Evaluation of Blood Vessel State from Nailfold Micro-Capillary Image

Katsuya Nagayama[1] Ichiro Miura[2] and Keiji Kawagoe[3]

1 Kyushu Institute of Technology (Fukuoka, Japan)
2 Juntendo University (Tokyo, Japan)
3 Toku Corporation (Tokyo, Japan)

We examined the evaluation method by image processing of the fingertip blood vessels. Using the clinical Figures of the nailfold capillary, we tried to clear characteristics of the fingertip capillaries by the feature point extraction. Also it has been realized to simplify the process by performing the numerical values for the state of the fingertip blood vessel from the clinical picture, to prepare a program for calculating the parameters automatically. Further, it could be useful to evaluate the performance of supplementation measuring the parameters of the microcapillary shape by image processing.
Keywords: microscope, capillary fingertip, image processing, radar chart

1. Introduction

According to the 2012 vital statistics of the Ministry of Health, Labour and Welfare, cause of death in about 30% of Japanese are vascular lesions such as heart disease and cerebrovascular disease. Microcirculation can be mentioned as one of those that contribute to its pathology. The impaired blood flow in lifestyle-related diseases has suggested involvement of vasa vasorum; perivascular capillaries. It is assumed that change of capillary structure is the initial lesion of impaired blood flow. Observation of nailfold capillary is a simple method with non-invasive and blood sampling is not required. In collagen diseases including scleroderma, participation of capillary disorder is clear[(1)]. Its involvement in hyperlipidemia, and other disease with high morbidity, is also becoming apparent.

The health status of the capillary, have been conventionally determined by observations of experts who have experienced many cases. The development of quantitative techniques has been desired. In our study, we propose a new processing method of capillary fingertip image taken by the microscope. The quantification of microcapillary shape was performed by thickness, width, length, bend etc, and the objective is to contribute to preventive medicine.

Katsuya Nagayama Ph.D.,
Dept. of Mechanical Info. Science and Technology
Kyushu Institute of Technology
680-4 Kawazu, Iizuka, 820-8502 Japan
Tel:+81-948-29-7778 Fax:+81-948-29-7751
http://www.nl.mse.kyutech.ac.jp/

2. Method

Normal pattern of nailfold capillaries is hairpin shape with thin line from the previous studies. In abnormal patterns with the disorder of microcapillary blood flow, the length is short, the width and vessel diameter is large, image is unclear and has meandering shape. Thus, we selected particularly 6 parameters as the index, such as, bending frequency, vessel diameter, clearness, capiliary width, blood velocity and roundness, and quantified them and examined for usefulness. In addition, we have quantitatively evaluated the microcapillary change by supplement intake.

Vessel diameter and sharpnes were measured from the capillary image, and length and bending was calculated from the feature points that were classified into 2 classes width. Width was calculated the maximum between an artery and a vein and thickness was measured in the artery part, the bend part, and the venous part. Clearness was measured the luminosity difference of a blood vessel and a background in a picture. Velocity was measured with software of KK Research Technology inc[(5)].

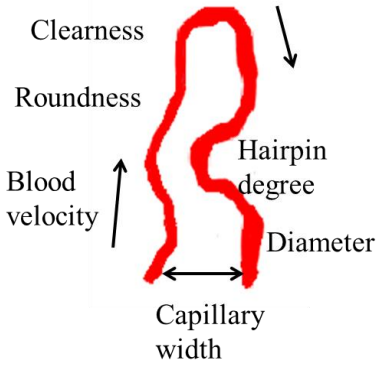


Fig.1 Evaluation items

3. Results and Analysis

About 25 persons who were commissioned by the company, the nailfold capillary images of before and after supplementation was evaluated to quantitatively (Table.2). For example, showed the picture of microcapillary figures (Fig.1). It was possible to perform the extraction of the outline of the vessel by the feature point extraction in Fig.2. Two capillaries shown as an example were able to acquire the numerical value sensuously near evaluation by macroscopic observation. After eight weeks of supplementation, meandering of a blood vessel slightly improves and that is well reflected in the numerical value, The value of Hairpi degree and roundness decreased, and length and the flow velocity improve sharply(Table 1). On the other hand, clearness, thickness and width did not change mostly. In this research, in order to grasp health condition intuitively, a numerical value is displayed using a radar chart(Fig.3). In addition, the radar chart shows wide area when blood flow is so good. Deviation from circular form, crookedness and width convert by subtraction, and on a radar chart, deviation from circular form is made into roundness, and it makes crookedness into hairpin degree. The velocity, roundness, and hairpin degree improve also on a chart, and it can be expressing that change is deficient in clearness, thickness, and width.

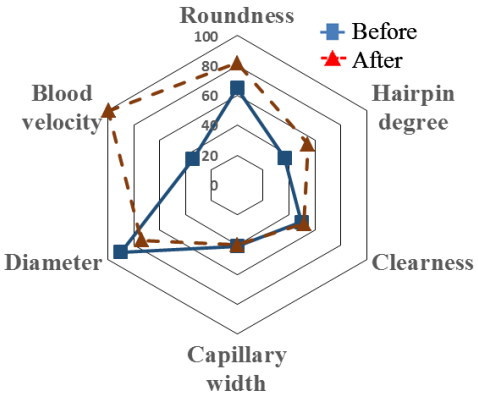
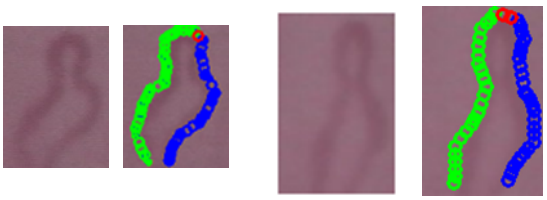


Fig.3 Radar chart

When understanding a health indicator by a radar chart, it is necessary to evaluate the relationship of parameters quantitatively. Therefore, the correlation coefficient of each parameters, clinical laboratory test result and parameter were calculated(Table 2,3). Correlation of parameters has been arranged next in a radar chart in high items. Although roundness and crookedness have negative correlation, two or more indices are expressing the bend condition of a blood vessel. Hairpin degree and width, width and diameter have positive correlation, and it is considered to be an index for lipid metabolism. Moreover, relation with metabolism, tiredness, edema, etc. is suggested from correlation or clinical information to clearness.



Original Processed Original Processed

(a) Before (b) After 8 weeks

Fig. 2 Image processing of fingertip blood vessel

Table 1. An example of quantification

	Before	After
Roundness	0.42	0.22
Hairpin degree (rot/mm)	4.44	3.17
Clearness	11.9	12.4
Capillary width (μm)	42.5	43.1
Diameter (μm)	7.4	11.5
Blood velocity (μm/s)	414	1195

Table 2. Correlation coefficient between shape parameters (n=25)

	Hairpin degree	Roundness	Width	Velocity	Clearness	Diameter
Hairpin degree		-0.46	0.44	-0.36	-0.08	0.14
Roundness	-0.46		-0.62	0.51	-0.09	0.09
Width	0.44	-0.62		-0.19	0.49	0.48
Velocity	-0.36	0.51	-0.19		0.30	0.28
Clearness	-0.08	-0.09	0.49	0.30		0.27
Diameter	0.14	0.09	0.48	0.28	0.27	

Table 3. Correlation coefficient of clinical parameters and shape (n=25)

	Hairpin degree	Roundness	Width	Velocity	Clearness	Diameter
Total protein	-0.16	-0.12	0.11	0.36	0.41	0.21
Creatinine	0.24	-0.25	0.20	-0.49	0.07	0.07
Uric acid	0.15	-0.04	0.06	-0.23	0.15	-0.01
γ-GTP	0.22	0.04	0.21	-0.13	-0.10	0.31
Total cholesterol	-0.29	-0.13	0.33	0.33	0.46	0.22
Neutral fat	-0.15	-0.07	0.00	-0.17	0.11	0.10
LDL cholesterol	-0.19	-0.26	0.38	0.07	0.45	0.08
HDL cholesterol	-0.10	0.22	-0.08	0.45	-0.03	0.22
Blood glucose level	0.34	-0.28	0.28	-0.27	0.02	-0.19
White blood cell	-0.02	0.00	-0.16	-0.17	-0.24	-0.08
Red blood cell	0.22	-0.02	0.02	-0.22	-0.19	0.08
Hemoglobin	0.35	-0.33	0.32	-0.39	-0.01	0.28
Hematocrit	0.34	-0.29	0.28	-0.36	-0.03	0.31
Systolic blood pressure	-0.14	0.08	-0.35	-0.11	-0.18	-0.27
Diastolic blood pressure	0.00	0.11	-0.28	-0.24	-0.08	-0.27
Pulse	0.04	-0.16	0.08	-0.02	0.11	-0.10

The nailfold microcapillary is straight state in normal person. It shows a variety of image when the disease is known and it is very useful from early detection to advance of a stage, about especially collagen disease such as scleroderma associated with inflammation and oxidation. However, the relationship between such inflammation and oxidation which is the cause of the bend and the thickness of the capillaries has not been revealed until now. In this study, we inquired to objectify using several indicators for the imaging findings and the flow velocity in capillaries. Flow rate and clarity is easy to change empirically, on the other hand, it does not change within hours bending and thickness It is considered necessary to be objectified by using multiple indicators for it was thought to reflect the status of several weeks, and were expressed using the radar chart as perceived intuitively them yet. Changes in blood flow and capillary image is captured well and as shown in the example, the change can be understood easily even in the radar chart. Correlation of the roundness and hairpin degree is low and requires the further discussion for future.

4. Conclusion

We examined the evaluation method by image processing of the fingertip blood vessels. Using the clinical figures of the nailfold capillary, we tried to clear characteristics of the fingertip capillaries by the feature point extraction. Also it has been realized to simplify the process by performing the numerical values for the state of the fingertip blood vessel from the clinical picture, to prepare a program for calculating the parameters automatically. Further, it could be useful to evaluate the performance of supplementation measuring the parameters of the microcapillary shape by image processing.

In the future, high accuracy image processing is indispensible. It is scheduled to be generalized as a health evaluation system. Overlaid comparison with the laboratory examination and the verification, it is expected to clarify the relationship between the nailfold microcapillary deformation and vascular disease.

References

1) Atlas of capillaroscopy in rheumatic disease Maurizio Cutolo Elsevier, 2010 ISBN 8821432033, 9788821432033
2) Saburo Ogawa, "Clinical and capillary, Toriumi Syobo, 1994, Japan
3) Hiroya Torii and Yoshitaka Shibata, Remote automatic decision making of diseases recognition from vessel images, Information Processing Society of Japan, p157-162, 1997
4) Support Vector Machines: SVM, http://www.support-vector-machines.org/
5) KK Technology Instrumentation for Microcirculation, http://www.kktechnology.com/