inspiratory or expiratory pressure
• Can you a flow meter to measure maximum expiratory flow
• Use noseclips
• Need to obtain disposable filters for either for infection control
Clinical Assessment and Treatment of Respiration

Measuring Maximum Expiratory Pressure
- Place nose clips on patient
- Instruct patient to breathe in as much air as possible
- Instruct patient to hold his/her breath
- Place the device in the patient’s mouth, getting a tight lip seal
- Instruct the patient to blow air out hard and fast
- Hold patient’s cheeks to keep them from puffing out

Types of Respiratory Difficulties
- Primary respiratory impairment due to the neurological insult
  - Address the respiratory function directly
- Compensatory strategy for problems with another speech subsystem
  - Work on the subsystem which is impaired
- Maladaptive behaviors which have developed
  - Address the maladaptive behavior

Weak Respiratory Muscles
- Symptoms:
  - May have difficulty generating subglottal pressure ($P_s$) for speech
  - May be unable to produce phonation
  - Minimum $P_s > 3$ cmH$_2$O required for speech
  - May have weak, soft voices
  - May be unable to increase their loudness – sound pressure level (SPL)
  - SPL may decline as the utterance continues
  - Short breath group length
  - Breathing at syntactically unimportant locations
  - May complain of fatigue while speaking
- Common in individuals with spinal cord injury, flaccid and hypokinetic dysarthrias, and in children with spastic CP
Respiratory Coordination Problems

- May lead to mistiming of respiratory movements with initiation of phonation and air wastage
- Symptoms:
  - More time between the end of inspiration and the onset of phonation
  - Speaking on inhalation
  - Fewer preparatory inhalations
  - Shorter utterances
  - Breathing at syntactically unimportant locations
  - Variable loudness
- Can be seen in individuals with ataxic dysarthria, hypokinetic dysarthria (due to difficulties initiating speech), and in children with CP

Compensation for Inefficient Valving

- Inefficient valving (laryngeal, articulatory, velopharyngeal) leads to air wastage
- Symptoms:
  - May initiate speech at a higher lung volume or….
  - Reduce breath group length
  - Produce a weak, soft voice
  - Breathe at syntactically unimportant locations
  - Speak at very low lung volumes
  - Weak pressure consonants
- Commonly seen in flaccid or hypokinetic dysarthria, people with voice disorders, children with clefts or velopharyngeal incompetence

Maladaptive Behaviors

- No preparatory inhalation for speech:
  - Begin speech at whatever lung volume they are at in the rest breathing cycle
- Take small frequent inspirations during speech, rather than taking longer pauses and bigger inspirations:
  - Short breath groups
  - Speaking at lower and lower lung volumes
  - Breathing at syntactically unimportant locations
- Speaking at very low lung volumes, rather than taking a breath:
  - Fatiguing
  - Hoarse/sharsh voice or glottal fry at lower lung volumes
  - Potentially vocal abusive behavior
  - Reduced sound pressure level as the utterance continues into lower lung volumes

DISORDERS WHICH AFFECT RESPIRATION FOR SPEECH
Clinical Assessment and Treatment of Respiration

Spinal Cord Injury

- Speech Characteristics (Hoit et al., 1990):
  - Reduced loudness due to weak expiratory muscles and reduced expiratory force
  - Monoloudness due to weak expiratory muscles and reduced expiratory force
  - Short breath groups due to weak inspiratory and expiratory muscles
  - Begin to speak at a lower LV due to weak inspiratory muscles
  - Can not extend speech utterance below end expiratory level due to weak expiratory muscles
  - Slow inspirations due to weak inspiratory muscles and/or due to weak abdominal muscles (so diaphragm not tuned to rest length)
  - Imprecise consonants due to weak driving pressure which reduces pressure for speech across entire system

Parkinson’s disease: Lower lung volume initiations and terminations

Spastic Cerebral Palsy

- Reduced expiratory reserve volume, leading to reduced vital capacity
  - Reduced vital capacity may not directly impact speech
  - More air volume used per syllable, potentially due to poor laryngeal valving
  - Reduced vital capacity with poor laryngeal valving = speech problems
  - Less flexible respiratory patterns than typically-developing children
  - Difficulty breathing below end expiratory level, due to involvement of abdominal muscles
  - In severe cases, rib cage muscles may also be involved
  - Involvement of respiration increases with age due increased postural problems
  - May increase speech difficulties with age

Athetoid Cerebral Palsy

- Delay in the development of childhood breathing patterns
  - "belly breathe" for longer
  - May be due to lack of postural stability, extension of vertebral column, and delayed head balance and sitting position
  - Paradoxical breathing patterns – rib cage paradoxing (moves in when inhaling rather than out)
  - Due to lack of rib cage muscle and neck muscle strength, the rib cage caves inward when diaphragm contracts
  - Reduced vital capacity
  - Children with athetoid CP have poorer respiratory control than children with spastic CP, but children with spastic CP get worse with age

For more information, see Solomon & Charron (1998)
Down's Syndrome

- Have reduced muscle tone, including in the respiratory muscles
- Contributes to reduced vocal intensity
- Have been shown to respond well to expiratory muscle strength training

For more information, see Cerny, Panzanella, & Stathopoulos (1997)

Subglottal Pressure Generation

- If the respiratory muscles are too weak to produce adequate subglottal pressure, you can use non-speech, blowing activities until speech is possible
- However, these are unlikely to improve a person's ability to generate subglottal pressure during speech once the muscles are strong enough to produce adequate pressure
- Most patients are not this weak
- Can use inspiratory and expiratory muscle trainers
  - These are effective even in patients who have weak muscles but can generate adequate subglottal pressure
  - Can reduce fatigue with speaking

Inspiratory and Expiratory Muscle Trainers

- Individual breathes into a tube with nose clips on or into a mask
- On the end of the tube or mask is a resistance
- Resistance makes it difficult to breathe in or out
- Expiratory: EMST 150 from Aspire Products
- Inspiratory: PowerBreathe (can buy on Amazon)
Clinical Assessment and Treatment of Respiration

Inspiratory and Expiratory Muscle Trainers

- Can increase the amount of resistance as the individual becomes stronger
- Can help with breath support for anyone with weak respiratory muscles
- Also may help for professional voice users who need additional respiratory support
- Do not use with patients who get fatigued easily (ALS, Myasthenia Gravis) or with those who problems do not involve muscle weakness
- Generally need an MD script for use
- Must follow basic muscle training guidelines

Basic Muscle Training Guidelines

- Specificity of training:
  - Train with the task you are trying to improve
  - Muscle trainers do this to a point (especially in expiratory muscle training)
  - You are training with a downstream resistance and speech is breathing with a downstream resistance (larynx and articulators)
  - But do not use the trainers instead of speech therapy, only in conjunction – continue to work on speech
  - Must overload the muscle
    - Low resistance, high repetition
    - High resistance, low repetition
  - Must repeat the movements
    - But do not go to the point of exhaustion

Basic Muscle Training Guidelines

- Frequency:
  - Must train regularly – 5-6 days per week
  - Generally only use with individuals who can continue to train on their own, outside of therapy
  - During therapy, you check progress
  - Takes less to maintain strength than build
    - Once strength is increased, do not need to continue with strengthening exercises as often
    - Can just do exercises a few times per week

EMST Program (Sapienza and colleagues)

- 5 sets of 5 breaths completed 5 days per week
- Do the training in the seated position at the same time of day
- Set muscle trainer to 75% of the patients maximum expiratory pressure (MEP)
  - Obtain by asking patient to breathe to top of VC and then blow hard and fast into pressure meter
  - Wear nose clips with trainer
  - Can follow a similar protocol with inspiratory training
  - Sapienza recommends training for 4 weeks, but that is likely not long enough for people with motor disorders
Other Methods for Changing Subglottal Pressure

- Can use sound pressure level as gross feedback about subglottal pressure
  - Work up a hierarchy:
    - Sustained phonation
    - Syllables
    - Words
    - Utterances, increasing in length
- Biofeedback and hierarchies work whether you are trying to increase or decrease subglottal pressure

Posture

- If inspiratory muscles are ok, but expiratory muscles are weak, the patient may respond to postural adjustments
  - To assess gravity’s effect, have the individual speak while lying down
    - Gravity assists with expiration, but works against inspiration
    - However, individual may want to sit up to speak, so must address communicative needs (see next slide on binders)
- Spastic dysarthria: work with OT and PT to position the person so hypertonicity does not interfere with speech
- Hypokinetic dysarthria: encourage to sit up straight so rib cage expansion is less limited

Prostheses for Respiratory Support

- Paddles: board which individual can lean into when speaking
  - Clients who need it usually do not have the truncal stability and movement control to use them
- Binder: used with individuals with abdominal muscle weakness or paralysis
  - Elastic corset-like band, placed around the abdomen, below the last rib
  - Make sure it does not encompass the rib cage
  - Individual will not wear the binder to sleep or eat
  - Should get a MD script to use a binder with a patient

Prostheses – Binder

- Supports the abdominal wall – performing some of the functions of the abdominal muscles during speech
  - Diaphragmatic tuning
  - Supports RC movement Do not use if individual has inspiratory weakness
- A good quick test for whether a binder will work is if the individual’s speech improves laying down
  - Will make it harder for the diaphragm to contract since the abdominal contents can not be displaced outward as easily

For more information, see Watson & Hixon (2001)
Individuals On Ventilators

- People on ventilators speak on inhalation and can not control the timing of their speech breaths
  - Can make adjustments to their ventilators, but need MD script and to work with the Respiratory Therapists

- Passy-Muir valves:
  - One way speaking valve – allows air into tracheostomy tube, but redirects expired air through larynx
  - Can be used with individuals who have tracheostomy tubes or who are on ventilators

For more information, see Hoit & Banzett (1997) and Hoit et al. (2003)

Respiratory Pattern

- Can use a pictorial representation to improve respiratory-laryngeal timing
  - For example, with kids, show a bike going up a hill and then down
  - Want them to begin to speak near (not at) the top of the hill

- Can mark reading passages with breath pausing to teach them how to break a passage up naturally and how to gauge a preparatory inhalation
  - Then progress to them marking the passage, to producing short passages without marks, to answering short questions, first by preparing the answer and determining where to breathe then spontaneously

Respiratory Pattern

- Once they are doing better:
  - Teach them to pause for emphasis
  - Work on speech naturalness
  - Work on phrasing at syntactically appropriate locations

SpeechVive

- Designed for people with Parkinson’s disease
- Uses the Lombard effect to automatically improve speech
- After 8 weeks of wearing the device,
  - Increased SPL
  - More efficient (normal) respiratory patterns
  - Improved vocal fold closure

Huber, Stathopoulos, and Sussman (2014)
Compensations
- Increased respiratory drive due to inefficient valving (laryngeal, articulatory, velopharyngeal):
  - Leads to air wastage
  - Reduced breath group length
  - Weak, soft voice
  - Initiate speech at a higher lung volume (LV)
  - Need to address laryngeal system
- Increased respiratory drive due to increased laryngeal airway resistance:
  - Patient wants to generate a higher P_s to overcome the increased laryngeal airway resistance
  - Need to address laryngeal system

Maladaptive Behaviors
- No preparatory inhalation for speech:
  - Begin speech at whatever LV they are at in the rest breathing cycle
- Speaking well into expiratory reserve volume, rather than taking a breath:
  - Fatiguing
  - Hoarse/harsh voice or glottal fry at lower LV
  - Reduced SPL as the utterance continues into lower LV
- For all maladaptive behaviors, respiratory pattern treatments can help

Adaptability
- Make sure to work on how speaker adapts to different speech tasks:
  - Short vs. long utterances
  - Stressed vs. unstressed words
  - Conversational speech vs. reading
  - Speaking to one listener vs. a group
  - Speaking in quiet vs. in noise

QUESTIONS
Case 1: Presentation

- 39 years old referred for a speech production evaluation
- Diagnosed with a demyelinating disease of unspecified type when she was 10 years old
- Perceptual evaluation:
  - Severely breathy voice
  - Low vocal loudness
  - Short utterances (2-3 syllables)
  - Weak, imprecise articulation
- Had limb symptoms of both flaccid and spastic type

Case 1: Respiratory Assessment

- Spirometry: very reduced vital capacity
- Respiratory Patterns:
  - Rib cage moved more than abdomen
  - Was able to inspire to some extent, but speech initiations were low
  - Indicated somewhat weak inspiratory muscles
  - Could not expire much below end expiratory level
  - Terminated speech at or just slightly below end expiratory level
  - Indicated that expiratory muscles were very weak
  - Chest wall followed recoil configuration during speech expiration
  - Indicated she was not using active muscles forces during expiration but instead using recoil pressure to provide driving pressure for speech

Case 1: Recommendations

- Further testing to see if a binder was an option for her, but weak inspiratory muscles were a contraindication
- Followed-up at her facility:
  - Her vocal loudness and intelligibility was significantly improved in supine position
  - Supine position did not seem to affect inspiration significantly
  - Went on to recommend a truss for her
- Use of an expiratory muscle trainer to improve expiratory muscle strength
Case 2: Presentation

- 64 year old referred for a speech production evaluation
- History of schizophrenia, pharmacological treatment for 24 years
- Began to have difficulty speaking about 9 months prior to evaluation
- Diagnosed with tardive dyskinesia by physician
- Drugs were changed about 3 weeks post-onset of speech difficulties
- Previous speech eval found:
  - Reduced lip muscle tone, tongue fasciculations, reduced lingual control, and tongue and jaw spasms
  - Poor respiratory support was indicated so referred to our laboratory for evaluation

Case 2: Perceptual Evaluation

- Moderately hoarse voice
- Breathy voice at times
- Voice breaks and voice stoppages
- Audible inspirations prior to speech
- Intermittent mild hypernasality
- Imprecise articulation with mild to moderately reduced intelligibility

Case 2: Respiratory Assessment

- Spirometry: low vital capacity
- Respiratory Patterns:
  - During rest breathing, rib cage and abdomen were often out of phase with one another
  - During speech breathing, rib cage and abdominal paradoxing
  - Involuntary, hyperkinetic movements of the rib cage and abdomen
    - High frequency tremor present in abdominal wall
  - Diagnosed with hyperkinetic dysarthria, as a result of tardive dyskinesia, also present in respiratory system

Case 2: Recommendations

- Speech therapy to work on compensatory strategies
- Work to facilitate continued communication when the involuntary movements occur
- Can not stop the involuntary, hyperkinetic movements
- Referred to ENT for exam due to voice quality issues and audible inspirations
### Case 3: Presentation
- 21 year old referred for speech production evaluation, specifically to determine if a speech amplification device would be effective
  - Speech amplification device: amplifies the individual’s voice
  - Some companies manufacturing these devices claim it improves intelligibility, but that really depends on the underlying cause of the intelligibility issues and how severe the articulatory difficulties are
  - Etiology: TBI causing spastic quadriplegia and left vocal fold paralysis

### Case 3: Perceptual Evaluation
- Severely dysarthric
- Very gravely voice quality
- Slightly low SPL, but could increase loudness
- Mild-moderate hyponasality
- Poor oral motor control, reduced ROM of tongue and lips, little palatal movement

### Case 3: Respiratory Assessment
- Spirometry: reduced vital capacity
- Respiratory patterns:
  - Most of the lung volume change accomplished with abdominal movement, rather than rib cage
  - Incoordination between rib cage and abdomen
  - Speaking was very effortful
  - Reduced utterance length (4-5 syllables)

### Case 3: Recommendations
- Discussed results with his PT
  - Reduced rib cage movement due to spasticity of rib cage muscles and respiratory system
  - More abdominal function because abdominal muscles were very strong and main source of postural control
- Did not recommend the speech amplifier due to
  - His loudness was adequate for conversation in a quiet room and he could increase loudness
  - Reduced intelligibility mainly due to articulatory disruption
  - AAC device to assist with unfamiliar listeners
REFERENCES


