

flows into the measuring chambers. Blood from animal X is now pumped into chamber B1 instead of Chamber A1, thereby expelling into animal X the blood from animal Y which had been collected in chamber B2 during the preceding cycle. The number of changes of the valve mechanism is recorded automatically on a meter and provides an easy and convenient way of determining mean blood flow and total amount exchanged. The volume of the chambers is 50 cc each.

This arrangement has the following advantages: It measures and equalizes the flow of blood in both directions automatically. It provides for simultaneous withdrawal and administration of equal amounts of blood. The accuracy of the registration of blood flow is about $\pm 1-3$ cc in 10,000 cc, depending upon the fit of the piston and on the pres-

sure differential in the two circuits. The device has been found completely satisfactory in experiments involving the exchange of a total, to date, of 500,000 cc of blood in both animals and human beings. The amount of heparin needed to prevent coagulation is within the clinically acceptable limits. Hemolysis does not occur if the pump is properly adjusted. Cross transfusion itself has proved to be a safe, efficient and relatively easy procedure, when performed with the apparatus described above. No fatalities attributable to the procedure itself have occurred.

Summary. A safe, effective and easily controlled apparatus for cross transfusion is described.

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17271. Vasomotor Reactions in the Mesenteric and Serosal Capillary Bed During Fright and Violent Muscular Activity.*

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Recently, technics were devised for painless exposure, with local anesthesia, of the guinea pig mesentery and gut and its maintenance in a warmed chamber where the capillary bed could be observed continuously with the microscope.¹ This permitted study of peripheral vasomotor reactions, and vascular responses to drugs without possible variables introduced by general anesthesia. In addition, the fact that the animal studied was fully conscious afforded the opportunity to witness the behavior of terminal arterioles and capillaries in this splanchnic area during

various emotional states and spontaneous muscular activity.

Methods. Studies were made on 20 animals receiving a normal well supplemented diet, and on 21 animals in moderately advanced Vitamin C deficiency after 3-4 weeks on a standard scorbutogenic diet. The apparatus and diet have been described previously.¹ In brief, it includes holding a trained animal under light restraint, with cautious painless exposure of the mesentery and gut via a denervated or procaine field block in the flank. The preparation is maintained in a suitable warm chamber and continuously bathed with a drip solution of warmed buffered Ringer-gelatin solution, while being observed under the microscope.

Results. A. Animals receiving a "normal" diet. The changes found in the capillary bed of this splanchnic region in the control animals could be divided into 2 major categories. The

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¹ Lee, Richard E., and Lee, Nina Z., *Am. J. Physiol.*, 1947, 149, 465.

terms "startle reaction" and "flight reaction" are based on the degree of overt manifestation of "emotional" disturbances.

1. The "startle reaction." It was first noticed that following a sudden loud noise, the animal being examined might shudder, or otherwise appear startled. The great majority of such responses were not accompanied by any observed phenomena in the splanchnic vascular bed. In approximately 20% of such situations, however, there was a slight narrowing of mesenteric and serosal arterioles of diameters ranging from 50-80 μ with general slowing of capillary blood flow. Precapillary sphincters usually narrowed partially. This vasoconstriction generally began 1-2 seconds after the brief startle response by the animal, and lasted 5-10 seconds at most. It frequently involved isolated regions of the arteriole, producing a band-like constriction of 30-40 μ in length, in which the arteriolar diameter was reduced occasionally by 25-50%. As repeated "startle" responses were induced in the same animal, it was noted that these sphincterlike constrictions of the arterioles invariably occurred at the same locus. Apparently, certain "key sites" along the small peripheral vessels, perhaps associated with the terminals of particular nerve fibers, are capable of response at levels of psychic stimulation below those required for a more generalized vasoconstriction.

2. The "flight reaction." Occasionally, the auditory and other stimuli would be followed by a much more vigorous and prolonged sudden reaction, in which the animal would struggle violently to escape from his bonds. This muscular effort (and apparently emotional disturbance) usually lasted for 5-20 seconds, then ceased as suddenly as it had begun. Motion of the fields under observation often prevented accurate visualization during these episodes.

Of those instances in which the mesentery remained relatively undisturbed, approximately 25% were accompanied by no observed vascular changes. In 50% of the episodes, vascular phenomena were found resembling those of the startle reaction but generally of greater magnitude. The remaining 25% of the "flight reactions" were ac-

companied by profound changes in the vessels. Within 1-2 seconds after the onset of struggling the "key sites" of the larger arterioles became greatly narrowed to completely occluded. Apparently at the same time, narrowing occurred in the entire remainder of the arteriolar components, with marked to complete constriction of all pre-capillary sphincters in the mesentery and serosa. This intense and widespread vasoconstriction resulted in a complete cessation of observed arteriolar blood flow to the gut, with limitation of active circulation to the larger mesenteric arterial arcades. The blood flow in the venules and veins became very sluggish, but continued. This afforded a relatively rapid drainage into the general circulation of much of the residual capillary blood.

This picture of complete capillary stagnation lasted throughout the period of excitement and muscular activity. When struggling ceased, frequently no change was seen for 5-10 seconds. The first areas to release their spasm were the "key sites" along the larger arterioles. Flow gradually increased through the narrowed arteriolar tree along the more direct A-V channels. Within 15-20 seconds, the smaller arterioles began to dilate, resulting in augmentation of flow in the arteriolar net. It was frequently 1-2 minutes, however, before sufficient pre-capillary sphincters had opened to permit a return of adequate capillary circulation. Following the disappearance of this vasospastic state, no further obvious changes were noted in this study.

In 3 instances, observations on arteriolar and precapillary sensitivity to topical epinephrine were made immediately after the resumption of a normal capillary flow. In each it was found to be at least 300% greater than control readings of 1:2,000,000. Five minutes later it had returned to normal values.

B. The scorbutic animals. Although the "startle responses" and the "flight responses" occurred as frequently and as readily in the scorbutic guinea pigs as compared to the pair-fed controls, circulatory changes during or following these episodes were not observed. The relatively depressed condition of the peri-

pheral vascular system in this nutritional deficiency, and its possible significance has been reported previously.¹

Discussion. Although the mucosal blood vessels were not observed directly in this study, the complete cessation of blood flow found frequently in the small arteries and arterioles supplying the mesentery and traversing it to supply the intestine support the assumption that accompanying the "flight reaction" there is often a complete stagnation of blood flow in this viscus. This is apparently maintained throughout the period of response to the stimulus, and subsequently returns slowly. Of particular interest is the fact that even at the height of response, continuous blood flow through the arterial arcades and the larger venules and veins in the mesentery affords a means of draining much of the residual capillary blood in this region and returning it, along with the blood shunted to the arcade system, back to the general circulation. One can assume that this would considerably increase the volume of blood available for other somatic areas during the period of active vascular response.

The absence of vasospasm in the mesentery and serosa during the flight response in scor-

butic animals is associated with a general depression of arteriolar and precapillary tone, and impaired venular flow.¹ It remains to be determined whether these manifestations of ascorbic acid deficiency are a result of general tissue disfunction or are perhaps a specific defect in some vasotonic mechanism.

Summary and conclusions. 1. Technics were devised for viewing the mesenteric and serosal capillary bed of guinea pigs not under a general anesthetic agent.

2. The degree of emotional response to auditory stimuli could be correlated with the magnitude of changes in the visualized splanchnic vessels.

3. (a) A "startle response" was occasionally accompanied by transient slight vasoconstriction and slowing of blood flow.

(b) A "flight response" was frequently characterized by intense vasoconstriction of arterioles, complete stagnation of capillary blood flow, and a drainage of residual capillary blood into patent venules.

3. Certain "key sites" along the arteriolar tree have a lower threshold of response than remaining areas, and exert much control of arteriolar flow by sphincter-like activity.

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17272. Reversal of Insulin-Induced Hypoglycemia in Chick Embryos by Nicotinamide and α -Ketoglutaric Acid.*

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In a series of papers Landauer and his collaborators¹⁻⁴ have described the teratogenic effects which insulin produces when it is in-

jected into the yolk sac of chick embryos. When the insulin is applied in this manner to early embryos (0-72 hrs) caudal defects (rumplessness) are the most frequently encountered anomalies. When injected into older embryos (96-168 hrs) the insulin causes a high incidence of disproportionate shortening of the legs (micromelia). These effects of insulin disappear when the insulin is inactivated and reappear when inactivated insulin is reactivated. Landauer⁵ demonstrated that when

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¹ Landauer, W., *J. Exp. Zool.*, 1945, **98**, 65.

² Landauer, W., and Lang, E. H., *J. Exp. Zool.*, 1946, **101**, 41.

³ Landauer, W., and Bliss, C. I., *J. Exp. Zool.*, 1946, **102**, 1.

⁴ Landauer, W., *J. Exp. Zool.*, 1947, **105**, 145.

⁵ Landauer, W., *J. Exp. Zool.*, 1948, **109**, 283.