Artificial intelligence-based referral and progression of diabetic kidney disease using retinal fundus images

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RESULTS

The sensitivity of DR classifier was 88%. The specificity and sensitivity of the referral workflow were 79%, and 86%. The efficacy of the referral algorithm was AUC: 86%. Further, the sensitivity of baseline progression was found to be 82%. The results show strong correlation between DR and DKD stages.

PURPOSE

• Diabetic kidney disease (DKD) is a chronic condition of prolonged diabetes, and there is a pressing need to detect at an early stage. Past studies have substantiated diabetic retinopathy (DR) as a strong predictor of risk for DKD. But none have investigated noninvasive staging and progression.
• Machine learning techniques were utilized to predict stage of DKD through retinal fundus images and clinical parameters refer the outcome of predictions to a nephrologist for renal assessment.

METHODS

• The referral workflow to nephrologist consisted of identifying DR and DKD stages (Figure 1).
• Participants: 970 patients’ fundus photographs and noninvasive clinical parameters such as History of hypertension (Yes/No), Urine protein, Age, Gender, Other comorbidities (cardiac diseases, sepsis, peripheral diseases, urinary tract infection, peripheral neuropathy, edema, etc.), diabetes duration.
• Each patient had multiple visits and visit date of creatine value collected <= 1 year from ophthalmic visit date were selected. Closest visit with creatine date collected to diabetic visit were mapped. Each visit at eye level observation were Independent and Identically distributed.
• A deep learning algorithm was developed to classify the DR stages into severe, mild, and no DR. The DR classifier was based on pathologies such as microaneurysm(s), dot/blot hemorrhages, hard exudates, cotton wool spots, intraretinal hemorrhages, venous beading, intraretinal microvascular abnormalities, neovascularization, vitreous / preretinal hemorrhage (Figure 2).
• The predicted DR stages, exudates, cotton wool spots, and non-invasive clinical parameters were fed as an input to second deep learning model to predict the stage (i.e., early, late) of kidney disease (Figure 2).
• A third deep learning algorithm then predicted the progression of the kidney disorder to rapid, slow, or no progression based on staging information, and non-invasive nephrological parameters.
• The algorithm also performed an internal mapping between DR stages and pathologies extracted from retinal fundus images (Table 1).

CONCLUSIONS

This study demonstrates a potential to detect DKD at an early stage in patients with diabetes. This method provides the ophthalmologist with an additional decision-making support on whether to refer the patient to nephrologist based on the staging of kidney disorder.