are discussed in relation to the action of plasma albumin on cell metabolism and to interactions between fatty acids, plasma albumin, and red blood cells.

1. Bellis, C. J., Scott, F. H., PROC. SOC. EXP. BIOL. AND MED., 1931, v29, 1105.

2. Davis, B. D., Dubos, R. J., *J. Exp. Med.,* 1947, v86, 215.

3. Dervichian, D. G., *Ann. Inst. Pasteur* (Paris), 1950, v79, 338.

4. Glinos, A. D., in: *A Symposium on the Chemical Basis of Development,* Edited by William D. McElroy and Bentley Glass (Johns Hopkins Press, 1958), p813.

5. Goodman, D. S., *J. Am. Chem. Soc.,* 1958, v80, 3892.

6. Fritz, I. B., Davis, D. G., Holtrop, R. H., Dundee, H., *Am. J. Physiol.,* 1958, v194, 379.

7. Furchgott, R. F., *J. Exp. Biol.,* 1940, v17, 30 and 126.

8. Helinski, D. R., Cooper, C., *J. Biol. Chem.,* 1960, v235, 3573.

9. Hewitt, L. F., *Biochem. J.,* 1938, v32, 27 and 1540.

10. Hrachovec, J. P., Leblanc, M., Rockstein, M., PROC. SOC. EXP. BIOL. AND MED., 1961, v107, 205.

11. James, A. T., Lovelock, J. E., Webb, J. P. W., in: *Essential Fatty Acids,* edited by H. M. Sinclair, Butterworth Scientific Publications, London, 1957, p72; *Biochem. J.,* 1959, v73, 106.

12. Mines, C. J., Fillerup, D. L., Mead, J. F., *Nature,* 1961, v190, 92.

13. Sacktor, B., O'Neill, J. J., Cochran, D. G., *J. Biol. Chem.,* 1958, v233, 1958.

14. Scott, F. H., *J. Physiol.,* 1915, v50, 128.

15. Shipp, J. C., Opie, L. H., Challoner, D., *Nature,* 1961, v189, 1018.

Received February 15, 1962. P.S.E.B.M., 1962, v110.

Arteriovenous Pressure Differences Following Arterial Occlusion in the Intestine.* (27480)

LERNER B. HINSHAW

Environmental Physiology Branch, Civil Aeromedical Research Institute, Federal Aviation Agency, Oklahoma City, Okla.

Vascular resistance has been observed to increase markedly at low perfusion flow rates in the whole animal(1,2) and in isolated tissues(3-5). It has been postulated that as flow is further diminished, the increase in resistance may proceed to total occlusion of small arterial vessels once a critical pressure has been reached(6). Recent investigations have been concerned with the magnitude of this pressure at which blood flow is reduced to zero(7-10). Results have shown that if a positive arteriovenous pressure difference is found at zero flow it is produced by extravascular pressure acting as a collapsing force on blood vessels(8,9). It was considered of interest to extend these earlier observations to incorporate the visceral circulation.

Methods. The perfusion technics used have been previously reported(7-9,11,12). Adult dogs intravenously anesthetized with sodium pentobarbital, 30 mg/kg, were used in 8 perfusion experiments. A loop of the small intestine was carefully dissected free, together with its connection to the superior mesenteric artery and aorta, and perfused in a retrograde fashion *via* the aorta, the tip of the perfusion cannula positioned just distal to the origin of the superior mesenteric artery. This procedure permitted transfer of the intestine to the perfusion apparatus without interruption of blood flow. Great care was taken to avoid severing arterial vessels so that all blood perfused tissue and drained through a large severed mesenteric vein. Intestines were transferred to the perfusion apparatus, suspended on a strain gauge weighing device(13) and perfused with a sigma-motor pump at the highest flow compatible with the isogravimetric state. Blood for the intestinal perfusion circuit was obtained from a pump-lung apparatus(8,9), or anesthetized

* Research completed in part at Univ. of Minnesota, Dept. of Physiology, supported by grant from Life Insurance Medical Research Fund.

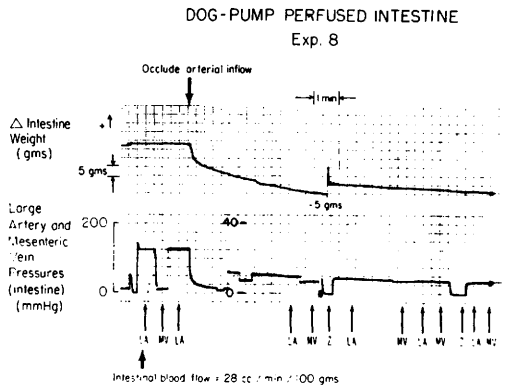

FIG. 1. Arteriovenous pressure differences following occlusion of arterial inflow in the isolated perfused intestine. LA = large artery pressure; MV = small mesenteric vein pressure; Z = zero pressure (catheter tip placed at mid-point of organ), also equal to large mesenteric orifice vein pressure.

donor dog(12). Plastic cannulae were secured in each end of the intestine loop to allow for drainage of fluid into a separate reservoir. "Mesenteric vein pressure" from vessels of a diameter approximately 0.7 mm was obtained *via* retrograde cannulation. This pressure is to be compared with "mesenteric orifice vein pressure" which refers to the large severed mesenteric vein from which perfused blood was collected at atmospheric pressure. The intestinal loop was arranged to lie flat on a perforated plastic plate suspended from the strain gauge weighing device. All pressures were measured with a strain gauge transducer and recorded on a direct writing Sanborn recorder. The zero catheter tip was placed in position by sighting across the midline of the intestine, and arterial and venous pressures were also taken at this level. Stopcocks were arranged so that pressures could be alternately recorded from the same strain gauge, which minimized errors due to zero drift and permitted accurately recorded arteriovenous pressure differences. Pressures and weight changes were measured following cessation of arterial inflow to the intestine by simultaneously stopping the sigmamotor pump and clamping the pump outflow tubing with a large hemostat. In the absence of release of contents from the intestine lumen, the rate of fall in organ weight was taken to indicate the venous outflow under the declining arterial pressure head. The post-occlusion period was extended until the arteriovenous pressure difference became stable. The estimated technical error in measurement of arterial and venous pressures in regard to zero catheter placement was 0.5 mm Hg.

Results. Fig. 1 shows the raw data from one experiment following cessation of arterial inflow (Exp. 8). Values are seen to fall rapidly during the first 40 seconds following interruption of inflow. Thereafter changes are more gradual until large artery and small mesenteric vein pressures are equal. This figure illustrates the importance of waiting until all measurements become stable before choosing an arteriovenous pressure value at zero flow.

Table I summarizes the results from 8 experiments. It is seen that pressures and flows are highly variable during control periods. An average post-occlusion period of 10 minutes is required before the arteriovenous pressure differences become relatively stable and rate of venous outflow becomes negligible. At this time there is an average arteriovenous pressure difference of + 0.6 mm Hg which is not statistically significant.

Discussion. Our findings are in agreement with previously reported investigations on the lung, limb, kidney and heart(7-10). Following cessation of arterial inflow the arteriovenous pressure difference steadily declined and as the rate of venous outflow approached zero, a relatively stable arteriovenous pressure difference not significantly different from zero mm Hg was observed. Since considerable time is required for large artery and mesenteric vein pressures to come together, a high resistance appears to exist in the vascular circuit. However, resistance though high presumably remains finite and flow continues through vascular channels until the driving pressure has disappeared.

Recent work has emphasized vascular reactions following sudden changes in pressure and flow(14). On the basis of these findings it is possible that the sustained interruption of arterial inflow in the present experiments may have obliterated a previously existing "critical closing pressure." This possibility

TABLE I. Stable Arteriovenous Pressure Differences Following Cessation of Arterial Inflow in the Isolated Intestine.

	Initial values			Values following cessation of arterial inflow			
Exp.	LA (mm Hg)	MV (mm Hg)	Blood flow (cc /min./100 g)	Time (min.)	LA (mm Hg)	MV (mm Hg)	LA – MV (mm Hg)
1	157	7.5	61	9	2.2	2.0	+ .2
2	70	5.0	55	13	4.5	4.5	.0
3	191	12.5	140	7	3.9	4.4	– .5
4	113	10.2	58	10	2.5	2.0	+ .5
5	106	15.5	46	6	7.5	7.5	.0
6	92	14.5	57	6	7.5	5.0	+2.5
7	129	4.0	15	19	4.8	3.0	+1.8
8	125	11.0	28	11	6.8	6.8	.0
Mean	123	10.0	58	10	5.0	4.4	.6
S.E.					± .8	± .8	
S.E., difference between means						± 1.1	

LA = large artery pressure; MV = mesenteric vein pressure (vessel diameter approximately equal to 0.7 mm); orifice vein pressure = 0 mm Hg.

Time refers to min. required for stable pressure values following cessation of arterial inflow.

Exp. 1-6, pump-lung perfused intestine; Exp. 7-8, dog-pump perfused intestine.

merits serious consideration in future investigations.

It is to be observed that if pressures of small mesenteric veins were not measured, a statistically significant positive arteriovenous pressure difference would have been obtained at zero flow. The presence of the elevated venous pressures at zero flow may be due to the effects of a residual extravascular pressure (8,9), so that the venous transmural pressure is zero. Although the present experiments were carried out on the isolated denervated intestine, these results and previous findings from other isolated organs(7-9) show good agreement with those obtained from intact dogs(2).

Summary. Previous investigations have been concerned with the magnitude of the arteriovenous pressure difference when the blood flow is reduced to zero. The purpose of the present study was to extend earlier observations to include the mesenteric circulation. Isolated dog intestines were perfused with a pump-lung or dog-pump apparatus. Following cessation of arterial inflow the arteriovenous pressure difference steadily declined. As the rate of venous outflow approached zero, an arteriovenous pressure difference not significantly different from zero mm Hg was observed. Results suggest the importance of the role of the transmural pressure in interpretation of pressure-resistance relationships.

1. Read, R. C., Johnson, J. A., Kuida, H., *Am. J. Physiol.*, 1957, v190, 49.

2. Read, R. C., Kuida, H., Johnson, J. A., *Circ. Res.*, 1957, v5, 676.

3. Nichol, J., Girling, F., Jerrard, W., Claxton, E. B., Burton, A. C., *Am. J. Physiol.*, 1951, v164, 330.

4. Doyle, A. E., *Circulation Res.*, 1953, v1, 375.

5. Selkurt, E. E., Scibetta, M. P., Cull, T. E., *ibid.*, 1958, v6, 92.

6. Burton, A. C., *Am. J. Physiol.*, 1951, v164, 319.

7. Gilbert, R. P., Hinshaw, L. B., Kuida, H., Visscher, M. B., *ibid.*, 1958, v194, 160.

8. Hinshaw, L. B., Day, S. B., *ibid.*, 1959, v196, 489.

9. Hinshaw, L. B., Day, S. B., Carlson, C. H., *ibid.*, 1959, v196, 1132.

10. Day, S. B., Johnson, J. A., *ibid.*, 1959, v196, 1289.

11. Kuida, H., Hinshaw, L. B., Gilbert, R. P., Visscher, M. B., *ibid.*, 1958, v192, 335.

12. Hinshaw, L. B., Gilbert, R. P., Kuida, H., Visscher, M. B., PROC. SOC. EXP. BIOL. AND MED., 1958, v99, 684.

13. Stish, R. J., MacLean, L. D., Visscher, M. B., *J. Appl. Physiol.*, 1956, v9, 297.

14. Stainsby, W. N., Renkin, E. M., *Am. J. Physiol.*, 1961, v201, 117.

Received February 26, 1962. P.S.E.B.M., 1962, v110.