Peritoneal Lavage Treatment in Experimental Peritonitis

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DIFFUSE peritonitis secondary to gangrenous bowel segments results in exposure of a large absorptive surface to bacteria, their endotoxins and toxic products formed by the interaction of bacteria and blood. Filler and Sleeman [2] have demonstrated an initial decreased absorption rate from the peritoneal cavity secondary to peritonitis caused by a mixture of *Escherichia coli* and hemoglobin. The lethality of the inoculum was attributed to the decreased clearance of bacteria from the peritoneal cavity, permitting their continued growth and the production of soluble absorbable toxins. Since the abdomen is a closed cavity, irrigation with large amounts of fluid to remove these bacteria and toxic products should be effective in the treatment of late peritonitis. There remains a lack of convincing evidence, however, that the application of this principal will affect the outcome of peritonitis unless applied very early in the disease process or in combination with antibiotic treatment. This study was designed to evaluate the role of intermittent peritoneal lavage in the treatment of late peritoneal sepsis secondary to a gangrenous loop of ileum.

Material and Methods

After a 16-hour fast, adult male mongrel dogs weighing 12 to 20 Kg. were anesthetized with intravenous pentobarbital and operated upon under sterile conditions. A 10 cm. section of ileum located 10 to 15 cm. from the cecum was isolated, and the two ends closed with a silk ligature. The arterial supply to the loop was doubly ligated with a silk ligature. Gastrointestinal continuity was reestablished by a continuous single layer silk anastomosis (Fig. 1). The right paramedian incision was closed with two continuous layers of silk sutures. The omentum was not removed. This method of creating peritonitis seemed reasonably analogous to the clinical situation, with the gradual development of peritonitis from a focal point in the peritoneal cavity.

Percutaneous Catheter Placement. Control animals were given 500 ml. of intravenous saline solution during the operation and again at 24 and 48 hours. Food and water were then given *ad lib* if the dog was still alive.

Test animals were given the same intravenous fluid therapy. At 24 hours, the dog was lightly anesthetized and a dialysis catheter was inserted through a percutaneous steel trochar. The peritoneal cavity was then infused with 500 ml. of lactated Ringer's solution. This was left in place for 10 minutes and was then drained off through the same catheter. This procedure was repeated to give a total volume of 2 to 4 liters of wash solution. The end point of the dialysis was a change of the returning solution from a red-brown, foul-smelling fluid to a pink or straw colored and odorless

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solution. If the animal survived, this procedure was repeated 48 hours after the operation. No antibiotics or other drugs were added to the dialysate, and no antibiotics were given to the animals by any other route. Complete return of the lavage fluid within 100 ml. was obtained in all experiments.

Operative Catheter Placement. A second test group had the same avascular ileal loop created. These dogs were re-operated upon at 24 hours and the remains of the loop were removed. No effort was made to remove fluid by suction or to break down loculations in the peritoneal cavity. Dialysis catheters were inserted into the left upper quadrant and both lower quadrants. The abdomen was then closed and lavage was immediately performed, using 2 to 4 liters of lactated Ringer's Solution. These animals were given only this single period of lavage. Control animals for this group were treated in the same way except no catheters were left in place at the second operation and no lavage was performed.

Aerobic bacterial colony counts were performed on the peritoneal fluid before and after dialysis in order to test the effectiveness of lavage in reducing peritoneal bacterial flora.

Results

Table 1 summarizes the results in both groups of dogs.

Percutaneous Lavage. Ten dogs were controls and all died between 24 and 84 hours after the initial operation. At autopsy, diffuse peritonitis with foul-smelling, bloody fluid was present in every instance. Anastomotic leak was present in one dog so that the severe peritonitis was due solely to the isolated loop in 90% of the dogs.

Seven out of 20 dogs treated by percutaneous lavage survived. When sacrificed, 14 to 36 days later, there was no evidence of peritonitis except in one dog which had a 10 milliliter collection of pus contained in the small bowel mesentery. No remains of the avascular loop could be found in any of the dogs. Thirteen dogs died despite peritoneal lavage. At autopsy, 500 ml. or more of foul-smelling, bloody fluid was found in 11, and the other two had localized collections of pus in the right lower quadrant. An anastomotic leak was present in six dogs. However, in four of these, death occurred 6 to 12 hours after lavage. The quantity and diffuse distribution of the fluid, together with its bloody character, strongly suggested

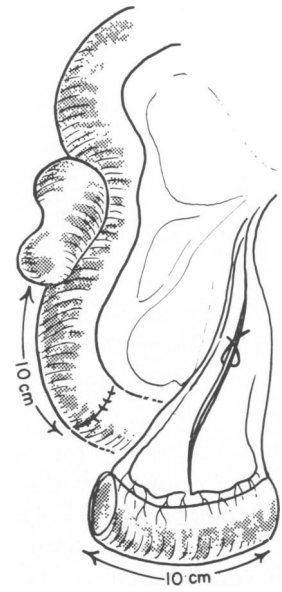

FIG. 1. Illustration of experimental preparation.

TABLE 1

Percutaneous Placement	No.	Survivors	Anastomotic Leak
Controls	10	0	1
Treated	20	7	6
Operative Placement			
Controls	5	0	1
Treated	6	2	1

Results of peritoneal lavage treatment in two groups of dogs. Survival in the treated group is significantly different from the control group. ($p < 0.009$; Fisher exact test.)

TABLE 2

Dog #	Initial	Final	Outcome
717	$>10^5$	0	Survived
720	$>10^5$	0	Survived
734	$>10^5$	100	Survived
529	$>10^5$	0	Survived
660	$>10^5$	200	Died
679	1.5×10^4	300	Died
689	$>10^5$	1,800	Died
705	$>10^5$	0	Died

Aerobic bacterial colony counts before and after dialysis.

that the fluid had been present at the time of the lavage. Certainly, in the seven dogs without anastomotic leak, technical failure of the lavage was clearly indicated by the quantity of fluid present at autopsy despite an apparently successful lavage performed 6 to 12 hours earlier.

Operative Catheter Placement. Five control dogs died with diffuse peritonitis, again demonstrating the lethality of the control preparation. In the dialyzed group, two animals survived and had negative autopsies when sacrificed. Two animals died with large collections of peritoneal fluid despite what appeared to be a successful lavage. One animal died 4 days after operation with peritonitis due to an anastomotic leak. The final dog died from aspiration pneumonia shortly after lavage. The peritoneal cavity appeared clean at autopsy. Survivorship in this small series was similar to percutaneous lavage and, once again, the dialysis was technically unsatisfactory in one third of the cases.

Aerobic bacterial counts showed a diminution to essentially zero in four dogs which survived (Table 2). However, in four others with decline to very low levels, the animals died within 12 hours of the lavage and large collections of bloody foul-smelling fluid were present. The decline of bacterial counts in the effusate once again indicates technical failure of the lavage fluid to communicate with large quantities of infected peritoneal fluid.

Discussion

Peritoneal lavage has been shown to be effective in various experimental models when applied shortly after the induction of peritonitis. Artz *et al.*[1] demonstrated in dogs that antibiotics plus irrigation of the abdominal cavity within 15 minutes after intraperitoneal injection of a fecal suspension statistically increased the survival rate compared to control animals treated with antibiotics alone. This increased survival rate was no longer present if a 2-hour delay was allowed before irrigation. Sleeman *et al.*[6] demonstrated increased survival in rats when irrigation was carried out within 8 hours following the induction of peritonitis but, at 12 hours, lavage was completely ineffective. Similarly, in other experiments, lavage alone as a treatment of late peritonitis was ineffective in dogs [3] and guinea pigs.[5]

This series of experiments has demonstrated that peritoneal lavage can increase survival rates even when no other form of treatment is employed. At first glance, survival rates of 35% may not seem exceptional, but this experiment was deliberately designed to be a severe challenge for peritoneal lavage. No antibiotics were used systemically or in the dialysate and peritonitis was allowed to develop for an 18- to 24-hour period before treatment was begun. Ceratinly, in the clinical application of this technic, antibiotics should be employed, since they have been clearly demonstrated to improve survival in bacterial peritonitis.

Problems with technical management of the irrigation were evident in these studies. The high incidence of anastomotic leaks in the percutaneous lavage series raises the possibility of perforation by catheter placement and/or manipulation to provide good drainage. Although lavage served to remove both blood and bacteria from the peritoneal cavity, as judged by dialysate color and bacterial counts, 13 dogs died shortly after what appeared to be a successful lavage.

Large quantities of loculated fluid were found at autopsy, indicating failure of the dialysis solution to reach all areas of the peritoneal cavity. This re-emphasizes the need to manually break down all loculations and abscesses so that the irrigating fluid may reach the infected material. No such attempt was made in this series and probably accounts for the high failure rate to completely remove infected fluid. McKenna *et al.*[4] have demonstrated good dispersion of lavage fluid in human beings with operative placement of multiple catheters after thorough irrigation of the peritoneal cavity during laparotomy. These technical problems also suggest that large animals with rigid rib cages represent a superior experimental model for the treatment of diffuse peritonitis; they do not present the technical advantage of manual dispersion of fluid by external compression that is so readily possible with small animal models. What remains unanswered is the value of prolonged dialysis as compared to operative lavage with or without a short period of postoperative dialysis. In the very small series utilizing operative catheter placement, a single postoperative lavage period was as effective as lavage administered at both 24 and 48 hours.

Summary

A total of 41 dogs were prepared with an isolated avascular ileal loop to produce peritonitis. Fifteen dogs received only intravenous fluid treatment, resulting in a 100% mortality. Twenty-six dogs were treated with peritoneal dialysis and nine of these (35%) survived and returned to full health. Lavage served to remove both hemoglobin and bacteria, as judged by the dialysate color and bacterial counts. Each dog which died, except one, had significant peritonitis at autopsy. This was due to technical failure of the dialysis to remove large amounts of loculated fluid.

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