

Comparative Estimation of Blood Supply of Skin Areas from Photoelectrically Recorded Volume Pulse.

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The principle of the photoelectric plethysmograph¹ has been applied to the comparison of the richness of the blood supply in several skin areas. Vertical illumination of the skin is provided by an ophthalmoscope bulb. Enough light is scattered through the subcutaneum to provide a sufficiently satisfactory transillumination to permit the detection of changes in the circulation in the skin by a photoelectric cell placed over the transilluminated area. The variations in the photoelectric current with changes in the blood content of the skin are recorded on the electrocardiograph after amplification.

The volume pulse of the skin so recorded probably is an index of the arterial inflow with each heart beat and so can be used as an index of the blood supply of that skin area. (Special hemodynamic conditions will, of course, limit the specific application of the statement). Arterial constriction in the skin decreases the volume pulse; vasodilatation increases it. The amplitude and form of the recorded wave will also vary with the size and number of arterial vessels in the transilluminated area.

Quantitation of the recorded wave in terms of arbitrary units is effected by comparing the size of the wave with the deflection obtained from inserting a glass filter (a thin glass sheet) between the photoelectric cell and the transilluminated skin area. Although the question as to what is the actual blood equivalent of the filter in terms of cc of blood per 100 cc of skin tissue is an involved one,¹ a tentative approach to the problem is provided in the data of Turner, *et al.*² Their average volume pulse in the finger tip at heart level is 2.8 mm³ or .06% of the soft tissue volume. Calling this value equivalent to 1.85 filter units (which is the average amplitude of the photoelectrically recorded volume pulse in the finger tip also at heart level), one obtains by substitution of the blood equivalent of the filter, the values for the volume pulse in the different skin

¹ Hertzman, A. B., *Proc. Soc. Exp. Biol. and Med.*, 1937, **37**, 290, 529.

² Turner, R. H., Burch, G. E., and Sodeman, W. A., *J. Clin. Invest.*, 1937, **16**, 789.

areas as recorded in Table I. These values were obtained on 6 physically vigorous medical students, in the sitting position, comfortably clothed, after 20 minutes of rest. (Room temperature usually 80°F; relative humidity 30.) The values showed considerable variation in the different individuals although the order of amplitude of the volume pulse in the different skin areas was essentially the same in the different subjects. Simultaneous skin temperature measurements showed a general correlation with the amplitude of the volume pulse, although marked exceptions appeared if the skin were moist. Wrapping the subject in heavy blankets and making the observations on the warm covered skin gave notable increases in the amplitude of the volume pulse of the skin but even so it was not possible thus to obtain waves in the warm covered skin of the forearm and thigh more than 40% as large as those in the exposed skin of the forehead. It is, therefore, tentatively concluded that the figures in the table represent the approximate order of differences in the richness of the arterial supply to the corresponding skin areas.

The high values for the finger tips correlate with the abundance of small arteries here. Skin vessel counts are needed to extend such correlations. It is interesting to note that the areas (finger and face) which show the largest volume pulse values are also those in

TABLE I.
Amplitude of the Volume Pulse in Several Skin Areas.

Skin Area	Amplitude of Volume Pulse in Filter Units	Calculated Amplitude Vol. Pulse cc/100 cc Tissue
Finger tip (palmar)	1.85	.06
Thumb tip "	1.85	.06
Lip	1.16	.038
Nose	1.07	.035
Hypothenar eminence	1.04	.034
Forehead	1.00	.032
Ear	0.97	.031
Thenar eminence	0.90	.029
Palm of hand	0.90	.029
Cheek	0.68	.022
Big Toe (plantar)	0.66	.021
Finger (dorsum)	0.54	.017
2nd toe (plantar)	0.46	.015
Hand (dorsum)	0.37	.012
Neck (dorsum)	0.34	.011
Foot (plantar)	0.25	.008
Knee	0.20	.006
Forearm	0.17	.005
Big toe (dorsum)	0.15	.005
2nd " "	0.15	.005
Foot "	0.11	.003
Tibia, thigh, arm	indeterminate	

which vasomotor reactions seem to be most marked. Studies are in progress to determine the maximum circulation which can be attained in the various skin areas, as well as to examine the effects of peripheral vascular disease on the blood supply of these areas.

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Studies on the Effects of the Administration of Insulin by Iontophoresis.

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We have been able to show that by iontophoresis a large molecule such as acetyl beta methylcholine could be introduced through the intact skin and be absorbed into the blood stream.¹ Acetyl beta methylcholine bears a positive charge and was electrolysed at the anode. Insulin bears a negative charge, for experimental purposes the effects of electrolysis at each pole was attempted.

Dogs were used as the experimental animal. They were in an 18-hour postprandial state when the experiments were performed. The hair from the abdomen and one thigh was carefully shaved. The animal was restrained in a supine position and a folded piece of asbestos paper, saturated with insulin U-80 was placed on the bare abdominal skin. It was covered by a piece of block tin of sufficient size to fit within the limits of the paper. The other pole was placed on the thigh and held in place by means of a cotton bandage.

The instrument used was a simple but effective one consisting of a 45-volt B battery with rheostat control and an attached ammeter capable of measuring milliamperes. The circuit was closed and the amperage was slowly raised to 30 milliamperes and kept there 30 to 60 minutes as indicated in Table I. Capillary blood sugar estimations were made by the Folin micro method.² The control level was determined just before the circuit was closed. Subsequent estimations were made after the circuit had been broken for 30, and for 60 minutes, and then at hourly intervals for 6 hours.

Two control tests were made with distilled water. In one instance it was placed beneath the cathode and in the other anode.

¹ Martin, L., *New England J. of Med.*, 1937, **207**, 202.

² Folin, Otto, and Malmros, Haqvin, *J. Biol. Chem.*, 1929, **83**, 115.