The Newcastle upon Tyne Hospitals NHS
NHS Foundation Trust

Cervical auscultation, pulse oximetry and FEES: what do we think we are evaluating?

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Choosing instrumental evaluations: 4 questions to ask ourselves

1. What is it evaluating?
2. What's the evidence for its use?
3. Is it relevant to my practice – can it be used with my patients?

Greenhalgh 2010

4. Will the findings of this evaluation have a positive outcome for my patients?

Cervical auscultation: what is it evaluating?

- Listening to swallowing sounds with stethoscope (placed?)*Takahashi1994, Cichero 2002*
- Gain information about pharyngeal swallow

Listening for:

- Aspiration, penetration?
- Pharyngeal pooling?
- Delayed swallow?



How have swallowing sounds been studied? *Youmens 2005*

- As heard from a stethoscope → perceptual analysis (listened to) *Stroud 2002, Leslie 2004, Borr 2007*

- From a microphone or accelerometer → acoustic analysis (analysed by machine)

  Cichero 2002, *Lee 2006, Almeida 2008, Moriniére 2008, Reynolds 2009*



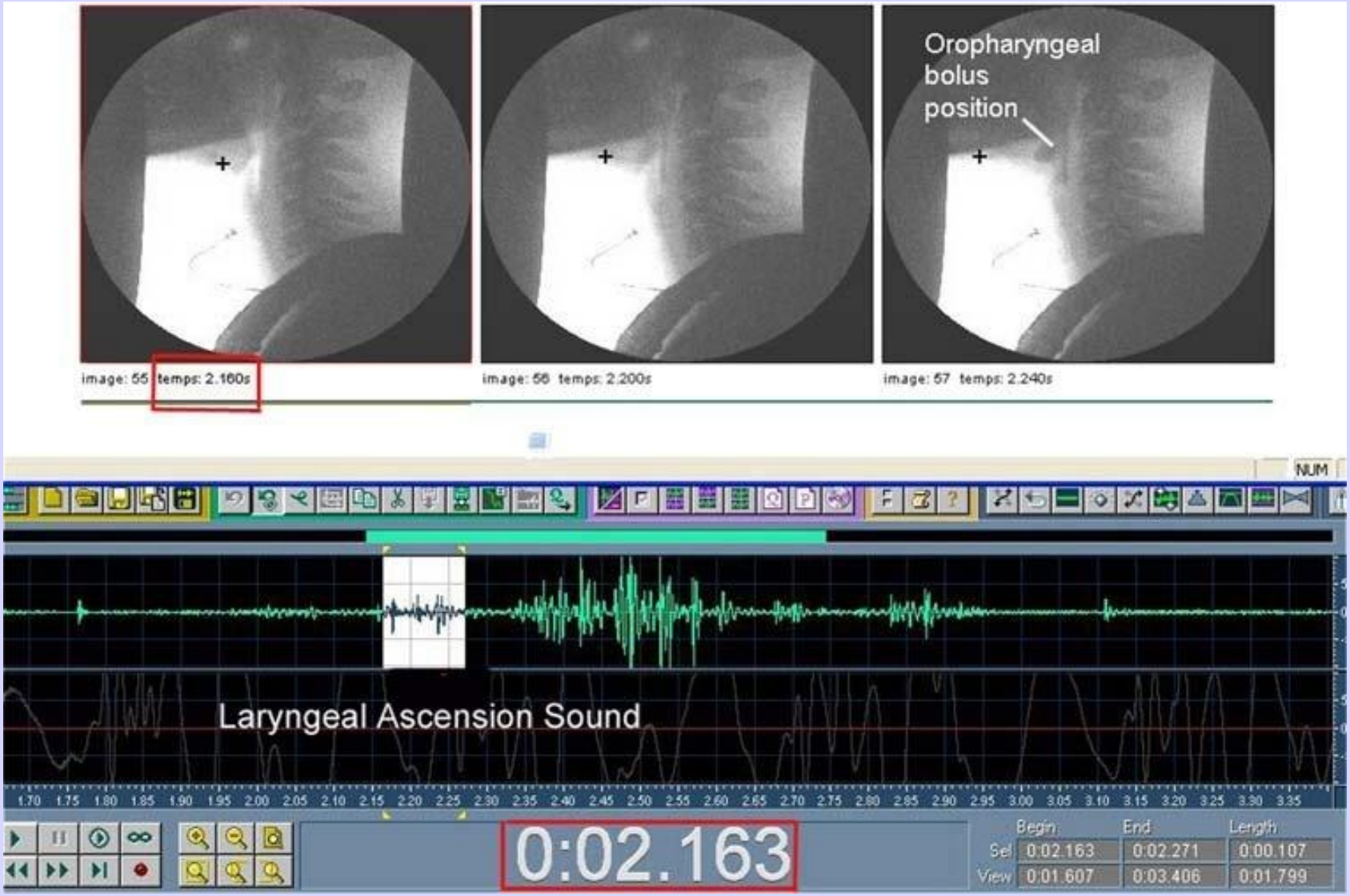
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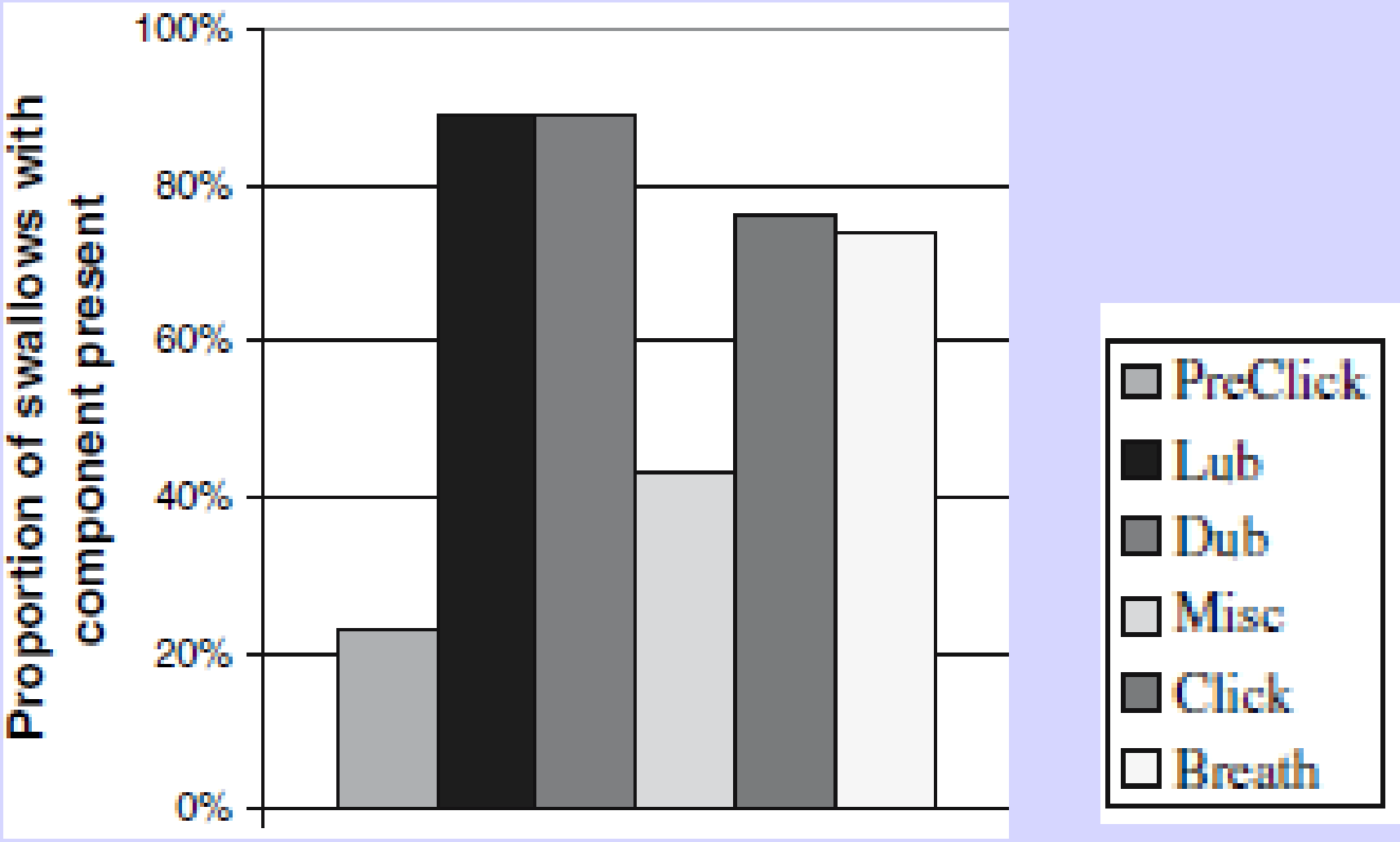
Acoustic analysis *Moriniére 2008*



Sounds in healthy adults ***Leslie 2007***

- Stethoscope with simultaneous FEES and airflow direction measurement
- 19 healthy adults
- 6 boluses of water and yoghurt each →171 boluses
- Raters blind to clinical information
- Perceptual analysis of the swallow sounds
- Sounds associated with swallow physiology?

Proportion of swallows where each sound component was identified *Leslie 2007*



Sounds in healthy adults *Leslie 2007*

- Preclick: heard in 23% swallows
- Lub & dub: heard in 85% swallows
- Mid swallow: heard in 40% swallows
- Click: heard in 76% swallows
- Breath: heard in 74% swallows

+ not all sounds were consistently associated with a physiological event

Sounds in healthy children *Almeida 2008*

Microphone + acoustic analysis

- Discrete Initial Signal: heard in 83% children
- Discrete Final Signal: heard in 73% children
- DIS-Main Signal-DFS-Expiratory Return: heard in 60% children
- DIS, DFS or ER absent in 40%

→ Not all sounds heard consistently

How has cervical auscultation used to investigate swallowing?

- Describe healthy vs dysphagic swallows
- Differences between consistencies, bolus volumes, gender, ages *Cichero 2002*
- Adults vs infants *Reynolds 2009*
- Children: similarities between different consistencies *Almeida 2008*
- How physiological swallow events are associated with swallow sounds

What are dysphagic sounds

- Different timing to healthy swallows?
- Different sounds – that are not heard in healthy swallows?
- Absence of a sound heard in healthy swallows?
- Timings of swallow sounds in relation to respiration?

Stroud 2002 ***Clinical Rehabilitation***

- 16 adults, mean 52 years (29-62 yrs)
- Consecutively referrals for VF
- Simultaneous VF and CA
- 3/16 aspirated on VF
- 5 raters, blinded, rated independently
- Re-rated 2 weeks later
- Question: aspiration yes/no on ca

Results *Stroud 2002*

Interrater agreement:

- Overall: 0.28 kappa (fair)

Intrarater reliability:

- 0.31 to 0.85 kappa, mean 0.55 (fair to very good)

Results *Stroud 2002*

Raters have only fair agreement with each other, were they correct in their identification of aspiration?

- Sensitivity: 86%
- Specificity: 56%

Discussion *Stroud 2002*

- Adults
- Only 3 of 20 swallows were aspiration
- Raters from same centre
- Over identified aspiration
- Agreement between raters only ‘fair’
- Don’t know exactly what the SLTs were hearing as aspiration / no aspiration

Leslie 2004 *Dysphagia*

- 14 of 20 consecutive dysphagic stroke adults
- 10 adult controls
- Simultaneous VF and CA
- 10 aspiration/penetration swallows + 10 normal swallows
- 31 raters, blinded, rated independently
- Re-rated 4 weeks later
- Question: normal **or** abnormal, probably **or** definitely

Results *Leslie 2004*

1. Interrater reliability on normal swallows:
   0.02 kappa (poor)
2. Interater reliability on abnormal swallows:
   0.18 kappa (poor)

3. Intrarater reliability: 0.12 to 0.71 kappa, mean 0.35 (poor to good)

Can CA detect aspiration? *Leslie 2004*

- Sensitivity: 62%
- Specificity: 66%

- By **majority consensus:**
- Sensitivity: 90%
- Specificity: 80%

17/20 swallows were correctly identified as normal or abnormal – does this mean that training is in theory possible?

Borr 2007 *Dysphagia*

- 14 adults with aspiration/penetration on VF, mean 71 years (44-89 years)
- VF a week after CA
- Plus 25 young and 25 older non-dysphagic adults
- Raters blinded, rated independently
- Question: aspiration/penetration **or** dysphagia **or** young healthy **or** older healthy

Results *Borr 2007*

‘Expert raters’

- Sensitivity: 94%
- Specificity: 70%

‘Lay people raters’

- Sensitivity: 85%
- Specificity: 80%

Discussion *Borr 2007*

- Not a study of aspiration detection in dysphagic patients
- CA and VF not simultaneous so was there actually aspiration or penetration on the swallows that they recorded?
- Lay people appear to have a concept of how a dysphagic swallow sounds

Does CA result in better outcomes?

- No evaluations of this reported in the literature

CA: conclusions

What we want to know as clinicians is can we use it to:

- Pick out those children who are aspirating and exclude those who aren't
- Identify those at risk of aspirating eg pharyngeal residue, delayed swallow
- Get the same 'results' whichever SLT does it

CA: conclusions

- On aspiration vs normal swallows – sensitivity and specificity is weak

CA: conclusions

- Literature describes different swallow sounds for dysphagic and healthy – but can we actually hear them or will this require acoustic analysis?
- What do we expect of cervical auscultation clinically?
- Does the individual's skill in detecting dysphagia depend on training or innate skills?

Can CA be used with my children?

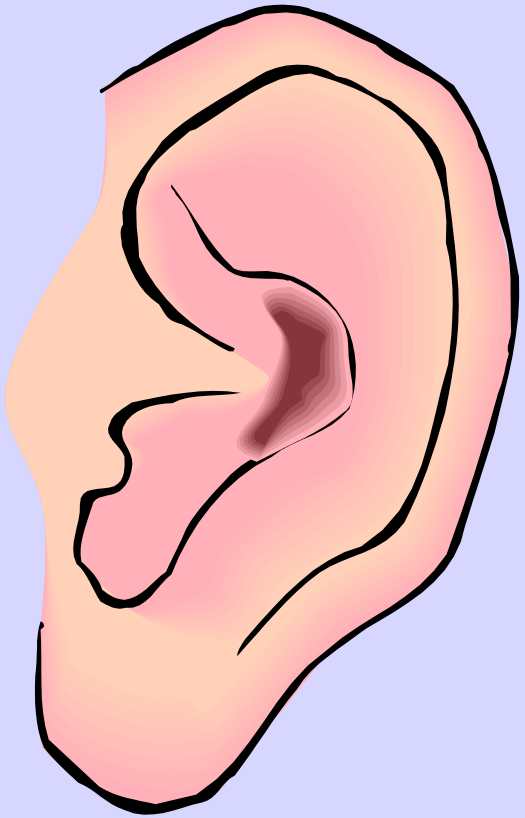
In addition to the evidence for reliability and validity:

- Artifacts as child moves
- Access to neck in babies
- Tolerance of stethoscope

Can CA be used with my children?

Can it help me to:

- Count swallows?
- Time swallow in relation to bolus moving over back of tongue?



- What do we hear just with our ears and how does it influence our evaluation?

Pulse oximetry: what is it evaluating?

Oxygen saturation levels (SpO_2) measured during feeding using a pulse oximeter



What might pulse oximetry be detecting?

- Aspiration → occlusion of airway or reflex bronchospasm?
- Extended deglutition apnoea?
- Impaired coordination of respiration during swallowing?

SpO^2 levels

- SpO_2 in range of 96-99% in healthy adults
- Fluctuations in healthy adults at rest 1-3% *Wang 2005*
- Pulse oximeters have error level of ≤ 2%

- Fluctations in many activities in dysphagics *Leder 2000*
- In many children on our caseloads their usual SpO_2 range can be low

Colodny 2000 *Dysphagia*

- 104 adults,(64-102 yrs)
- All referred for feeding evaluation
- 77 healthy controls
- Simultaneous FEES for dysphagic adults
- Raters blinded
- Question: presence of SpO_2 desaturation event when aspiration seen on FEES

Results *Colodny 2000*

1. **In the 69% dysphagic adults who aspirated:** no dramatic changes in SpO_2 during **or** after swallow **or** during aspiration
2. **Aspirators:** SpO_2 lower before, during and after feeds than healthy adults
3. **Solid aspirators:** SpO_2 lower before, during and after feeds than liquid aspirators
4. **Penetrators:** SpO_2 levels between healthy and solid aspirators

Discussion *Colodny 2000*

- Desaturation more a function of dysphagia than it is of aspiration
- Pulmonary function is compromised in dysphagic adults?
- Hypoxia due to lack of coordination between swallowing and breathing rather than aspiration events?
- Lower SpO_2 during other activities as well?

Morgan 2008 ***Dev Neurorehab***

- 9 children, mean 14 yrs (10-16)
- Recruited from a special school
- 9 healthy controls, mean 14 yrs (10-16)
- Clinical evaluation **then** pulse oximetry
- No blinding details
- Question: Difference between groups in SpO_2 levels and number of desaturation events?

Results *Morgan 2008*

1. Before feeding: no difference between groups
2. During feeding pulse oximetry had:

   Sensitivity: 88.9%

   Specificity: 88.9%
3. Post feeding: no difference between groups
4. Desaturation events: seen in 3/9 dysphagic children (≥ 4% for ≥ 5 secs)

Discussion *Morgan 2008*

- Small numbers
- No children with neurodisability without dysphagia
- Puree only
- Desaturation events in only 3/9
- Unable to relate SpO_2 levels to aspiration events as no VF or FEES

Discussion *Morgan 2008*

- Difference between pre and during feeding SpO_2 in dysphagic children only 1.3% (97.9% and 96.6%)
- ≥ 0.6% difference in SpO_2 between pre and during feeding discriminated between dysphagic and healthy children

Are these differences clinically significant?

Sasaki 2009

Wang 2005 ***Arch Phys Med Rehabil***

- 60 dysphagic adults (mean 61 yrs,19-89)
- All referred for VF
- 40 healthy controls (mean 41 yrs, 30-52)
- Baseline, swallowing, post swallow SpO_2
- Simultaneous pulse oximetry +/- VF
- Rater blinded to VF findings
- Question: SpO_2 differences between groups?

Results: before swallowing *Wang 2005*

Before swallowing:

- < 3% SpO_2 fluctuation in healthy group
- < 2% SpO_2 fluctuation in dysphagic group

Results: during swallowing *Wang 2005*

In healthy group:

- ≤ 2% SpO_2 fluctuation

In dysphagic group:

- 23/60 aspirated on VF
- 39% aspirators had SpO_2 fall of > 3%
- 41% non-aspirators had SpO_2 fall of > 3%

Can pulse oximetry detect aspiration?

Wang 2005

- Positive predictive value: 39.1%
- Negative predicted value: 59.4%

- Aspiration on VF cannot be predicted based on decrease in SpO^2 on pulse oximetry

Does pulse oximetry result in better outcomes?

- Has not evaluated in the literature
- If it can’t detect aspiration it is unlikely to demonstrate outcomes that are better than investigations that we currently use

Can pulse oximetry be used with my children?

- Already used routinely to evaluate SpO_2
- Is something that we take note of during feeding
- But in the absence of evidence that it can detect dysphagia we need to be very clear what it is that we are using it for
- Do they desaturate with other activities?
  Leder 2000

Pulse oximetry conclusions

Current evidence does not support its use:

- to determine presence or absence of dysphagia

or

- to determine presence or absence of penetration or aspiration

FEES: what is it evaluating?





What can be seen? *RCSLT 2005*

Part A: **Laryngopharyngeal structures - anatomy and physiology**

1. Velopharyngeal competency
2. Pharynx
3. Larynx and supraglottis
4. Laryngopharyngeal sensation
5. Secretion management

What can be seen? *RCSLT 2005*

Part B: Bolus presentation

1. Premature spillage
2. Pharyngeal residue
3. Penetration and aspiration
4. Timing, strength of swallow, fatigue, glottic closure, regurgitation

Part C: Therapeutic interventions

Part D: Biofeedback



www.nature.com/gimo

.wmv file

www.nature.com/gimo

.avi file



Rao 2003 *Journal Appl Research*

- 11 adults, mean 50 yrs (29-70)
- All referred for swallowing evaluation
- Simultaneous VF and FEES
- Raters did VF and FEES directly with adult
- Question: presence of aspiration, penetration and pharyngeal residue – yes/no

Results *Rao 2003*

Agreement between FEES and VF

Laryngeal penetration: 89.58%

Aspiration: 96.9%

Pharyngeal residue: 84.38%

FEES detected more events of penetration, aspiration and pharyngeal residue than VF

Discussion *Rao 2003*

- Small sample size
- Raters not blinded
- Interrater reliability evaluated using a second blinded rater: ≥ 90% agreement with original rater for each parameter

Kelly 2007 ***Laryngoscope***

- 15 adults, mean 53 yrs (22-73)
- All referred for swallowing evaluation
- Simultaneous VF and FEES
- 17 raters blind to clinical detail and to other investigation
- Question: score for each swallow on the Aspiration- Penetration Scale *(Rosenbek 1996)*

Results: reliability *Kelly 2007*

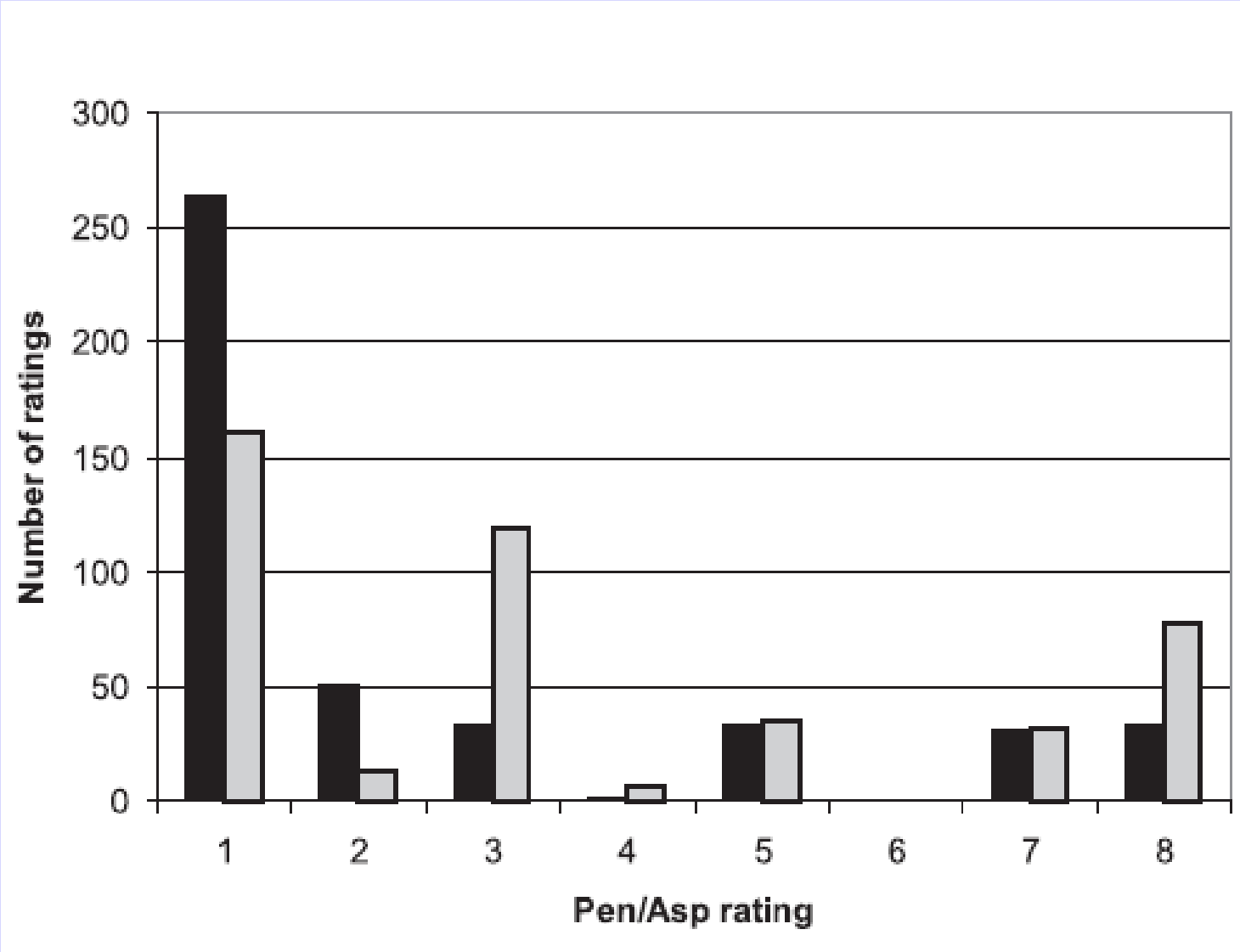
Interrater reliability (weighted KAPPA):

- VF: 0.67
- FEES: 0.64

Intrarater reliability (weighted KAPPA):

- VF: 0.79
- FEES: 0.73

Results: scores on Penetration-Aspiration Scale *Kelly 2007*



Results: agreement *Kelly 2007*

- Penetration Aspiration Scale scores higher when used FEES than VF

Discussion *Kelly 2007*

- Conclusion: raters judgement of severity of aspiration/penetration is higher when FEEs is used than VF
- Pharyngeal residue is detected in greater amounts on FEES compared with VF *Kelly 2006*

Can FEES be used with my children?



FEES + children: tolerated?

Hartnick 2000

- 643 FEES on 568 children ages 2 mths to 17yrs (median 2.5 yrs) over a 6 year period
- Local anaesthetic
- Parent/nurse ‘assist in stabilising the child’

Leder 2000

- As with VF not all tolerate it

FEES + children: tolerated?

Migliore 1999

- Children and adults with learning disabilities
- 10-30 minute exam (average 21 mins)
- Prepare the child
- No topical anaesthetic
- Head support for some

Willging 2001

- How to use FEES with children

Summary: the evidence



- **CA**: what can we hear? Evidence does not yet demonstrate that it discriminates ‘dysphagia’ or aspiration
- **Pulse oximetry**: unsupported by the literature
- **FEES:** identifies **some** aspects of the pharyngeal anatomy and swallowing physiology as well as VF (if not better for some features). But FEES + children?