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ELECTROPHYSIOLOGICAL CHARACTERISTICS OF RENORENAL REFLEXES IN THE CAT

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SUMMARY

1. Experiments were done in anaesthetized, paralysed and artificially ventilated cats to determine the fibre composition of renal nerves and to study the functional characteristics of reflex responses recorded in efferent renal nerves during electrical stimulation of contralateral and ipsilateral afferent renal nerves.

2. Renal nerves were found to contain three afferent fibre groups (Aβ, Aδ and C); the majority of these fibres reach the sympathetic chain through the least splanchnic nerve. Efferent sympathetic nerves to the kidney were found to originate from the greater, lesser and least splanchnic nerves through a synapse in the coeliac ganglion.

3. Two contralateral renorenal reflex responses were demonstrated during selective stimulation of renal afferent A and C fibres. The first (A renorenal reflex) was elicited by stimulation with trains of pulses at low voltage and high frequency (200 Hz), had an onset latency of approximately 100 msec and was followed by post-excitatory depression. The second (C renorenal reflex) was demonstrated by trains of pulses at high voltage and low frequency (20–30 Hz), had an onset latency of approximately 350 msec and was also followed by post-excitatory depression.

4. Ipsilateral renorenal reflexes with characteristics similar to the contralateral reflexes were also demonstrated.

5. Renorenal reflexes were abolished by destruction of the spinal cord and administration of nicotine sulphate (5–20 mg/kg, I.V.), but were not affected by bicuculline (0·4 mg/kg, I.V.).

6. The significance and the physiological role of these renorenal reflexes as well as their pathways within the central nervous system remain to be determined.

INTRODUCTION

The physiological characteristics of somatosympathetic reflexes have been investigated extensively (for reviews see Koizumi & Brooks, 1972; Sato & Schmidt, 1973). By comparison, little is known about the electrophysiological properties of sympathetic reflex responses due to excitation of visceral afferent fibres. These responses have been referred to either as viscero-visceral reflexes or have been named after the organ from which receptors originate and to which efferent responses are directed. For example, it has been shown that stimulation of splanchnic afferent fibres elicits,

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in lumbar white rami, reflex discharges which are essentially similar to those evoked by stimulation of somatic nerves (Sato, Kaufman, Koizumi & Brooks, 1969). As an example of reflexes limited to a specific organ, cardiocardiac spinal reflexes have been investigated by recording activity from single fibres in cardiac sympathetic nerves either during application of haemodynamic stimuli to the heart or during stimulation of afferent sympathetic fibres originating in the heart (Malliani, Lombardi, Pagani, Recordati & Schwartz, 1975).

One of the visceral organs for which there is some preliminary information regarding viscerovisceral reflexes is the kidney. Previous attempts at demonstrating the existence of a renorenal reflex have shown that stimulation of a bundle of afferent renal fibres elicits a decrease in electrical activity recorded from an ipsilateral efferent bundle (Aars & Akre, 1970; Ueda, Uchida & Kamisaka, 1967). On the other hand, stimulation of afferent renal nerves has failed to affect renin release or blood flow to the innervated contralateral kidney (Calaresu, Stella & Zanchetti, 1976), although stimulation of these nerves has been reported to decrease systemic arterial pressure in dogs and rabbits (Aars & Akre, 1970; Ueda *et al.* 1967), and to increase it in cats (Calaresu *et al.* 1976). In addition, it has been reported that there are renal afferent fibres whose frequency of firing is augmented by increases in pressure in the renal vein and in the ureter (Åström & Crafoord, 1968; Beacham & Kunze, 1969), and by changes in pressure in the interlobar arteries (Niijima, 1971, 1972), demonstrating the existence of renal mechanoreceptors.

In view of these previous findings suggesting the existence of renorenal reflexes and of the importance of renal nerves in the regulation of renal function and renin release (for reviews see Calaresu, Stella & Zanchetti, 1977; Di Bona, 1977), experiments were done in cats to determine the fibre composition of renal nerves and to investigate electrophysiologically the functional characteristics of reflex responses recorded in efferent renal nerves during electrical stimulation of contralateral and ipsilateral renal nerves. A preliminary account of these experiments has been presented (Calaresu, Kim, Nakamura & Sato, 1978).

METHODS

Experiments were done in twenty-one cats (2·6–6·4 kg) anaesthetized with a mixture of α-chloralose and urethane (50 and 100 mg/kg, I.P. initially, and supplementary doses of 5 and 10 mg/kg, I.V. when needed). A polyethylene cannula was inserted into a femoral vein for administration of drugs. The trachea was cannulated and the animals were immobilized with an initial I.V. dose of 10–20 mg gallamine triethiodide (Teisan, Teikoku Chemicals, Osaka) and then artificially ventilated with an Acoma AR-100 pump adjusted to maintain a tracheal end-expiratory CO_2 concentration of 2·5–3·5 % monitored on a Beckman Medical Gas Analyzer LB-1. During the experiment gallamine triethiodide (5 mg/kg.hr) was administered continuously through a Harvard infusion pump which delivered Tyrode solution into the femoral vein at a rate of 2·5 ml./hr. Arterial blood pressure measured from a femoral artery via a polyethylene cannula filled with heparinized saline was connected to a Nihon-Kohden pressure transducer and recorded on a polygraph (Nihon-Kohden RM-5). A 6 % solution of dextran (Macrodex-D, AB Pharmacia) was infused when necessary to keep systolic blood pressure above 90 mm Hg. The rectal temperature was monitored with a thermistor probe and was maintained at 38·0 ± 0·5 °C by means of a DC heating pad and direct radiant heat from an infrared lamp.

One or two renal nerve branches were dissected retroperitoneally on each side, and they were cut just proximal to their entry into the renal hilum. The greater, lesser and least splanchnic nerves as well as the coeliac ganglion were also carefully dissected. A diagram of the anatomical relations of these structures is shown in Fig. 1. The central segment of one of the renal nerves

was stimulated electrically by rectangular pulses of 0·5 msec duration at different frequencies and intensities (Digitimer Stimulator 3290, Gated Pulse Generator 2521, Isolated Stimulator 2533), and the reflex electrical activity elicited by stimulation was recorded from the central segment of a different renal nerve, either ipsilaterally or contralaterally. The afferent volley elicited by stimulation of an afferent renal nerve was monitored by recording electrical activity from the three splanchnic nerves. In addition to the renal afferent nerves, the right or left superficial radial nerve was also dissected for stimulation and the afferent volley was monitored

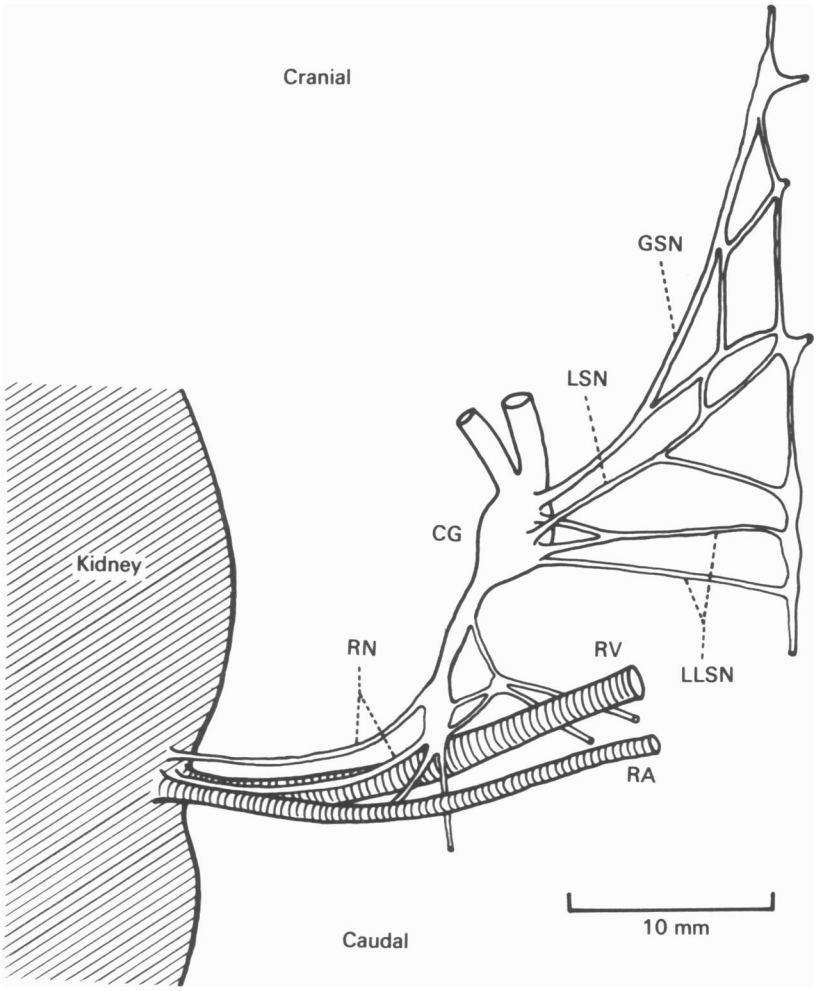

Fig. 1. Schematic diagram of the anatomical relations of renal and splanchnic nerves on the left side in one cat. RN, renal nerves; GSN, greater splanchnic nerve; LSN, lesser splanchnic nerve; LLSN, least splanchnic nerve; CG, coeliac ganglion; RA and RV, renal artery and vein.

by placing recording electrodes a few centimetres proximally to the site of stimulation. The cat was fixed to a Narishige spinal frame by clamping the spinous process of T8 and the iliac bones. All dissected nerves were kept in paraffin oil pools and bipolar platinum electrodes were used for recording and stimulation.

Evoked electrical activity was led through a preamplifier (Nihon Kohden AVB-8, time

constant 0·3 sec) to a Tektronix 5103 N storage oscilloscope for Polaroid photography or to a signal analyser for averaging (Hewlett Packard 5480 B). The averaged data were plotted on an X/Y recorder (Yokogawa 3087).

Nicotine sulphate (Tokyo Kasei, Tokyo) and bicuculline (Sigma Chemical Corp., St Louis) were injected into the venous cannula.

RESULTS

Identification of fibre groups in renal nerves

In eleven experiments the fibre composition of renal nerves was estimated by recording the compound action potential elicited by electrical stimulation. For identification of afferent fibres the cut proximal segments of renal nerves were stimulated and the evoked electrical activity in the greater, lesser and least splanchnic nerves was recorded. Efferent renal fibres were identified by reversing recording and stimulating electrodes and by the effect of nicotine on the potentials recorded.

Afferent renal nerves

In eleven experiments a compound action was consistently recorded in the least splanchnic nerve, but only occasionally in the lesser splanchnic nerve, and never in the greater splanchnic nerve. A representative example of action potentials recorded from the least splanchnic nerve is shown in Fig. 2*A*, *B*. Three separate peaks may be observed. As the distance between stimulating and recording electrodes was 44 mm the fastest conduction velocities of these fibres were calculated as at least 37, 15 and 2 m/sec, corresponding to fibre groups Aβ, Aδ and C. The relation between strength of stimulation of renal afferents and height of action potentials of A and C fibres is shown in Fig. 2*C*. For the Aβ fibres threshold (T) was 200 mV and the action potential reached a maximum at approximately 3 T, while the action potential of the C fibres appeared at approximately 14 T and reached a maximum at around 40 T. No results are presented in Fig. 2*C* for the Aδ fibres because of the difficulties encountered in most cases in separating the Aβ and Aδ potentials. In this Figure it should also be noted that the action potential of the C fibres was larger than the action potential of the A fibres; this was a consistent finding in all the cases studied.

Efferent renal nerves

Action potentials from efferent renal nerves were recorded in nine experiments. Electrical activity could be recorded during stimulation of any of the three splanchnic nerves. Typical action potentials recorded from a renal nerve during stimulation of the least splanchnic nerve in the same preparation used for Fig. 2*A*, *B* are shown in Fig. 2*D*. In addition to the *A* and *C* action potentials due to activation of renal afferent fibres (Fig. 2*A*, *B*), an action potential with an onset latency of 15 msec was also observed. By close examination of the records in Fig. 2*B*, *D* and *E* it may be noted that there is a discrepancy in the latency of the C potentials between records in *B* and in *D*, *E*. As records Fig. 2*D*, *E* were obtained approximately seven hours after record 2*B* the discrepancy may be accounted for by changes in recording conditions or in the conditions of the nerve which took place in the intervening time. The action potential with a 15 msec latency was elicited by low intensities of stimulation (threshold 380 mV, maximum response 1·3 V). This low threshold indicates that the stimulated fibres were myelinated, most probably B fibres. Furthermore,

this potential was completely abolished after I.V. administration of 5–20 mg/kg of nicotine sulphate while the other A and C afferent action potentials remained, as shown in Fig. 2*E*. It is therefore concluded that the action potential with a 15 msec latency

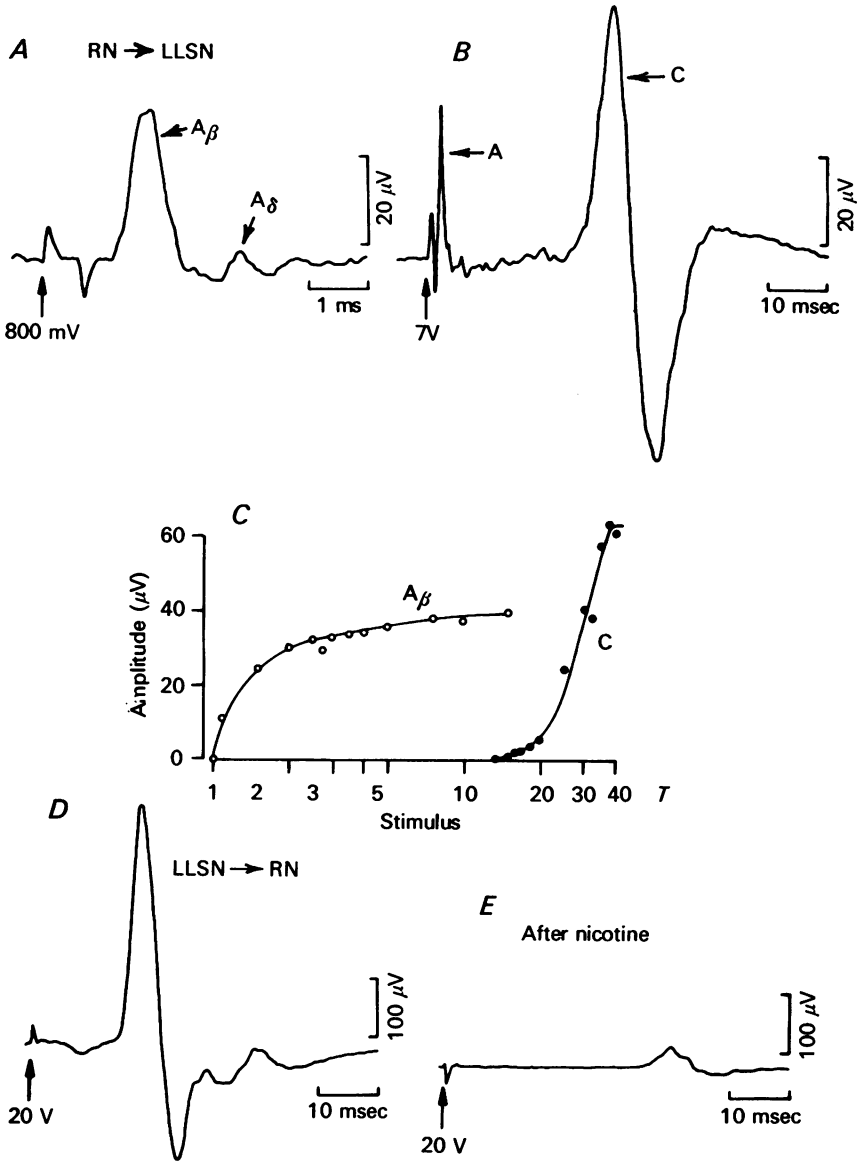

Fig. 2. Fibre composition of renal nerves. *A* and *B*, action potentials of Aβ, Aδ (in *A*) and C afferent fibres (in *B*) recorded from the least splanchnic nerve during stimulation of a branch of the renal nerve. Intensities of stimulation are shown. *C*, the height of action potentials of Aβ and C fibres in the least splanchnic nerve (ordinate) are plotted against the strength of stimulation of the renal nerve (abscissa); the threshold for Aβ was 200 mV, shown as *T*. *D* and *E*, action potentials recorded from a renal branch during stimulation of the least splanchnic nerve. Record in *E* was taken 9 min after administration of nicotine sulfate 20 mg/kg, I.V. All records of action potentials are averages of sixteen sweeps. The stimulus repetition rate was 1 Hz. Arrows indicate time of stimulation. Negativity of potentials in this and subsequent Figures is upwards.

was due to excitation of efferent fibres and that these fibres synapse between the stimulating and recording electrodes, probably in the coeliac ganglion. Although the latency of this component and the conduction distance were measured it was not possible to determine the conduction velocity of these fibres because the efferent renal pathway is composed of two different types of fibres, one proximal and the other distal to the coeliac ganglion, with different conduction velocities. Additional evidence that this potential was due to stimulation of efferent fibres is that it decreased to about two thirds of the amplitude recorded at 1 Hz when the frequency of stimulation was increased to 20 Hz, whereas the amplitude of the afferent potentials did not change

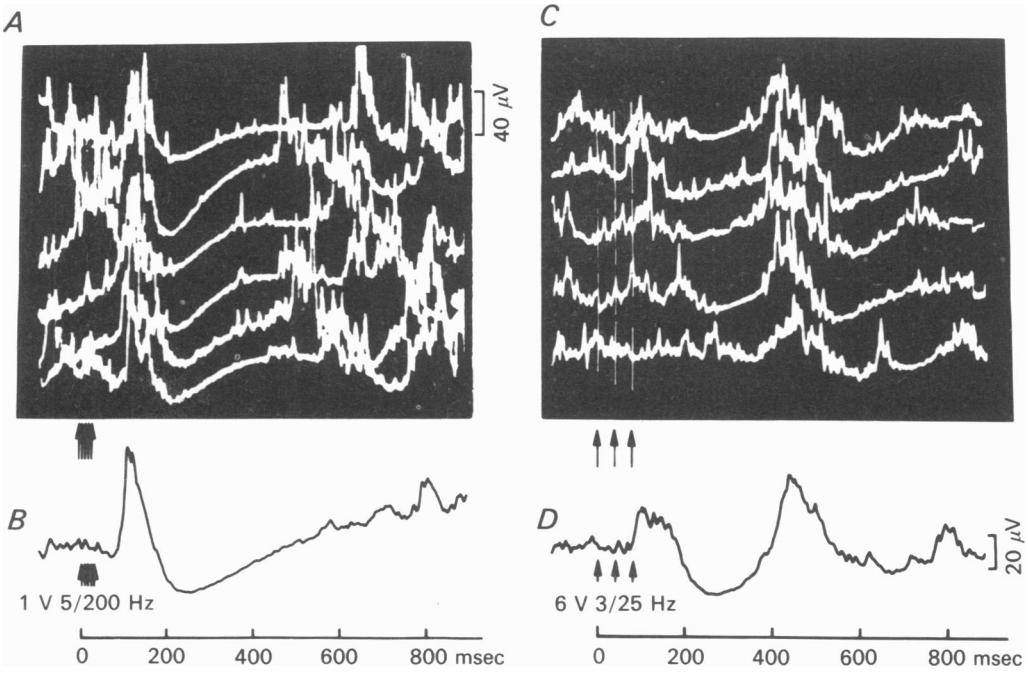

Fig. 3. Reflex potentials recorded from a branch of the right renal nerve (RN) during stimulation of a branch of the left RN. Records in *A* and *C* are single sweeps; those in *B* and *D* are averages of thirty-two responses. Stimulus intensities are indicated. Trains of 5 pulses at 200 Hz were used in *A* and *B*. Trains of 3 pulses at 25 Hz were used in *C* and *D*. In all cases, repetition rate of stimulation was 0·25 Hz. Arrows indicate time of stimulation.

even at frequencies of stimulation as high as 30 Hz. Finally, although it is conceivable that the efferent potential was a response originating in the ganglion, because of the short length of nerve available it was technically impossible to stimulate and record simultaneously from the least splanchnic nerve to demonstrate that the presynaptic potential was unchanged after administration of nicotine.

Reflex responses in efferent renal nerves during electrical stimulation of renal afferents

Reflex responses in contralateral renal nerves

A renal afferent nerve on one side was stimulated and reflex responses were recorded from a contralateral renal nerve in twelve experiments.

When renal afferent A fibres were stimulated with five pulses at high frequency (200 Hz) every 3–5 sec a reflex discharge with an onset latency of about 100 msec was elicited. Single shock stimulation of the same fibres often did not evoke any reflex responses. The ranges of onset latency and duration of the discharge were 75–125 msec and 90–150 msec, respectively. The renal nerve always had some spontaneous activity which was sometimes synchronous with the artificial respirator, or with the heart beat, or was completely random. Thus the reflex response was not always obvious in single oscilloscope sweeps as shown in Fig. 3*A*, but it became quite clear after averaging a number of sweeps as demonstrated in Fig. 3*B*. A period of inhibition of approximately 200 msec followed the reflex discharge, and at times, as seen in Fig. 3*A*, there was an irregular late response. This reflex response will be referred to as the A renorenal reflex.

When renal afferent C fibres were stimulated with trains of 3–5 pulses at low frequency (20–30 Hz) a reflex discharge with an onset latency of approximately 350 msec was elicited (Fig. 3*C*, *D*). The ranges of onset latency and duration of the reflex were 300–400 msec and 200–303 msec, respectively. Single shock stimulation of the renal afferent C fibres did not elicit the reflex. Furthermore, train stimulation at 20–30 Hz of renal afferent A fibres did not produce this late reflex, indicating clearly that it was due to the excitation of afferent C fibres. This late reflex was followed by a 200–300 msec post-excitatory depression (Fig. 3*C*, *D*) and will be referred to as the C renorenal reflex.

In two animals after the spinal cord between C2 and L5 was destroyed by passing through the spinal cord a metal wire of 1 mm diameter the reflex responses in the renal nerves were completely eliminated.

The relation between strength of stimulation of renal afferent fibres and the magnitude of both the A and C reflexes in efferent renal nerves was systematically studied in five animals. A typical experiment is shown in Fig. 4, which shows that the A reflex elicited by 5 pulses at 200 Hz appeared between 2 and 3 T for renal afferent A fibres and increased in magnitude until the stimulus strength reached about 5 T. On the other hand, the C reflex elicited by 3 pulses at 25 Hz started to appear around 20 T and increased in magnitude until the stimulus strength reached about 50 T. It was noted, however, that the C reflex discharge showed a considerable increase in magnitude (not shown in Fig. 4) at intensities of stimulation much greater ($> 100\ T$) than those necessary to elicit the maximum C potential in the renal afferent nerves (cf. Fig. 2*C*). This increase cannot be readily explained, but it may have been due to current spreading to non-renal visceral afferents in the vicinity of renal nerves during stimulation at high intensities.

Reflex responses in ipsilateral renal nerves

In five cats two separate renal nerve branches were dissected on the same side for a length of approximately 15 mm. In these cases, afferent fibres in one renal nerve branch were stimulated and the reflex efferent responses from the other branch were recorded. The reflex responses in ipsilateral renal nerves were essentially the same as those in contralateral renal nerves, except that the A reflex was elicited even by single shock stimulation of renal afferent A fibres and the magnitude of the A reflex was almost equal or even larger than that of the C reflex, which was elicited only by

stimulation with trains of pulses (3–5 pulses at 20-30 Hz) as shown in Fig. 5. The ranges of onset latency and duration of the A reflex were 80–140 msec and 70–200 msec, respectively, while those of C renal reflex were 300–400 and 80–200 msec, respectively.

Comparison of renorenal reflex with somatorenal reflex

In six experiments the A and C renorenal reflex potentials were compared with the reflex responses evoked in renal nerves by stimulation of the superficial radial nerve. Confirming previous results (Sell, Erdelyi & Schaefer, 1958; Weidinger, Fedina, Kehrel & Schaefer, 1961), a single shock stimulation of afferent A fibres of the superficial radial nerve elicited a reflex potential in the renal nerve with an onset latency of approximately 80–100 msec. The magnitude of this reflex potential was augmented

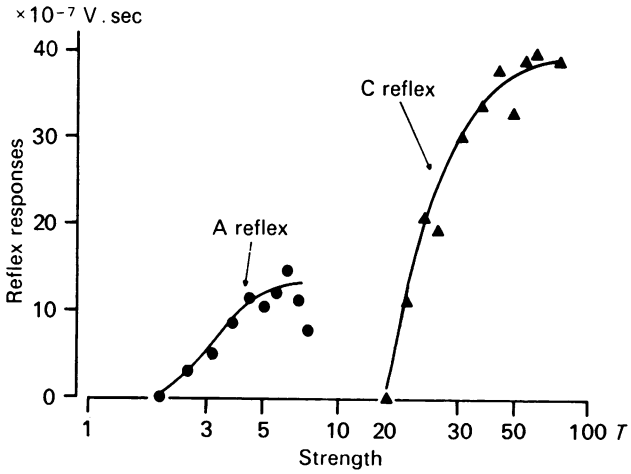

Fig. 4. Relation between magnitude of renorenal A reflex (●) and C reflex (▲) responses and stimulus intensity of contralateral renal afferent nerve. Ordinate: magnitude (V. sec. 10^{-7}) of the response measured as the area under the curve of the average response (thirty-two sweeps) from 80 to 200 msec for the A reflex, and from 350 to 600 msec for the C reflex. Abscissa: intensity of stimulation expressed as multiples of *A* threshold (*T*). For eliciting A reflex trains of 5 pulses at 200 Hz were used; for C reflex 3 pulses at 25 Hz. Repetition rate was 0·25 Hz.

by using 2–5 pulses at high frequency (100–200 Hz) and the potential was followed by a period of post-excitatory depression. This renal reflex will be referred to as the A somatorenal reflex. When the intensity of single shock stimulation was increased to excite all C fibres, this A somatorenal reflex did not change. However, when the C fibres of the superficial radial nerve were stimulated with 3 pulses at low frequency (25 Hz), in addition to the A reflex, another reflex potential of approximately 350 msec onset latency and 100 msec duration was elicited as shown in Fig. 6*A*. Stimulation with trains of 3 pulses at 25 Hz at lower intensity to stimulate only A fibres of the superficial radial nerve could not elicit such a late reflex potential. It is therefore concluded that this reflex potential was due to excitation of somatic afferent C fibres, and this reflex will be called the C somatorenal reflex. A and C somatorenal reflex responses and their temporal relation with A and C renorenal reflexes are shown in Fig. 6.

Renal reflexes and the dorsal root reflexes

To examine the possibility that the renal reflexes described above may have been due in part to dorsal root reflexes, nicotine or bicuculline were used in two experiments. The renorenal reflexes were present even after administration of bicuculline (0·4 mg/kg, I.V.) which is known to block the dorsal root reflex (Miyamoto, 1976),

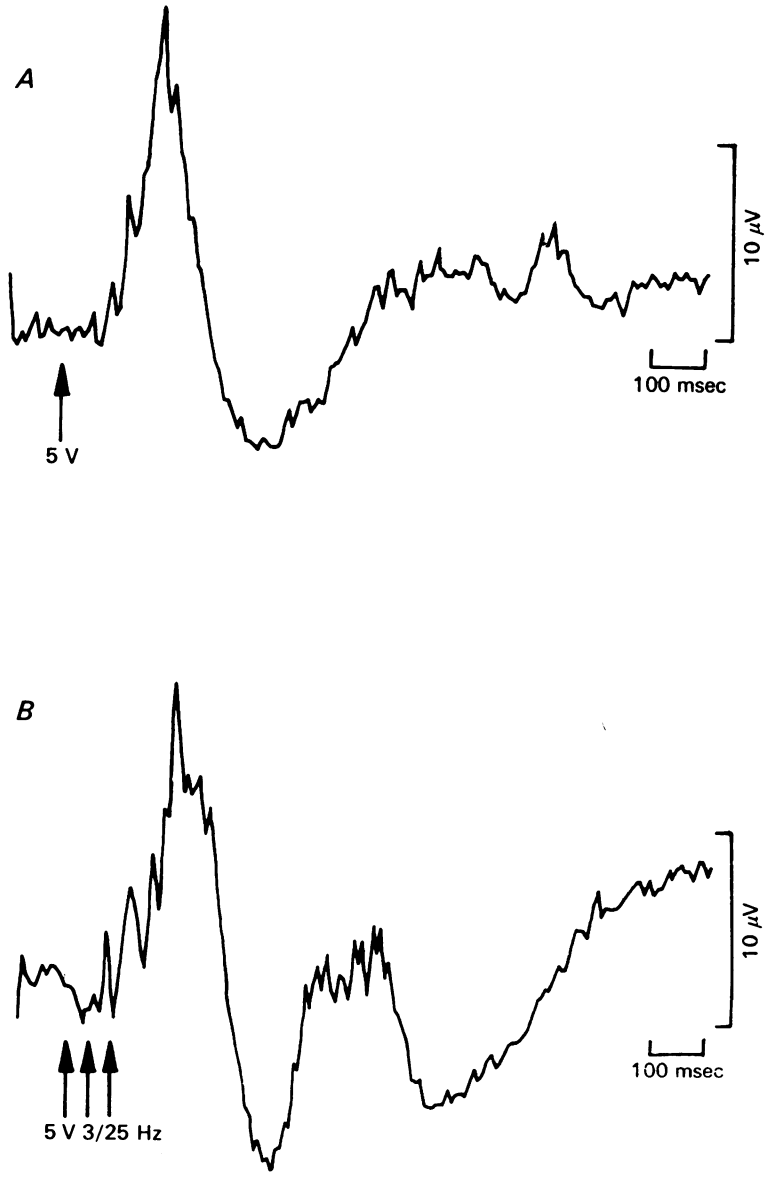

Fig. 5. Reflex responses in a renal efferent nerve during stimulation of an ipsilateral afferent branch. The stimulus in *A* was 5 V, 0·5 msec, single shock, and in *B* 5 V, 0·5 msec, 3 pulses at 25 Hz. Note the A reflex in A and B and the C reflex in B. Each record is the average of thirty-two sweeps.

but were abolished after administration of nicotine (5–20 mg/kg, I.V.), which is known to block synaptic transmission at sympathetic ganglia (Lundberg & Thesleff, 1953). These findings indicate that the renorenal reflexes described were not contaminated by dorsal root reflexes.

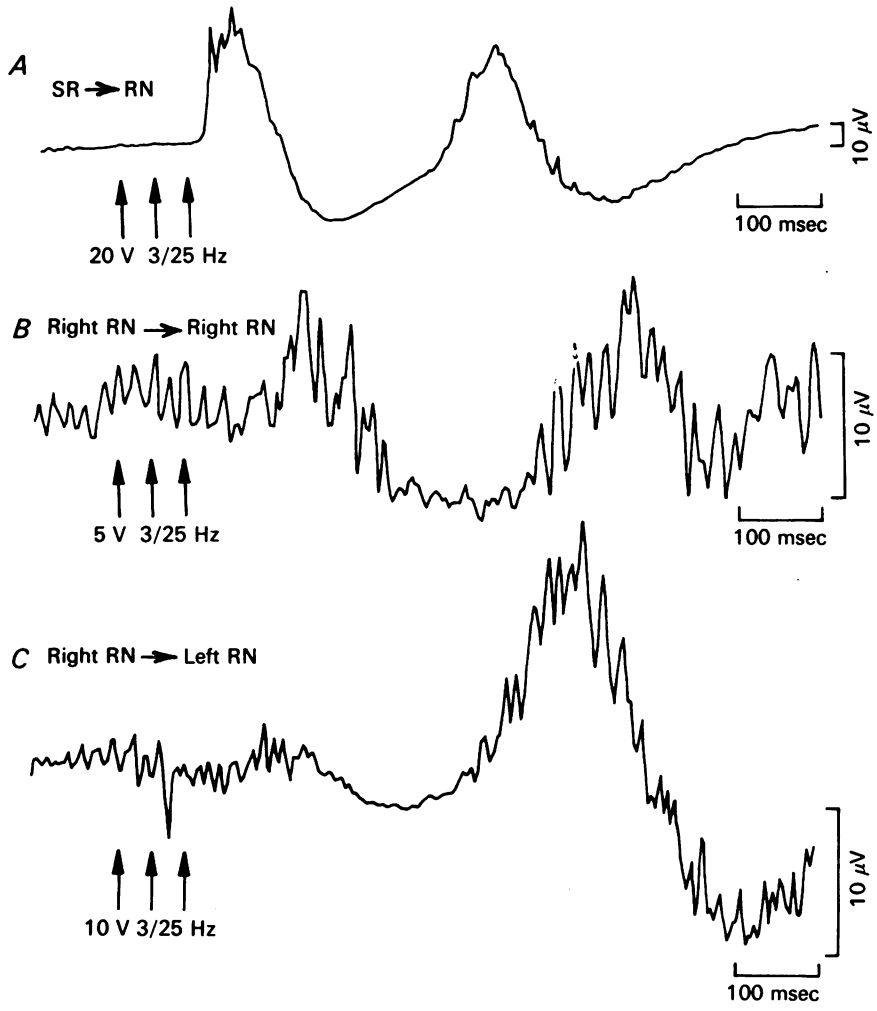

Fig. 6. Comparison between somatorenal and renorenal reflexes. Each record is the average of sixteen responses. *A*, response in a renal nerve to stimulation of the superficial radial nerve (20 V, 0·5 msec, 25 Hz, 3 pulses). *B* and *C*, responses in the same renal nerve to stimulation of an ipsilateral (*B*) or contralateral (*C*) renal afferent nerve. Stimulus in *B* and *C*: 5 V, 0·5 msec, 25 Hz, 3 pulses. Stimulus repetition rate was 0·25 Hz.

DISCUSSION

Stimulation of afferent renal nerves was found to elicit reflex responses in contralateral and ipsilateral efferent renal nerves. To our knowledge this is the first electrophysiological demonstration of the existence of renorenal reflexes, although it had been previously shown that electrical stimulation of one afferent branch of the renal

nerve elicited a decrease in multifibre spike activity in an ipsilateral branch of the renal nerve in the dog (Ueda *et al.* 1967) and in the rabbit (Aars & Akre, 1970). These reflex responses in renal nerves are undoubtedly mediated by the central nervous system as they were abolished by destruction of the spinal cord and by administration of nicotine at doses known to block transmission at sympathetic ganglia (Lundberg & Thesleff, 1953). It may also be concluded that there was no contamination by dorsal root reflexes because administration of bicuculline at a dose known to abolish dorsal root reflexes (Miyamoto, 1976) did not alter any of the characteristics of the reflex responses.

Two components of the renorenal reflex were identified. The first was elicited by activation of renal afferent A fibres at suitable parameters of stimulation, had an onset latency of approximately 100 msec and was followed by post-excitatory depression. The second, elicited by stimulation of renal afferent C fibres, appeared with a longer onset latency (approximately 350 msec) and was also followed by post-excitatory depression. To elicit both A and C reflexes it was necessary to provide temporal facilitation of afferent impulses by using stimulation with trains of pulses at high frequencies (100–200 Hz) for the A reflex, and at low frequencies (20–30 Hz) for the C reflex, a characteristic already described for somatosympathetic reflexes (Sato, 1973; Schmidt & Schönfuss, 1970; Schmidt & Weller, 1971).

The nature of the renal receptors connected to the afferent fibres stimulated in the experiments reported can only be surmised from a review of the available evidence in the literature and from our results on the fibre composition of afferent renal nerves. With regard to afferent A fibres, their existence is clearly established both by the evidence presented here and by previous physiological and histological studies (Aars & Akre, 1970; Åström & Craaford, 1967; Beacham & Kunze, 1969; Niijima, 1975; Ueda *et al.* 1967). The precise function of the receptors connected to myelinated fibres is not clear although the available information suggests that they are arterial mechanoreceptors (Aars & Akre, 1970; Niijima, 1971, 1972; Uchida, Kamisaka & Ueda, 1971). Regarding the afferent C fibres, their large contribution to the afferent compound action potential has been demonstrated in our experiments, confirming previous morphological evidence indicating that the majority of fibres in renal nerves are unmyelinated (Niijima, 1975). Although electrical activity from single C fibres from the kidney has never been recorded, their possible baroreceptor function has been suggested by physiological experiments (Aars & Akre, 1970). Their precise physiological properties, however, have been investigated recently in experiments demonstrating that in rats renal ischaemia and systemic hypoxia and hypercapnia cause the number of action potentials of long duration and small amplitude recorded from renal afferent nerves to increase considerably, suggesting that these fibres are unmyelinated chemoreceptor fibres (Recordati, Moss & Waselkov, 1977). It may therefore be reasonable to suggest that the C reflex may be elicited by activation of renal chemoreceptors.

The function of efferent renal nerves may now be considered. Morphological studies have shown the existence of a rich synaptic innervation of the smooth muscle cells of renal arterioles as well as of the basement membrane of proximal and distal tubules in Macaca monkeys (Barajas, Silverman & Müller, 1974; Müller & Barajas, 1972). The function of efferent renal nerves has been studied and there is evidence for a constrictor action of these nerves on renal arterioles (e.g. Richardson, Stella, Leonetti,

Bartorelli & Zanchetti, 1974) and for a role in the release of renin probably by direct innervation of the juxtaglomerular apparatus (e.g. Zanchetti & Stella, 1975). The role of tubular innervation has not been studied in detail, but it has been established that efferent renal nerves affect the excretion of ions (Di Bona, 1977), and it has been suggested, on morphological evidence, that there probably is a close functional coupling between vasomotor changes and changes in tubular function (Müller & Barajas, 1972).

We should now consider the functional significance of renorenal reflex arcs which receive an afferent input from arterial mechanoreceptors and chemoreceptors in the kidney and can influence blood flow, renin release and excretion of ions through efferent renal fibres. Experiments attempting to demonstrate the existence of renorenal reflexes have shown that neither blood flow nor renin release in one kidney were influenced by stimulation of the contralateral renal nerves (Calaresu *et al.* 1976). However, these results did not exclude the possibility of the existence of a renorenal reflex; in fact the suggestion was made that in the study of renorenal reflex responses more precise methods of activation of renal afferent fibres and sensitive methods for the study of renal function are required. Although it would be possible to speculate on the function of renorenal reflexes given the information available, we have reviewed the available evidence and must wait for new experimental findings to assign a role to these reflexes. An additional reason for suggesting caution in assigning functional significance to our electrophysiological data is the existence of A and C somatorenal reflex responses with characteristics similar to those of renorenal reflexes. These somatorenal reflexes have been described before (Sell *et al.* 1958; Weidinger *et al.* 1961) and have been confirmed in our experiments (cf. Fig. 6). Although the physiological significance of somatosympathetic reflexes has been discussed at length (Koizumi & Brooks, 1972; Sato & Schmidt, 1973), it is difficult to suggest a physiological role for somatorenal reflexes and to evaluate the significance of the electrophysiological similarity of renorenal and somatorenal reflexes. It may, however, be proposed that the physiological significance of these reflex relations between autonomic and somatic nervous systems may be related to the coordination of regulatory processes in the whole animal.

Extensive investigations on the central pathways of somatosympathetic reflexes have revealed that different reflex responses are mediated by different central structures during stimulation of myelinated and unmyelinated afferent fibres (Sato & Schmidt, 1973). It is possible that a similar separation of pathways applies to the two renorenal reflexes described. However, as no attempts were made to investigate this possibility, the central distribution of afferent and efferent pathways involved in renorenal reflexes remains to be determined.

To conclude, we have demonstrated the existence of contra- and ipsilateral renorenal reflexes and we have described their electrophysiological characteristics. The demonstration of these reflexes opens new vistas in the study of the neural control of the kidney, but only investigations with sensitive techniques for the study of renal function will determine the functional role of these neural mechanisms.

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