Relationship Between Size of Bolus and the Act of Swallowing on Esophageal Peristalsis in Dogs[1] (35683)

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In dogs, esophageal peristalsis is not induced by the act of swallowing if the bolus is diverted from the esophagus (1). On the other hand, esophageal peristalsis is induced by distention of the esophageal lumen even though unaccompanied by the act of swallowing (2). These studies suggested that the act of swallowing and the presence of a bolus within the esophagus are completely dissociated with respect to the stimulation of esophageal peristalsis. The present studies were performed to determine if the act of swallowing and the presence of a bolus were related in the genesis of esophageal peristalsis by the former reducing the threshold stimulus (size) required of a bolus to produce peristalsis.

Materials and Methods. Two types of experimental models were prepared using mongrel dogs:

Group I (2 dogs). In the manner described by Olbe (3), the cervical esophagus was elevated from its normal position, exteriorized and wrapped with skin. The neck was closed forming a tunnel beneath the esophagus which was maintained in continuity. After complete wound healing, the exteriorized portion of the esophagus was cannulated. When experiments were performed, the cannula was opened and the esophagus distally occluded by a light ligature of gauze to prevent the swallowed bolus from entering the tubular esophagus.

Group II (2 dogs). The manner in which the cervical esophagus was prepared was the same as it was in animals of Group I except that no cannula was introduced. After wound healing was complete, the exteriorized portion of the esophagus was transected, leaving proximal and distal skin covered stomas of the esophagus. Esophageal motility was measured with three water filled polyethlyene tubes (Intramedic PE 190) with side openings in their metallic tips. The tubes were bound together with a separation of 24 cm between the proximal (P) and medial (M) tips and 5 cm between the medial (M) and distal (D) tips. They were connected to Statham strain-gauge transducers (P23De) and the system was calibrated in cm of water. Respiration was recorded with a strain-gauge pneumograph. A model 7 Grass Polygraph was used for recording.

Following overnight fasting, dogs were placed in Pavlov stands, tubes were passed through the dog's mouth and positioned so that the proximal (P) tip in the pharynx or pharyngoesophageal sphincter recorded swallowing and the medial (M) and distal (D) tips in the tubular esophagus recorded peristalsis. Records of esophageal motility were made while water was continuously infused through the medial (M) and distal (D) tubes with Harvard pumps at rates of 2.00 ml/min or 4.20 ml/min. The proximal (P) tube was not infused in order to avoid the induction of swallowing. A plastic catheter was placed in the oropharynx for the administration of water when it was desired to initiate swallowing. Manometric recordings were obtained (i) when the dog was forced to swallow repetitively by the pharyngeal administration of water and (ii) when the dog was under resting conditions and either swallowed spontaneously or not at all. Esophageal

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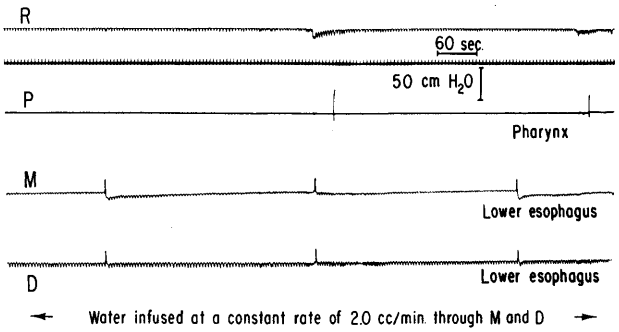

FIG. 1. Induction of esophageal waves by constant infusion of water in the distal isolated esophagus of a dog. In this and the following illustrations, water filled tubes marked (P) proximal; (M) medial; and (D) distal are located as indicated. (R) respiration.

Esophageal contractions occur without swallowing after sufficient time has permitted an adequate balus of infused water to accumulate in the esophagus. Two swallows were not followed by peristalsis because the bolus was of inadequate size.

waves recorded after the dog was made to swallow were called swallowing waves (S) and those recorded when the dog did not swallow or swallowed spontaneously were called noninduced swallowing waves (NIS). The elapsed time between consecutive esophageal waves was measured and the size of the bolus infused during that period was calculated in milliliters of water. A comparison was made between the volume of infused fluid required to initiate peristalsis when there was and was not the antecedent act of swallowing.

Results. Peristaltic waves, in response to the infusion of water, occurred with greater frequency when the dogs were made to swallow than occurred when the dogs were not made to swallow. Peristaltic waves did not occur spontaneously or following the act of swallowing unless a bolus of water was present in the esophagus (Figs. 1, 2, and 3).

Infusion of water at the rate of 2.0 ml/min. A total of 48 esophageal waves were analyzed. They were equally divided between those associated with swallowing and those that were not. The volume of water required in the esophagus to induce a peristaltic wave when swallowing did not occur was twice the volume required if swallowing did occur (Table I).

Infusion of water at the rate of 4.2 ml/min. At the increased perfusion rate, 42 peristaltic waves equally divided between S and NIS were analyzed. The volume of water

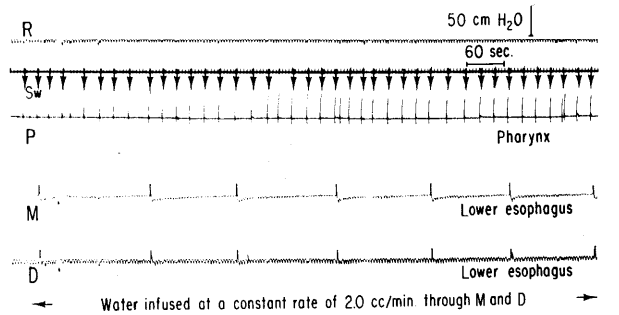

FIG. 2. Induction of esophageal waves by repetitive swallowing during continuous infusion of water in the distal isolated esophagus of a dog. Multiple pharyngeal contractions induced by swallowing (arrows) in the same dog as represented in the previous figure were not followed by peristaltic waves in the lower esophagus until a critical volume of infused water was reached. The decreased time between esophageal waves in this figure, compared with Fig. 1, represents reduced volumes of perfusate between esophageal waves.

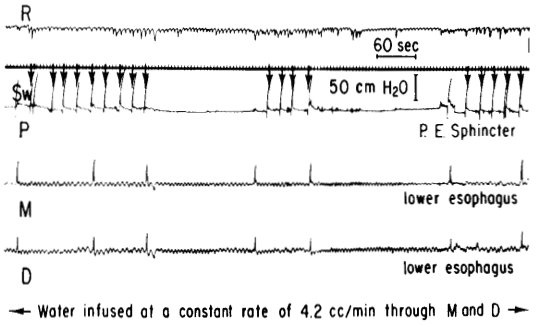

FIG. 3. Induction of esophageal waves with and without repetitive swallowing during continuous infusion of water in the distal isolated esophagus of a dog. The time interval between esophageal peristaltic waves was less when the dogs were made to swallow repetitively than when they were not made to swallow. These shorter time intervals are commensurate with the administration of smaller boli required to induce esophageal peristalsis when there is concomitant swallowing.

required to induce peristalsis was again twice as great if swallowing did not occur as it was if swallowing did occur (Table II). Peristaltic waves that occurred either with or without swallowing were dependent on the volume of infused water and were independent of infusion rate when this was increased as high as 11 ml/min. Thus, the volume of water in the tubular esophagus required to induce a peristaltic wave in the dog was significantly smaller when the dog was forced to swallow repetitively than when he did not swallow. Both surgical models behaved the same and there appeared to be no difference between them.

Discussion. In the canine models used in this study swallowing could be initiated without ejecting a bolus into the tubular esophagus and alternatively a bolus could be introduced into the esophagus without initiating the act of swallowing. We were thus able to study the relationship between the act of swallowing and the size of the bolus in the genesis of esophageal peristalsis. According to our data, as water was infused into the tubular esophagus, the time interval between peristaltic waves was less (smaller bolus) when the dogs swallowed repetitively than when they did not swallow. The size of bolus required to initiate esophageal peristalsis was significantly smaller ($p<.01$) when swallowing was present than when it was absent (Tables I and II). Previous observations in our laboratory have shown that swallowing without the bolus entering the tubular esophagus does not induce esophageal peristalsis (1).

In the light of those studies, which were reconfirmed in the present experiments, our data indicated that the threshold stimulus required for esophageal peristalsis which resulted from the presence of a bolus in the tubular esophagus was decreased by the act of swallowing. Even so, in dogs forced to swallow repetitively, peristalsis did not occur until a critical bolus of water was infused into the tubular esophagus. These results suggested that an afferent stimulus provided by an intraesophageal bolus was necessary to

TABLE I. Size of Bolus Required to Initiate Peristalsis.

Rate of infusion, 2.0 ml/min	Without swallowing ($n = 24$) (ml)	With swallowing ($n = 24$) (ml)	p
Mean	8.74	4.24	$<.01$
SD	2.78	1.41	

TABLE II. Size of Bolus Required to Initiate Peristalsis.

Rate of infusion, 4.2 ml/min	Without swallowing ($n = 21$) (ml)	With swallowing ($n = 21$) (ml)	p
Mean	8.07	3.83	$<.01$
SD	2.36	0.76	

initiate peristalsis and that the act of swallowing reduced the threshold for this stimulus so that the magnitude of the intraesophageal bolus required to initiate peristalsis was less. Thus esophageal peristalsis in the tubular esophagus of the dog was initiated by an intraluminal stimulus; and did not occur after swallowing until this stimulus obtained a critical level.

Summary. The respective roles that the act of swallowing and the presence of an esophageal bolus exert on the genesis of esophageal peristalsis were studied in dogs. In the absence of a bolus, peristalsis in the esophagus did not follow the act of swallowing, while in the absence of swallowing peristalsis did occur if the bolus was of adequate size. The size of the bolus required to induce esophageal peristalsis was significantly less when swallowing occurred than when it was absent. Thus, the threshold stimulus required to initiate peristalsis was related to the volume of bolus and the magnitude was reduced by the act of swallowing. When the size of the bolus was below a critical volume, peristalsis was not initiated even though this intraesophageal stimulus was reinforced by swallowing.

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