MEASUREMENT OF VOLUME CHANGES IN THE CENTRAL RETINAL ARTERY

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Abstract: *The diagnostic of the chromatic pulse is of established importance in diagnostics of glaucoma. The applicability of noninvasive method for monitoring of intraocular pathology has been investigated. The proposed hardware solutions solved the problem with synchronization of the fundus-camera and patient's pulse.*

Introduction

The diagnostic methods in clinical ophtalmology have undergone a rapid development in the past several years. Medical Electronics played a major role in this process. The first digital imaging was introduced in the 80's and the technique was considerably improved since, resolving many problems in clinical diagnostics [1]. The use of eyeground digital imaging was established as a method for assessment the condition of the blood vessels, nerve fibres and retina [2,3].

After application of precision techniques for eyeground imaging, the problem of the existing chromatic pulse, synchronous with the cardiac rhythm, came into view. The chromatic pulse is the systolic – diastolic difference in blood filling of the eyeground, which results in different picture brightness, depending on the time and duration of the image acquisition. The diagnostic and prognostic potential of the chromatic pulse is being discusses in ophtalmology since 1994 and today is of established importance in the diagnostics of glaucoma.

A noninvasive method is being developed in the Dept. of Ophtalmology of the Medical University for diagnostics and monitoring of intraocular pathology by detection and systolic-diastolic comparison of the chromatic pulse in the branchings of the central retinal artery.

Method

Digital images are acquired using a fundus-camera in a range of 40 deg of the eyeground during systole and diastole and a comparison is undertaken according to a defined procedure. The accuracy of the obtained result depends on the synchronization of the fundus-camera and the patient's pulse. The camera should be activated once at the instant of maximum intravessel pressure and a second time during diastole - at about after 450 ms the systole. The recording of the systolic and diastolic phases is obtained by a photoelectronic method, using the

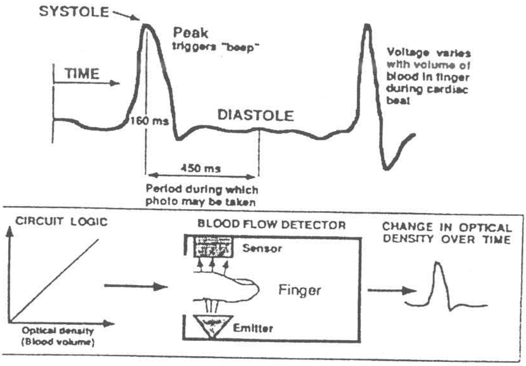

Fig. 1

pulse wave recorded from an earlobe or a finger (Fig.1). The two images thus recorded are subjected to processing and interpretation, resulting in assessment of the state of the blood vessels in the eyeground.

Hardware solutions

The recording of pulse wave is analogous to other noninvasive methods (pulse oxymetry, photometric blood pressure detecction, etc), selecting a body region where there is a superficial and well expressed artery. Earlobe and finger are convenient. Some problems if this method are reviewed in [4]. In our case trans-illumination by infrared light is used, i.e. just the artery volume changes due to blood filling are detected.

The block-circuit of the recording module is shown in Fig. 2. The emitter intensity (infrared LED) is controlled by a voltage controlled constant current amplifier. The receiving part includes a photodiode and a preprocessing circuit with a band-pass filter (0.5-20 Hz) to separate the pulse wave and an additional amplifier. Then the signal is AD converted (8 bit, 200 Hz) by a microcontroller (68HC11A1, Motrorola). The signal amplitude is automatically fitted to the ADC range, adjusting the infrared LED current by an output of the microcontroller.

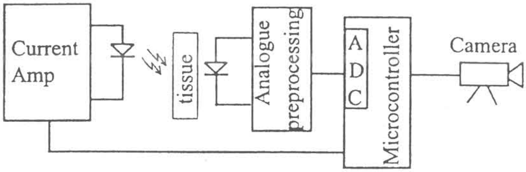

Fig. 2

The digital signal processing for te detection of systole and diastole is similar to that described in [5]. The higher sampling frequency of 200 Hz used here ensures a maximum delay of 5 ms from the detected systolic peak to the start of the camera. This delay is quite acceptable, having in view the velocity of change of the artery dimension. A second start of the camera is done 450 ms after the systolic peak, accepted to fall intgo the diastolic period in patients without rhythm disturbances.

Results

The clinical testing of the system was carried out in the Medical University, Department of Ophtalmology. Twelve subjects were selected, six health on age 24-35 years and six on age 55-65 years with diagnosed high blood pressure. The procedure of investigation consist of:

- digital images forming of the eyeground by fundus camera using green filter during systole and diastole;
- retinal artery image extraction using software filtration;
- determination of the levels of gray across blood vessel (fig. 3).

The obtained results shown that in the group of health subjects there is well pointed difference in the location of the border lines (vessel walls) during systole and diastole. In the group of subjects with vessel decease the difference is quite small.

Conclusion

The realized investigation by synchronization between eyeground images and phases of the heart activity increase the possibility of eyes diagnostics, especially for determination of blood vessels condition. The obtained results shown that in clinically health patients the elasticity of the retinal artery is well present, opposite in the patients with high blood pressure. Moreover in the patients with long-time hypertension the pathological increase of wall density was diagnosed.

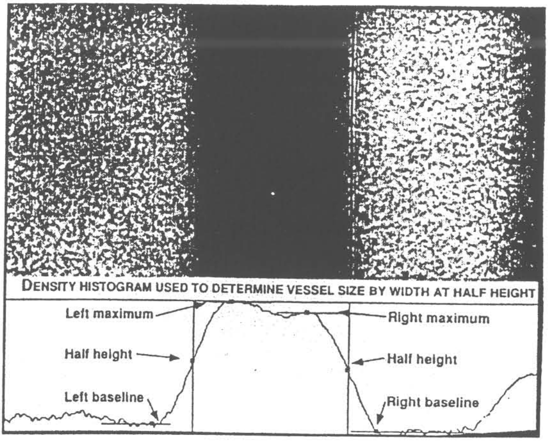

Fig. 3

References

[1]. Gagnon M, LovasikJV: *Correlating pulsatile ocular blood flow with chromatic attributes of the ocular fundus in man (abstract)*. Optom Vis. Sci 69 (suppl):75,1992

[2].Golgman MH, Chaterjee S, Chaudhuri S, Katz N: *Digital image prosessing for ophtalmology, in Masters BR (ed)*: Noninvasive Diagnostic Technigues in Ophtalmology. New York, Springer-Verlag, 1990, pp 548 568

[3]. Hague S, Hill DW, Grabtree A: *The calibre changes of retinal vessels subject to prolonged hypertoxia*. Exp. Eye Res 47:87-96, 1988.

[4]. Илиев И., *Фактори, влияещи на точността при определяне на кислородното насищане на кръвта,*. XXVIII Научна сесия " Комуникационни, Електронни и компютърни системи", 1993, 212-217.

[5]. Iliev I., *Improvements of the noninvasive long-term blood-pressure recording*. Journal of Clinical Engineering, 21/5, 1996, 392-397.