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ON THE CONTROL OF CAECAL MOTILITY IN SHEEP

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Résumé


Introduction.

The delay imposed on the passage of food residues by the large intestine in ruminants is considerable: only 2 hr are needed for a marker introduced into the duodenum to pass the terminal ileum but more than one day passed before it is excreted in the faeces (Coombe and Kay, 1965). The possible role of the cæcum in such a delay is still enigmatic due to the ignorance of both the motor profile and the factors involved in its control.

Peristaltic and antiperistaltic movements of the cæcum have been seen fluoroscopically in the unanesthetized lamb (Spörri and Asher, 1940) and periods of quiescence, of slow movements and of great activity have been recorded from pressure changes in sheep (Phaneuf, 1952; Berehoiu, 1966). According to Goodall and Kay (1965), cæcal filling was intermittent and series of small boli passed through the ileo-caecal junction at about 2-hr intervals. Such an interval has also been found for cæcal emptying which occurred at about 10 times per 24 hr (Ruckebusch and Laplace, 1967) and for the flow of digesta in the small bowel which lasted 10-15 min at the frequency of the myoelectric complexes, i.e. at least once in each 2 hr (Bueno et al., 1975).

In a recent paper on cæcal cannulation in the sheep, MacRae et al. (1973) examined the movements of contrast media. Monitoring over a prolonged period and recording of pressure changes revealed a complex
pattern of motility including (i) localized contractions, presumably tonic in nature; (ii) regular co-ordinated contractions which result in mixing of digesta, and at long intervals (iii) trains of 2-5 very strong contractions, associated with transfer of caecal contents to the proximal colon, and followed by a quiescent phase lasting 15-30 min. The following experiments were undertaken in sheep (i) to investigate the relation between the cyclic character of ileal activity and that of the caecum; (ii) to analyze the local and extrinsic factors involved in the control of caecal motility; (iii) to emphasize the role of local reflexes stimulated by the bulk of digestive contents.

Material and methods

Eight adult Lacaune ewes, weighing from 35 to 40 kg were housed in individual cages and fed ad libitum on hay. Six pairs of electrodes made of insulated nichrome wire were implanted under thiopentone anaesthesia (Ruckebusch, 1970). The pairs of electrodes 2 mm apart were positioned in front of the ileo-caecal valve (ICV), on the ileum at 10 and 50 cm from the ICV, on the caecum near the blind pole and on the mid-caecum; the last pair was fixed on the proximal colon at 40 cm from the ICV. In 2 of the 8 ewes, a caecal pouch was isolated in situ at the time of implantation by a transversal section of the caecum at 5 cm from the ICV and fitted with a cannula (20 mm in diam.) at 10 cm from the section; the pouch was washed at 48-hr intervals with an isotonic saline (9 g NaCl/l) solution warmed at 38°C. In another ewe, a T-cannula was inserted between the electrodes fixed on the distal ileum. In two additional ewes, the tips of three open catheters (2 mm in diam.) were inserted one into the lumen of the duodenum, the second in the lumen of the ileum at 50 cm above the ICV and the 3rd in the blind pole of the caecum.

Recordings of the electrical activity began one week after surgery and continued periodically for 8-12 weeks. The electrodes were connected to an e.e.g. machine (Reega VIII, Alvar, Paris). The activity of four chosen sites was automatically plotted each 20 sec by means of a four-line integrator connected to a potentiometric recorder (Latour, 1973).

The following procedures were also performed: (i) Increased flow of contents at the ileal and caecal levels by an intraluminal infusion of warmed saline at the rate of 20 ml/min during 15 min. (ii) Decreased flow of digesta during 24-hr periods by diversion of the ileal content through the opened cannula which was occluded at its distal branch by inflating a small balloon. (iii) Distension of the isolated caecal pouch at 5 cm and 10 cm H2O by introduction of saline, the cannula being connected to a water manometer and (iv) Osmotic diarrhoea by means of duodenal infusion of one litre of a D-mannitol hypertonic solution (900 mOsm/l) at a rate of 15 ml/min.

Results

Patterns of caecal motility

The electromyogram recorded from the caecum exhibited short bursts of spike potentials lasting 5 to 10 sec and recurring at a higher frequency near the ileo-caecal valve (ICV) than at the blind pole (1.1/min versus 0.7/min and 0.9-1/min in the mid-caecum. The majority of spike bursts (57%) were propagated from the ICV to the blind pole, 24% in the opposite direction. The others originated in the mid-caecum and faded out after traversing distances not exceeding 20 cm. The velocity of propagation was 2 cm/sec whatever the direction or the distance. The caecal contraction which occurred at a frequency of 0.7-1.1/min did not present any relationship with those of the distal ileum the frequency of which was that of the slow wave, i.e. 15/min in the sheep.

This pattern was suddenly changed when the phase of regular spiking activity of a myoelectric complex was propagated along the distal part of the ileum. The caecum then showed a period of hyperactivity characterized by a series of 4-12 spike bursts lasting 1-3 min and followed by an inhibition for 10-15 min (Fig. 1). This hyperactivity was detected 1-3 min after the phase of regular spiking activity was recorded at the 1st electrode site of the distal ileum, i.e. about 3 min before the phase of regular spiking activity reached the 2nd electrode site of the ileum at 10 cm from the ICV.
The analysis of the relationship between the occurrence of the periods of caecal hyperactivity and the site of propagation of the front of a phase of regular spiking activity showed that 2/3 of the caecal responses occurred when the phase of regular spiking activity propagated over the last 20 cm of the ileum and 1/3 when it had already reached the ICV.

Integrated recordings were particularly well-adapted to define the occurrence of a period of caecal hyperactivity linked to the propagation of myoelectric complexes along the distal ileum. As shown in Fig. 2, the phenomenon occurred for 4 of the 5 complexes and was followed by a period of quiescence.

**Ileo-caecal relationship**

Increased flow of the contents through the ileum by an infusion of saline increased by 200% the frequency of caecal contractions without any phase of hypermotility as previously described. The same infusion performed into the caecum had no effect.

When the ileal contents were withdrawn before the ICV during 24 hr, caecal responses to the propagation of the phase of regular spiking activity of the myoelectric complexes on the distal ileum persisted. A major difference was a prolonged phase of inhibition (20-30 min) following the period of caecal hyperactivity. In addition, the mean frequency of spike bursts were reduced to 0.6/min in the mid-caecum.

The duodenal infusion of a 1000 ml D-mannitol hypertonic solution at the rate of 15 ml/min was followed within 1 hr and during 6-7 hr by the occurrence on the caecum of strong bursts of spike potentials. These, usually grouped in pairs, had a frequency of 0.7-0.8/min and were rapidly propagated from the blind pole to the ICV at a velocity of 10 cm/sec (see Fig. 1). Concomitantly, the motor profile of the small intestine, including the ileum, was disorganized and characterized by an irregular spiking activity which was grouped in short phases of 0.5-2 min occurring continuously. This motor profile was present at the onset of diarrhoea with emission of liquid faeces 5-6 hr after the end of the perfusion. Recovery of normal caecal motility corresponded to the presence of myoelectric complexes on the ileum.

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**Fig. 1.**—Electrical activity of the ileo-caecal region in sheep. The electrode sites are indicated on the diagram. Upper panel: the frequency of the spike bursts which occurred at intervals of about 1 min on the caecum was increased during the development of the phase of regular spiking activity of a myoelectric complex on the ileum. Lower panel: The onset of diarrhoea which is characterized by a continuous irregular spiking activity of the ileum was accompanied by an uniform distribution of caecal spike bursts. Diarrhoea was induced by duodenal infusion of one liter of a 900 mOsm/l D-mannitol solution.

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**Fig. 2.**—Relationships between ileal and caecal motility. The electrical spiking activity of the distal ileum and the caecum was integrated at 20-sec intervals during about 6 hours. The propagation of a phase of regular spiking activity on the distal ileum is frequently accompanied by a period of hypermotility (dots) followed by quiescence. This event is well-patterned near the ileo-caecal valve.
The ileo-caecal relationships also persisted on the isolated caecal pouch and were enhanced when the pouch was emptied of its contents or submitted to the atmospheric pressure by opening the cannula (Fig. 3). The frequency of caecal contractions which varied from 0.3 to 0.5/min when the phase of irregular spiking activity occurred on the distal ileum increased to 5-7 spike bursts/min when a phase of regular spiking activity was recorded over the last 50 cm of the ileum. The subsequent period of quiescence lasted at times 40 min, i.e. the interval between two myoelectric complexes on the ileum. The caecal response was recorded for nearly all the myoelectric complexes and always started before the phase of regular spiking activity reached the ICV.

**Local reflexes**

The ileo-caecal relationship was modified by an increase of the intraluminal pressure in the isolated pouch. A local pressure of 5 cm H₂O increased the activity of the pouch by 30% without any subsequent inhibition. For a local pressure of 10 cm H₂O, the caecal electromyogram showed only strong bursts grouped in pairs as at the onset of diarrhoea and at a frequency of 0.7 to 0.8/min. No relation was recorded between the isolated pouch and the part of the caecum remaining near the ICV.

**Discussion**

With the use of integration of spike bursts at 20-sec intervals, it is relatively easy to follow the alternation of quiescent and spiking phases of the caecum, especially the phases of hyperactivity earlier observed by Phaneuf (1952). Both localized and co-ordinated contractions of the caecal wall described by MacRae et al. (1973) are also easily identified but from direct recordings.

The factors involved in the control of caecal motility seemed to be firstly the bulk of digestive contents and secondly the activity of distal ileum. The intrinsic activity of the caecal wall is very low since an isolated caecal pouch in situ and emptied per se shows a long-lasting phase of quiescence. An intracaecal pressure of about 5 cm H₂O is necessary to stimulate an electrical equivalent of localized and co-ordinated contractions.

That the phases of caecal hyperactivity are induced at the ileal level is demonstrated by three experiments. The increased flow of digesta obtained by infusion is effective at the ileal level but not in the caecum; furthermore, the caecal responses to the flow of digesta in advance of the regular spiking phase of the migrating myoelectric complex persist even when the digesta are diverted so they do not reach the caecum. Finally, the ileocaecal relationship is only suppressed by a high intracaecal pressure as occurs when an isolated pouch is subjected to an internal pressure of 10 cm H₂O or when the propagation of the complexes is disrupted at the onset of diarrhoea.

It may be stated that the flow of digesta in the small bowel, which is maximal just before the phase of regular spiking activity (Bueno et al., 1975), induces an ileo-caecal
reflex. Caecal emptying thus precedes the passage of digesta through the ICV. Such a mechanism is not effective in the case of a caecal response occurring when the phase of regular spiking activity has already reached the ICV. In this case, the digesta are directly propelled from the ileum towards the colon; this did not exclude the possibility of a caecal stasis lasting 7–11 hr and observed by Thewis et al. (1976) since backflow of colonic contents towards the caecum probably occurred, as pointed out by MacRae et al. (1973), at the end of the period of inhibition following hyperactivity.

While in monogastric herbivora such as rabbits or horses, caecal motility is directly influenced by gastric activity, it is suggested that in ruminants ileal activity is a more potent factor: the motility of the caecum is essentially related to the distal ileum by way of an ileo-caecal reflex modulated by caecal pressure.

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Summary

The electrical activity of the terminal ileum and of the caecum was recorded continuously from chronically implanted electrodes in 8 ewes fed on hay ad libitum. The caecum even as an isolated pouch showed a cyclic activity closely linked to the frequency of myoelectric complexes on the terminal ileum. This phenomenon disappeared in the absence of myoelectric complexes.

The distension of an isolated caecal pouch induced local changes in the electrical activity with disappearance of the cyclic activity.

It is concluded that two factors are involved in the control of caecal motility, one originating at the distal ileum and the other related to the endoluminal pressure.

References


