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Some Observations on Circulatory Changes in a Renal Glomerulus.

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In a female Necturus, anesthetized with urethane, a glomerulus showing sluggish blood flow was observed; the capillary loops were dilated, although not uniformly. The picture was unchanged by pithing the brain. This glomerulus was peculiar in that both afferent and efferent vessels were clearly seen; the afferent vessel came direct from a large ovarian artery. There was no alternation of flow. The afferent vessel was now stroked gently with a fine glass rod; there was no response. More vigorous stroking resulted in a shifting of the kidney region in the field after about a 5 second latent period; this was followed in 5 seconds more by constriction of the afferent vessel to the point of cessation, complete or practically so, of cell movement in the glomerulus. The shifting of the kidney region preceding afferent vessel constriction was seen to be due to a contraction of the ovarian artery from which the afferent vessel sprang, resulting in a tugging on the kidney. It was then found that traction on the ovarian artery was an adequate stimulus to this vasoconstriction, which spread from the artery to the afferent vessel. After this experiment had been repeated a few times at intervals of 3 or 4 minutes the phenomenon would occur without external stimulation; previous to its first production the flow had been steady for the 20 minute period of observation.

Both between and during periods of afferent vessel constriction the efferent vessel was seen to be constantly constricted, being narrower than the narrowest loop in the capillary tuft. Cells passed through it rapidly and in single file. Actual observation of such a constricted efferent vessel strengthens an idea which has been held for some time, that the slow blood flow through dilated glomerular capillaries at a time when the general circulation is vigorous is due to efferent vessel spasm.

The series of changes during a period as noted above was as follows. At first after mechanical stimulation and later spontaneously, at intervals of 4 or 5 minutes, the first step was a slowing, then cessation, then reversal of flow in the ovarian artery. This was due to a constriction which obviously involved the artery itself and probably its terminations; the reversal of flow was apparently due to the continued constriction of the artery after its peripheral branches were blocked, this constriction eventually involving the afferent vessel. The artery was about 400μ wide normally, about 280μ during constriction. The flow of blood in the accompanying ovarian vein was slowed but did not stop; the circulation in the adjoining glomerulus on either side of the one under observation was not affected. A few seconds after the first change was noted in the ovarian artery flow the afferent vessel disappeared from view and glomerular flow suddenly stopped, apparently in all the loops simultaneously. The capillary tuft appeared to collapse toward the arterial pole; the afferent vessel was emptied of cells but not all of the capillary loops were. The point of greatest interest is the appearance of the efferent vessel during such a cycle. Its diameter was apparently unchanged; usually an altered flow persisted in the efferent vessel through an entire cycle, at other times, when the afferent vessel constriction presumably was more vigorous, it stopped entirely. It was evident that the ratio of plasma to cells in the blood traversing the efferent vessel during periods of afferent constriction was greater than between such periods. These observations lend support to the idea expressed by Richards and Schmidt[1] that plasma skimming may occur in the afferent vessel. The mere fact that some forward movement of cells may be seen in the glomerular loops for some seconds after the afferent vessel has disappeared from view is open to two interpretations, plasma skimming in the afferent vessel or independent contractility of the loops. The behavior of the flow observed in the efferent vessel indicates that the former interpretation is correct. For if the slow and occasional

[1] Richards, A. N., and Schmidt, C. F., *Am. J. Physiol.*, 1924, lxxi, 178.

movement of cells seen in the capillaries during such a period were due only to capillary contractions, the afferent vessel being completely closed, it seems unlikely that the passage of these cells through the efferent vessel would be as rapid as was observed during this time. The increased ratio of plasma to cells must mean that the amount of plasma traversing the efferent vessel was more than could be accounted for by the mere squeezing out of blood preexisting in the capillaries. The fact that not all of the loops were emptied of cells at a time when there was, as evidenced by the appearance of the efferent vessel, a fairly rapid passage of plasma through the glomerulus may mean that the passage was largely confined to those loops which were emptied or that the diminished flow was insufficient to overcome in all cases the adhesion of the cells to the capillary walls. The assumption of a constriction at the junction of capillaries with efferent vessel would hardly help to explain this finding; in that event the cells should have been piled up at the efferent ends of the capillaries, which was not the case.

It has seemed worth while for several reasons to report these observations made on a single glomerulus. In the first place this is the first report so far as I know, of observations on a glomerulus whose efferent vessel was visualized during cessation of cell movement in the afferent vessel. At the time of the observations no one had reported having seen both afferent and efferent vessels of the same glomerulus in the living kidney. Only a few days later a paper by Bieter[2] appeared in which he mentions seeing both vessels in frogs' glomeruli but gives no description of the efferent vessel during afferent constriction. The significance of the efferent vessel picture in attempting to decide the question of capillary contractility has already been referred to. In the second place actual visualization of a constricted efferent vessel with a slow blood flow through dilated capillary loops affords an explanation for a type of glomerular flow often seen in Necturus. It was only natural to assume this explanation but until an efferent vessel could be seen under these conditions it could be only an assumption. In the third place the origin of an afferent vessel directly from a large ovarian artery is interesting, although probably not common. This vessel was seen throughout its entire length; it was 240μ long and, between periods of constriction, about 40μ wide. This peculiar origin of the afferent vessel, if it could be shown to occur with any significant frequency, which it probably does not, might afford an interesting explanation of a urine flow in the amphibian kidney after ligation of all the

[2] Bieter, R. N., *Am. J. Physiol.*, 1930, xci, 436.

renal arteries. The first part of the efferent vessel could not be seen, as it lay dorsal to the glomerulus. It could be seen, apparently just dorsal to the dorsal wall of the capsule, through the clear space that separated the capillary tuft from the capsule wall. The segment thus seen was about 150μ long and was narrower than the narrowest capillary in the glomerulus, being not more than 20μ wide. It could not be followed beyond the edge of the capsule. The fact that both vessels could be seen in this glomerulus is almost certainly due to the atypical arrangement.

It will be noted that the events described here are probably not the same as the alternation of glomerular flow described by Richards and Schmidt and by Bieter. In their experiments on the frog alternation of glomerular flow was a frequent spontaneous occurrence and there was no reason to believe that the vascular constriction involved anything central to the afferent vessel. In the observations reported here the afferent vessel constriction was secondary to that of the large artery from which it sprang; the phenomenon did not occur until initiated by mechanical stimulation, although after having been so initiated it recurred rhythmically.

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Use of the Interferometer for Serum Protein and Protein Fraction Determinations.

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Adams[1] stated that the interferometer was a precision instrument suitable for all sorts of determinations in which the refractometer has been used, with the additional advantage of being much less susceptible to temperature change and much more accurate. He states that with the refractometer one must regulate the change in temperature to 0.01° in order to secure an accuracy of one unit in the sixth place, but the interferometer requires no special regulation of temperature to secure an accuracy of one unit in the seventh place. In determining serum proteins, we found that a serum which read 454 at 15°, would read 452 at 30°, the difference being equivalent to 0.014% protein. Therefore, all readings have been made at room temperature.

[1] Adams, L. H., *J. Am. Chem. Soc.*, 1915, xxxvii, 1181.