Inhibition of Upper Gastrointestinal Secretions by Reinfusion of Succus Entericus into the Distal Small Bowel

A Clinical Study of 30 Patients with Peritonitis and Temporary Enterostomy

ÉTIENNE LÉVY, M.D.,* DONALD L. PALMER, M.D.,† PASCAL FRILEUX, M.D.,‡ ROLLAND PARC, M.D.,§ CLAUDE HUGUET, M.D.,‖ JEAN LOYGUE, M.D.¶

We prospectively studied peritonitis secondary to small bowel leakage in 30 critically ill patients, each of whom had complete diversion of intestinal continuity by stoma, fistula, or both. All patients received total parenteral nutrition during implementation of the protocol. The proximal intestinal effluent was collected and recycled into the distal small bowel. During reinfusion of succus entericus, a significant reduction in the output of the proximal stoma was observed (mean 30.2%, $p < 0.001$). The reinfusion also significantly reduced the volume from isolated small bowel loops in six patients (32.6%, $p < 0.001$). When isotonic dialysate solution was infused into the distal intestine, a lesser though significant reduction in stoma output occurred (mean 20.3%, $p < 0.001$). These findings demonstrate a consistent inhibitory effect upon upper gastrointestinal secretions by reinfusion of succus entericus. Clinical benefits of this technique include simplified control of fluid and electrolyte balance in patients with high output stomas and optimal utilization of remaining absorptive capacity for enteral nutrition.

From the Laboratoire de Recherche de Réanimation Chirurgicale Digestive, Institut National de la Santé et de la Recherche Medicale (INSERM), Hôpital St. Antoine, Paris, France and the Department of Surgery, Kaiser-Permanente Medical Center, Walnut Creek, California

IN PERITONITIS SECONDARY TO colonic leakage, the techniques of exteriorization or resection followed by colostomy and mucous fistula, in contrast to the methods of primary repair *in situ* or of resection and reanastomosis are widely accepted as a means to reduce morbidity and mortality. Experimental evidence of enhanced collagenase activity and poor colonic wound healing in the presence of inflammation clearly justifies this clinical practice.[5,6] A similar approach to peritonitis due to small bowel leakage has not achieved such wide acceptance despite reports suggesting benefit.[4,12]

At the Hôpital Saint-Antoine, Paris, Center for Digestive Surgery, a referral center for septic abdominal conditions and gastrointestinal fistula, the policy was adopted in 1969 of avoiding primary repair of small bowel leakage with associated generalized peritonitis. Of nearly 500 patients with peritonitis and 350 with either spontaneous or postoperative enterocutaneous fistula, 250 have required resection and double enterostomies; in the remainder, surgical procedures have been limited to drainage of abscesses and appropriate local care during the acute phase. In such critically ill patients, it is necessary to treat systemic sepsis, to correct malnutrition, and to maintain fluid and electrolyte balance, often in the presence of intestinal losses of great volume, until spontaneous closure occurs or definitive surgical repair can be safely accomplished.

In 1972, a technique was developed whereby succus entericus from high output small bowel stomas could be efficiently reinfused into the distal enterostomy; 75 patients have received this treatment. In conjunction with continuous enteral nutrition by nasogastric catheter or gastrostomy, this approach permits optimal utilization of

* Director of Research, Laboratoire de Recherche de Réanimation Chirurgicale Digestive, INSERM, Hôpital St. Antoine, Paris, France.

† Surgeon, Department of Surgery, Director, Intensive Care Unit, Kaiser-Permanente Medical Center, Walnut Creek, California.

‡ Surgeon, Laboratoire de Recherche de Réanimation Chirurgicale Digestive, INSERM, Hôpital St. Antoine, Paris, France.

§ Associate Professor of Surgery, Centre de Chirurgie Digestive, Laboratoire de Recherche de Réanimation Chirurgicale Digestive, INSERM, Hôpital St. Antoine, Paris, France.

‖ Associate Professor of Surgery, Centre de Chirurgie Digestive, Laboratoire de Recherche de Réanimation Chirurgicale Digestive, INSERM, Hôpital St. Antoine, Paris, France.

¶ Professor and Chairman, Centre de Chirurgie Digestive, Laboratoire de Recherche de Réanimation Chirurgicale Digestive, INSERM, Hôpital St. Antoine, Paris, France.

Reprint requests: Étienne Lévy, Director of Research, Laboratoire de Recherche de Réanimation Chirurgicale Digestive, INSERM, Hôpital St. Antoine, F75571 Paris, Cédex 12, France.

Submitted for publication: February 9, 1983.

the remaining absorptive capacity and frequently allows total parenteral nutrition to be discontinued.[12] During reinfusion, a consistent phenomenon has been observed: the output from the proximal stoma promptly decreases.[13] Our study confirms the apparent inhibition of upper gastrointestinal digestive secretions by reinfusion.

Methods

We studied 30 patients with peritonitis requiring hospitalization in the critical care unit for surgical digestive diseases. Sixteen had complete enterocutaneous fistula and accessible distal mucous fistula; 14 had one or more temporary double enterostomies. The initiating septic events were 18 cases of postoperative anastomotic leakage, four cases of spontaneous perforation of the hollow viscus, four cases of Crohn's disease, three cases of ischemic necrosis of the small bowel, and one case of Zollinger-Ellison syndrome with postgastrectomy duodenal stump fistula. Twenty-four patients had only single loss of gastrointestinal continuity; the level of origin was the duodenum in four patients, the jejunum in seven patients, the ileum in 12 patients, and the right colon in one patient. Among these subjects, two had required extensive bowel resection, leaving total lengths of small intestine of 125 cm and 130 cm, respectively. In the remaining six patients, multiple double enterostomies had isolated one or more segments of the intestine (Table 1). The level of the distal stoma or mucous fistula, and therefore of the infusion site, was the upper jejunum in nine patients (four of whom had duodenal fistula), the mid small bowel in 11 patients, the last 100 cm of the ileum in nine patients, and the colon in two patients.

Integral to the reinfusion technique is a specially designed apparatus consisting of a roller pump for aspiration, a sterile 50-ml disposable plastic container, from which both volume and weight are electronically measured, and a servo-controlled roller pump for infusion (Automate Systeme, Medicale Recherche, 46, Avenue d'Ivry, F75013 Paris). Although the aspiration and measurement are discontinuous, the reinfusion is continuous at a computed rate corresponding to the stoma output; cumulative output values are continuously displayed on an electronic digital counter. Collection is by a Karaya-Seal ostomy appliance connected to the aspiration side of the machine. Reinfusion is through a silicone rubber balloon catheter inserted well into the distal intestine. This device establishes a true extracorporeal gastrointestinal circulation (Fig. 1).

The study protocol was maintained for five consecutive days. The subject received nothing by mouth; effective peristalsis had resumed and nasogastric suction was unnecessary. Parenteral nutrition, initiated and stabilized earlier, was maintained throughout, supplying an average of 1,960 kcal/day and 4.7 g/day of nitrogen. Supplemental parenteral fluid intake was adjusted every 8 hours. Fluid and electrolyte balance was corrected each morning after review of the patient's weight, as well as of intake and output for the preceding 24 hours. Adjustments were made for the clinical and biochemical state of the patient.

TABLE 1. *Approximate Length of Excluded Small Bowel Loops in Patients with Multiple Enterostomies*

Patient No.	Length of Proximal Small Bowel (cm)	Length of Excluded Loops (cm)	Length of Distal Small Bowel (cm)
1	50	200	50
2	150	150	30
3	5	(a) 130 (b) 100	30
4	50	75	200
5	200	(a) 75 (b) 75	50
6	100	(a) 60 (b) 100	0

(a) Proximal.
(b) Distal.

After an initial control period, 48 hours of baseline measurement and adjustment, reinfusion was started on day 3, continued for 24 hours, then terminated. Day 4 was a secondary control period, during which losses were monitored but succus entericus discarded rather than reinfused. The subjects thus served as their own controls. On day 5, 13 of the patients received continuous infusion of isotonic dialysate solution into the distal stoma at the same rate as the reinfusion on day 3 (dialysate formula: sodium 141 mmol, calcium 1.75 mmol, magnesium 0.75 mmol, chloride 101 mmol, acetate 45 mmol, glucose 83 mmol). Only on the day of reinfusion was the output monitored from the machine's electronic digital counter. On Days 1, 2, 4, and 5, both proximal stoma/fistula output and losses from the isolated loops were measured by hand. We used the Student's t-test for coupled series to assess the statistical significance of the results.

Results

The individual and mean values of the daily proximal stoma and/or fistula output are indicated in Figure 2. The inhibitory effect of reinfusion consistently ($p < 0.001$) reduced output by a mean value of 30.2% (range 17% to 44.9%). Rebound to preinfusion control values was observed on the fourth day.

The mean inhibitory effect by level of reinfusion was determined to be: 34.7% in the proximal 100 cm of the jejunum; 30.5% in the mid small bowel; 28.2% in the distal 100 cm of the ileum; 18.2% in the only case of right colon. These differences were not significant. In one

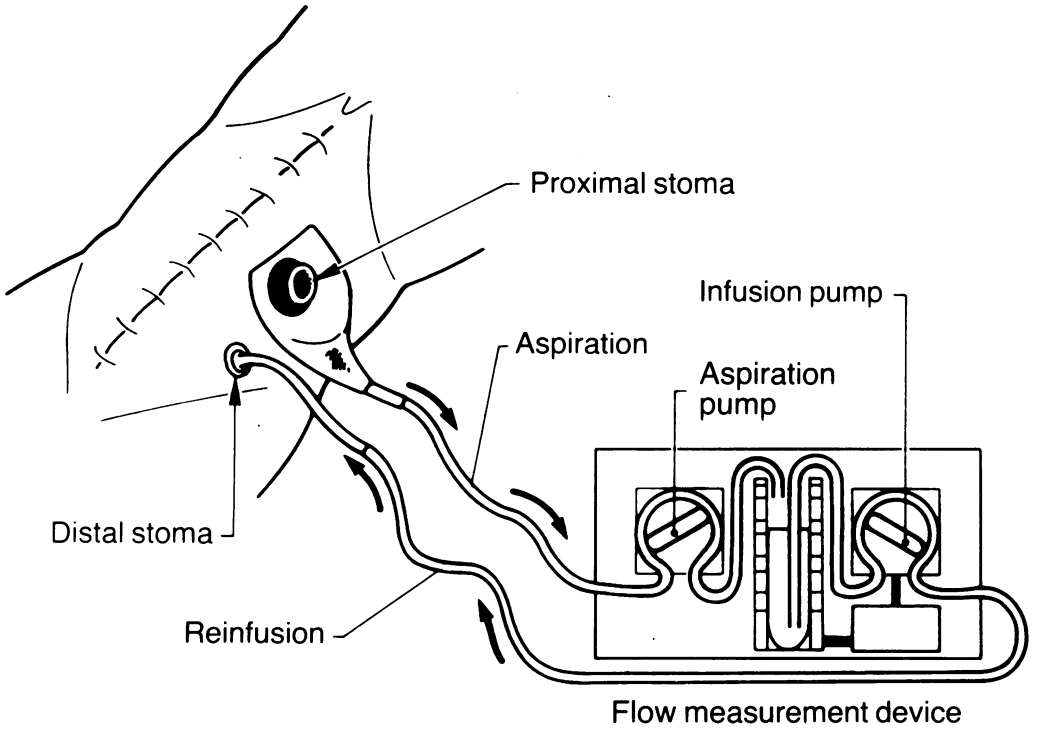

FIG. 1. Schematic for extracorporeal gastrointestinal circulation.

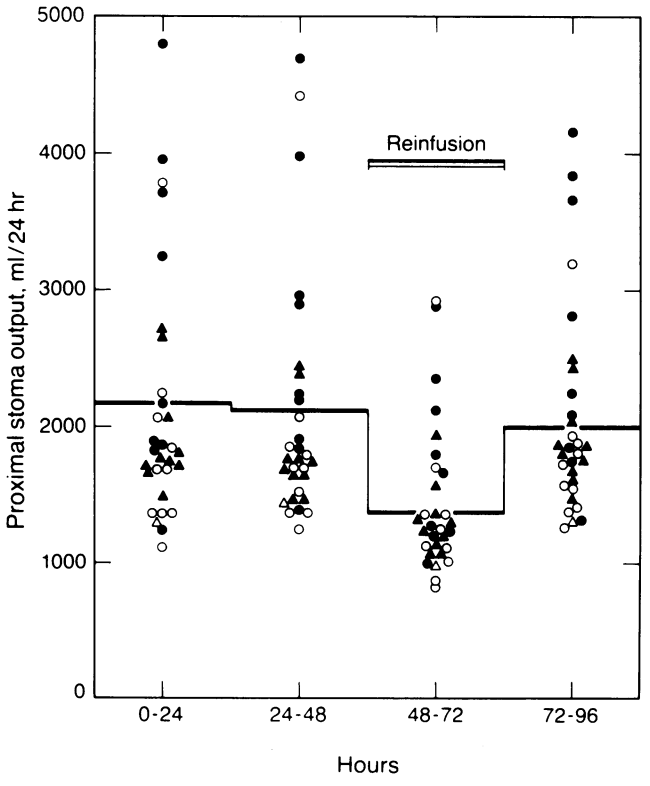

FIG. 2. Daily proximal stoma output in patients having succus entericus reinfusion. Key for reinfusion level: ● within 100 cm of duodenojejunal flexure; ▲ mid small bowel; ○ within 100 cm of ileocecal valve; △ colon.

subject having two isolated segments, the ileum and the left colon, colonic reinfusion was accomplished on the fifth day and a reduction of 11.4% recorded, compared with 23.5% during reinfusion into the ileum on the third day.

The output of the isolated loops was equally significantly reduced ($p < 0.001$) during reinfusion (mean inhibition 32.6%, range 18.5% to 43%) (Fig. 3). Like the output of the proximal stomas, measured losses from the isolated loops returned to initial control period levels on day 4 during the 24 hours post infusion.

The continuous instillation of dialysate solution was accompanied by significantly reduced ($p < 0.01$) proximal output (mean 20.3%). This inhibition was significantly ($p < 0.01$) weaker than that secondary to reinfusion of succus entericus, but the two were strongly correlated (Fig. 4).

Discussion

Our study demonstrates that the use in man of an extracorporeal gastrointestinal circulation providing continuous reinfusion of succus entericus into the distal gut yields a consistent, significant reduction (mean 30%) in the volume of effluent from the proximal stoma or fistula. Because the data were obtained from critically ill patients evaluated within 2 weeks of the initiating septic event, extraordinarily large losses were observed from both the

proximal stomas and isolated loops, reflecting a hypersecretory state and extensive peritoneal inflammation. In man and in dogs, basal outputs are substantially lower;[10,11] moreover, determinations in similar patients at a later stage, when sepsis and inflammation have resolved, show lower outputs.[12] By keeping the time frame narrow and including 24 hours of control observations after the reinfusion, the protocol minimizes the possibility that subsiding inflammation explains the decrements noted. The effect occurs despite peritonitis and disappears when reinfusion ceases.

The clinical advantages which accrue from this technique are at least two. First, intestinal losses can be reduced during the early phase of treatment when maintenance of fluid and electrolyte balance is particularly challenging. Later, as sepsis is controlled, optimal utilization of the remaining absorptive capacity for enteral nutrition is permitted.

The inhibitory effect appears to be independent of any fluid balance changes induced by the volume of reinfusion. Careful attention was given to fluid and electrolyte equilibrium by regularly reviewing clinical and biochemical parameters and adjusting parenteral intake accordingly. An imbalance may have escaped detection, but the error would have been toward expansion of the extracellular fluid compartment; in animal models this is associated with increase rather than reduction in stoma output.[3,7,9]

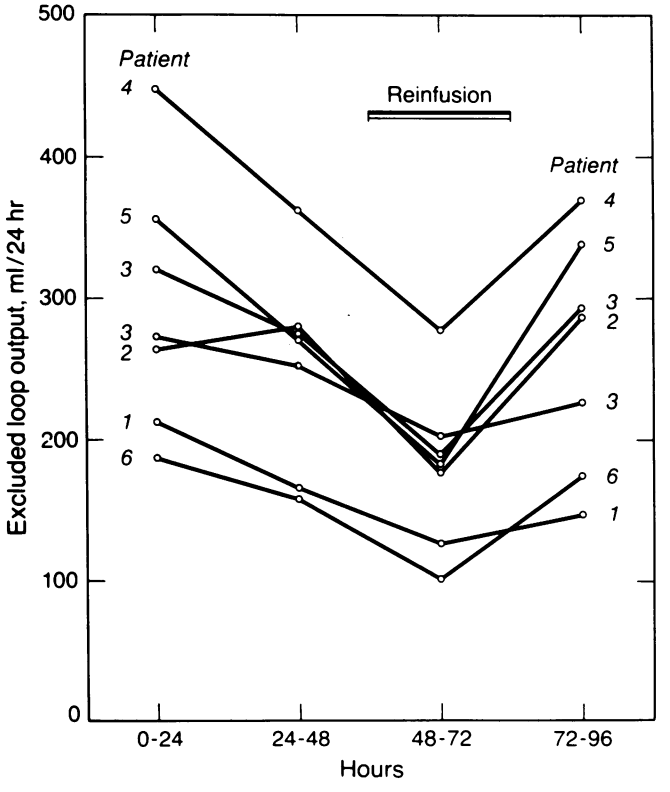

FIG. 3. Daily output from excluded loops.

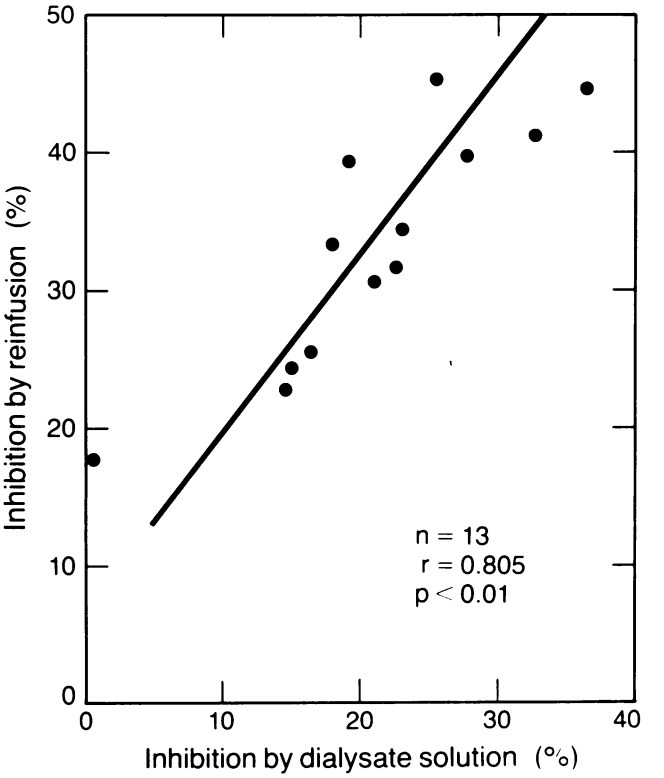

FIG. 4. Percentage inhibition of proximal stoma output. Correlation between succus entericus reinfusion and infusion of isotonic dialysate solution.

Regarding which of the digestive secretions affects the reduction in stoma output, only inferences can be drawn on the basis of the previous work. Whereas definitive conclusions might have been possible had gastric intubation been utilized, this type of manipulation would have introduced error. In dogs, exclusion of wide segments of small bowel results in considerable gastric hypersecretion,[15,16] reversible when the excluded segment is restored in continuity.[9] The human corollary, short bowel syndrome, is associated with gastric hypersecretion,[14] but a consistent and prolonged effect has not been as clearly demonstrated. Postprandial gastric secretion, measured in normal humans, is stimulated by chyme in the jejunum[1,8] and is inhibited by its presence in the ileum.[2] Thus, reinfusion into the jejunum might be expected to increase stoma output. However, in our study, reinfusion of chyme into the jejunum reduced the output to an even greater degree than reinfusion into the ileum. Finally, observations in seven patients demonstrated effects independent of gastric contribution. In the single case of duodenal fistula after total gastrectomy for Zollinger-Ellison syndrome, output was substantially reduced (42.6%),

presumably reflecting biliary and pancreatic influence. In the six patients with isolated small bowel loops, the degree of reduction (mean 32.6%) was similar to that of the proximal stomas and solely a consequence of intestinal inhibition. This result suggests that the inhibition involves multiple levels and that all digestive secretions are affected.

The design of the study allowed some speculation about the stimulus initiating the feedback loop. Because isotonic dialysate produced a significant decrease in proximal output, fluid alone, independent of osmolality, is certainly one of the stimuli. Stronger inhibition by succus entericus suggests the influence of some intrinsic factor, such as bile salts, pancreatic enzymes, or even mucosal cellular debris. Current investigation aims to clarify the mechanism and identify the mediators of the inhibitory phenomenon.

References

1. Clain JE, Malagelada J-R, Go VLW, Summerskill WHJ. Participation of the jejunum and ileum in postprandial gastric secretion in man. Gastroenterology 1977; 73:211–4.
2. Clain JE, Go VLW, Malagelada J-R. Inhibitory role of the distal small intestine on the gastric secretory response to meals in man. Gastroenterology 1978; 74:704–7.
3. Duffy PA, Granger DN, Taylor AE. Intestinal secretion induced by volume expansion in the dog. Gastroenterology 1978; 75: 413–8.
4. Goligher JC. Resection with exteriorization in the management of faecal fistulas originating in the small intestine. Br J Surg 1971; 58:163–7.
5. Hawley PR, Faulk WP, Hunt TK, Dunphy JE. Collagenase activity in the gastro-intestinal tract. Br J Surg 1970; 57:896–900.
6. Hawley PR, Hunt TK, Dunphy JE. Etiology of colonic anastomotic leaks. Proc R Soc Med 1970; 63(Suppl 1):28–31.
7. Humphreys MH, Earley LE. The mechanism of decreased intestinal sodium and water absorption after acute volume expansion in the rat. J Clin Invest 1971; 50:2355–67.
8. Ippoliti AF, Maxwell V, Isenberg JI. Demonstration of the intestinal phase of gastric acid secretion in man [Abstract]. Gastroenterology 1976; 70:896.
9. Landor JH, Baker WK. Gastric hypersecretion produced by massive small bowel resection in dogs. J Surg Res 1964; 4:518–22.
10. Kayser C. La digestion de la partie terminale (ascendante) du duodénum, le jéjunum et l'iléon. In: Kayser C (ed). Physiologie; vol 1. Paris: Flammarion, 1963; 315–6.
11. Lévy E, Loygue J. Stase et hypersécrétion gastriques post-opératoires. Étude inédite du débit gastrique quotidien en chlore total. Valeur diagnostique, pronostique et thérapeutique (175 cas). In: Journées de chirurgie digestive de l'Hôpital Saint-Antoine. Paris: Doin, 1973; 5–19.
12. Lévy E, Parc R, Loygue L, Loygue J. Stomies terminales, jéjunales ou iléales temporaires de sauvetage avec réinstillation autorégulée. Nouv Presse Med 1977; 6:461–2.
13. Lévy E, Cosnes J, Loygue J. Rétro-action négative sur le débit sécrétoire digestif de la réinstillation continue du suc digestif dans des entérostomies temporaires artificielles et pathologiques. C R Acad Sci [D]. Paris: 1976; 288:509–11.
14. Osborne MP, Frederick PL, Sizer JS, et al. Mechanism of gastric hypersecretion following massive intestinal resection. Clinical and experimental observations. Ann Surg 1966; 164:622–34.
15. Saik RP, Copeland EM, Miller LD, Smith GP. Effect of ileal exclusion on the Heidenhain pouch acid response to histamine in dogs. Ann Surg 1971; 173:67–77.
16. Santillana M, Wise L, Schuck M, Ballinger WF II. Changes in gastric acid secretion following resection or exclusion of different segments of the small intestine. Surgery 1969; 65:777–82.