operated upon repeatedly for intestinal obstruction of adhesive origin, air has been put into the peritoneal cavity, after a complete lysis or freeing up of the adhesions was done, to mechanically separate the gut from the abdominal wall during the healing phase. Surprisingly good results have been obtained in a few such instances.[3]

Summary. Sodium ricinoleate, 1%, papain 1-50,000, and amfetin and defibrinated rabbit's blood were found most efficacious in obviating adhesion formation after painting the traumatized peritoneal surface with iodine. Sodium ricinoleate would appear to be particularly valuable in that it is not rendered inactive in the presence of infection.

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Character of the Gaseous Distension in Mechanical Obstruction of the Small Intestine.

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McIver[1] and his associates have shown that gaseous distension of the stomach after abdominal operations is largely due to swallowed air. In mechanical obstructions of the gut, McIver[2] believes that decomposition of intestinal contents is probably the most important source of the gaseous distension. Wangensteen and Rea[3] by excluding the swallowing of air by transecting the esophagus in the dog have indicated that swallowed air is probably the chief source of gaseous distension in mechanical obstructions of the small intestine as well.

In this study the nature of the gases present in the distended intestine was subjected to chemical analysis. Determinations were made in a group of dogs with terminal ileal obstructions, the gut being divided a few centimeters proximal to the ileo-cecal sphincter; in a similar group of dogs in which a preliminary esophagostomy had been made, and in a third group with closed intestinal loops.

The gases of the obstructed intestine were analyzed with the

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3 Wangensteen, Owen H., *Arch. Surg.*, 1933, **26**, 933.

1 McIver, M. A., Benedict, E. B., and Cline, J. W., *Arch. Surg.*, 1926, **13**, 588.

2 McIver, M. A., *Am. J. Surg.*, 1933, **20**, 509.

3 Wangensteen, O. H., and Rea, C. E., PROC. SOC. EXP. BIOL. AND MED., 1934, **31**, 1060.

employment of the U. S. Bureau of Mines apparatus.* The gas sample was drawn over mercury into specially made gas tubes while the animals were under ether. In some analyses, brine was used in the gas apparatus instead of mercury, and this accounts for the lack of the estimation of the volatile basic group in some of the experiments.

TABLE I.
(Group A) Simple Ileal Obstruction.

Wt. lbs.	Duration days	Fluid Content cc.	Gaseous Content Amount cc.	CO_2 %	O_2 %	N_2 %	CH_4 %	H_2 %	H_2S %	Volatile Basic Group %
55	3	150	100	—	—	—	—	—	—	—
50	2	—	—	4.70	10.92	61.+	0	0	4.68	+
42	3	300	150	6.20	1.48	71.+	0	0	7.86	+
48	3	290	200	12.71	1.11	60.+	0	0	14.00	+
42	3	150	220	12.19	0.69	70.+	0	0	1.99	+
46	3	220	290	9.36	1.00	74.+	0	0	0.92	+
44	3	235	320	9.10	0.52	70.+	0	0	4.33	+
55	3	1198	325	13.10	1.82	73.64	0	0	9.41	2.03
36	5	400	200	11.50	0.97	79.4	0	0	6.58	1.54
34	7	200	300	8.80	2.14	66.+	0	0	13.23	8.75
48	3	210	225	24.20	0.30	53.04	0	0.35	17.90	4.21
32	6	750	250	—	—	—	—	—	—	—
43	3 Dead	420	430	15.09	1.15	23.+	0	0.49	45.14	+
Average		373	234.5							

TABLE II.
(Group B) Simple Ileal Obstruction with Esophagostomy.

Wt. lbs.	Duration days	Fluid Content cc.	Gaseous Content Amount cc.	CO_2 %	O_2 %	N_2 %	CH_4 %	H_2 %	H_2S %	Volatile Basic Group %
42	3	250	110	12.8	1.1	76.3	0	0	9.8	—
36	3	240	140	9.0	3.2	85.0	0	0	3.1	—
40	3	300	40	9.5	0.4	73.4	—	8.2	8.0	0.5
52*	3	250	100	12.	5.7	76.2	0	0	6.1	—
46*	3	225	160	—	—	—	—	—	—	—
39*	3	150	60	12.8	0.9	71.6	.3	4.	10.4	—
Average		236	100							

*Were fed a mixed diet previous to operation.

The composition of the gas appearing in all groups (Tables I, II, and III) was different in some respects than the composition occurring in other conditions reported in the literature. Nitrogen tended to come into equilibrium with the blood and surrounding tissue, decreasing to about four-fifths of an atmosphere. In the early hours of obstruction the oxygen content was found to be

*Bulletin 197, U. S. Bureau of Mines, 41.

TABLE III.
(Group C) Closed Loop Obstruction of Small Intestine.

Wt. lbs.	Duration days	Fluid Content cc.	Gaseous Content Amount cc.	CO_2 %	O_2 %	N_2 %	CH_4 %	H_2 %	H_2S %	Volatile Basic Group %
36	2	60	90	—	—	—	—	—	—	—
42	2	150	70	4.5	12.35	87.00	—	—	—	—
40	3	225	83	8.26	2.39	74.84	0	0	12.78	1.62
42	3	1050	40	10.00	4.00	—	—	—	3.00	Trace
30	5	130	10	—	—	—	—	—	—	—
44	8	200	100	—	—	—	—	—	—	—
38	3 Dead	600	40	5.12	2.8	51.+	0	0	15.36	+
46	3 Dead	—	—	18.40	1.02	11.94	0.13	3.25	62.74	+
52	3 Dead	—	—	13.17	1.75	37.34	0	2.33	42.20	3.21
26	4 Dead	350	20	—	—	—	—	—	—	—
Average		136	65.5							

quite high (10 to 12%), but after the 72 hour period its value fell to a uniformly low figure. Even in early obstruction, the carbon dioxide showed a decided approach to that found in the blood. Apparently this was due to its high diffusion rate. The average percentage of these gases agrees quite favorably with other conditions previously reported.

Hydrogen sulphide was present in all experiments and increased as the severity of the obstruction increased with a marked rise after death. The volatile basic group (ammonia, methyl amine, etc.) although not high, appeared quite consistently throughout and showed some increase in the later stages. Since the formation of this group of gases is entirely dependent upon protein putrefaction, the high percentage found as death approached suggests the marked degree of putrefaction present in the terminal stages of obstruction.

The results obtained in the combustible group of gases were entirely unexpected. Methane was present in only 2 experiments, and then only in a very small amount (0.13 and 0.30%). Similarly, hydrogen was consistently absent, occurring in only 2 animals (8.2 and 4.0%). The results obtained in the combustible group of gases can be explained on the basis of Kantor's[4] suggestion, *viz.*, that the greatest amount of combustible gas is formed in the colon by a specific bacterial action on cellulose. This explanation is supported by McIver, who found large quantities of combustible gases in paralytic ileus in which the samples were obtained by rectum.

Comparing the results in Table I with those in Tables II, and III,

[4] Kantor, J. L., *Am. J. Med. Sci.*, 1918, **155**, 829.

it is quite evident that the quantity of gas occurring in the closed loops is much less. The average amount found in the closed loops was 76 cc. as compared to 234.5 cc. occurring in open loops of a comparable length. Since the quantity of gas produced in the closed loops arose either from food decomposition or from the blood stream, since nitrogen gas can not originate from food material, it is obvious that the larger part of the gas present must have come from diffusion from the blood stream. Certainly, a much larger quantity than 30% of the gas found in the closed loops is formed by food decomposition, but through rapid absorption and nitrogen displacement it disappeared quite readily. The results of previous studies in this Department support these findings.[5]

Additional analyses are being made on clinical cases, and experimental large bowel obstruction, which will be reported at some subsequent time.

Summary. The average percentage composition of the different gases is as follows: (a) Nitrogen 70%; (b) carbon dioxide, 6-12%, approached that found in blood gases; (c) oxygen, 10-12%, with a decided drop after the 72 hour period; (d) combustible gases (methane and hydrogen), a very low percentage in only a few experiments; (e) hydrogen sulphide, 1-14%, with a marked increase after death; (f) volatile basic group (ammonia, methyl amine, etc.) 0.5-4.0%, with an increase with longer duration of the obstruction.

In a quantitative determination of the origin of gases occurring in small bowel obstruction, about 68% of the gas was estimated to have arisen from swallowed air. The amount formed within the body was 32%, of this about 70% originated from diffusion from the blood into the bowel lumen, and the remaining 30% arose from decomposition of food material.

[5] Scott, H. G., Dvorak, H. J., Borman, C. N., and Wangensteen, O. H., PROC. SOC. EXP. BIOL. AND MED., 1931, **28**, 902.