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MOTOR AND ELECTRIC ACTIVITY OF THE DUODENUM OF BROILERS

ABSTRACT

Recordings of pressure changes and electrical activity from the proximal small intestine of seven to eight week-old unanesthetized chickens (Arbor Acres 70 ♂ x Cobb ♀) were made with chronically implanted transducers. The recordings were used to quantitate and to determine the relationships among Basic Electric Rhythm (BER), Spike Potentials (SP), and Intestinal Contractions (IC) of the duodenum. The omnipresence of the BER was demonstrated. SP were recorded whenever IC were detected. SP numbers and amplitudes were directly related to the strength of IC. Acetylcholine caused a general increase in the number and amplitude of both SP and IC. Epinephrine completely abolished both SP and IC. The results suggest that BER may represent the stimulus which initiates SP, and therefore, IC of the duodenum.

INTRODUCTION

Basic Electric Rhythm (BER) and Spike Potentials (SP) are normally present in the small intestine of mammals. They are associated qualitatively and quantitatively with the mechanical activity of the small intestine (Daniel *et al.*, 1960; Bass and Wiley, 1965; and Daniel, 1969). The frequency and amplitude of BER, SP, and intestinal contractions (IC) decrease from the duodenum to the ileum (Bass *et al.*, 1961; and Daniel, 1969).

Duke *et al.*, (1975a, b), Ruckebusch (1973), and Roche *et al.*, 1971 recorded the BER, the SP, and the IC from the avian small intestine. They demonstrated that SP were associated qualitatively with IC. According to Duke *et al.*, (1975a, b), there is no frequency gradient in turkeys for the BER from the duodenum to the ileum. Thus, the BER may not be the principal regulator of the intestinal motility in turkeys. On the other hand, the duodenum of the avian species is more active and more rhythmic than the ileum (Pastea *et al.*, 1969; Roche *et al.*, 1971). There is,therefore, a frequency gradient from the duodenum to the ileum in the intestine of the avian species.

The objective of the present investigation was to relate and quantitate the electrical activity of the avian duodenum to its motility in domestic chickens.

MATERIALS AND METHODS

Four domestic chickens (Arbor Acres 70 ♂ x Cobb ♀) were used as experimental animals. Their ages varied between seven and eight weeks and their body weights between 1.5 and 2.0 kg.

The birds were anesthetized by the intravenous injection of allobarbital in urethane solution[4] (0.6 ml. solution/kg. body wt.). Under aseptic surgical conditions, a 5 cm. incision was made through the abdominal wall, 1 cm. caudal to and parallel to the last left rib. A portion of the duodenum was then brought to the outside by passing a retractor beneath it and pulling gently. Transducers were implanted on the exposed segment after which it was returned to its position in the abdomen. The incision was closed by suturing[5] in succession the peritoneum, the muscle layers, and the skin. Just before the animal recovered from the anesthetic, it was placed in a restraining cage (Hulan *et al.,* 1972) containing food and water. Gallimycin[6] (0.3ml./kg. body wt.) was given subcutaneously daily postoperatively for 10 days.

The electrical activity was recorded by means of bipolar silver-silver chloride electrodes. A bipolar electrode was implanted on the proximal, the middle, and the distal areas of each duodenum. The distance between successive electrodes varied between 7.5 and 9.0 cm. The proximal electrode was implanted 5 cm. below the gizzard.

The changes of pressure within the lumen of the gut were recorded by means of soft rubber balloons connected to pressure transducers[7], via polyethylene tubing[8] filled with water. The balloons were inserted into the lumen of the gut through a stab wound made 5 cm. below the distal electrode. A balloon was positioned under each of the bipolar electrodes. The electrode locations were designated as proximal (PE), middle (ME), and distal (DE) areas of the duodenum. The corresponding balloons were designated PB, MB, and DB.

Acetylcholine[9] (1 ml./kg. body wt., 2 mg./ml.) and epinephrine[9] (1 ml./kg. body wt., 1:1,000) were given subcutaneously.

Motor and electric activities were recorded simultaneously on a 7-channel physiograph[10] with the amplifiers set at a time constant of one second. Recordings were taken three days after the operation when the animal was completely recovered. The birds were fed a commercial-type poultry feed *ad libitum.*

The analysis of variance and the Pearson correlation (Nie *et al.,* 1975; and Dixon and Massey, 1969) were used to analyze the data. The annotations of Dixon and Massey (1969) for the means and means of the means are used in this presentation.

RESULTS AND DISCUSSION

BER, SP, and IC were recorded (Figure 1) from the duodenum of unanesthetized chickens. Individual comparisons in a 3 x 2 factorial experiment (the two variables being: location on the duodenum and bird number) showed that the amplitudes of BER, SP,

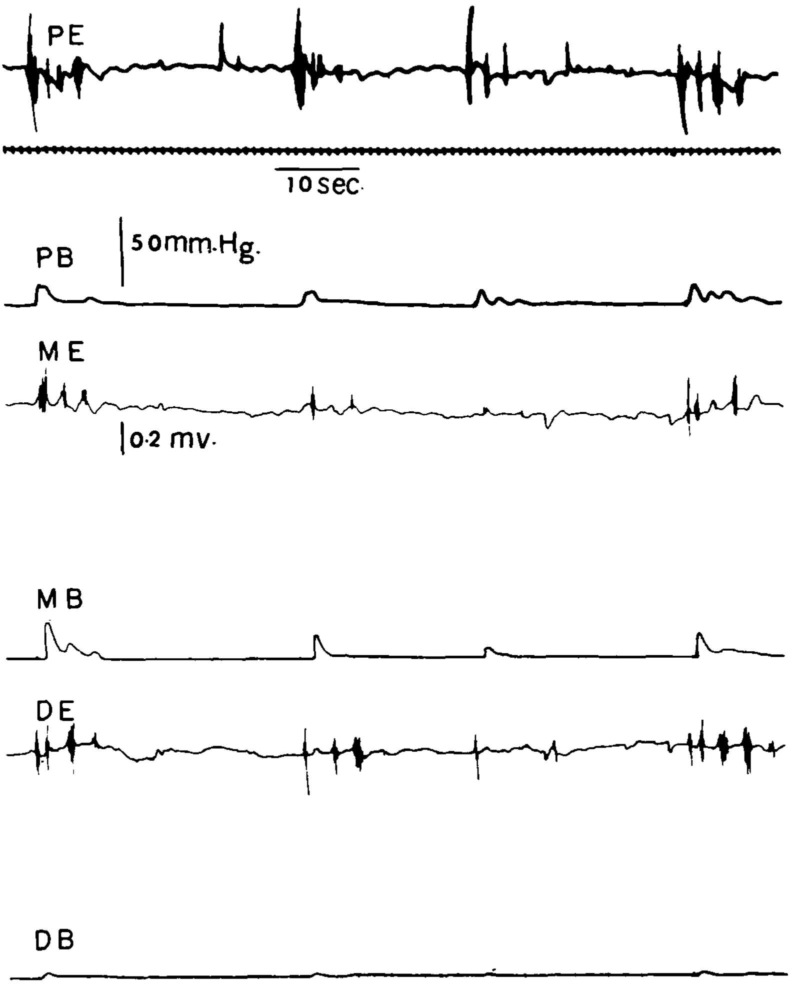

Figure 1. Simultaneous recordings of the electric and the motor activities of the proximal, middle and distal portions of the duodenum from unanesthetized chickens. The basic electric rhythm, the spike potentials and the intestinal contractions are present. The spike potentials and the intestinal contractions are qualitatively and quantitatively related. The amplitudes of the recordings decrease from the proximal to the distal areas. Proximal electrode (PE) and balloon (PB), middle electrode (ME) and balloon (MB), distal electrode (DE) and balloon (DB).

Table 1. Relationships between the motor and electric activities of the proximal, middle and distal areas of the avian duodenum comparing the frequencies and amplitudes of the Basic Electric Rhythm (BER), the Spike Potentials (SP) and the Contractions (IC).

Location	Chicken	BER Frequency (No./min.)	BER Amplitude (mv.)	SP Frequency (No./min.)	SP Amplitude (mv.)	IC Frequency (No./min.)	IC Amplitude (mm. Hg.)
Proximal	X1.	28.00±0.6	0.05±0.01	6.41±5.68	0.37±0.13	6.41±5.68	29.33±10.22
	X2.	28.20±0.50	0.05±0.01	6.40±4.48	0.44±0.14	6.40±4.48	25.42±10.12
	X3.	27.26±0.82	0.05±0.01	7.20±5.98	0.24±0.10	7.20±5.98	26.19±15.92
	X4.	29.20±0.52	0.05±0.01	8.32±6.05	0.43±0.09	8.32±6.05	25.33±10.22
	X..	28.17±0.80[a]	0.05±0.00[a]	7.08±0.91[a]	0.37±0.09[a]	7.08±0.91[a]	26.57±01.88[a]
Middle	X1.	26.37±0.94	0.04±0.01	6.41±5.68	0.18±0.08	6.41±5.68	21.14±11.86
	X2.	27.20±1.42	0.04±0.02	6.40±4.48	0.21±0.05	6.40±4.48	20.50±11.21
	X3.	25.42±0.92	0.04±0.02	7.20±5.98	0.15±0.06	7.20±5.98	22.86±14.92
	X4.	26.15±0.90	0.04±0.02	8.32±6.05	0.24±0.09	8.32±6.05	20.46±12.30
	X..	26.29±0.73[b]	0.04±0.00[b]	7.08±0.91[a]	0.20±0.07[b]	7.08±0.91[a]	21.24±01.12[b]
Distal	X1.	24.99±0.04	0.03±0.02	6.41±5.68	0.12±0.05	6.41±5.68	10.05±06.08
	X2.	25.00±0.05	0.03±0.02	6.40±4.48	0.13±0.05	6.40±4.48	12.06±06.06
	X3.	23.78±0.83	0.03±0.01	7.20±5.98	0.10±0.02	7.20±5.98	10.10±08.80
	X4.	25.37±0.05	0.03±0.02	8.32±6.05	0.13±0.05	8.32±6.05	12.50±06.05
	X..	24.79±0.69[c]	0.03±0.00[c]	7.08±0.91[a]	0.12±0.02[c]	7.08±0.91a	11.18±01.28[c]

Each mean of BER is derived from 460 measurements and each mean of SP and IC from 200 measurements.
Values with same superscripts are not significantly different ($P < 0.05$)

and IC decreased from the proximal position on the duodenum to the distal position ($P < 0.05$, Table 1). There were no gradient phenomena for the frequencies of SP or IC ($P < 0.05$, Table 1). The amplitudes and frequencies of BER, SP, and IC did not differ significantly among birds (P 0.05). The BER with superimposed SP generally had greater amplitudes ($\leq$ 0.05 mv.). The BER generally occurred earlier than their corresponding SP. Thus, the BER could be considered as the initiators of SP and IC, as suggested by Bass *et al.* (1961), Bass and Wiley (1965), Daniel *et al.* (1960), Pastea *et al.* (1969), and Roche *et al.* (1971). SP and IC were qualitatively and quantitatively related. Each set of SP had its corresponding wave of contraction. The stronger and more numerous were the SP, the greater were the amplitudes of their corresponding contraction waves (Figures 1 and 2), (Tables 1 and 2), ($r = 0.761$, $P < 0.05$). Since SP occurred earlier than their corresponding IC (100 observations gave a mean lag time of 0.20 - 0.10 sec., $P < 0.05$, Figure 2), they could be considered as the action potentials

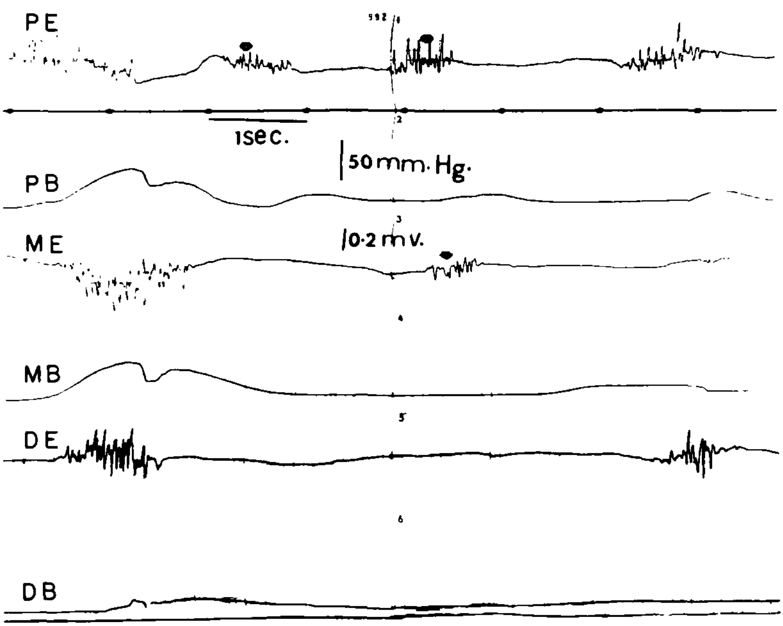

Figure 2. Simultaneous recordings of the electric and the motor activity from the chicken duodenum showing a time lag in the appearance of spike potentials and the corresponding contraction waves. The basic electric rhythm is initiated before the appearance of its set of spike potentials. Proximal electrode (PE) and balloon (PB), middle electrode (ME) and balloon (MB), distal electrode (DE) and balloon (DB).

Table 2. Action of acetylcholine on the relationship of the motor and electrical activities of the proximal, middle and distal areas of the avian duodenum comparing the frequencies and amplitudes of the Basic Electric Rhythm (BER), Spike Potentials (SP) and the Intestinal Contractions (IC).

Location	Chicken	BER		SP		IC	
		Frequency (No./min.)	Amplitude (millivolts)	Frequency (No./min.)	Amplitude (millivolts)	Frequency (No./min.)	Amplitude (mm. Hg.)
Proximal	X1.	28.20±1.60	0.06±0.01	13	0.58±0.20	13	60.14±16.56
	X2.	28.00±0.00	0.05±0.01	14	0.42±0.12	14	68.75± 6.25
	X3.	28.67±0.69	0.06±0.01	12	0.52±0.20	12	40.32± 5.83
	X4.	29.28±0.87	0.05±0.01	10	0.25±0.05	10	38.50± 6.02
	X..	28.54±0.57^{a}	0.06±0.01^{a}	12.25±1.71^{a}	0.44±0.14^{a}	12.25±1.71^{a}	51.93±14.89^{a}
Middle	X1.	25.17±0.80	0.05±0.01	13	0.33±0.10	13	80.08±22.29
	X2.	28.00±0.50	0.04±0.02	14	0.33±0.05	14	84.88± 9.13
	X3.	28.12±0.50	0.05±0.02	12	0.38±0.10	12	71.07± 6.02
	X4.	27.40±0.49	0.05±0.02	10	0.23±0.02	10	61.43± 6.39
	X..	27.17±1.37^{a}	0.05±0.01^{a}	12.25±1.71^{a}	0.33±0.06^{b}	12.25±1.71^{a}	74.37±10.35^{b}
Distal	X1.	25.17±0.80	0.05±0.01	13	0.33±0.01	13	24.24±17.94
	X2.	28.00±0.50	0.05±0.01	14	0.24±0.09	14	31.71±22.82
	X3.	28.12±0.50	0.05±0.01	12	0.38±0.10	12	17.07± 6.02
	X4.	25.67±0.47	0.04±0.02	10	0.22±0.02	10	15.00± 5.00
	X..	26.74±1.54^{a}	0.04±0.01^{a}	12.25±1.71^{a}	0.29±0.08^{c}	12.25±1.71^{a}	22.01± 7.59^{c}

Each mean of BER, SP and IC are derived from 50 measurements.
Values with same superscripts are not significantly different ($P < 0.05$)

associated with the contractions of the smooth muscle of the gut. This is in agreement with the findings of Bass *et al.* (1961), Bass and Wiley (1965), Daniel *et al.* (1960), and Roche *et al.* (1971).

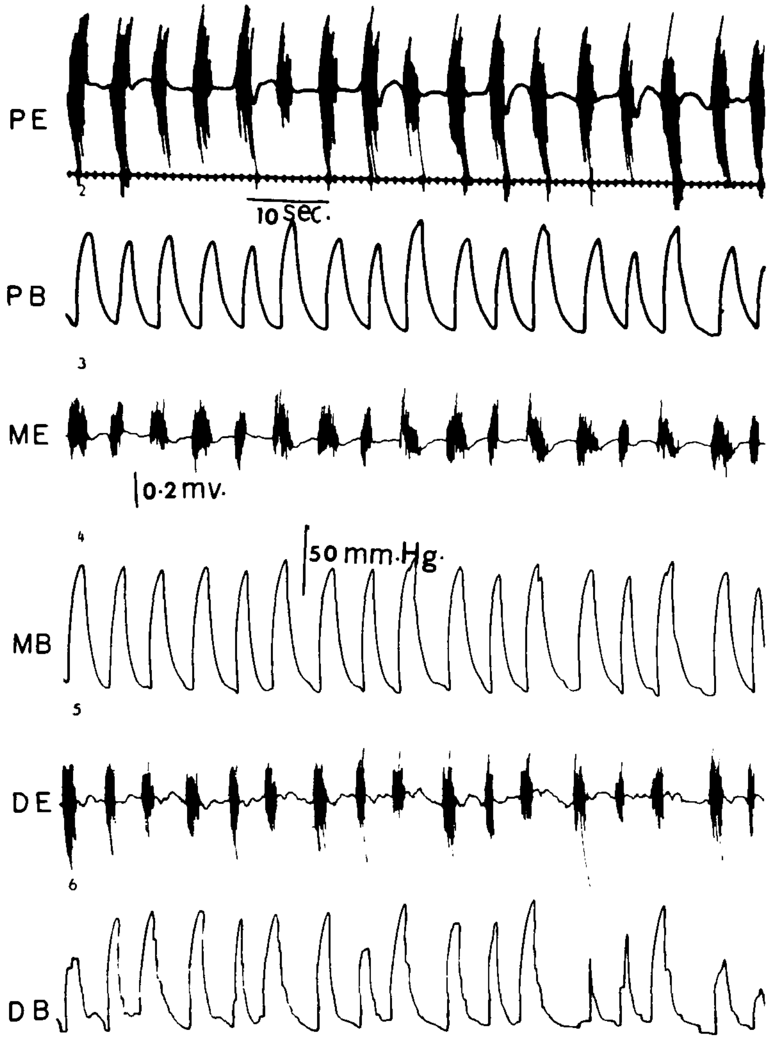

Figure 3. Tracings showing the action of acetylcholine (2 mg./kg. body wt.) in increasing the frequencies and the amplitudes of the basic electric rhythms, the spike potentials and the intestinal contractions observed in unanesthetized chickens. Proximal electrode (PE) and balloon (PB), middle electrode (ME) and balloon (MB), distal electrode (DE) and balloon (DB).

Acetylcholine caused a general increase in the frequencies and amplitudes of SP and IC ($P < 0.05$), Table 2, Figure 3). Epinephrine completely abolished the occurrence of SP and IC ($P < 0.05$, Table 3, Figure 4). These results confirm the relationship between SP and IC observed under normal physiological conditions.

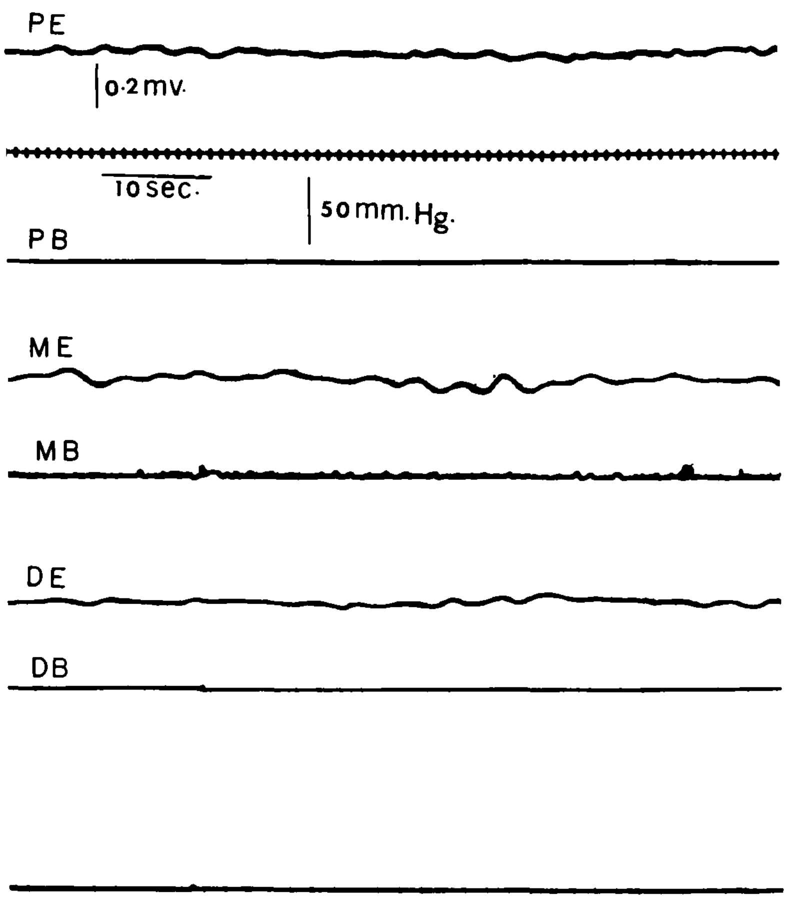

Figure 4. Tracings showing the effect of epinephrine (1 ml. of 1: 1,000 soln./kg. body wt.) in abolishing the spike potentials and the intestinal contractions in the unanesthetized chicken duodenum. The basic electric rhythm is still present. Proximal electrode (PE) and balloon (PB), middle electrode (ME) and balloon (MB), distal electrode (DE) and balloon (DB).

Table 3. Action of epinephrine on the relationship of the motor and electrical activities of the proximal, middle and distal areas of the avian duodenum comparing the frequencies and amplitudes of the Basic Electric Rhythm (BER), Spike Potentials (SP) and the Intestinal Contractions (IC).

Location	Chicken	BER		SP		IC	
		Frequency (No./min.)	Amplitude (millivolts)	Frequency (No./min.)	Amplitude (millivolts)	Frequency (No./min.)	Amplitude (mm. Hg.)
Proximal	X1.	21.63±1.22	0.02±0.01	0.00	0.00	0.00	0.00
	X2.	26.50±0.50	0.04±0.01	0.00	0.00	0.00	0.00
	X3.	24.71±0.93	0.02±0.01	0.00	0.00	0.00	0.00
	X4.	27.42±0.83	0.03±0.02	0.00	0.00	0.00	0.00
	X..	25.07±2.54^{a}	0.03±0.02^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
Middle	X1.	15.63±0.49	0.02±0.01	0.00	0.00	0.00	0.00
	X2.	23.63±0.43	0.03±0.01	0.00	0.00	0.00	0.00
	X3.	23.92±0.99	0.01±0.01	0.00	0.00	0.00	0.00
	X4.	25.08±0.53	0.03±0.02	0.00	0.00	0.00	0.00
	X..	21.93±4.28^{a}	0.02±0.01^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
Distal	X1.	15.63±0.49	0.01±0.01	0.00	0.00	0.00	0.00
	X2.	22.49±0.65	0.03±0.02	0.00	0.00	0.00	0.00
	X3.	0.00*	0.00*	0.00	0.00	0.00	0.00
	X4.	0.00*	0.00*	0.00	0.00	0.00	0.00
	X..	19.06±4.85$^{a\#}$	0.01±0.01$^{a\#}$	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}

Each mean of BER is derived from 30 observations.
*Results due probably to the fact that the sensitivity of recordings was unable to show any positive usual observation.
#Value obtained from 2 means only.
Values with same superscripts are not significantly different ($P < 0.05$)

The findings from the present study suggest that the BER is responsible for the initiation of SP which represent the action potentials associated with the contractions of the smooth muscle of the duodenum. There is general agreement between the results obtained in this study and those obtained from studies on mammals (Bass *et al.*, 1961; Bass and Wiley, 1965; Daniel *et al.*, 1960; and Daniel, 1969) and with the avian species (Duke *et al.*, 1975a, b; Roche *et al.*, 1971; Pastea *et al.*, 1969; and Ruckebusch, 1973).

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FOOTNOTES

1. Supported in part by Hatch Project 5-5-28302, Maine Agricultural Experiment Station and the African-American Institute.

2. Adapted from a M.S. Thesis submitted by C. Mba-Mezoui to the Graduate School, University of Maine, Orono, Maine, December, 1975.

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5. Chromic 000 gut, Ethicon Inc., Somerville, New Jersey 08876.

6. Abbott Laboratories, North Chicago, Illinois 60064.

7. Statham Model P23, Statham Transducers, Inc., Hato Rey, Puerto Rico.

8. PE 160, i.d. 0.045" x o.d. 0.062", Clay Adams, Div. of Becton, Dickinson and Co., Parsippany, New Jersey 07054.

9. Wolins Pharmacal Corp., Melville, New York 11746.

10. Model 7 Polygraph, Grass Instruments, Quincy, Mass. 02169.