terium oxide seemed to have a stimulating effect on rat sarcoma R-39 in 6 of 50 rats so treated.

7439 C

Comparative Efficacy of Substances Employed in Prevention of Intra-Peritoneal Adhesions.

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In this study, the following substances were compared with regard to their relative effectiveness in preventing peritoneal adhesions in rabbits: defibrinated ox blood, defibrinated rabbit blood, amniotic fluid, amfetin,* sodium ricinoleate (1%), blood serum of dog, ether, hypertonic glucose (10%), normal saline, papain 1-50,000, air, air and sodium ricinoleate (1%), air and amfetin.

The method was as follows: under ether anesthesia, the abdomen of the rabbit was opened and a culture taken with sterile precautions. Intraperitoneal adhesions were produced by roughening the peritoneum and intestines with a knife or rubbing with gauze, and painting the raw surfaces with tincture of iodine. In 12 animals so treated (controls) 2 died from the procedure, and of the 10 surviving 9 developed peritoneal adhesions (90%). Twenty cubic centimeters of the substance to be tested were introduced into the peritoneal cavity after the iodine was applied. When air was also added, 20 cc. of the solution and 60 cc. of the air were used. About 10 rabbits were used in each series. In the 4 best series the effectiveness was studied in another 10 rabbits to make the number of animals used (20) significant. The rabbits were allowed to live one week before being killed, when a culture was again taken. The peritoneal reaction was studied. Adhesions were graded as slight, medium or dense. The results of the experiments are tabulated in Table I.

Results. The 4 substances that were most effective in preventing adhesions in this study were: Sodium ricinoleate (1%), 85%; Papain 1-50,000, 75%; Amfetin, 70%; defibrinated rabbit's blood 65%.

Ochsner and Garside demonstrated that papain and trypsin are inactive in the presence of infection. Sodium ricinoleate, or castor oil soap, not only prevented adhesions most often, but has the added

* Lilly trade name for amniotic fluid.

TABLE I.

Treatment	No. of rabbits	Procedure	Adhesions—No. of cases — Time—1 wk. — Dense	Medium	Slight	None	Operative mortality	Remarks
Controls	12		5	3	1	1	2	
Sodium ricinoleate 1%	10 (20)		0 (0)	0 (0)	0 (1)	9 (17)	1 (2)	Numerals in parenthesis
Papain 1-50,000	10 (20)		0 (0)	0 (0)	1 (2)	8 (15)	1 (3)	refer to total number
Amfetin	18 (20)		0 (0)	1 (1)	1 (2)	6 (14)	0 (2)	of cases, using 20
Defibrinated rabbit blood	10 (20)		0 (0)	1 (1)	2 (3)	6 (13)	1 (2)	animals
Defibrinated ox blood	10	Roughening peritoneum	0	1	1	6	2	
Amniotic fluid (dog)	12	+ tincture of iodine	0	0	4	6	2	
Air	10	+ 20 cc. solution to	0	1[a]	1[b]	2[c]	3	
		be tested. When air				3[d]		
Air + amfetin	10	was also added, 20 cc.	0	1	1	5	3	
" + sodium ricinoleate 1%	10	solution + 60 cc. air	0	0	1	7	2	
Blood serum (dog)	10	were used.	0	0	3	5	2	
Ether	9		0	1	4	4	0	10 cc. ether used
Hypertonic glucose	10		0	0	2	5	3	
Normal saline	10		0	1	4	3	2	

[a] 4 days. [b] 3 days. [c] 4 days. [d] 5 days.

advantage of acting in either in a sterile or infected peritoneum. Its action on bacteria is a surface tension phenomenon; it destroys the cell membrane of the bacteria (Larson[1]). While *B. coli* and *Cl. welchi* will grow in sodium ricinoleate, papain, amfetin, and defibrinated blood, they are rendered nonpathogenic by sodium ricinoleate. Its action in preventing adhesions, except for its effect in limiting bacterial growth, is not clear. The manner in which it works is more than by just mechanical separation of the bowel, for in rabbits most of it is absorbed within one hour (B. Olson[2]). Studies on the peritoneal fluid of rabbits using supravital staining methods (neutral red) would suggest that half the histiocytes are either killed or injured by the sodium ricinoleate, judging from the amount of dye in these cells. Thus, sodium ricinoleate may destroy the cell membrane of the histiocytes as well as bacteria, thereby limiting the repair process. It emulsifies fibrin *in vitro;* papain actually digest fibrin, while amfetin and defibrinated rabbit's blood have no effect.

Cultures were taken from the peritoneal cavity before and after the adhesions were produced. It is interesting that some type of bacterial growth was cultured in approximately half (42 out of 79) of the peritonea of apparently normal rabbits before the trauma and iodine were applied. The technique was checked by members of the Surgery and Bacteriology Departments and no errors could be detected. Controls were taken routinely from the applicators and media. For the most part the growths were mixed cultures of Gram positive and negative rods and cocci; *B. coli* was never found. At death all cultures of the peritoneal cavity showed some growth; 20% of the cultures showed *B. coli* and 15% *Cl. welchi.* However, in 3 of the 9 cultures taken from rabbits that had received sodium ricinoleate, there was no demonstrable growth, and one of these had shown a positive culture of mixed organisms before operation.

It is the practice of this hospital when sodium ricinoleate is used to put 60 cc. in the peritoneal cavity. Our clinical results with it or any of the other substances are too meager to draw conclusions. However, since in this study, sodium ricinoleate was most effective in preventing peritoneal adhesions in rabbits, its further clinical use would seem warranted.

The addition of air to sodium ricinoleate (1%) or amfetin in these experiments did not appear to enhance the protecting mechanism against adhesion formation. In a few patients who have been

[1] Larson, W. P., personal communication.

[2] Olson, B. J., personal communication.

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.

7440 C

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

[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.