Improving Patient Outcomes By Quantifying the Risk of Aspiration Pneumonia

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Objectives
- Identify 3 factors that increase the risk of pneumonia
- Calculate an individual patient's statistical probability of developing pneumonia
- State 2 clinical applications of calculating statistical probability of developing pneumonia that may help improve outcomes

Outline
I. Background/Rationale
II. Review of Evidence
III. Statistical Analysis
IV. Case Studies
   i. Apply the tool
   ii. Clinical Applicability
V. Questions/Feedback

Pilot Study /Systematic Review
Applicability of Bayesian Probability to Dysphagia Treatment Planning
1. Pub Med search of risk factors for pneumonia
2. Statistical Analysis of the data supplied to calculate likelihood ratios
3. Calculate Probability of developing pneumonia using Bayes Theorem

Systematic Review and Meta Analysis of Risk Factors for Developing Pneumonia
1. Systematic Review of multiple data bases and hand-searched references for relevant articles
2. Meta analysis for pooled LR’s wherever possible
3. Disseminate information to clinicians for improved clinical decision making

Background/Rationale
What are the outcomes associated with our most usual intervention?
Most usual intervention is modified PO Intake - Mertz 2005

Patient Preferences
Adherence to Modified Diets 51.3% -(Beck,2018)
75% of Patients Don’t Like Thickened Liquids -(MacQueen, 2003)

Nutritional Complications
- Modified Texture Diets and Liquids have a strong correlation with malnutrition and dehydration -(Beck,2018; Sato, 2018; Macqueen, 2003; Andersen, 2013; Cichero, 2018; Keller, 2012)
- Dehydration related to dislike
- Reduced intake due to early satiety related to increased volume of food
- Increased volume of food related to less nutrient density
- Changes in muscle mass related to nutrition or possibly disuse atrophy
- Impaired ability to absorb medicine

Nutritional Complications
- Systematic review comparing incidence of pneumonia in patients using thickened and thin liquids - No significant difference in the likelihood of pneumonia between those taking thin liquids with safety strategies and those taking only thickened liquids. -(Kaneoka, 2017)

Are all modified diets bad and should be outlawed?

Balance the Risks and the Benefits of Modified PO
- Risks
- Benefits
- Nutritional Complications
- Poor Adherence
Solution

We need a way to target our interventions to the patients that will benefit from them.

Figuring out which patient might benefit can feel like...

Risk Factors/Literature Review

Pathogenesis of Pneumonia

- Aspiration Pneumonia
- Community-acquired pneumonia
- Hospital-acquired pneumonia
- Nursing home-acquired pneumonia
- Aspiration pneumonia

Aspiration Pneumonia

Aspiration ≠ Pneumonia

Aspiration Pneumonia

Pneumonia

Aspiration
Pneumonia

**Frequency and volume of aspiration**

- Dysphagia (anterograde)
  - Aspiration of secretions, aspiration or pharyngeal residue VFSS. Need for suction for secretion management. (Langmore, 1998)
  - Reduced laryngeal sensation. (Kaneoke, 2018)
  - CVA. (Manabe, 2015; Langmore, 1998; Miyata, 2017)
  - Lethargy. (Langmore, 1998)
  - Dependent for feeding. (Langmore, 1998; Terpenning, 2001)
  - TF. (Langmore, 1998; Manabe, 2015)

**Volume and Frequency of Aspiration**

- GI (retrograde)
  - Conditions that may predispose the patient to retrograde macro-aspiration. (Lo, 2019; Langmore, 1998)

**Bacteriologic Contents of Aspirate**

- Anterograde
  - Oral Hygiene. (Terpenning, 2001; Langmore, 1998)
  - Diabetes. (Terpenning, 2001)

- Retrograde

**Susceptibility of the Host**

- Pulmonary Clearance
  - Chronic Pulmonary Disease. CHF, COPD, Asthma, and markers for impaired respiratory function. (smoking, supplemental oxygen, inhaled medication). (de Jager, 2012; Langmore, 1998; Lo, 2019; Manabe, 2015; Terpenning, 2003)
  - Reduced Mobility and Functional Dependence. (Manabe, 2015; Langmore, 1998)

**Immune Resources**

- Nutritional Status/BMI. (Miyata, 2017)
- Medical Factors (comorbidities). (Lo, 2019; Terpenning, 2003; Manabe, 2015)
- Immune Resources; number of active infections. (Langmore, 1998; Miyata, 2016)
Statistical Analysis

- Raw data from a paper usually looks something like this...from Hibberd 2013

2X2 Contingency Tables

Likelihood Ratios

Positive Likelihood Ratio = Risk factor present
greater than 1 increases the probability from the pre test probability

Negative Likelihood Ratio = Risk factor absent
less than 1 decreases the probability from the pre test probability

Likelihood Ratios numbers less than 1

- McGee, 2002
Likelihood Ratios numbers larger than 1

<table>
<thead>
<tr>
<th>Likelihood Ratio</th>
<th>Change in Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>15%</td>
</tr>
<tr>
<td>3</td>
<td>20%</td>
</tr>
<tr>
<td>4</td>
<td>25%</td>
</tr>
<tr>
<td>5</td>
<td>30%</td>
</tr>
<tr>
<td>6</td>
<td>35%</td>
</tr>
<tr>
<td>7</td>
<td>40%</td>
</tr>
<tr>
<td>8</td>
<td>45%</td>
</tr>
<tr>
<td>9</td>
<td>50%</td>
</tr>
<tr>
<td>10</td>
<td>60%</td>
</tr>
</tbody>
</table>

McGee, 2002

Bayes Theorem

Pre test odds x LR of variable 1
x LR of variable 2 ... x LR of variable N = post test probability (de Dombal, 1985).

Pre test Probability

This is the prevalence of the disease.
Before you know anything about the patient, how likely is it that they will develop pneumonia?

How many patients in this environment have or will get pneumonia?
- Acute care 15%
- 65 and older community dwelling 3%
- 85 and older community dwelling 5%
- Nursing Home patients 30%

Odds and Probability

From prevalence data -- needs to be converted to odds
15% probability = .18 odds
Odds = Probability/(1-probability)
.15/.15 = .18

Convert the final calculation back to Probability
.18 odds = 15% probability
Probability = Odds/(Odds + 1)
.18/1.18 = .15

Application and Case Studies

Case Study 1 -- PH

HPI: 79 y/o male adm to hospital from community with SOB, leg swelling, exacerbation of CHF. Failed 3 oz water swallow on admission, referred to SLP for swallowing evaluation per protocol

PMH: GERD, DM, HTN, CHF. Community ambulator, no assistive device, independent in ADLS and iADLS. Not considered a fall risk, allowed to ambulate in room, go to the bathroom ad lib. On fluid restrictions, BMI 39

Meds: Metoprolol, Nexium, Eliquis, simvastatin

Clinical Features: On 2L/min NC, O2s to chair, alert and oriented, has natural teeth in good condition.

MBSS: Aspirating on thin liquids, due to increased LV/Clr, no significant residue on liquids or solids, delayed esophageal emptying.
### List of Likelihood Ratios and Risk Factors

#### Key:
- **Green** are **Modifiable Risk Factors** related to Dysphagia
- **Yellow** are **Modifiable Risk Factors** related to Care Team or Patient
- **Blue** are **Non-modifiable Risk Factors**

#### Electronic Calculation

- **Google Forms**
- **Google Sheets**

Access the form and spreadsheet here:

- **Form**
  - https://forms.gle/i3NqMn9qJFe628meA
- **Spreadsheet**
  - https://docs.google.com/spreadsheets/d/1OehyPDJn-_2V5fZlyvl1oP2VYBNtBVKqNHTH7ipMVw/edit?usp=sharing

### Risk Factor Reference Value Likelihood Ratio

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Reference Value</th>
<th>Likelihood Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVA</td>
<td>Absent</td>
<td>.72</td>
</tr>
<tr>
<td>MI</td>
<td>Absent</td>
<td>.96</td>
</tr>
<tr>
<td>DM</td>
<td>Present</td>
<td>1.52</td>
</tr>
<tr>
<td>Dementia</td>
<td>Absent</td>
<td>.96</td>
</tr>
<tr>
<td>Asthma</td>
<td>Absent</td>
<td>.90</td>
</tr>
<tr>
<td>COPD</td>
<td>Absent</td>
<td>.79</td>
</tr>
<tr>
<td>CHF</td>
<td>Present</td>
<td>1.8</td>
</tr>
<tr>
<td>GI</td>
<td>Present</td>
<td>1.8</td>
</tr>
<tr>
<td>More than 1 of the previous 3 factors</td>
<td>Present</td>
<td>1.44</td>
</tr>
</tbody>
</table>

**Current Status (Pretest odds):** 0.18 x (LRRs for the risk factors): 0.72 x 0.96 x 1.52 x 0.96 x 0.79 x 1.8 x 1.8 x 1.44 = 41%
### Risk Factors Reference Value Likelihood Ratio

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<tr>
<th>Risk Factor</th>
<th>Reference Value</th>
<th>Likelihood Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent for Oral Care</td>
<td>Absent</td>
<td>.73</td>
</tr>
<tr>
<td>Up Less than ½ the Day</td>
<td>Present</td>
<td>1.73</td>
</tr>
<tr>
<td>Urinary Catheter</td>
<td>Absent</td>
<td>.9</td>
</tr>
<tr>
<td>Active Smoker</td>
<td>Absent</td>
<td>.88</td>
</tr>
<tr>
<td>BMI &gt;20</td>
<td>Present</td>
<td>2</td>
</tr>
<tr>
<td>Supplemental Oxygen</td>
<td>Present</td>
<td>7.88</td>
</tr>
<tr>
<td>Dentate</td>
<td>Present</td>
<td>7</td>
</tr>
<tr>
<td>Reduced Oral Hygiene</td>
<td>Absent</td>
<td>9</td>
</tr>
<tr>
<td>Hemiplegia</td>
<td>Absent</td>
<td>.69</td>
</tr>
<tr>
<td>Lethargic</td>
<td>Absent</td>
<td>.9</td>
</tr>
</tbody>
</table>

### Risk Factors Reference Value Likelihood Ratio

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<thead>
<tr>
<th>Risk Factor</th>
<th>Reference Value</th>
<th>Likelihood Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need for Suction</td>
<td>Absent</td>
<td>.82</td>
</tr>
<tr>
<td>Absent LAR</td>
<td>Unknown</td>
<td>1</td>
</tr>
<tr>
<td>Aspiration on Liquids</td>
<td>Present</td>
<td>1.58</td>
</tr>
<tr>
<td>Aspiration on Secretions</td>
<td>Absent</td>
<td>.71</td>
</tr>
<tr>
<td>Residue on Liquids</td>
<td>Absent</td>
<td>.88</td>
</tr>
<tr>
<td>Residue on Puree</td>
<td>Absent</td>
<td>.94</td>
</tr>
<tr>
<td>TF</td>
<td>Absent</td>
<td>.82</td>
</tr>
</tbody>
</table>

Continue combining the Likelihood Ratios until all have been included. Current probability of pneumonia + 23%

### Clinical Decision Making

#### Aspiration

- **Supplemental Oxygen**: 7.86 [.96]
- **PPI Use**: 1.78 [.74]
- **Up Less than ½ Day**: 1.73 [.3]
- **Aspiration of Liquids**: 1.58 [.6]

Risk of Pneumonia: 23%

#### Mobility

- **Supplemental Oxygen**: 7.86 [.96]
- **PPI Use**: 1.78 [.74]
- **Up Less than ½ Day**: 1.73 [.3]
- **Up more than ½ Day**: 1.14
- **Aspiration of Liquids**: 1.58 [.6]

Risk of Pneumonia: 23%
Clinical Decision Making --Discharge

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplemental Oxygen</td>
<td>7.86 .96</td>
</tr>
<tr>
<td>PPI Use</td>
<td>1.78 .74</td>
</tr>
<tr>
<td>Up Less than ½ Day</td>
<td>1.73 .3</td>
</tr>
<tr>
<td>Risk of Pneumonia</td>
<td>1.58 .6</td>
</tr>
<tr>
<td>Aspiration of Liquids</td>
<td>1.73 .3</td>
</tr>
<tr>
<td>Risk of Pneumonia less than 1%</td>
<td>23%</td>
</tr>
</tbody>
</table>

Case Study 2 AJ

HPI: 84 y/o female admitted from a SNF after a fall. Nursing home staff report increased confusion. CT scan of head negative. Prior to admission ambulates with a walker, feeds self regular diet, mild confusion. Urine culture positive for UTI. Referred to SLF on Day 2 for coughing with meds.

PMH: Dementia without behavioral disturbance, GERD, HTN, DM
Meds: omeprazole 40 mg, Metformin 1,000mg BID

Clinical Features:
- Currently on bedrest, edentulous, oral hygiene good, more lethargic than at baseline, needs to be fed, nursing currently doing oral care, BMI 23.8
- edentulous, oral hygiene good, inconsistent cough with thin, reduced command follow, not oriented Instrumental exam
- Aspiration on thin, no aspiration with nectar, however significantly increased pharyngeal residue present on nectar, trace residue with puree or thin

Case Study 2 AJ Discussion

Using the data from the literature search adjusting the probability up or down depending on the presence or absence of risk factors the probability of the patient developing pneumonia is 88%

What interventions would you consider?

Case Study 1 Interventions --Dysphagia

Let’s look at swallowing…
- residue on liquid 2.81 (nectar/mildly thick only)
- Aspiration on liquid 1.58 (thin liquid only)

Case Study 1 Interventions (Mobility)

Let’s see what else we can do if OT and PT can get her moving a little more....
- Dependent for Feeding 6.82
- Bedbound 4.21
- Needs assistance with eating 3.26
- Up less than half a day 1.73

Now her risk of pneumonia is down to 54%

Case Study 2 Discussion Discharge

What happened to AJ?
- Kept on thin liquids, seen by PT, OT. Antibiotics for UTI
- Reassessed Day 4—UTI is resolved. Pt. has improved alertness and functional independence. She is feeding herself and is once again ambulating (with supervision) with a walker. Additionally she has transitioned from a PPI to an H2 blocker as per hospital protocol.

Probability of pneumonia with aspiration of thin liquids untreated 8%

Probability of pneumonia with aspiration eliminated via nectar thick liquids 8%
Case Study 3 AB

HPI: 86 y/o male admitted from ALF with fever and AMS. Prior to admission pt was on regular diet with thin liquids, ambulates with rolling walker and supervision, feeds self with adapted utensils and requires assistance for denture care. dx aspiration pneumonia

PMH: Previous CVA, Dementia, CHF and GERD

Medications: Ranitidine BID, Metroprolol, Eliquis, Seroquel

Clinical Features: BMI 33, Bedbound, requires assistance for feeding and wholly dependent for oral care

Results of Exam: on 2L/min via nasal cannula, oral hygiene good, lethargic

MBSS: aspiration on thin, delayed laryngeal elevation, no aspiration on nectar, no residue

Case Study 3 Interventions AB

Initial Probability 100%

Modifiable Risk Factors

Mobility 4.21

Feeding 6.82

Aspiration 1.58

Change liquids to nectar 98%

Get him up less than ½ day 99%

Change liquids to nectar and increase mobility/self feeding 95%

Case Study 3 Discharge

AB discharged to SNF with oxygen, via stretcher with recommendations for W/C, on Milly Thick (nectar) Soft and Bite Sixed Diet with recommendations for OT, PT and Speech Therapy at next level of care.

Probability of Pneumonia 95%

Case Study 4 ES

HPI: PT is a 78 y/o female adm from SNF with AMS and right sided facial droop. Prior to admission pt was independent in ambulation with walker, regular diet, thin liquids, independent in oral care and feeding. Dx New L MCA

PMH: HTN, L CVA, GERD

Medications: Metoprolol, Simvastatin, Omeprazole

Clinical Features: Bedbound, wholly dependent for oral care, NPO, RUE weakness BMI 22, edentulous

Exam: Lethargic, dysarthric speech, adequate oral hygiene, right facial droop, Unable to feed self

MBSS: aspiration on thin, incomplete laryngeal elevation, no residue on thin, no aspiration on any other consistency, no residue on nectar, and residue on puree

Case Study 4-ES

Modifiable Risk Factors

Residue on Puree 4.88

Bedbound 4.21

Wholly dependent for feeding 6.82

Aspiration on thin 1.58

52%

Case Study 4 ES

ES Interventions

Probability with Mobility Interventions Only 68%

Probability with Dysphagia Interventions Only 89%

Probability of discharge with both Mobility and Dysphagia Interventions. Lethargy now<40 and Acid Medication Changed to H2 Blocker per hospital policy 23%

If patient still aspirating on thin (not on nectar) 42%
Case Study 5
JM

HPI: 100-y/o male admitted from home after a fall. Prior to admission pt was independent in ambulation without a device, independent in ADLs, had part-time assistance for IADLs. Dx: hip fracture, s/p ORIF, coughing with liquids following surgery, new onset acute kidney injury.

PMH: CAD, HTN, CHF

Clinical Features: NPO, 2L/Min via nasal cannula, up less than half the day. BMI 24

Exam: alert, follows commands not oriented. Oral motor function WFL, coughing on thin liquids, no cough on nectar, and cough strength WFL.

Is instrumental assessment warranted?

What are the risks associated with aspiration or residue?

If patient does have reduced safety or efficiency, how does that impact his risk of pneumonia?

With aspiration and residue?
Risk of pneumonia 30%

Case Study 5

And without?
16%

Using probability we can discuss with patient and caregivers.

Caveats

Statistical Probability
Not a crystal ball

Best used as a method to determine impact of intervention rather than as a predictive tool

Limited research pool
Some factors may be disproportionately weighted
Some factors don’t have clear descriptors

Questions?
Feedback

- Is this something you could incorporate into your practice?
- How do you think it could be helpful?
- What are some concerns you might have?
- Any suggestions?