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The Circulation

OF THE

Blood in the Orbit

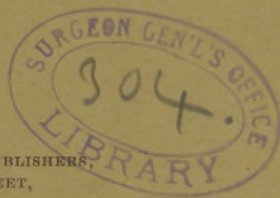
STUDIED BY MEANS OF THE

Plethysmograph.

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THE CIRCULATION OF THE BLOOD IN THE ORBIT STUDIED BY MEANS OF THE PLETHYSMOGRAPH.

BY F. W. ELLIS, M.D., SPRINGFIELD, MASS.

THE vascular system of the orbit may be considered as an appendage of that of the cranial cavity. The ophthalmic artery is given off at the base of the brain, and the ophthalmic vein may be regarded as the commencement of the cavernous sinus. The circulation in the orbit is, therefore, intimately connected with that of the brain.

The circulation of the blood in the brain is subjected to peculiar conditions. The cranial cavity of the adult is inextensible, and practically filled with fluid. A certain amount of this fluid must be expressed from the cavity at the time when a new supply of blood enters it. The blood finds a sudden obstacle to its free propulsion when it passes into the cranium. This increased resistance that the blood encounters expresses itself in a very marked manner in the pulse-tracing of the brain.

Mosso¹ made an elaborate series of experiments with individuals who had lost portions of the skull either from accident or disease. He employed the graphic method in these investigations, and was thereby enabled to obtain permanent records of the circulation of the brain. Upon inspecting the numerous tracings published by him one is forcibly struck by the peculiar form of the pulse-curve, which is very dissimilar to that of ordinary sphygmograms obtained

¹ Sulla Circolazione del Sangue nel Cervello dell'Uomo.



from peripheral arteries. In many of Mosso's experiments, the circulation of the arm was recorded at the same time as that of the brain. The arm was enclosed in a plethysmographic apparatus, which Mosso calls a hydrosphygmograph, and has been extensively employed by him in studying the local variations of the pulse.²

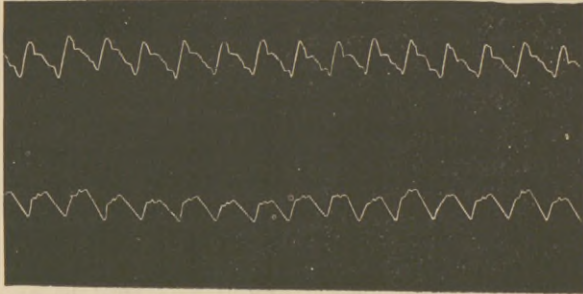


FIG. 1.

Figure 1 is a reproduction of a portion of one of the illustrations in Mosso's work, "The Circulation of the Blood in the Brain." The upper tracing is that of the arm obtained with the hydrosphygmograph, the lower that of the brain. The striking differences in the characters of the two tracings are very apparent. In the plethysmogram of the arm, the secondary undulations all occur in the descending portion of the pulse-curve, and the pulse is, according to Landois, catacrotic. In the brain-tracing, however, the secondary undulations, all occur in the ascending portion of the pulse-curve; the pulse is, therefore, anacrotic. In many of Mosso's

² Die Diagnostik des Pulses, Leipzig, 1879.

illustrations, the projecting point between the two notches in the pulse-curve of the brain occupies a higher level than the remaining portions of the curve. Mosso calls this the tricuspid form.

The apparatus employed by Mosso to record the circulatory changes within the skull was a simple one. A piece of gutta-percha was made to cover the part of the skull where there was a loss of substance. The centre of the piece was perforated with a glass-tube connected by means of rubber-tubing with a Marey's drum. The lever of the drum recorded the circulatory changes upon smoked paper covering a revolving cylinder. By means of this simple apparatus used in conjunction with the arm plethysmograph, a series of very interesting experiments were made upon the effects of different psychical conditions upon the circulation of the brain.

Several investigators have endeavored to record the intracranial circulation in animals, removing a portion of the skull of the animal experimented upon by means of the trephine. The experiments of Frédéricq³ are among the latest and most successful in this direction. He obtained pulse-curves, in experimenting with dogs, quite comparable to those recorded in Mosso's experiments with the human subject.

It occurred to the writer that it would be of considerable interest to record the circulation of the orbit. The physiological importance of the subject is apparent. The circulation of the orbit is so intimately connected with that of the brain that there would seem to be great liability of circulatory changes in the larger cavity affecting the blood-supply of the smaller. If it could be proven that psychical changes affect the circulation of the orbit in the same way as they have

³ La Courbe pléthysmographique du Cerveau du Chien, Travaux du Laboratoire, Univ. de Liège, Tome I, 1885 and 1886.

been shown by Mosso to express themselves in the records of the circulation in the cranial cavity, then a very important advance in the means of investigating the physiology of the cranial circulation in the human subject would be made. Direct investigation of the cranial circulation can only be made in the adult upon persons who have lost portions of the skull. Such subjects are rare, and opportunities to utilize them for experimental purposes rarer. The orbit, however, is always accessible.

For the purposes of this investigation, it was necessary to have apparatus much more delicate than that employed by Mosso. The blood-supply of the orbit is brought through an artery only a millimetre in diameter. I therefore employed some forms of apparatus that I had devised for very delicate physiological work.⁴ This apparatus is the piston-recorder for air connections, and the ether piston-recorder. For the purposes of this article it is not necessary to give a minute description of this exquisitely delicate apparatus. I hope to do this in a future article, treating of the finger plethysmograph and its applicability to clinical research.

The experiments were performed as follows: A piece of gutta-percha, five millimetres in thickness, was accurately moulded to the portion of face surrounding the orbit, after previous softening in warm water. A hole was made in this in a part corresponding to the centre of the orbit. A short glass-tube was fixed hermetically to this aperture. The gutta-percha shield was securely bandaged over the orbit, and the glass-tube in its centre was put in communication with the piston-recorder by means of a rubber-tube. If there is no leakage of air beneath the shield, which, with proper care, may be obviated, it is easy to obtain a

⁴Journal of Physiology, Vol. VII, p. 309.

record upon smoked paper of the circulatory changes in the orbit. The most striking feature of these records is the peculiar shape of the pulse-curve. The curve is anacrotic, the secondary undulations appearing in the ascending portion and vertex. In order to greatly magnify these curves, I employed the ether piston instead of the ordinary form, and recorded its excursions by photography according to the method

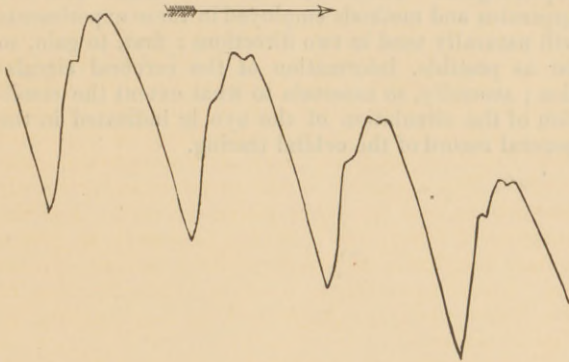


FIG. 2.

described by me in the *Journal of Physiology*.⁵ Figure 2 is a somewhat reduced reproduction of the outline of one of the records obtained. The very marked similarity of the form of the pulse-curves in this record to that of the brain-tracing in Figure 1, is very apparent. This tracing is entirely different from one taken from the carotid in the neck or from any peripheral bloodvessel. It shows very clearly how intimately the circulation of the orbit is related to that of the cranial cavity. The peculiar form of the

⁵ Vol. VII, p. 314.

pulse-curve may also contribute in a measure toward the advancement of our knowledge of vascular physiology in general. The purpose of this preliminary account of these researches is to call attention to the exceeding delicacy of the methods employed, and to record the interesting fact that the pulse-curve of the orbit is very similar to that of the brain. The subject should be of interest to ophthalmologists as well as physiologists. The researches to be made with the apparatus and methods employed in these experiments will naturally tend in two directions: first, to gain, so far as possible, information of the cerebral circulation; secondly, to ascertain to what extent the condition of the circulation of the eye is indicated in the general record of the orbital tracing.

