Computer aided detection of endolymphatic hydrops to aid the diagnosis of Meniere's disease

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1. Introduction

Meniere's disease is associated with chronic dizziness, tinnitus, and pressure in the ears due to endolymphatic hydrops, fluid swelling in the scala media compartment inside the cochlea [1]. Although detection of endolymphatic hydrops (swelling in the inner ear) is the gold standard for diagnosing Meniere's disease, this test currently can only be made during postmortem histopathologic examination [2].

Optical coherence tomography is a new frontier for *in vivo* detection of cochlear abnormalities. Using OCT images of cochlea from healthy mice and mice exposed to large blast sounds to induce endolymphatic hydrops [3], we trained and tested machine learning algorithms to detect endolymphatic hydrops. These algorithms may help enable physicians to analyze OCT images of cochlea in the future to diagnose Meniere's disease without histopathologic examination.

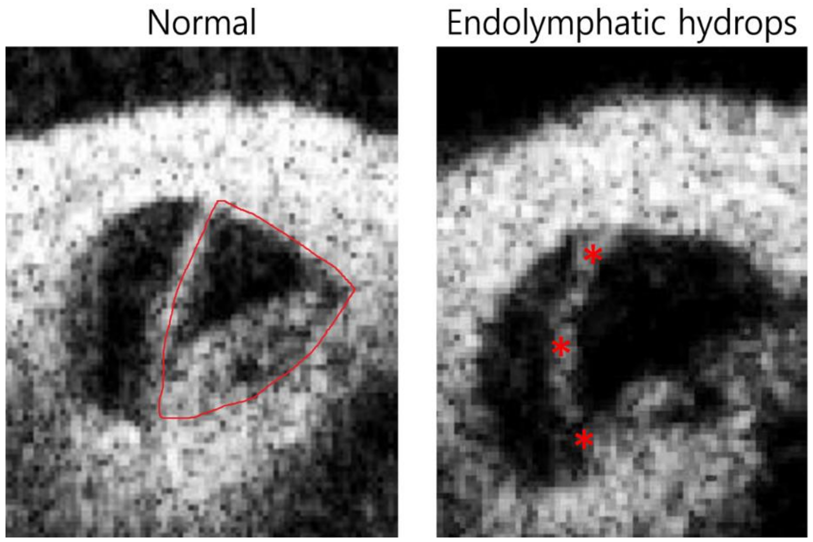

Figure 1: OCT images of scala media obtained by cochlear endoscopy in live mice before (*left*) and after (*right*) exposure to blast noise. The scala media is outlined in red in the normal mouse image (*left*) to orient the reader. Red asterisks (*right*) mark three user-selected points on Reissner's membrane for calculating its curvature.

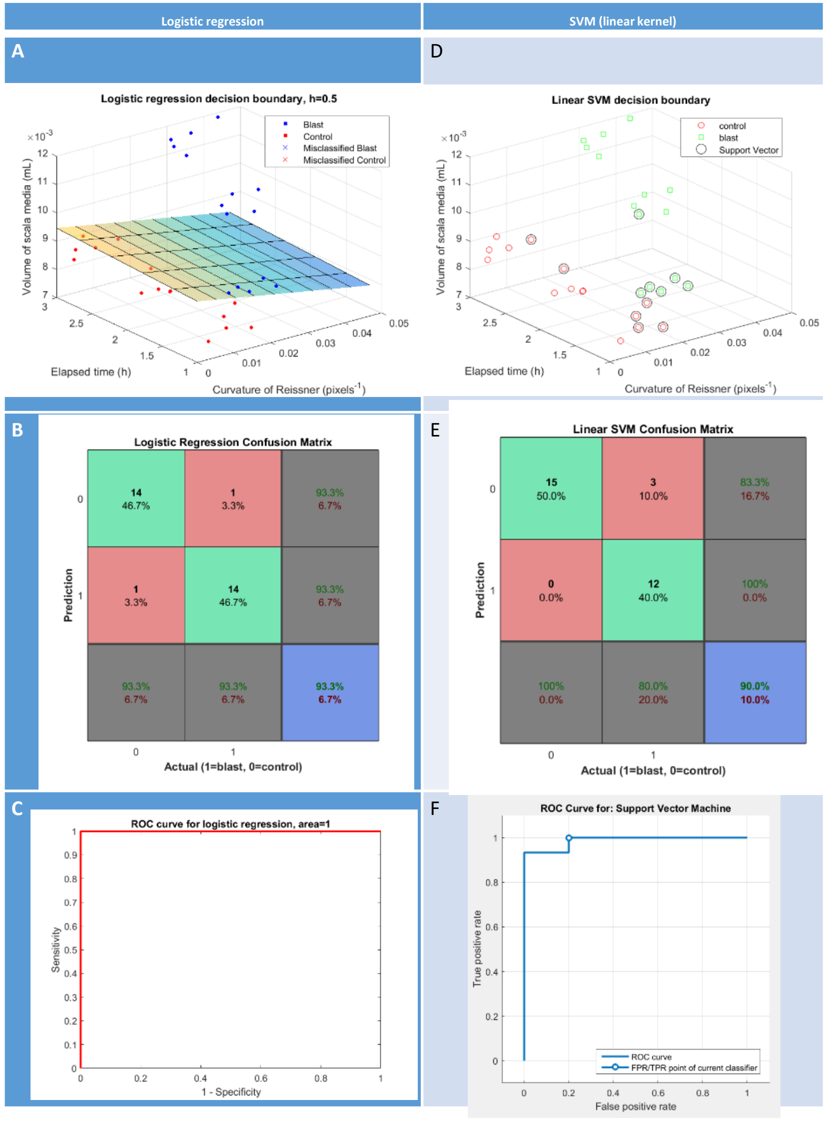

Figure 2. Trained models for logistic regression and linear kernel SVM, and their LOOCV confusion matrices and ROC curves.

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Model	Leave-one-out cross validation accuracy (k=30)
Logistic regression (h=0.5 cutoff)	93.3%
Naïve Bayes	90%
SVM (linear kernel)	90%
SVM (quadratic kernel)	93.3%
SVM (cubic kernel)	96.7%

Table 1. Summary of learning models and their leave-one-out cross-validation accuracies.

2: Dataset and Features

Data was obtained from OCT imaging of cochlea in five mice exposed to blast sound to induce endolymphatic hydrops [3], and five control mice of the same age and background. OCT images were taken in mice one, two, and three hours after exposure. Images of cochlea were obtained as z-stacks of cross-sections of the cochlea. The volume of scala media, curvature of Reissner's membrane bounding the scala media, and time of image acquisition were used as the three features for images. Volumes of the scala media (figure 1) were manually measured in each z-stack file using Amira visualization software prior to this work. These volume measurements were measured along the first 0.15 mm of the basilar membrane. The curvature of Reissner's membrane (second feature) was calculated in MATLAB using three user-specified points (Figure 1).

3. Results/Conclusion/Future Work

Machine learning algorithms were able to accurately classify severe manifestations of endolymphatic hydrops (Figure 2, Table 1). However it suffered when trying to separate milder hydrops at the one hour mark (data not shown). More data is needed to confirm these results for a larger sample of endolymphatic hydrops from the population in blast mice and, if possible, in human patients with related hearing loss.

References:
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[3] Cho S-I II, Gao SS, Xia A, Wang R, Salles FT, Raphael PD, Abaya H, Wachtel J, Baek J, Jacobs D, Rasband MN, Oghalai JS. Mechanisms of hearing loss after blast injury to the ear. PLoS One [Internet]. 2013/07/11 ed. 2013 Jan [cited 2014 Aug 13];8(7):e67618.