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Abstract

In guinea pigs the lumen of an excised jejunal segment was perfused to study the effect of intraluminal pressure on the frequency of rhythmic contraction waves. Within the range of 0 to 40 mmH2O, increases in intraluminal pressure caused increases in the frequency of contraction waves. At pressures of 10, 15, 20, 30 and 40 mmH2O the frequency was 7.9, 9.0, 10.9, 12.5 and 13.3 per min (mean of ten preparations), respectively. An exponential relationship was proved to exist between the pressure and the frequency.

KEYWORDS: intestinal motility, intrinsic reflex.

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THE EFFECT OF INTRALUMINAL PRESSURE UPON THE FREQUENCY OF INTESTINAL CONTRACTION WAVES

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Abstract. In guinea pigs the lumen of an excised jejunal segment was perfused to study the effect of intraluminal pressure on the frequency of rhythmic contraction waves. Within the range of 0 to 40 mmH_2O, increases in intraluminal pressure caused increases in the frequency of contraction waves. At pressures of 10, 15, 20, 30 and 40 mmH_2O the frequency was 7.9, 9.0, 10.9, 12 5 and 13 3 per min (mean of ten preparations), respectively. An exponential relationship was proved to exist between the pressure and the frequency.

Key words: intestinal motility, intrinsic reflex.

It has been demonstrated that increase of intraluminal pressure in an intestinal loop regulates the amplitude and the direction of contraction waves (1, 2). The aim of the present study was to elucidate whether the frequency of contraction waves was regulated by changes in intraluminal pressure of a jejunal segment from a guinea pig.

METHODS

The upper part of the jejunum about 3 cm long was excised from nonanesthetized guinea pigs weighing 400 to 600 g. The excised segment was placed horizontally in a bath filled with 50 ml of Tyrode's solution, the temperature of which was kept constant at about 37°C. The experimental arrangement for perfusing the segment was largely the same as that described previously (2) (Fig. 1).

By means of a midget motor (Toshiba, Type G-2) the pressure bottle was elevated with a uniform velocity, which was altered by combining driving pulleys of various radii with movable pulleys. By means of cannulae and rubber tubes the oral and anal ends of the segment were respectively connected to the pressure bottle; the oral cannula, moreover, served as an angular lever which was movable around the axis of rotation. A tension corresponding to 1.5 g was exerted on the excised segment in the longitudinal direction by means of a weight. By using a strain gauge transducer the contractions of the segment in its longitudinal direction

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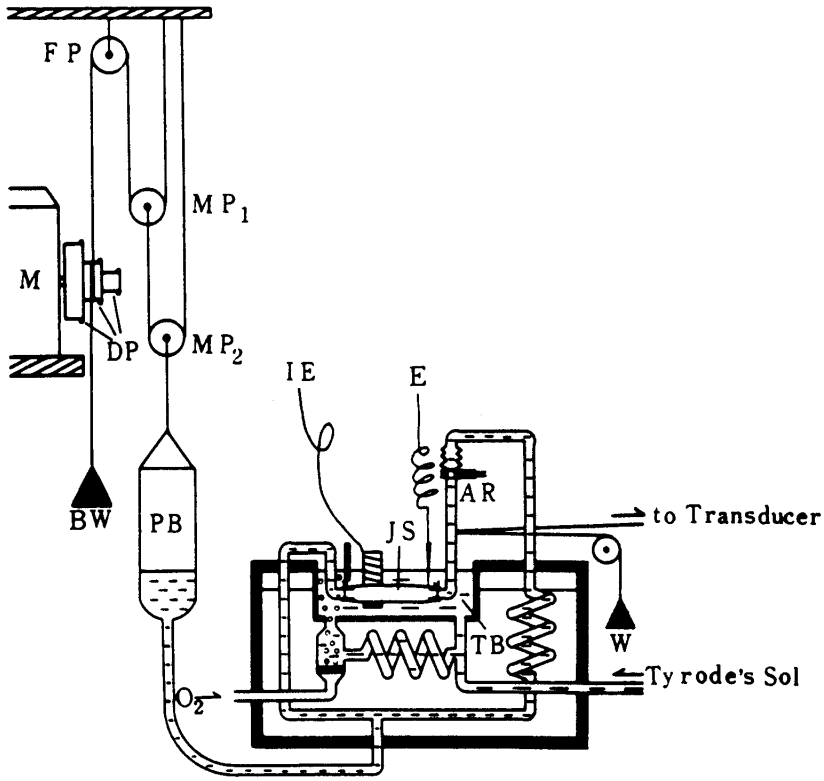

Fig. 1. Experimental arrangement. TB : Tyrode bath, JS : Jejunal segment, E : Microelectrode, IE : Indifferent electrode, PB : Pressure bottle, W : Weight, AR : Axis of rotation, FP : Fixed pulley, MP_1 and MP_2 : Movable pulleys, BW : Balance weight, M : Driving motor, DP : Three driving pulleys set on the axle of the motor.

were recorded on paper running at a speed of 10 mm/sec. Action potentials were also recorded intracellurally. The frequency of the contraction waves was measured from these tracings.

RESULTS

When an excised segment of guinea-pig small intestine was maintained under intraluminal pressure as low as zero, it was usually quiescent. In such preparations pressure-raising was repeated at various speeds. The course of the change of the frequency of contraction waves thus observed is shown in Fig. 2. The trial was, at first, carried out at a lower speed (0.4 mmH_2O/sec) as shown in Fig. 2, a. When the pressure attained about 10 mmH_2O, the pulsatile contractions appeared at the oral end of the segment with a frequency of 8.7 per min, propagating throughout the whole length of the segment. With

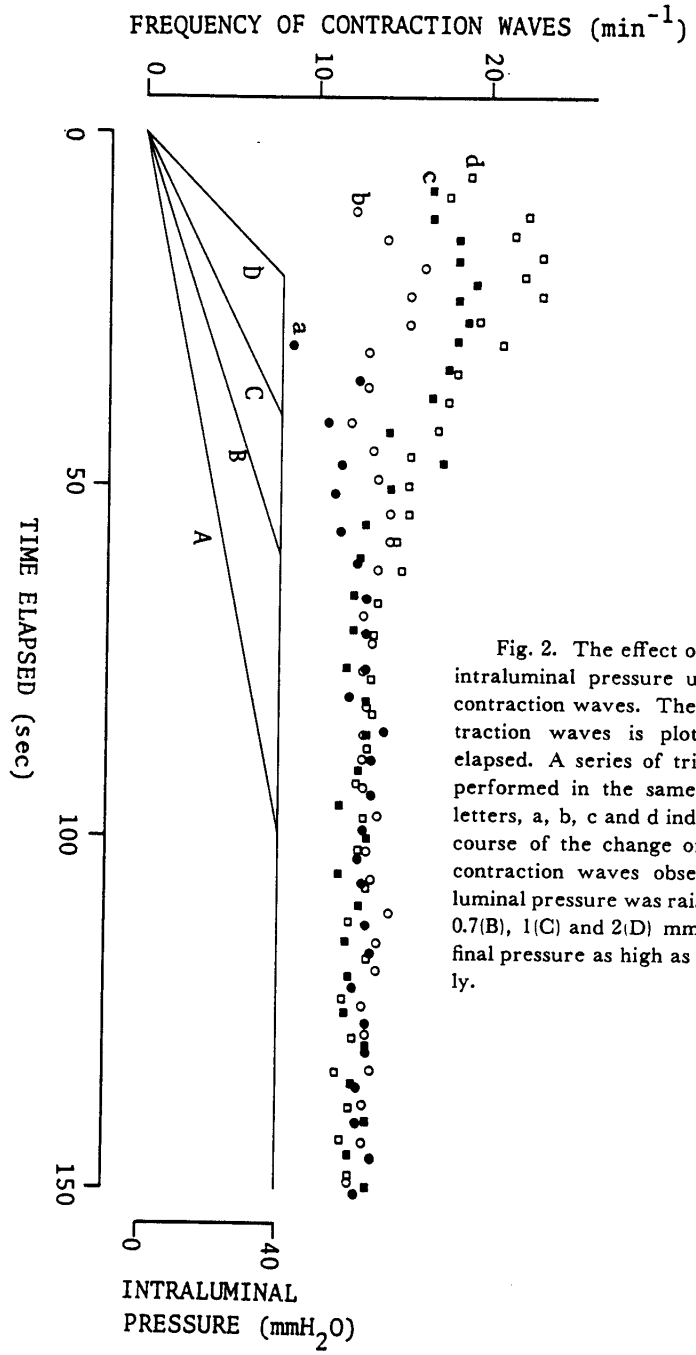

Fig. 2. The effect of the rate of rise of the intraluminal pressure upon the frequency of contraction waves. The frequency of the contraction waves is plotted against the time elapsed. A series of trials in this figure were performed in the same jejunal segment. The letters, a, b, c and d indicate, respectively, the course of the change of the frequency of the contraction waves observed when the intraluminal pressure was raised at the rate of 0.4(A), 0.7(B), 1(C) and 2(D) mmH_2O/sec, to attain the final pressure as high as 40 mmH_2O, respectively.

a further increase of the pressure the frequency of contraction waves gradually increased becoming as high as 13.3 per min, when the pressure attained was as high as 40 mmH_2O, and this frequency was then maintained for the following 3 to 4 min. It then decreased slowly with lapse of time, until the waves were abolished in about 5 min. If the pressure was then lowered and kept at zero for 6 min or longer, the preparation was restored again to show a response similar to that described above.

Similar trials were then taken at a speed higher than that in the first trial, that is, 0.7, 1, and 2 mmH_2O/sec respectively, interposing a rest period of 6 min between each trial. As is obvious from the diagrams, b, c and d in Fig. 2, the frequency was from the very first markedly high as compared with that obtained in the first trial; and the higher the rate of increase of the pressure was, the higher the frequency was, being estimated at 12.2, 16.7 and 18.8 per min corresponding to the speeds of 0.7, 1 and 2 mmH_2O/sec, respectively. With a further increase in the pressure, the frequency then successively increased to some degree, but soon decreased, until it eventually attained the frequency corresponding to the final pressure, 40 mmH_2O, that is, about 13 per min.

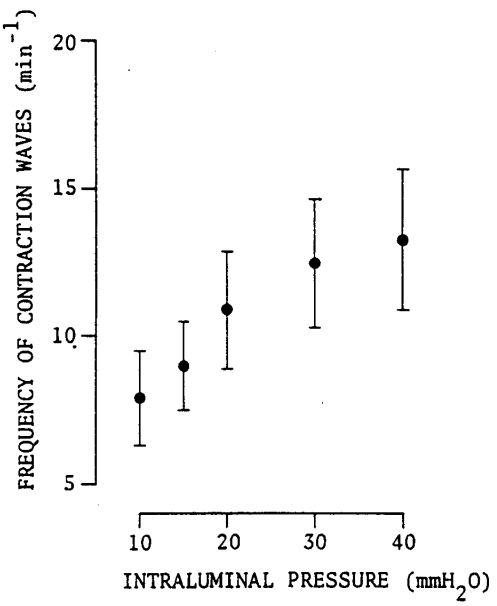

Fig. 3. Relationship between the frequency of contraction waves and the intraluminal pressure. Trials were taken of 10 guinea-pig jejunal segments. Solid circles represent the means of frequencies of contraction waves. Vertical bars represent standard deviations.

When the pressure was raised at a speed higher than 2 mmH_2O/sec and/or the pressure attained was higher than 40 mmH_2O, the extracontractions were frequently initiated here and there along the whole length of the segment; in other words, contraction waves fell into disorder, forcing us to suspend the measurement of the frequency.

The results obtained in the experiments described above revealed that the frequency was maintained at a fairly constant level, provided that both the rate of increase of the pressure and the pressure to be finally attained were within the range such as described above. Thus, in each of 10 different preparations the frequency of contraction waves corresponding to varying pressures, 10, 15, 20, 30 and 40 mmH_2O were measured. As a result, the means of the frequencies proved to be 7.9 ± 1.6, 9.0 ± 1.5, 10.9 ± 2.0, 12.5 ± 2.2 and 13.3 ± 2.4 per min corresponding to the pressures 10, 15, 20, 30 and 40 mmH_2O, respectively. By plotting the frequencies against the corresponding pressures a diagram was obtained, which revealed that an exponential relationship existed between the frequency of contraction waves and the intraluminal pressure (Fig. 3).

DISCUSSION

Surveying the literature, Trendelenburg (3) and Hukuhara and Fukuda (1) failed to establish any definite relationship existed intraluminal pressure and the frequency of contraction waves. On the other hand, Hukuhara (4) recognized that the frequency of intestinal contraction waves was increased by raising the intraluminal pressure. He attributed this frequency-increase to extracontractions.

In the present experiment it was corroborated that in the guinea-pig small intestine, pressure-raising produced a considerable increasing of the frequency of contraction waves, and that the increasing varied with the height as well as the rate of rise of the pressure. The mechanism underlying the phenomena is probably the same as that already described (1, 2); namely, rise of the pressure produces an intrinsic mucosal reflex (5), resulting in an increase of the excitability of the intestinal muscles, which in turn increases the frequency of contraction waves.

In addition, in the experiment which was carried out on the jejunal loop of dogs, Nakayama (6) showed that the increase of the frequency of contraction waves due to the intrinsic mucosal reflex was reinforced by applying hydrochloric acid to the mucosa.

In this connection, Hukuhara (7) confirmed that in rabbits provided with an abdominal window the frequencies of contraction waves propagating along the duodenum, jejunum and ileum, were, before feeding, 22, 20 and 17–18 per min, respectively, while they were increased after feeding to 24–25, 22–

23 and 21–22 per min, respectively. On the basis of the results obtained in the present experiments this frequency-increase observing after feeding can be attributed to the intrinsic mucosal reflex, which is initiated when the mucosa is rubbed or distended by the intestinal content.

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