Combination of Two Ancient Technologies to Improve Diagnosis of Otitis Media

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A mom rushes into the pediatrician's office with her screaming two-year old girl, Becca. Becca has been irritable for several days and has not been eating, but now she also has a fever and is crying incessantly. The pediatrician evaluates Becca's middle ear with an otoscope, knowing that an ear infection (i.e., otitis media), is the most common childhood illness (Cripps et al., 2005). The otoscope has been used for centuries with the first depiction illustrated in 1364. Since then the otoscope has undergone many advances to improve its function and ease of use, but has remained relatively unchanged since the development of the pneumatic otoscope in 1864. This 1864-based model is what the pediatricians use currently. Becca's pediatrician was well trained, but has only been practicing independently for a few years. Her evaluation of Becca's ear is subjective - she rates the severity based on her past experience. She confirms that Becca has otitis media (OM) and rates it as severe. Because the pediatrician believes the OM is severe, she decides to treat with a high dose antibiotic regimen. In fact, Becca's acute otitis media (AOM) was fairly mild, and would have spontaneously cleared within 48 h without treatment. As a side effect of the high dose antibiotics, Becca suffered from cases of vomiting and later became infected with an antibiotic-resistant strain of bacteria causing chronic OM.

While Becca's case was fictional and likely represents a worse case scenario, it illustrates a fundamental problem in the diagnosis of OM. In the January highlight article "Chemical Imaging in Middle Ear Pathology: Quo Vadis?" October Postdoc of the Month Winner Dr. Rishikesh Pandey, and his colleague Dr. Tulio Valdez, review recent work in the field of spectroscopy, showcasing how this technology can revolutionize the use of otoscopes in the diagnosis of OM (Pandey and Valdez, 2016).

A classical otoscope uses white light and a low-power magnifying lens to look into the ear canal and examine the tympanic membrane of the middle ear. Normally the tympanic membrane is translucent and pale gray in appearance, but in times of infection or irritation becomes opaque, reddish-yellow in color, and may appear to bulge. Because these are not concrete, defining features of OM, diagnoses are subjective and often inaccurate. Dr. Pandey is attempting to standardize OM diagnosis through spectroscopy – a technique that, ironically, was also developed centuries prior. Spectroscopy is the study of the interaction between matter and electromagnetic radiation. Analysis of light dispersion from an object allows us to infer several physical properties of the object including mass and composition. In the middle ear, the type and severity of OM can be distinguished based on the autofluorescent properties of the structures of the middle ear, infiltrating immune cells, water (edema), and inflammatory mediators.

In their article Drs. Pandey and Valdez describe several spectroscopy approaches, focusing on three they have developed and/or used to enhance detection and characterization of OM: Raman spectroscopy, fluoro-otoscope spectroscopy, and narrow-band reflectance spectroscopy. Each provides information on morphological features, biochemical features, or both in the middle ear. Fluoro-otoscope spectroscopy is particularly promising as the design allows for effortless incorporation into the current otoscope. Rather than shining white light, however, it shines lights with multiple discrete wavelengths using a filter wheel to assess absorption and excitation. The images are then recorded on a computer and characteristic autofluorescent signals of ear pathology are examined. For example cholesteatoma (an expanding growth of keratinizing squamous epithelium in the middle ear) can be differentiated from surrounding, uninvolved mucosa through its robust autofluorescent signal permitting Otolaryngologists to clearly demarcate lesion boundaries and intertwining blood vessels.

Although additional training would be required to use this and similar spectroscopy-based otoscopes, a defined set of guidelines diagnosing the type and severity of middle ear pathologies could be easily employed. In their article Drs. Pandey and Valdez examine the benefits and concerns associated with each type of spectroscopy technique agreeing that the selected technique for use in the clinics must assimilate seamlessly into the current design and approach of the widely used otoscope (Pandey and Valdez 2016).

Accurate diagnosis would not only improve patient-doctor confidence and prevent the misdiagnoses that lead to meningitis and deafness, but would also give doctors a better guideline on when to use antibiotic treatments. Antibiotic resistant pathogens are becoming an increasing cause of OM in developed countries (Pichichero and Casey 2007), likely due to the over-use of antibiotics in the clinical profession. Moreover, several double-blind studies of OM treatment show that antibiotics provide statistically and biologically insignificant improvements in symptoms and OM clearance compared to placebos (Vergison et al., 2010). Indeed, over 80% of OM cases spontaneously recover in just a few days without treatment. A formalized scale for diagnosing the presence and severity of OM based on morphological and biochemical properties of the tympanic membrane would facilitate standardized practices on when to provide antibiotics.

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Irrespective of what clinicians decide for the recommended treatments, the work of Dr. Pandey and his colleagues will open the door for these discussions by providing unbiased and objective diagnoses of OM through the combination of two disparate and ancient technologies.

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