ANTRAL MOTILITY RESPONSE TO PASSIVE LIMB JOINT MOVEMENTS IN HUMANS

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Summary: The afferent propioceptive signals have been known to modulate autonomic activity (3,5,6,9 and 17) as revealed by passive movements of joints and other experimental techniques. In the present investigation, effect of passive movements of wrist and ankle joints at 30 c/min for 10 mins, was studied on antral motility in 10 young male volunteers by balloon kymograph technique (23). The results revealed spontaneous inhibition of rythmic activity as well as tone of antral wall following flexion and extension of wrist which persisted throughout the test period and eventually recovery appeared, within 30 mins of beginning of movements, after termination of movements. The response was reproducible and did not appear to be because of emotional factor or artifact. This, response therefore, suggested likelihood of its being integrated reflex in nature initiating from proprioceptors within and around wrist joint. The inhibitory response could not be obtained from ankle joint subjected to dorsi-and-planter-flexion and thus arouses suspicion wheather this reflex presumably from proprioceptors of upper limb joint is related to feeding in primates and could well be an important component for receptive relaxation to stomach prior to entry of food in the gastric lumen.

Key words: antral motility natural receptor stimulation passive movement phasic intraluminal pressure waves proprioceptive

INTRODUCTION

Somatosensory inputs have been known to modulate autonomic effector responses and recently been reviewed by several workers (12,13,25,27,30,31,32 and 35). Of the muscle afferents, some are considered to signal nociceptive information (1,8,20,26), whereas others show excitation during non painful muscular contraction (40). These receptors are characterized as 'exercise type' (28) and were found to be responsible for cardio-respiratory changes appearing at onset of muscular exercise or contraction (1,14,15,16,17 and 40). Some of similar nerve endings also behave functionally as metaboreceptors and sense metabolities released during exercise (11,15,24,28 and 40). The above studies were based basically on electrical stimulation of afferents and recording neuronal potentials. Very recently Coote (12) has pointed out that innumerable factors could be involved in such studies leading to misinterpretation of results and suggested that the effector response to natural stimulation of receptors would possibly provide more meaningful information.

However, limited number of observations have been made on changes in visceral activity following natural stimulation of limb joint receptors by passive movements. Some attempts on anaesthetised and decerebrated animals revealed trivial cardio-respiratory changes in response to passive movements of hind limb joints (3,5,6,9 and 17).

The effects on gastrointestinal tract have only been explored following natural stimulation of receptors other than those of joints (10,12,29,33 and 34). Cutaneous warm and cold receptor stimulation in rabbit produced enhanced sympathetic vasoconstrictor activity to G.I.T. (29). More recently nociceptive stimulation in anaesthetised rat with intact brain revealed excitatory influence on sympathetic outflow to gastrointestinal system (33,34).

No animal or human experimentation seems to have been carried out to observe contribution of proprioceptive afferent signalisation from within and around joints on gastric motility produced by passive movements (non painful). The present investigation, therefore, has been conducted in normal human volunteers.

MATERIALS AND METHODS

The intraluminal phasic pressure wave pattern was recorded in 10 healthy young male medical students between 19 to 23 years from whom necessary consent was taken in advance. Each of them was kept in fasting state for about 12 hours prior to experiment.

Recording technique :

The gastric motility from antrum was recorded by modified balloon-kymograph method using a small balloon (23). A Ryle's tube assembly with a small condom balloon at the terminal end (5 cms x 3 cms, capacity when undistended = 35 *ml*) secured with a fine silk thread was voluntarily swallowed with sips of water till standard mark II on the tube reached incisors and eventually balloon was positioned in antrum. The placement was finally confirmed fluroscopically by locating metal bead at tip of the tube. The other end of the tube was simultaneously connected to Mary's tambour recorder and water manometer through a glass 'T' cannula. Another glass 'T' cannula was interposed before manometric junction to which pressure raising device with a rubber bulb and unidirectional air flow valve was connected. Prior to increasing pressure in the recording system, 20 *ml* of water was introduced into the Ryle's tube to fill in the balloon. The entire experimentation onwards was carried out in supine position.

The pressure in the recording system was gradually raised to 40 cms of water at which constant motility pattern could be recorded. The control tracings were taken following lapse of 60 mins of introducing tube in antrum for a duration of 30 mins.

Passive movements :

The passive movements of wrist of right arm was carried out by fixing hand in a specially disigned grip attached to a metal rod anchored eccentrically on a wheel (radius = 2") driven by a variable speed motor. The extension and flexion (1 cycle) at wrist were adjusted at the rate of 30 cycles/min for 10 mins with around 30° movement from mid position. During the procedure, the arm was carefully immobilised by a series of belts fixed on the table to ensure that the movements are restricted to this joint only and do not interfere with pneumographic recording. The dorsiflextion and planterflexion at ankle joint were car ied at the same frequency and duration as wrist by putting the aforementioned setup at right angles to planter surface and immobilising entire lower limb with belts so that the vibrations are not transmitted to abdomen. A continuous record of gastromotor activity was obtained during the test period and recovery phase. Throughout the entire experiment, pneumographic tracings were recorded by placing stethograph around the chest wall and connecting it to tambour recorder.

Analysis of records :

The classification of phasic intraluminal pressure waves was not possible by the method of Templeton and Lawson (37) as the waves could not be differentiated on the basis of their amplitude in the present study. The method of Texter and Smith (36,38) was used to classify the pressure waves in our study. These authors demonstrated that the histograms of frequency of waves based on duration from stomach have wave pattern divisible into two groups: waves less than 30 sec duration were termed type 'A', those greater were termed type 'B'. The method of Hightower *et al.* (22) was utilised to obtain quantitative estimate of gastromotor activity. The proportion of the period for a given type of activity was expressed as percentage of time of total period of record. The mean and their standard errors for percentage durations of both waves were finally calculated. The statistical analysis of recovery phase was not conducted.

RESULTS

The percentages of both A and B types of phasic pressure waves and durations for various events are mentioned in Table I. A constant pattern of intraluminal pressure waves was obtained at the baseline pressure of about 40 cms of water which revealed two distinct types of phasic activity throughout the control period. The 'A' waves were distributed in average time of 40.7 $\pm$ 2.55% and did not have any definite correlation with 'B' waves (Fig. 1, panels-1 and 2, Table I), covering rest of the control time. However, no appreciable quiescence was observed between these waves. Generally 'A' waves were taller and suggested greater rise in antral pressure.

TABLE I : Percentage control activity and durations for various gastromotor changes during and after passive joint movement at wrist.

Exp. No.	Percentege antral activity: control		Onset of relaxation		Maximal* relaxation		Recovery time	
	A	B	Min	Sec	Min	Sec	Min	Sec
1	50	50	2	32	5	15	20	25
2	38	62	2	50	6	00	25	20
3	40	60	2	10	5	34	30	00
4	30	70	1	59	4	10	19	40
5	45	55	2	10	5	22	22	15
6	40	60	3	00	6	06	28	10
7	56	44	2	40	5	50	25	05
8	32	68	2	00	5	20	18	48
9	42	58	2	36	4	28	21	18
10	34	66	2	45	4	50	23	24
Mean	40.7	59.3	2	28.2	4.9	23.9	23.1	20.5
± S.E.	±2.55	±2.6	±0.15	±6.18	±0.23	±5.1	±1.2	±4.6

*Pressure recorded on water manometer during this phase was nearly zero cm H_2O.

On beiginning the passive movements of wrist both these antral activities disappeared promptly within 2-3 mins and were associated with the gradual decline in the baseline. Simultaneously the pressure in water manometer decreased which approached

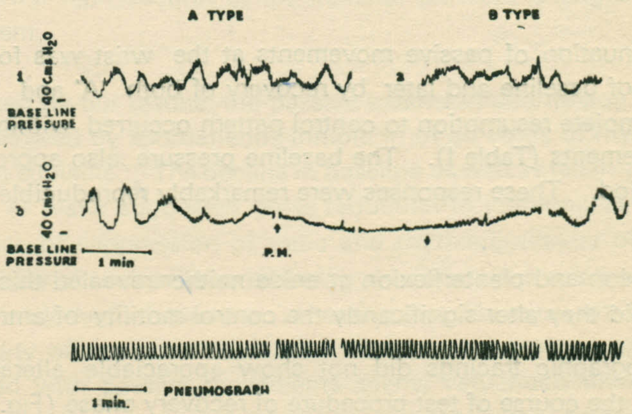

Fig. 1 : Panels-1 and 2 show distinct A and B pressure waves from antrum with marked difference in their durations and amplitude.

Panel-3 reveals spontaneous relaxation of antrum on passive movement of wrist. The recovery follows stoppage of movement. Bottom panel of pneumographic tracings does not show any significant change in rate of respiration during passive movement of wrist.

nearly zero cm of water after a time of 4.9±2.3 mins and 23.9±5.1 sec after the beginning of passive movements. This was concomittantly associated with the maximal decline in the baseline which persisted throughout the test period (Fig.1, panel-3 and Fig. 2).

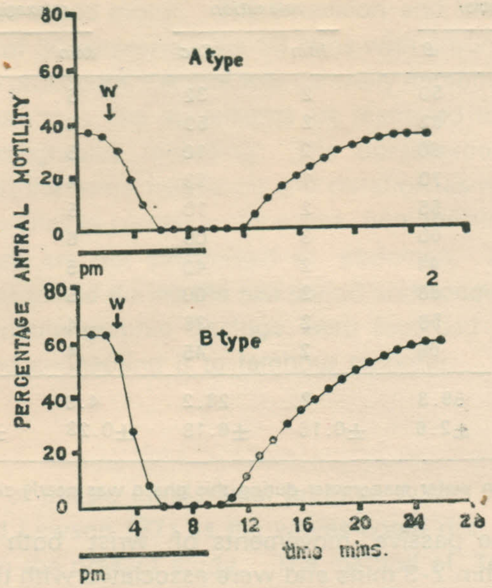

Fig. 2 : Panels-1 and 2 showing classical antral inhibitory response on passive movements (pm).

The discontinuation of passive movements at the wrist was followed initially by a gradual elevation of baseline and later by recovery of both 'A' and 'B' types of phasic waves. Almost complete resumption to control pattern occurred within 30 mins of termination of wrist movements (Table I). The baseline pressure also approached the control level within this period. These responses were remarkably reproducible after full recovery has taken place.

The dorsiflexion and planterflexion at ankle neither revealed this kind of inhibition in any subject nor did they alter significantly the control motility of antrum.

The pneumographic tracings did not show appreciable alteration in respiratory rate or depth during the course of test procedure of recovery phase (Fig. 1).

DISCUSSION

With the present recording technique (23), a fairly constant pattern of antral motility could be recorded in fasting volunteers. The peripheral joints of both extremities (wrist and ankle) were selected for natural stimulation of receptors by passive movements with an idea to avoid transmission of moving joints to chest or abdomen which could have occurred in more proximal joints and interefered with pneumographic recording or antral motility pattern respectively. The direct influence of vibration already reported (9) in producing tachypnea was thus also avoided.

The quantitative approach of records in our experiment (22,38) differed from commonly used classification of Templeton and Lawson (37) for gastric pressure waves into type I, II and III based on duration and magnitude of pressure. However, type 'A' phasic activity in the present study closely resembled type II (high amplitude) and 'B' pattern mimicked type I (low amplitude) waves described in the former classification. However, in our study, wave pattern resembling type III activity in Templeton and Lawson's (37) description could not be recorded presumably because of the fact that their classification was based on earlier studies using larger balloons leading to considerable stretch and irritation of gastric wall (7) and consequently type III activity. The control motility pattern of antrum did not reveal quiescence periods which might primarily be because of prolonged fasting state in our subjects which has been shown to initiate vigorous gastric motility resembling post meal pattern (39). Nevertheless, small contribution of persistent irritation by even small balloon in causing absence of silent periods between the pressure waves could not be ruled out in our study. The other experiments (8,19,21 and 22) showing quiet phases employed open tip tubes connected to pressure recording probes. However, comparison of small balloon kymographic recording with pressure probes (transducer) revealed (19,21) that besides difference in time lag, balloon method provides fairly faithful reproduction of intraluminal pressure changes and is comparable to transducer system.

As evidenced by our results, the passive extension and flexion at wrist joint at 30 cycles/min was followed by spontaneous inhibition of all kinds of rhythmic motor activity of antrum in fasting subjects. The decline in baseline as well as fall in manometric pressure to nearly zero cm of water suggested gross reduction in intraluminal pressure of antrum presumably because of suppression of tonic and rhythmic activity of gastric wall. Even most remote possiblity of such a response being an artifact was ruled out as these changes were reproducible in all the individuals on repeating test procedure after recovery. Furthermore, any possibility of appearance of this inhibitory response on account of emotional changes associated with passive movements seems very much unlikely since emotional stimuli would also produce concomitant changes in respiratory pattern (2), which in our experiment remained uneffected. The antral inhibition following natural stimulation of wrist joint receptors, therefore, appears to be an integrated reflex in nature. We could not compare these responses as no such observations seem to have been made in fasting humans.

It was interesting to observe that the passive movements of inferior extremity joint (ankle) carried out at the identical frequency and duration failed to alter antral motility pattern.

Very recently, Coote (12) has reviewed somato-sympathetic connections and given considerably importance to them in bringing about aberrant autonomic responses. Some of these reflexes show strong spatial organisation as observed by Beacham and Pearl (4) who found that sympathetic neurones in T1 white ramus could be inhibited by squeezing the forelimb whilst another unit did not respond so. In contrast, other units could be activated by manupulating hind paw and did not influence T1. Presence of such an organisation could explain absence of gastromotor response from natural stimulation of joint receptors of inferior extremity and its appearance from upper extremity joints in our experiments.

Another finding of significance in the present investigation was absence of respiratory response (hyperpnea) following natural stimulation of joint receptors of both extremities. On the other hand, previous authors (3,5,6,9 and 17) reported respiratory stimulation following passive movement of hind limb of different animal species (3,5,6,9 and 17) and also man (9). Recently, Barron and Coote (3) carried out passive movement in decerebrated cat at the rate of 120 c/min and confirmed that only larger rate can produce temporal facilitation of afferent input leading to smaller degree of respiratory response. They further concluded on the basis of their (3) as well as previous experiments (5,6,9 and 17) that the role of nerve endings from joint in causing hyperpnea is very minor whereas input from muscle receptors is more powerful which probably facilitates weaker reflex from joint if the extent and rate of movement is sufficiently greater.

In contrast to earlier studies, fairly low frequency of ankle and wrist *(30 c/min)* movement was carried out in the present study and care was taken to avoid stretching of limb muscles (to avoid muscle stretch receptor stimulation) by limiting the extent of flexion or extension of these joints to approximately 30° only, from midposition, which is well within normal range of discrete movements at these joints. It seems, therefore, conceivable that our experimental condition failed to produce respiratory stimulation presumably because of absence of occurrence of temporal facilitation of the afferent input and non-involvement of muscle receptors. Our results are, therefore, in agreement with most recent conclusion of Coote (12) that the gastrointestinal changes usually appear in response to more specific somatic stimulation whereas cardiorespiratory effects follow only wide-spread stimulus to meet out major readjustments in internal homeostasis.

To conclude, the natural stimulation of joint receptors in humans at slow rate produces gastric inhibition through upper extremity joints only. The absence of such an inhibition from lower extremity joints strongly suggests spatial organisation of this relfex and arouses suspicion whether this phenomenon, presumably arising through mediation of proprioceptors from within and around joints, is related to feeding mechanism for which the upper extremities in primates have evolved. Further, the spontaneity of this reflex could well be an important contributing factor for receptive relaxation of gastric wall which soon follows feeding involving cordinated movements for joints of upper extremity.

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