

tarded but on transplanting it grew normally. *Staphylococcus aureus* and *Coli communis* were also irradiated with the X-rays for varying lengths of time up to 5 hours but no change was noted in the growth of the bacteria.

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Comparative Study of the Quantity of Gas in the Bowel in Simple and Closed-Loop Obstruction.\*

H. G. SCOTT, H. J. DVORAK, C. N. BORMAN AND O. H. WANGENSTEEN.

*From the Department of Surgery, University of Minnesota.*

The results of previous studies have indicated that whereas the accumulation of gas as detected by X-ray examination is a reliable agent in the early diagnosis of simple obstruction, in strangulation obstructions Roentgen evidence is not of the same value in its early recognition.<sup>1, 2, 3</sup> The results of the following study are based on direct measurements of gas in simple and closed-loop obstructions.

*Method:* Studies of 36 dogs form the basis of this report. Dogs with closed-loop rather than strangulation obstructions were used in this comparison because the dogs with strangulation obstructions only survive for short periods. In the closed-loop, as a rule there are no gross vascular changes until late in the course of the obstruction at which time closed-loop obstruction partakes of the features of strangulation obstruction. In the closed loop obstruction the oral source of gas has been eliminated and in establishing this type of obstruction every trace of gas was "milked out" of the bowel before the last bowel end was inverted. Thirty-one closed-loop obstructions of small bowel of varying lengths and at various sites were established by the usual standard methods. The dogs were then observed for various lengths of time and either killed when they appeared moribund or were reoperated upon before they reached this stage. At operation the closed-loops were removed and im-

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<sup>1</sup> PROC. SOC. EXP. BIOL. AND MED., 1930, **27**, 674.

<sup>2</sup> PROC. SOC. EXP. BIOL. AND MED., 1930, **27**, 952.

<sup>3</sup> PROC. SOC. EXP. BIOL. AND MED., 1931, **28**, 343.

mediately thereafter the gas and contents were measured by aspiration with a syringe and hollow needle. The length of gut, site and duration of obstruction were accurately recorded in all cases. In some the diameter of the bowel was also measured. If the dogs were killed, an autopsy was performed immediately after death and similar measurements of the gas, fluid contents, etc., were made. Dogs that died at night in which immediate examination could not be carried out are excluded from this series as are all dogs that showed evidence of leakage peritonitis or any other lethal complication at time of operation or killing. Measurements of gas in the proximal bowel of 5 dogs with simple obstruction were made. These dogs were killed and the pylorus clamped. The fluid and gas intervening between the pylorus and the obstruction were measured.

Data showing the type of obstruction, average duration in hours or days, the site and average length of gut obstructed and the average amount of gas found are here tabulated.

TABLE I.  
Closed-loop Obstruction.

| No. of dogs | Site          | Av. length gut (cm.) | Av. No. hrs. | Av. No. cc. gas | Av. No. cc. fluid |
|-------------|---------------|----------------------|--------------|-----------------|-------------------|
| 20          | Lower ileum   | 57.8                 | 82.1         | 15.0            | 91                |
| 11          | Upper jejunum | 32.0                 | 31.0         | 8.5             | 40                |

Simple Obstruction.

| Experiment | Obstruction | Time in days | Gas in cc. | Fluid in cc. |
|------------|-------------|--------------|------------|--------------|
| 1          | Lower ileum | 5            | 350        | 350          |
| 2          | " "         | 3            | 80         | 80           |
| 3          | " "         | 4            | 160        | 180          |
| 4          | " "         | 14           | 525        | 590          |
| 5          | " "         | 9            | 525        | 900          |

The relatively small amount of gas in the closed-loops bespeaks the importance of the oral source for the greater quantity of intestinal gas in bowel obstruction. McIver<sup>4, 5</sup> and his associates have previously emphasized swallowed air as the significant factor in postoperative distension. The quantity of gas accumulating in the bowel under obstructive conditions (closed-loop) through the agency of bacterial activity does not appear to be great. The smallest amounts observed in simple obstruction are greater than any found in the 31 closed-loop obstructions.

<sup>4</sup> *Arch. Surg.*, 1926, 13, 588.

<sup>5</sup> *Am. J. Physiol.*, 1926, 76, 92.

In the first 3 dogs with simple obstruction only the last 2 feet of small bowel proximal to the obstruction were found distended at all. In dogs 4 and 5 the last 3 or 4 feet were distended. These latter 2 dogs more nearly approximate the average distension usually seen at autopsy in this type of obstruction.

In 7 of the closed-loop animals, no gas at all could be found in the loops. The greatest amount found was 75 cc. and the second largest amount was 35 cc. In this last dog, 600 cc. of fluid material was also recovered from the loop. As to variations in lengths of the loops the shortest was 12 cm. and the longest 100 cm. These lengths compare favorably with the lengths of gut found to be dilated in dogs having simple obstruction. As to a comparison of the time factors in the 2 series, 6 of the dogs with closed-loops of the ileum lived more than 4 days before they were sacrificed. One lived 7 days and one 10 days. One dog not included in this series because of death occurring during the night lived 29 days with a 3 foot loop of the terminal ileum. The time factor in the 2 series is practically the same.

In another study, strangulation obstructions have been established in 36 dogs. This type of obstruction was brought about by tying off the mesenteric blood supply with umbilical tape and then wrapping the tape around the outside of the bowel wall at the proximal and distal ends of obstructed segment. In this manner the lumen of the bowel was obstructed as well as its blood supply. The oral source of gas was thus eliminated in these obstructions. Although no direct measurements of gas in the first 30 dogs of this series were made, frequent attempts to aspirate gas with a needle and syringe at the operating table failed to reveal any gas in these loops. In 6 of the dogs in which the loops were resected, no gas could be found when the usual technique for gas collection was employed. The short duration of these experiments lasting from 3 to 12 hours probably accounts for the fact that gas from bacterial sources is of no practical consequence.

*Summary:* In simple obstructions gas accumulates in the proximal bowel in far greater amounts than within closed-loop or strangulated segments. Gas formation in the latter 2 types is an inconstant and irregular feature. Gas accumulation in these instances is due largely to the activity of intestinal bacteria. The exclusion of swallowed air from the closed and strangulated loops accounts largely for these significant differences.