Rhinology and the Electronic Nose

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What is Rhinology?

• Subspecialty of Otolaryngology involving disorders of the nose and paranasal sinuses
  – Medical and surgical management
Case Presentation

- ST is a 35 yo M with h/o chronic sinusitis
- 6 mo h/o watery eyes, runny nose, yellow discharge, and pressure and pain above his left eye
- Saw an ophthalmologist who found no problems – no visual disturbance
- Primary MD had given him a ten day course of levaquin without much benefit
Case presentation

• On Exam:
  – Exophthalmos with displacement of the globe anteroinferiorly
  – On Nasal exam, edema of the middle meatus with the uncinate pushed laterally
  – No drainage seen
Case Presentation

• Treatment
  – Medical: Antibiotics and steroids (levaquin and prednisone) for a month prior to surgery and post-op
  – Surgical: endoscopic sinus surgery to open and drain the obstructed sinuses into the nose
Otolaryngology is a technology-driven field of medicine

- Use of operating microscopes began in the 1960s
  - Dramatically changed ear surgery
  - Allowed for the development of microvascular surgical techniques, which have completely changed reconstruction for head and neck cancer surgery (1970s)

- Endoscopic revolution in the 1980s and 1990s
  - Eliminated need for open procedures on the nose and sinuses
  - Completely changed surgical management of sinusitis
Otolaryngology is a technology-driven field of medicine

- **Intraoperative imaging -- 1990s**
  - Intraoperative navigational devices and powered instrumentation makes endoscopic surgery safer

- **Robotic Surgery -- 2000s**
  - Allows access to previously inaccessible locations in the head and neck (base of tongue)
Technology and Research in ORL

- Implantable devices:
  - Cochlear implant
  - Glossopharyngeal stimulator for OSA
Technology and Diagnosis

• Are there ways to improve diagnostic abilities with new technologies?
  – Electronic nose research
What is an Electronic Nose?
“Electronic Nose”

Two Parts:

- An array of differentially-sensitive chemical vapor detectors.
- Odor = point in multidimensional space
- A pattern recognition algorithm to classify detector array outputs.
  - Neural network
  - Principal component analysis
  - Grouping algorithms
Diagram Of An E-nose

Array of Vapor Sensors

ADC Circuitry

Data Preprocessing

Statistical Pattern Recognition
Signal Generation

- Conducting particles
- Insulating polymer
- Electrodes

The diagram shows a device with conducting particles forming a chain, connected to electrodes and surrounded by an insulating polymer. The chart on the right indicates a graph with resistance on the y-axis and time on the x-axis, marked with "On".
Polymer Composite Sensor Array

Composite sensor = polymer + conducting particles

• Sample polymers:
  • poly(vinyl butyral)
  • poly(vinyl acetate)
  • poly(styrene)
  • poly(ethylene oxide)

• Conducting particles:
  • carbon black
Visualizing 32-d Space

- Pattern Recognition
- Comparison of complex data
- Yields simple answers
- Not data specific
Utility of the E-nose in Rhinology

- Diagnosis of CSF rhinorhea
- Diagnosis of bacterial sinusitis
Current techniques for the diagnosis of CSF leak

- B2 transferrin
- Fine cut coronal CT
- Intrathecal contrast CT
- Intrathecal nuclear medicine study
- Flourescein
Pitfalls of current techniques

- Beta 2 transferrin
  - Need at least .5 cc of fluid
  - Often requires 24 hour turn-around
  - Cannot localize site of leak
Pitfalls of current techniques

• Intrathecal contrast studies
  – Require lumbar puncture with contrast, with associated risks
  – Require active leak at time of study
Diagnosis of CSF Rhinorhea by an Electronic Nose
CSF unknowns

Score Plot in Canonical Space with Mean Center
Current techniques for the diagnosis of sinusitis

- Patient history
- Nasal endoscopy
- Culture of sinonasal secretions
- Imaging
Pitfalls of diagnostic techniques

- Patient history may be unreliable
- Different specialties rely on different criteria to diagnose sinusitis
- Nasal endoscopy may or may not confirm the diagnosis
- Culture requires 48 hours, and beyond for sensitivities
- Imaging must be done at an appropriate time interval
Diagnosis of Bacterial Species by an Electronic Nose

Score Plot in Canonical Space with MeanCenter

PC 1, 77.36 %

PC 2, 22.54 %

PA
AB
KO
Control
Diagnosis of Sinusitis by an Electronic Nose
Discrimination of Sinusitis versus Normal by an E-Nose
GC/MS analysis

Staphylococcus aureus

isovaleric acid

Pseudomonas aeruginosa

2-amino-acetophenone

dimethyl disulfide