Depressor Reflex from the Kidney with Altered Perfusion Pressure

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The cardiovascular effects of altering perfusion pressure in the kidney on systemic pressure were studied in the cross-perfusion experiments of dogs. Perfusion pressure was varied through a range of 120–300 mm.Hg with and without simultaneous compression of the renal vein. It was demonstrated that small but observable depressor reflex originated from the kidney. Evidence indicated that renal venous pressure played an important role in the reflex.

During previous cross-perfusion experiments of the kidney in this laboratory on dogs,1) it was occasionally found that obstruction of the outflow of the perfused kidney caused systemic hypotension in the recipient. This observation implied a possible role of the kidney in the reflex control of the cardiovascular system. However, the presence of baroreceptors in the renal vascular circuit has not been fully established. The present study was undertaken to define the vasomotor effects of alterations in pressure in the kidney of anesthetized dogs.

Methods

The experiments were performed on 10 mongrel dogs anesthetized with morphine chloride (3 mg./Kg.) and chloralose (80 mg./Kg.). Our cross-perfusion technique has been described in a previous article.2) Using polyethylene tubes, the femoral artery of the donor dog was connected with the renal artery of the recipient dog and the recipient's renal vein was linked to the donor's femoral vein through an electromagnetic flowmeter. Systemic arterial pressure of the recipient animal was measured in the femoral artery and perfusion pressure was recorded from a side arm which was placed proximal to the recipient's renal artery in the perfusion circuit. Pressures in these places were measured utilizing electromanometers. Variations in perfusion pressure were produced by injecting physiological saline from a syringe into a perfusion circuit or by clamping the circuit tube. Compression of the renal vein was also carried out by a clamp. Renal blood flow and the pressures were continually and simultaneously recorded. Heparin was given intravenously. In the course of the experiments, the sinus nerves and vagi were sectioned in the cervical level and subdiaphragmatically, respectively. In some experiments, the splanchnic nerves, greater and lesser, were eliminated to analyse the reflex arc of the response.

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**Results**

Fig. 1 presents the effect of variations in perfusion pressure (−20% to +140% in mean pressure) upon systemic arterial pressure of the recipient with and without renal venous obstruction and the typical responses are demonstrated in Fig. 2. It is easily noted that the effects are modified by changes in resistance to renal outflow.

Without renal venous compression, observed changes in systemic pressure were small despite large variations in perfusion pressure. When perfusion pressure was elevated, at least 80% increase in mean pressure was necessary for just recognizable response, while there was no appreciable alteration in systemic pressure during a fall in perfusion pressure. Furthermore, the more
than 10% decrease in systemic pressure was elicited only in 3 out of 9 dogs. Thus the thresholds determined were exceedingly high and the responses were not constant among animals.

On the other hand, with simultaneous compression of the renal vein, elevation of perfusion pressure was far effective in eliciting systemic hypotension. In this series, a small but observable lowering in systemic pressure was usually obtained in the range of 10-40% increases in mean perfusion pressure. In 3 experiments, venous occlusion by itself produced a minor reproducible reduction in systemic pressure. Again in this series, however, no dog responded to negative perfusion pressure.

In several experiments, sinus denervation potentiated the response, whereas the response was found to be invariably inhibited or diminished by bilateral splanchnicectomy (Fig. 3). Vagotomy or atropinization did not modify the reflex.

![Fig. 3. Sinus denervation potentiates the depressor effect without renal venous obstruction, while splanchnicectomy abolishes the effect. A and B: before and after sinus denervation respectively. C and D: before and after splanchnicectomy respectively.](image)

**DISCUSSION**

As to whether reflexes originating within the kidney, which influence systemic pressure, can exist, controversy has been continued. Heymans and coworkers\(^3\) found no reflex response from the kidney in their perfusion experiments on the spinal dogs. The work of Page and McCubbin\(^4\) confirmed the results. They noted that there was no accompanying change in arterial pressure in the recipient dog, though very large rises in perfusion pressure were elicited by many pressor substances or by the increased output of the pump. On the other hand, the presence of the reflex from the kidney has been suggested in several papers. Abraham\(^5\) noted receptors, similar to those of the carotid sinus, in the wall of the renal artery of the cattle histologically. Iri-sawa\(^6\) demonstrated in the dogs that a reflex decrease in systemic blood pres-
sure was elicited by raising the pressure in the renal artery sac with saline. Afferent impulses in nerves of the renal plexes have also been recorded by several investigators.\textsuperscript{7,8)}

In our first series of experiments in which the renal outflow was intact, the thresholds of the responses were extraordinarily high. Since the significant effects were scarcely produced with mean perfusion pressure over 100\% up to the control level, the results observed would be in essential agreement with that of Page and McCubbin. But the second series of experiments revealed that venous occlusion always augmented the effects and made the responses apparent in the physiological range of perfusion pressure. The results also showed that the induced vasomotor responses were depended on an intact nerve supply of the kidney and often became more pronounced after eliminating circulatory reflexes from the sinus nerves. These findings, therefore, suggest that the responses represent reflex ones and the kidney plays a significant role in the reflex control of the cardiovascular system in the condition of the high renal venous pressure.

Recently much has been written on the subject of participation of the vein in the cardiovascular reflex.\textsuperscript{9)} In the perfusion experiments of the pulmonary vascular bed, it has been observed that no reflex hypotension can be evoked in the recipient's systemic pressure unless the pulmonary venous drainage is obstructed.\textsuperscript{10,11)} In the renal vascular circuit, Pines\textsuperscript{8)} obtained the marked discharge of afferent impulses in the renal nerves by constricting the renal vein. Taking such reports into account, it seems possible that stretching the venous wall in the kidney not only elicits a local venous-arteriolar reflex,\textsuperscript{12)} but also affects systemic blood pressure, supplementing the central buffer reflexes. However, since graded increment in perfusion pressure with concomitant compression of the renal vein would cause a rise in pressure in various parts of the kidney,\textsuperscript{13)-15)} the precise localization of the renal barosensitive area can not be decided from the present results.

Concerning the reflex arc, the response was consistently abolished or decreased after sectioning the splanchnic nerves which therefore might be the afferent pathway for the reflex.

Under the condition of the present experiment, the effects were always of depressor type and was not modified by vagotomy or with atropine. According to a recent paper of Folkow et al.,\textsuperscript{16)} manipulation of the abdominal viscera elicits the depressor effects, which are identical with those obtained on baroreceptor stimulation, but the involved afferent fibers are possibly the same to pain fibers. As shown by Mitchell,\textsuperscript{17)} afferent renal fibers, including pain fibers, are conveyed through the various splanchnic nerves and sympathetic trunks. In view of such observations, it seems likely that the vasomotor effects
obtained in this experiments are non-specific viscerovascular reflexes. However, acute and extreme alterations in intraluminal urinary tract pressure are said not necessarily to cause systemic hypotension. Mukherjee observed even systemic hypertension by stretching the urinary bladder in the cat. These facts imply that the manipulation of hollow visceral organs does not vary systemic pressure in the same manner. The absence of distinct systemic pressor effects from the kidney, therefore, might be characteristic of this experiment.

In conclusion, the present evidence demonstrated the existence of small but observable depressor reflex from the kidney, though the physiological meaning of it remained to be determined. Since renal venous pressure plays an important role in this reflex, the mechanism which initially operates to compress the renal vein may be expected to cause the response. In this regard, the findings might be related to vasomotor instability in the patients with orthostatic proteinuria, because it has been reported that passive renal hyperemia is frequently produced by excessive mobility of the renal pedicle in these patients, with ptosis of the kidney in the erect posture.

**Summary**

(1) In anesthetized dogs the kidney was perfused in situ by another dog and the cardiovascular effects of alterations in pressure in the kidney have been investigated.

(2) Elevated perfusion pressure with intact renal outflow (mean pressure between 120 and 300 mm.Hg) infrequently produced a fall in systemic arterial pressure of the recipient; in 3 out of 9 dogs, systemic pressure decreased more than 10%; in 6 dogs, there was little or no effect.

(3) The increment in perfusion pressure with simultaneous occlusion of the renal vein caused systemic hypotension more effectively than without. In this series, a significant lowering in systemic pressure was obtained in the physiological range of perfusion pressure. The effects were ordinarily potentiated by sinus nerve denervation and abolished by splanchnicectomy.

(4) It is concluded that minor but reproducible decrease in systemic arterial pressure is reflexly elicited by increasing pressure in the kidney. Renal venous pressure plays an important role in this response.

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