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A METHOD FOR RECORDING THE MOTOR ACTIVITY OF THE RETICULUM IN CATTLE*

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In the clinical examination of the motor activity of the forestomachs auscultation, percussion, palpation and inspection are the methods most commonly used (*Ekelund* 1921, *Lagerlöf* 1930, *Hoflund* 1940, *Williams* 1955). Such methods usually supply good information regarding the movements, but when the ingesta in the reticulorumen is in liquid form, or when the contractions have decreased in strength, the motor activity is difficult to assess. An objective method for recording the movements of the forestomachs would therefore be of great value as a diagnostic aid.

The motor activity in the forestomachs can be recorded in several different ways. *Wester* (1926), *Schalk & Amadon* (1928), *Hoflund*, and others, used thin-walled rubber balloons for registering pressure changes in the ingesta. *Steven & Sellers* (1960), in investigations on eructation, regurgitation and swallowing, recorded the pressure via "open or whistle-tipped strain gauge catheter systems". The contraction cycles in sheep with a "partially exteriorized reticulorumen" were studied by *Reid & Titchen* (1959). Radiological studies of the movements of the forestomachs have been carried out by *Czepa & Stigler* (1926, 1929), *Phillipson* (1939) and *Dougherty & Habel* (1955). *Itabisashi* (1964) described the changes in the baseline of the EKG seen in connection with the forestomach contractions. *Dracy & Kurtenbach* (1965) used radiotelemetry in recordings of pressure

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changes in the reticulorumen. A method for recording the vertical movements of the different structures of the reticulorumen has been described by *Reid & Cornwall* (1959).

Our object was to work out a technique that would permit recording of the pressure in the reticulum and oesophagus in intact cattle. For this purpose we chose a so-called rigid system, in which the volume change is small in relation to the pressure change (*Quigley & Brody* (1952). The pressure is transferred through open-tipped catheters to pressure transducers.

MATERIAL AND METHODS

Four clinically healthy heifers and six clinically healthy cows of the Swedish red and white breed were used for the studies. The animals were given hay at 6 a.m. and 1.30 p.m., and concentrates consisting of barley, oats, wheat bran and oil cakes at 1 p.m.

Three of the cows were provided with a permanent fistula into the rumen by the method described by *Balch & Johnson* (1948) and *Balch & Cowie* (1955). These were used among other things to check the position of the recording catheters introduced through the nasopharynx, and also to ascertain whether there were pathologic conditions in the region of the reticulum. The animals not provided with fistulas were slaughtered after the experiments and examined to make sure that they were free from traumatic peritonitis.

The pressure in oesophagus and reticulum (or atrium ruminis) was transferred through two open, water-filled catheters (Ödman-Ledin, yellow-3, Kifa, Stockholm) over pressure transducers with a volume displacement of 3×10^{-4} mm³/mm Hg (EMT 34, Elema-Schönander, Stockholm), to electromanometers set for registration of mean pressure (EMT 31, Elema-Schönander), from which it was recorded with the aid of a mingograf (Mingograf 81, Elema-Schönander). The catheters were tied together so that the opening of the oesophagus catheter was positioned about 40 cm from the open end of the other. In the middle of the catheters Luer-Lock couplings were inserted. To keep the end of the reticulum catheter in position it was equipped with three rod-shaped brass weights measuring 40×11 mm. Each catheter was connected to the measuring chambers of the transducers by means of adapters. One-way and three-way stopcocks

were connected to the measuring chambers of the pressure transducers. The measuring chambers were filled with water, containing an anti-rust agent (Septinol®), from a calibration flask through polythene tubes attached to one of the openings of each three-way tap and with the one-way taps opened so that all air was evacuated from the chambers. The pressure transducers and calibration flask were mounted on a stand equipped with a sliding holder. For the recordings, the transducers were placed on a level with the point of the animal's elbow and the electromanometers were set at zero and calibrated against a column of water corresponding to 50 mm Hg with the aid of the calibration flask. Fig. 1 shows the apparatus in function.

The cows were placed in a separate stall during the recording, and were given no sedatives. The recordings were carried out 2—6 hrs. after feeding, and were continued for 15—45 min. In the cows provided with fistulas, recordings were made before and three months after the intervention. After sterilization by boiling, the catheters were passed down into the oesophagus and the reticulum through the nasopharynx. In a cow with a rumen

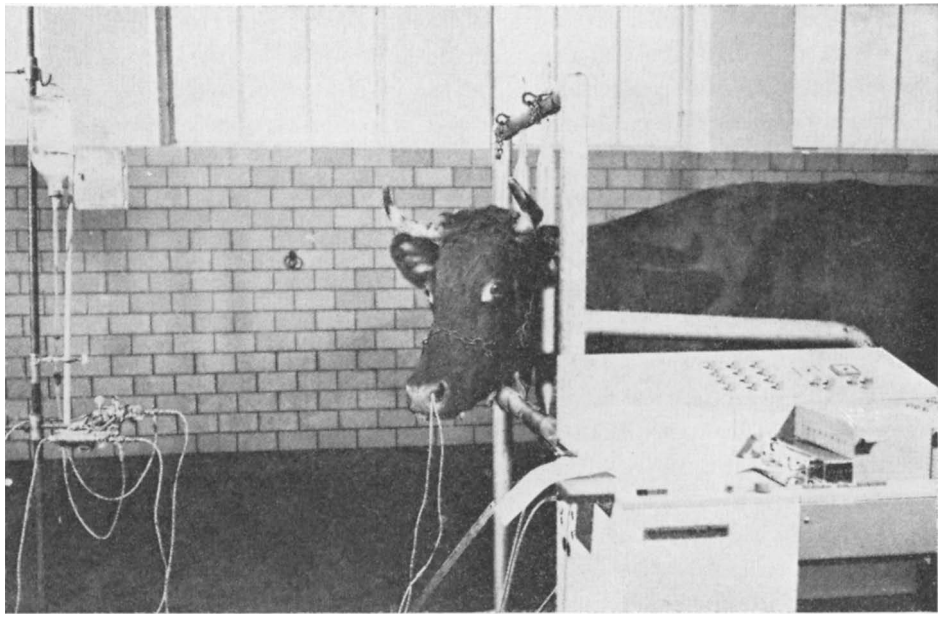

Figure 1. Arrangement of apparatus and subject for a study of pressure events in reticulum and oesophagus.

fistula recordings of the reticulum were obtained via a catheter first introduced through the nasopharynx and 1 hr. later through the fistula. In order to facilitate the introduction of the catheters through the nasopharynx, they were taken apart and a guiding wire of stainless steel measuring 0.5 mm in diameter was inserted into the reticulum catheter. When the distal end of the tandem catheter had reached the reticulorumen a tough resistance was felt through the catheter. If the wire guide was removed at this stage, the catheter usually passed into the reticulum, whereas if the catheter was passed a few more decimeters in before the guide was removed it passed into the atrium ruminis or the rumen. After the wire guide had been removed, the parts of the catheters in the cow were filled with water with the aid of a 20 ml syringe with a Luer-Lock holder. Both parts of the catheters were then quickly coupled together below the fluid level of the forestomachs and with the three-way taps open between the calibration flask and the catheters. Fluid was then allowed to run through the catheters for 15—30 sec., after which the stopcocks were switched to connect the measuring chambers and the catheters. A continuous flow of fluid was not used during registration. To prevent clogging of the open end, the catheters were instead flushed with the aid of the calibration flask every 10—15 min., or when one of the electromanometers showed that its catheter was obstructed. If the catheter could not be cleared by pressure from the calibration flask it was flushed with a syringe or cleaned with the wire guide. A paper speed of 2.5 mm/sec. was used, except in a few cases where studies of details in certain sequences were being made; for these, a speed of 5 or 10 mm/sec. was used.

RESULTS

The open end of the long catheter could in most instances be placed at once in the reticulum. In those cases where it found its way into the atrium ruminis it usually passed over into the reticulum within 5—10 min. as a result of the contractions. During the first few min., the animals showed signs of irritation in the form of snorting, head shaking, and expellent coughing, but they soon got used to the catheter, and as a rule it was possible to make undisturbed recordings within 10 min.

When once the open end of the long catheter had reached the reticulum it seldom altered its position. Once or twice, it passed

into the atrium ruminis, but in most cases it returned to the reticulum a few min. later. In a few instances, the catheter passed up into the oesophagus during rumination. We found that if it was not re-swallowed in time to record the net ruminating contraction the best measure was to withdraw it, as it otherwise tended to pass up into the mouth during subsequent regurgitations.

The basic pressure in the reticulum was 17 ± 2 ($\bar{x} \pm s$; $n = 10$) mm Hg. The same value was obtained with the catheter in different parts of the rumen. A two-phase pressure increase (Fig. 2) was recorded during the reticulum contraction. Table 1 shows

Table 1. Values for interval, duration and amplitude of the reticulum contractions in 10 normal cows. Ten contractions measured per animal. Mean values ($\bar{x}$) and standard deviations (s) are given.

	$\bar{x} \pm s$
Interval between beginning of first contraction phase and beginning of next corresponding first contraction phase (Fig. 2)	50.8 ± 7.4 sec.
Duration of first contraction phase	3.0 ± 0.2 sec.
Duration of second contraction phase	2.9 ± 0.2 sec.
Amplitude of first contraction phase	14.8 ± 3.8 mm Hg
Amplitude of second contraction phase	23.3 ± 11.6 mm Hg

the interval between the contractions, the duration of the first and second contraction phases, and the amplitude of the pressure increase.

In the cows provided with fistulas the curves of the reticulum movements before and three months after the operation showed no noticeable differences (Table 2).

Table 2. Mean values in three cows before and after the rumen fistula operation. Interval and duration in seconds, amplitude in mm Hg.

	Reticulum interval	Duration of first phase	Duration of second phase	Amplitude of first phase	Amplitude of second phase
Before operation	54	2.7	2.9	17.3	24.4
After operation	54	2.8	2.7	15.9	18.3

Table 3. Comparison between recordings of reticular contractions via nasopharynx and via rumen fistula. Interval and duration in seconds, amplitude in mm Hg.

	Reticulum interval	Duration of first phase	Duration of second phase	Amplitude of first phase	Amplitude of second phase
Catheter via nasopharynx	45	2.7	2.4	25.9	43.9
Catheter via fistula	44	2.8	2.6	25.8	39.0

Table 3 shows the figures obtained in the same cow, from recordings carried out at 1 hr. intervals, with the catheter inserted first through the nasopharynx and then through the fistula. As may be seen, there were no differences.

The recordings in the oesophagus revealed that the pressure fell and rose synchronously with inspiration and expiration. In five cows, the basic pressure varied from 9 to 14 mm Hg, with the mean value at 11.6. The changes in pressure recorded in connection with eructation and swallowing may be seen in Figs. 2 and 3. Eructation occurred regularly, once during each interval between two reticulum contractions. It began with a relatively slow increase in pressure, which was followed by a rapid increase to the maximum, and then by a rapid decrease. The pressure increase during eructation lasted 3—5 sec. A small pressure rise of 4—8 mm Hg was noted in the reticulum curves in connection with eructation. When the mean pressure recording was switched

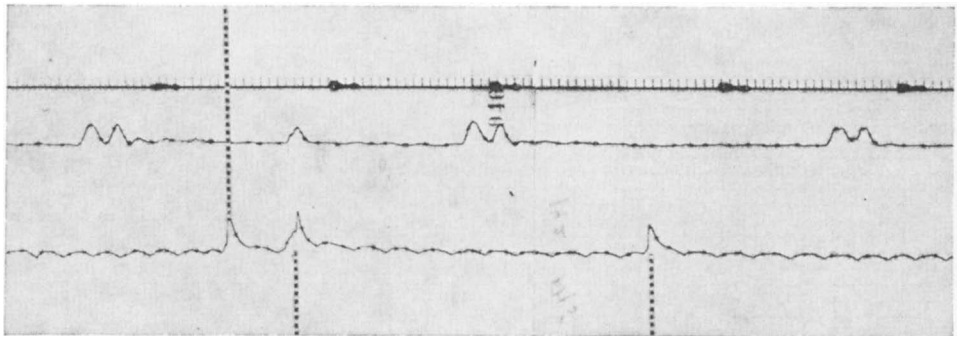

Figure 2. Recordings from the reticulum and the oesophagus of a normal cow. At top, time marker in seconds, in the middle the reticulum, at bottom the oesophagus.

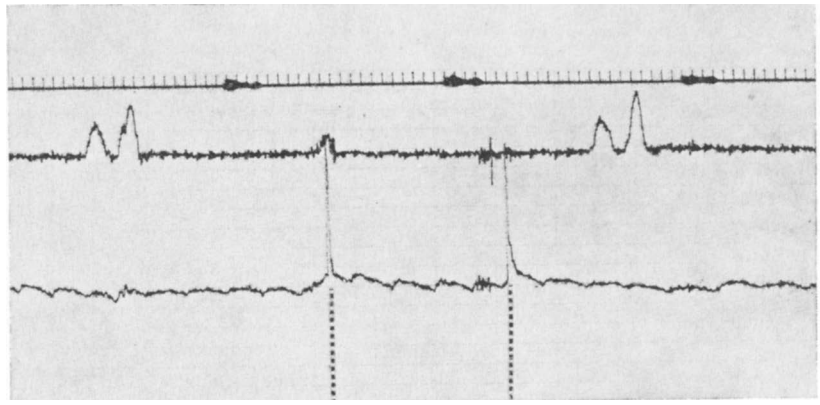

Figure 3. Registration of eructation, swallowing and reticular contractions with the instrument set for direct recording. At top, time marker in seconds, in the middle the reticulum, at bottom oesophagus.

to direct recording and the paper speed increased from 2.5 to 10 mm/sec., it was seen that the pressure increase in the reticulum reached its maximum 0.2 sec. before the maximum pressure increase in the thoracic part of the oesophagus. A swallowing movement was often registered when the oesophagus curve was on the way downward or shortly after the eructation. When this occurred, there was a rapid increase again, followed by a decrease (Fig. 4). In addition to this swallowing, a further swallowing movement occurred fairly regularly after each reticular contraction.

Fig. 4 shows the pressure variations in the reticulum and oesophagus in connection with rumination. A reticular contraction occurred, during rumination, 3—5 sec. before the ordinary biphasic contraction. The duration of the reticulum interval showed greater variations during rumination than during the periods before and after it. In most instances short intervals were noted at the beginning of the chewing period and long ones during its later stages. Regular series of pressure changes were observed in the oesophagus in connection with rumination (Fig. 4). First there was a rapid pressure rise, followed by a pressure fall to a level below the basic pressure. When the minimum value had been reached, there was a rapid rise to the maximum value. Following another decrease, there was a series of two, sometimes three, more increases and decreases. The fall to below the basic pressure reached its lowest value at the same time as the rumina-

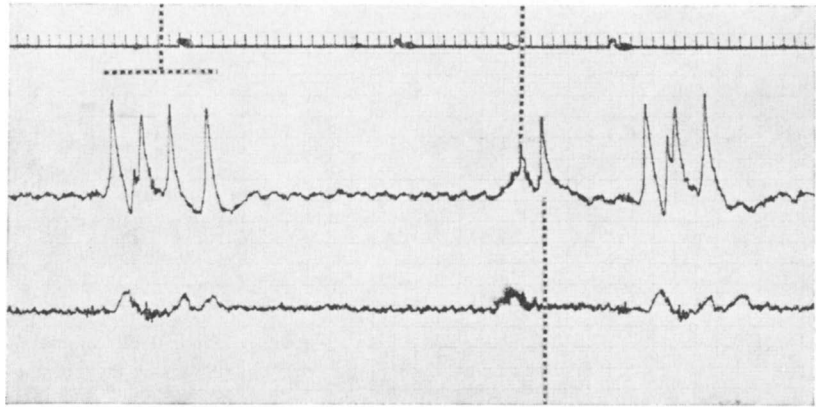

Figure 4. Recordings from the reticulum and the oesophagus in a normal cow during rumination. At top, time marker in seconds, in the middle the oesophagus, at bottom the reticulum.

tion contraction of the reticulum reached its maximum. The whole series of pressure changes in the oesophagus lasted for 8—12 sec.

DISCUSSION

Although the examination of the activity of the stomachs forms an important part of the clinical investigation in ruminants, the aids employed for studying the forestomach contractions in the clinical work are in most cases confined to the phonendoscope. Several investigations have been reported, in which objective methods for recording the motility were applied, but most of these methods can be used only in experimental animals and in particular in those provided with a permanent rumen fistula.

The method described in the present paper could be used at once without any surgical intervention or treatment with sedatives, and the animals were affected very little by the recording manoeuvres. The results obtained agree with those reported by other authors (*Wester* 1926, *Hoflund* 1940, *Dziuk & Sellers* 1955) using cattle with permanent rumen fistulas. *Dziuk et al.* (1963) have published exact information on the frequency, amplitude and duration of the contractions in the reticulorumen in two roe-deer with rumen fistulas. The values obtained differ slightly from those obtained by us in cattle, the frequency figures being higher and the amplitude and duration lower than ours; the

shape of the reticulum curve, with a very slight pressure fall between the two phases, was also slightly different.

The range of application of the present method is limited to recordings in the oesophagus, reticulum and atrium ruminis. After a little training, it is not difficult to place the catheter in these cavities. Information concerning the position of the catheter may be gained from the appearance of the curve; the atrium has simple pressure increases whereas the reticulum produces typical biphasic contraction curves. The basic pressure is lower in the oesophagus than in the stomach compartments, and the pressure changes at inspiration, expiration, swallowing and eructation give typical alterations in the curve. In the cows with fistulas, the position of the catheter was checked on several occasions and placed in different parts of the reticulorumen, and the appearance of the curve was studied.

It is the pressure in the ingesta which is recorded with the present method. The changes in pressure that occur in connection with the reticulum contractions are, according to *Reid & Cornwall* (1959), in large part the result of changes in the hydrostatic pressure arising through positional alterations in the floor of the reticulum. The latter authors used methods by which both positional and pressure changes of the reticulum were recorded. The curves they obtained of level changes accorded in general with those obtained by registration of the pressure. *Dracy & Kurtenbach* (1965) used radiotelemetry for measuring the pressure in the reticulorumen. They observed a slightly larger amplitude during the second phase of the reticulum contraction than was obtained in the present study. The probable explanation of this is that their radiosonde was so large (8 in. long and 1⅛ in. wide) that it was affected during the contractions not only by the hydrostatic pressure but also by the wall of the reticulum.

The apparatus described in the present paper permits the registration of very rapid sequences, if it is set for direct recording. With such an adjustment, a number of small, very rapid oscillations are noted, during the contractions, in addition to the large pressure changes. These small changes are the result of many different factors, such as variations in the consistency of the ingesta, the heart action, the respiratory movements, and other forms of muscular activity. These small oscillations are usually a disturbing factor. We have found that, in order to obtain information on the normal reticular motility that could be

of use as a basis for comparison in the investigation of pathologic states, the apparatus should be adjusted so as to record the mean pressure and exclude small pressure alterations. Direct recording was used for studying details in certain sequences.

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SUMMARY

A method for recording the motility of the reticulum in normal cattle has been devised. The method is based on measurement of the pressure variations occurring in connection with the reticular contractions. The pressure is transferred through open, water-filled catheters via a pressure transducer to an electromanometer, from which it is recorded with the aid of a mingograf.

Mean values for the interval, duration and amplitude of the reticular contractions in 10 normal cows are given.

The method permits recording in intact animals without any preliminary measures, and can therefore be used in clinical cases.

SAMMANFATTNING

Metod för registrering av nätmagsmotoriken hos nötkreatur.

En metod för registrering av nätmagsmotoriken hos nötkreatur har utarbetats. Metoden grundar sig på registrering av tryckvariationerna i samband med nätmagskontraktionerna. Trycket överfördes genom öppna vattenfyllda katetrar via en tryckgivare till en elektromanometer, från vilken det registrerades med en mingograf (Mingograf 81, Elema-Schönander).

Nätmagskontraktionernas intervall var 50,8 ± 7,4 sek., durationen av 1:a kontraktionen 3,0 ± 0,2 sek., durationen av 2:a kontraktionen 2,9 ± 0,2 sek., amplituden av 1:a kontraktionen 14,8 ± 3,8 mm Hg och amplituden av 2:a kontraktionen 23,3 ± 11,6 mm Hg ($\bar{x} \pm s$).

Med den utarbetade metodiken kan registrering ske på intakta djur utan någon förbehandling.

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