Convergence of Visceral Afferents on Candidate Units for the Pontine Defecation Reflex Center of the Dog

Hiroyuki FUKUDA and Kiyoko FUKAI

*Department of Physiology, Kawasaki Medical School, Kurashiki,
Okayama, 701-01 Japan*

Summary Convergence of visceral afferents was studied in 245 pontine reticular units that responded to afferent stimulation of rectal branches of the pelvic nerve of dogs. Afferents from the urinary bladder and the anal mucosa converged in about 90% of the units. Thoracic vagal afferents were projected in 20% of the units.

Key Words: pontine reticular unit, defecation reflex, visceral afferent.

It is widely accepted that rectal distention elicits colonic propulsive contractions, which in turn initiates defecation. Most of the colonic contractions are caused by reflex discharge of rectal branches of the pelvic nerve in dogs (OKADA *et al.*, 1975). As the reflex center, we have proposed the pontine defecation reflex center in the pontine reticular formation on the basis of studies of transection, localized lesions, stimulation, and recording of unit activity in the brain stem (OKADA *et al.*, 1976; FUKUDA *et al.*, 1981). On the other hand, motility of the distal colon was also enhanced reflexly by mechanical stimulation of the anal mucosa (the ano-colonic reflex), distention of the stomach (the gastro-colonic reflex) and distention of the urinary bladder (the vesico-colonic reflex). Transection experiments of the canine brain stem indicated that the supraspinal reflex center of these reflexes also exists in the pontine part and participates in the development of enhanced pelvic nerve outflow to the colon (OKADA *et al.*, 1977; OKADA and FUKAI, 1979; FUKUDA *et al.*, 1982). It appears that the afferent impulses from these organs may converge on the pontine reticular units forming the pontine defecation reflex center. The aim of this study is to examine this assumption.

The experiments were performed on 27 dogs anesthetized with intravenous injection of α -chloralose (100 mg/kg) and 14 dogs decerebrated precollicularly under electrical narcosis (FUKUDA *et al.*, 1981). The lumbar colonic nerve and the bilateral hypogastric nerves were severed in advance in all dogs. Unit activity was recorded extracellularly from cells in the pontine reticular area, 2.3 to

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福田博之, 深井喜代子

3.5 mm lateral to the mid line, by a silver wire microelectrode as described previously (FUKUDA *et al.*, 1981). This reticular area is where bilateral destruction completely abolished the long latency discharge in the recto-colonic reflex (OKADA *et al.*, 1976). Reticular units that responded to the hunting stimulation of the central cut-ends of the contralateral rectal branches of the pelvic nerve were selected as the candidate units for cells forming the pontine defecation reflex center.

The convergence of afferent impulses from the anal mucosa, the stomach, the urinary bladder, and the rectum was examined on these candidate units. The basic property of the candidate unit responses to such afferent impulses was similar under conditions of decerebration and chloralose anesthesia, therefore the results obtained under both conditions will be presented together.

Examples of the responses of a candidate unit are shown in Fig. 1A. This unit responded to the hunting stimulation of the contralateral rectal branches with an early discharge of high frequency spikes which were followed by a late discharge of a train of low frequency spikes (a). A similar pattern of discharges appeared in this unit after afferent stimulation of the ipsilateral rectal branches (b). This unit responded with a late discharge to the afferent stimulation of vesical branches of the contralateral pelvic nerve (c), and responded to electrical stimulation of the anal mucosa with an early discharge (d). These three discharge types and the inhibition of spontaneous discharges are commonly observed as responses of the candidate units.

Of the 86 candidate units, 74% responded to afferent stimulation of the ipsilateral rectal branches with the same discharge type as the responses to the hunting stimulation, while 61% discharged after electrical stimulation of the anal mucosa. About two-thirds of the responses consisted of only the early discharge, whereas 71% of the 86 units responded with only the late discharge to afferent stimulation of the contralateral vesical branches. These stimuli inhibited the spontaneous discharges of about 20% of the 86 units with varied latency (116 ± 81 msec, mean $\pm$ S.D., $n=60$) and duration (303 ± 194 msec, $n=60$). Twenty percent of 144 candidate units responded to afferent stimulation of the anterior vagal trunk at the central part of the diaphragm.

The initial spike latencies of these excitatory responses from the candidate units are shown as histograms in Fig. 1B. The early and late peaks exist in the latency histograms of the responses to stimulation of the hunting (a), the ipsilateral rectal branches (b), the anal mucosa (d), and the thoracic vagus nerve (e); however, only the late peak is present in that of the responses to the afferent stimulation of the contralateral vesical branches (c). Because the two peaks correspond to the early and late discharges, these unit responses should be divided into the fast and late groups at the trough between the two peaks. As shown in these histograms, however, some units discharged after the latency, so discharges could not be classified as early or late. Therefore, we adopted, for convenience,

Fig. 1. Responses of the candidate units for the pontine defecation reflex center to stimulation of visceral afferent nerves. A: responses of a candidate unit. The early and late discharges are indicated above a by bars of E and L, respectively. The central cut-ends of the contralateral rectal branches (a), the ipsilateral rectal branches (b), and the contralateral vesical branches (c) of the pelvic nerve were stimulated with a train of 10 pulses of 20 volts, 1 msec duration and 10 msec intervals. The anal mucosa (d) was stimulated with a train of 10 pulses of 24 volts, 1 msec duration and 10 msec intervals. B: histograms of initial spike latencies of responses of the candidate units to the following afferent stimulation; a) the contralateral rectal branches; b) the ipsilateral rectal branches; c) the contralateral vesical branches; d) electrical stimulation of the anal mucosa; e) the thoracic vagal nerve. Latencies of the early and late discharges are separated by a vertical dotted line. The mean latency of the early discharges is shown on the left side of each histogram with the standard deviation and response number, while the late discharges are given on the right side of each histogram.

a latency of 79 msec as the dividing point for the fast and late groups. The mean latencies of the fast and late groups are shown in Fig. 1B.

The early and late discharges seemed to correspond respectively to activation of A δ and C afferent fibers, because the threshold stimulation for the late discharges was more intense than that for the early discharges (unpublished results). The finding that only the late group responses were elicited by afferent stimulation of the vesical branches, however, does not mean that only C afferent fibers are involved in the branch, because A δ fibers were observed in the branch by electron microscopy (unpublished results). Therefore, some neuronal mechanism overriding A δ impulses activated by the afferent stimulation may exist in the ascending limb of the vesico-colonic reflex.

These results show the followings: 1) impulses of rectal A δ and C afferent fibers are projected bilaterally to the pontine defecation reflex center; 2) afferent impulses which elicit the ano-colonic and gastro-colonic reflexes, converge on units of the pontine defecation reflex center; 3) impulses from vesical afferent fibers converge on the pontine defecation reflex center through an ascending

pathway that involves a neuronal mechanism over-riding impulses of the A δ afferent fibers.

These results confirm the assumption that the pontine defecation reflex center acts as the reflex center of the ano-colonic reflex, the vesico-colonic reflex and the gastro-colonic reflex, and suggest that a large part of the integration of defecating activities is performed in the pontine defecation reflex center.

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