Automatic analysis of ambulatory oesophageal manometry

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Example of oesophageal manometry
Station manometry - problems

- Symptoms not present at investigation
- Clinical setting = day to day activity?
- Wide range of ‘normal’ values
- What information is important?
Ambulatory manometry

- Representative of daily activity
- First introduced in 1985
- Analysis using clinic reference values
- Large amounts of data produced
- How to analyse??
Analysis

- Identify peaks and patterns of peaks and calculate wave velocity, peak heights, peak widths, % or number propagating etc.

- Computer uses strict rules based peak detection and pattern matching algorithms
  - Start threshold, end threshold, minimum and maximum width/height/slope, no of peaks and many more....
Manual or computer?

- **Manual** - subjective / experience dependent
- **Computer** – many values used for strict rules
- **Combined approach**
  - computer assisted - manually identify peaks patterns to analyse; use computer to find parameter values
- **Problems : what to include / include?**
  - patterns, noise, cough like signals, baseline shifts etc?
Ambulatory Manometry
Progress over 20 years!

- Initial enthusiasm
- Analysis time consuming even computer aided
- Still used in combination with pH-metry/others
- Still seen mainly a research tool
- Big question still - what is normal motility?
Ambulatory Manometry Survey

How confident are you with the computer analysis?

- Very: 11.5%
- Reasonably: 26.9%
- Not Very: 61.5%
Problems with AOM

54% feel it only produces some clinically useful data - you have to be selective and find the relevant bits

43% are not confident with the computer analysis at all

38% feel an automated computer program is not very accurate at analysing 24 hour data

35% feel there has been little or no improvement in the understanding and analysis of AOM data during their working life as a clinician

22% of clinicians feel they have little or no experience in AOM

New Wave – Autumn 2007
Artificial Intelligence

- Use data clustering to find patterns
- Use minimum predefined parameters
- Data mining – no preconceptions
- Uses all of the data –
  - baby not thrown out with water!
How?

- Use a self-organising feature map (Kohonen)
- Cluster similar periods of data
- Need to identify candidate periods
Candidate window selection

Data from the 24 hour ambulatory manometry

Pressure

Time

'Snapshot'

'Snapshot'

Moving analysis window

Start analysis at Time = 0

'Windows' of peaks

The peaks in these windows of data are then used for our AI analysis. They are presented to the neural network and are grouped into similar patterns.

15 seconds
Which threshold value?

Threshold v Events Detected

Number of events

Threshold (mmHg)
Clustering using SOM

More peaks in a group shows that it is a common shape.

Squares closer together on the grid have more similar shapes than those further away.

Fewer peaks in a group shows that it is a more unique shape.

5 x 5 Grid
(= 25 groups)

\[ n = \text{Number of peaks that are similar in shape} \]

12 peaks with a similar shape

7 peaks with a similar shape

Pressure

Time
Classes identified – 1 pressure

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≈ 3500 / 24 hours
Examples of clusters

35

12

52

34
Comparing Barrett’s and controls – P2

Control Peaks (P2)

Note these are averages with the error shown as plus and minus standard deviation.

Barrett’s Peaks (P2)

Note again these are averages.

Some of the smaller peaks are artefacts resulting from very noisy signals. The number and quality of the peaks appears on first inspection quite different to the control peaks.
Examples - using 3 transducers
Progress

- 2004-2006 - proof of concept
- Used many software tools - days
- 2007- Integrated system – MATLAB©
- Minutes to produce results
Analysis

- Rates and patterns observed
- Differences between individuals
- Symptom association
- Pattern change during the day
Examples of control clusters
Example of peristaltic swallows clustering.
Example of non peristaltic swallow cluster
Example of peristaltic swallow cluster
Examples of Barrett’s clusters
Example of peristaltic swallow cluster
Example of non peristaltic swallow cluster
Example of cluster distribution over investigation

Controls
Classes 1-6
Distribution
Comparing Barrett’s & controls

- First cluster
- Post cluster classification
  - peristaltic, secondary peristaltic, non peristaltic
- Then compare results
  - (can be exported to excel as summary or complete)
### Post cluster classification results

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<tr>
<th></th>
<th>Primary</th>
<th>Secondary</th>
<th>Not peristaltic</th>
</tr>
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<tr>
<td>Barretts</td>
<td>334</td>
<td>190</td>
<td>3528</td>
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<tr>
<td>Controls</td>
<td>1054</td>
<td>591</td>
<td>2592</td>
</tr>
<tr>
<td>Ttest(2P)</td>
<td>0.0003</td>
<td>0.011</td>
<td>0.0089</td>
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</table>
Differences between patients with Barrett’s and controls
Compared to manual technique

- Manually > 40 days – subjective
- Computer ≈ hour – objective
  - Quantitative and qualitative
  - Compared to standard computer techniques – few assumptions
  - Easily investigate results to each individual waveform
  - Confidence – High! – Need a Study?!
Multi centre trial

Main goals:

- Develop a clinical system
- To inform clinical decisions
- Overcome barriers
Future

- Optimise reports etc
- Import data from various systems
- Setup study

- **Web /email based analysis**
  - Upload data
  - Reports created online / Help Files etc
  - **online summary example**
  - **online class example**
  - compare results
Interested?

- Now looking for interested units/sponsors

- Contact kevin.haylett@cmmmc.nhs.uk

- Future - Apply similar techniques to pH and luminal impedance analysis!