ARC'14
مؤتمر مؤسسة قطر السنوي للبحوث
QATAR FOUNDATION ANNUAL RESEARCH CONFERENCE
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Retinal Imaging: A Convenient Tool To Study Microvascular Responses To Cardiovascular Disease Risk Factors And To Predict Hypertension And Disease Development

10.5339/qfarc.2014.HBPP0455

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Abstract

The eye is the clearest and most accessible organ to observe anatomical and physiological characteristics of microvessels, the smallest blood vessels of the circulatory system. The microcirculatory bed of the retina shares similar anatomical and physiological characteristics with the cerebral and coronary circulations. Therefore, subtle changes in the retinal blood vessels can mirror early cardio- and cerebrovascular events long before their clinical manifestation (e.g. hypertension).

Retinal images contain information to develop quantitative diagnostic algorithms for morphology, physiology, and pathology. Analysis of retinal images allows quantification of many vascular features: the Central Retinal Arteriolar and Venular Equivalents (CRAE & CRVE), morphological features (branching, tortuosity and geometric pattern of the vascular bed), but also small changes in the diameter of microvessels in response to disease or external factors. Particularly CREA and CRVE have been associated with hypertension, coronary heart disease, stroke, and type II diabetes as well as with acute responses to environmental (e.g. air pollution exposure) and lifestyle (e.g. smoking and physical inactivity) risk factors.

We demonstrated in a longitudinal panel study with 52 healthy individuals aged 22 to 62 years that short-term changes in particulate air pollution (PM10-concentrations ranging from 9.16 $\mu g/m^3$ to 126.58 $\mu g/m^3$) caused a significant narrowing of the CRAE by 0.69 µm (95% CI= -1.13 µm to -0.26 µg; p = 0.0032) on the day following peak exposure. This narrowing was equivalent to 1.5 years of aging. The associations were independent of individual characteristics such as gender, age and BMI. The results indicate that microcirculatory blood vessels can be affected by short-term changes in air pollution, and may contribute to the development or aggravation of cardiovascular disease, perhaps even induce events.

To allow for a more automated analysis of retinal images, we developed stand-alone software which results in a faster, objective, and more precise grading of large numbers of images. VITO embeds this tool in a data portal, which includes batch processing and quality control. We are exploring if handheld retinal cameras can replace heavier and more expensive tabletop cameras. If these instruments are interchangeable, then we can work towards a truly mobile health solution.

The unobtrusive nature of retinal imaging has high potential for facilitating long-term, recurrent monitoring of the population in epidemiological settings, in line with the P4-Medicine paradigm (Preventive, Personalized, Participatory & Predictive). Also for specific vulnerable subpopulations such as elderly, pregnant women, and school children, the non-invasiveness and ease of routine allows for wide deployment in large-scale, even population-wide longitudinal studies.

Retinal imaging can also contribute to evidence-based population health programs. It addresses several