Detection of Germinal Matrix Hemorrhage on Neonatal Head Ultrasound Using Deep Convolutional Neural Network

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Introduction

Germinal matrix hemorrhage (GMH) is a major cause of morbidity and mortality in preterm infants and can lead to long term neurologic complications including cerebral palsy and developmental delay. The purpose of this paper is to evaluate the feasibility of automated detection of GMH in neonatal head ultrasound (US) using a deep learning approach.

Hypothesis

A deep convolutional neural network (CNN) can be trained to automatically detect GMH in neonatal head US.

Methods

From our institutional database, we retrieved 387 neonatal head US performed between January 2016-July 2018. Static images of the US scans (gray-scale coronal and sagittal views from the anterior fontanelle) were annotated by a radiologist according to the presence (grade I-IV; 62 scans, 500 images) or absence (325 scans, 500 images) of GMH. The mean post-conceptional age at the time of US for normal neonates (no GMH) was 38 weeks 3 days and those with GMH was 30 weeks 6 days. The 1,000 US images were split into 2 sets according to the transducer frequency: low frequency images (4 - 8.4 kHz; n=495) and high frequency images (9 - 15 kHz; n=505). The low frequency dataset contained 276 normal images and 219 abnormal images, while the high frequency set had 224 normal images and 281 abnormal images. For each of the 2 sets of images, we randomly selected 70%, 15%, and 15% of the images for training, validation, and testing, respectively. Two convolutional neural networks (CNNs) were built to process the low frequency and high frequency image separately. Performance of GMH detection by the two separately trained CNNs was compared with performance of a single CNN trained with both high and low-frequency datasets together.

Results

For the 2 CNNs approach, the test accuracies of GMH detection based on the low frequency images and high frequency images were 81.7% and 86.4%, respectively. The 2 CNNs approach achieved overall accuracy of 84.2% and area under the receiver-operating characteristic curve (AUC) of 0.90, in comparison to the 72.0% detection accuracy with an AUC of 0.79 obtained by the single CNN approach.

Conclusion

We demonstrate the feasibility of automated detection of GMH in neonatal head US using a deep learning approach.

Statement of Impact

Automated detection of GMH is feasible and may help improve its diagnosis in settings where subspecialty pediatric radiologist interpretation is not available.

Keywords

germinal matrix hemorrhage, deep learning, convolutional neural network