

Reappraisal of Open Intestinal Anastomoses

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CAPTAIN HOLLOWAY'S Navy group,⁴ in a recent exhibit based on dog experimentation, demonstrated a one-row through-and-through *everting* intestinal anastomosis which was apparently secure, quickly and easily performed, required no external cleanoff of bowel ends to be sutured and produced no luminal narrowing. Subsequently Getzen⁵ published a limited clinical experience with the method. This interesting work stimulated us to compare in our laboratories this and three other techniques in present use.

Technical Details

The four methods studied (Fig. 1) are: 1) the double-row inverting anastomosis, in most common use and therefore termed in this paper the "Standard"; 2) the "Halsted"⁶ or single-row inverting stitch in which the needle theoretically catches the submucosa only, but actually, we think, enters the lumen more often than not. Here we have used the single rather than the double Lembert or Halsted stitch; 3) the "Navy," described above; and 4) the modified "Gambee,"^{2,3} named for its author, a one-layer through-and-through *inverting* stitch, begins with the back row. The stitches, taken from the inside, pull up a slight inverted flange (Fig. 1) upon which their knots rest. Anteriorly, as each suture is tied its knot is poked inward toward its

intraluminal position, thus maintaining inversion. A few Lembert sutures may be taken as the end of the anastomosis is approached, or elsewhere if necessary, to insure inversion. Gambee employs a modified Lembert stitch for the entire front row.

A 5-0 Mersilene suture with very sharp swaged-on needle was used in most of the anastomoses studied. Immediate air inflation leak tests showed this suture to withstand pressures up to 300 mm. Hg before leaking (through suture holes or between sutures) and when the anastomosed loops were pulled apart by hand, the bowel tore adjacent to, but not through the suture line.

In this investigation 186 anastomoses were performed in 29 healthy mongrel dogs averaging 40 pounds in weight. Forty-nine, including 26 by a discontinued method, were discarded leaving 137. These were observed at intervals from immediately after completion to 5 months, but nearly all were within the critical first week and especially 3 to 6 days postoperative. By the twenty-first day, nearly all anastomoses were solid with very little individual difference to be noted. Anastomoses were done in tandem in the terminal ileum, the first located 6 inches above the cecum, the others each 5 inches proximal to the preceding and with rotation of position from dog to dog. Usually all four methods were carried out in each animal allowing a "same dog" comparison, but in a few animals, due to changes in experimental procedure, the methods were unequally represented, thus

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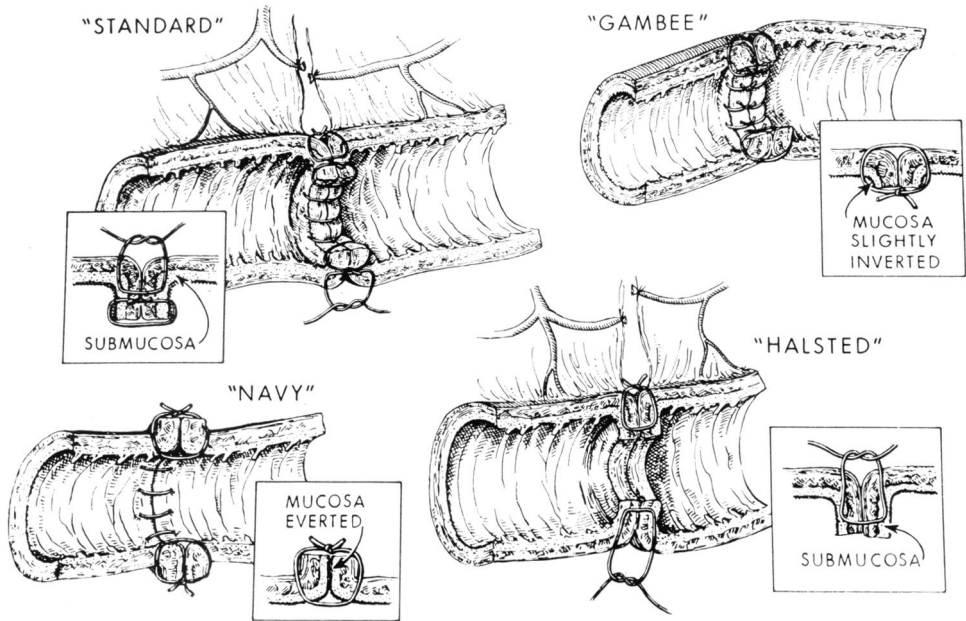


FIG. 1. The four suture methods under investigation.

allowing only a "different dog" overall type of comparison.

The four suture methods were studied from the standpoint of: anastomotic defects, associated adhesions, gross and histologic edema and inflammation of suture line, amount of inverted anastomotic cuff, operating time and air inflation leak test. In this test the bowel segment with its anastomoses was excised and held under

water and slowly inflated with air until each anastomosis leaked at a pressure measured in mm. Hg.

Results

Gross Anastomotic Defects (Table 1). There were only two free anastomotic disruptions with peritonitis among the 186 anastomoses performed: a Standard and a Halsted, both in the same animal examined

TABLE 1. Pathologic Anastomotic Defects with Spontaneous or Low-pressure Air Leaks. (All Primary Operations* 3 to 7 Days Postoperative)

Method	Details	Leak Pressure (mm. Hg)
Standard (4 defects)	1 disruption of anastomosis and fatal peritonitis	0
	1 partial separation of suture line, sealed off	30
	2 abscesses of suture line, sealed off	10 & 15
Halsted (1 defect)	1 disruption of anastomosis and fatal peritonitis	0
Gambée (3 defects)	2 tiny spots of suture line necrosis, sealed off	0 & 12
	1 small nodular granulation weakening anastomosis	30
Navy (3 defects)	1 tiny puncture where adhesion peeled off, 5th day	0
	2 low-pressure leaks where adhesion peeled off 3rd day	20 & 30

* These were in dogs not previously operated upon. A few "secondary" anastomoses were done after excising the "primary" series, usually for air leak test right after suture.

TABLE 2. Adhesions Produced by Each Anastomotic Method Shown by % of Each in the Estimated Grades of Severity. (All Primary Operations* at All Intervals Postoperative)

Method	% 0 to +	% 2+	% 3+	% 4+	% Adherent Bowel
Standard (23)**	30	39	26	4	30
Halsted (15)	60	33	7	0	7
Gambée (32)	41	47	9	3	6
Navy (25)	24	44	16	16	20

* As secondary anastomoses produced significantly more adhesions than primary and were unevenly distributed among the 4 methods, they were not included.

** Numbers in parentheses indicate number of operations.

the fourth day. The accompanying Gambée and Navy anastomoses, devoid of adhesions, were intact but leaked at air pressures of 10 and 28 mm. Hg, respectively, and demonstrated, we think, a lytic property in the septic exudate. It will be observed that with the Standard method there was another partial suture line disruption and two abscesses extending through the suture line, all sealed off by adhesions. The Halsted revealed no further defects while the Gambée and Navy each revealed three small defects sealed by adhesions. Doubtless none but the two open disruptions would have been suspected had the animals not been reopened for observation.

Adhesions (Table 2). These were graded in severity by +’s and when a knuckle of bowel was adherent to the suture line this was recorded as an added index of severity. It was surprising that the Navy with its everted oozing mucosa did not significantly surpass the Standard two-layer anastomosis in adhesion formation. If four Navy anastomoses done in one dog, all unexplainably showing 4+ adhesions, were excluded, this method actually showed fewer adhesions than the Standard. The Gambée method formed considerably fewer adhesions than the Standard and slightly more than the Halsted.

Edema and Inflammation of Suture Line. These related findings, combined in Table 3, were far more pronounced in the Standard and Halsted technics than in the Gambée and Navy. This was borne out by

the histologic studies made by our pathologist, Dr. Broghamer, who noted a considerably greater amount of suture line inflammation, edema, minute abscess formation, and of mucosal ulceration and hemorrhage in the Standard and Halsted than in the Gambée and Navy anastomoses. All these changes were most pronounced in the Standard, which showed in addition some areas of avascular necrosis.

Inversion of Anastomotic Cuff. A study of the lumen narrowing by the inverted anastomotic flange showed, by gross estimate, an average of 54 per cent for the Standard, 39 per cent for the Halsted, 4 per cent for the Gambée and 3 per cent for the Navy. This is illustrated in Figure 2, barium x-rays of the four anastomoses in tandem on the fourth day postoperative. Figure 3 shows the bulbous effect of the

TABLE 3. Suture Line Edema and Inflammation Produced by Each Method Shown by % of Each in the Estimated Grades of Severity. (All Primary Operations 1 to 7 Days Old)

Method	% 0 to +	% 2+	% 3+	% 4+
Edema				
Standard (18)	0	56	39	6
Halsted (12)	0	75	25	0
Gambée (25)	18	48	4	0
Navy (20)	20	55	25	0
Inflammation				
Standard (18)	6	72	22	0
Halsted (12)	50	42	8	0
Gambée (25)	84	16	0	0
Navy (20)	65	25	5	5

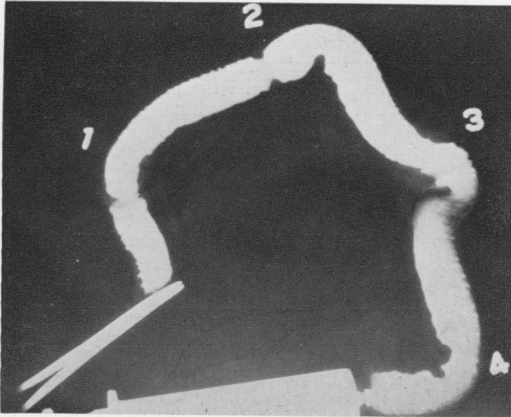


FIG. 2. Barium study fourth postoperative day: Standard (1), Halsted (2), Gambee (3), Navy (4). Deep grooves mark the Standard and Halsted anastomoses. Apparent narrowing of Gambee and Navy anastomosis due to spasm of gut on either side. The anastomoses in between are wide.

extensive turn-in of the Standard and Halsted anastomoses, the oozing everted mucosa in the Navy and the relatively slight inversion in the Gambee. The Gambee, within 3 to 4 days, straightens out almost to a flat junction. The intraluminal view (Fig. 4) shows the congested, eroded flange created by the Standard and Halsted methods and the relatively clean, flat

TABLE 4. Air Inflation Leak Tests by Time Postoperative. (All Operations Zero Time through 7th P.O. Day)

Time Postoperative	Average Leak Pressure (mm. Hg)
Immediately postop. (36)	173
Third Day postop. (8)	125
Fourth Day postop. (46)	115
Fifth Day postop. (14)	152
Sixth Day postop. (11)	228
Seventh Day postop. (2)	300

approximation of the Gambee and Navy methods. It is noteworthy that although, during the critical first week, the mucosal approximation of the Navy is cleaner than the Gambee which has suture ends protruding into the lumen, the latter is nonetheless considerably stronger.

Operating Time. The Standard anastomosis averaged 29 minutes, the Halsted 18 minutes, the Gambee 21 minutes, and the Navy 14 minutes. The Standard is by far the most lengthy of the four procedures.

Air Inflation Leak Test. The four methods were compared in three ways: last to leak, average leak pressure, and percentage of each method not leaking under 50 mm.

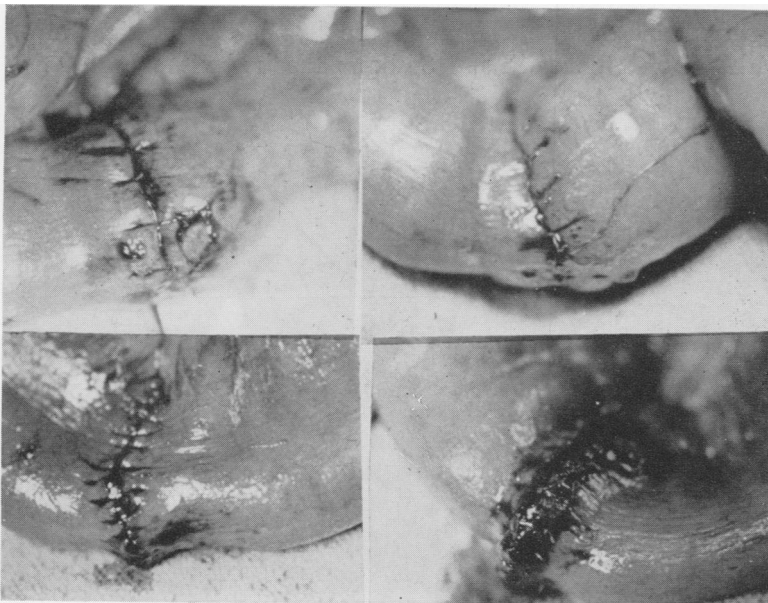


FIG. 3. Anastomoses immediately upon completion. Standard (upper left) and Halsted (upper right) thickened from extensive inverted cuff. Gambee (lower left) cleanly inverted but with obviously little cuff. Navy (lower right) showing oozing everted mucosa.

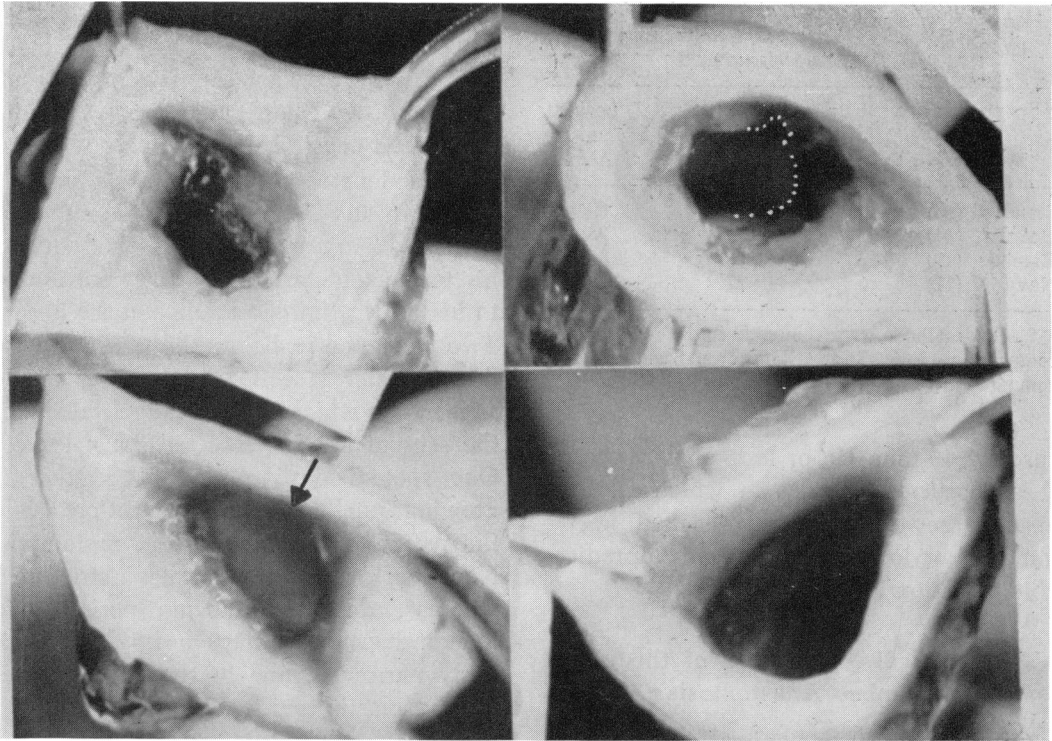


FIG. 4. Intraluminal view, fourth day. Note boggy obstructing cuff in Standard anastomosis (upper left), and somewhat less in Halsted (upper right); very little cuff in Gambee (lower left), luminal opening partly obscured by droop of bowel wall superiorly (shown by arrow); Navy (lower right) showing no cuff at all.

Hg, a pressure we believe to be above any that would exist under clinical conditions.

As in the classic investigations of Howes and Harvey,⁷ the four anastomoses as a group (Table 4) were at their weakest the third and fourth days, and thereafter rose sharply in holding power.

The air inflation tests taken immediately after completion of anastomosis (Table 5) showed the Standard anastomosis to be the strongest with its very wide turn-in and double row of sutures. The single-row everting Navy suture, as might be expected, was least secure at this early stage. There was little difference between the Gambee and the Halsted.

The leak tests taken during the crucial healing period from the third to the sixth day (Table 6) shows the Gambee to be slightly weaker throughout than the Hal-

sted anastomosis but stronger than the Standard. Again, the Navy is by far the weakest of the four anastomoses.

Two Standard and five Navy anastomoses, without obvious defect, leaked at pres-

TABLE 5. Air Inflation Leak Tests Immediately Postoperative. (Secondary Operations. Same Dog Comparisons*)

Method	% Last to Leak	Average Leak Pressure (mm. Hg)	% Leak at 50 mm. Hg or above
Standard (10)	90	212	100
Halsted (8)	25	185	100
Gambee (10)	30	146	100
Navy (8)	13	144	100

* All 4 methods were compared in 8 dogs, and 2 methods, Gambee and Standard, were compared in 10 dogs. Explanation of "primary" and "secondary" footnote Table 1.

TABLE 6. *Air Inflation Leak Tests, 3 to 6 Days Postoperative (Primary Operations. Same Dog Comparisons*)*

Method	% Last to Leak	Average Leak Pressure (mm. Hg)	% Leak at 50 mm. Hg or Above
Standard (19)	36	151	69
Halsted (14)	50	181	93
Gambée (19)	42	160	84
Navy (17)	6	77	59

* All 4 methods were compared in 14 dogs, 3 were compared in 17 dogs and 2, Gambée and Standard, were compared in 19 dogs.

tures of 40 mm. Hg or less. All but two of these occurred in dogs in which all four anastomoses unexplainably leaked at 60 mm. Hg or lower, revealing an unpredictable variation among animals.

Clinical Application of the Gambée Anastomosis

On the basis of our animal experimentation, the Gambée is becoming our procedure of choice, and we have been cautiously substituting it for the time-honored Standard method. Our small experience thus far in 113 procedures has been favorable and briefly is as follows:

1. Eighty-five unselected Weinberg¹¹ pyloroplasty closures without leak, included because of their close similarity to the Gambée method, incorporating its single-row, through-and-through principle with negligible turn-in.

2. Four closures and four anastomoses after small bowel surgery. One of these was a difficult reconstruction of the duodenum after the excision of a malignant duodenocolic fistula. Another was a Roux-Y hook-up after a Puestow operation for chronic pancreatitis. A third was a Roux-Y antiperistaltic remedial operation for severe dumping syndrome.

3. One esophagocolostomy in the neck, one esophagogastrectomy in the chest, both for cancer.

4. Two colostomy and two colotomy closures.

5. Twelve colectomies, partial or complete, and two colostomy excisions, all with end-to-end anastomoses.

A duodenotomy to explore the ampulla of Vater in a debilitated patient with chronic biliary obstruction leaked during his terminal deterioration and contributed to his death; the one fatality in the group. Two anastomoses below the peritoneal reflection after resection for cancer of the sigmoid, in which the undrained hollow of the sacrum became infected, have leaked. One spontaneously closed. The other is growing smaller under observation while the patient is at home and asymptomatic. None of these anastomoses strictured, whereas, during the same period, two Standard colonic anastomoses have seriously narrowed, one to the extent of requiring plastic revision.

Discussion

There were several surprises in this investigation. Although Captain Holloway's Navy group used Gambée anastomoses as controls and found everting anastomoses superior histologically and because of absence of obstructing cuff, our method of performing the Gambée anastomosis, taking relatively small bites, produced an anastomosis histologically similar and with a negligible inversion cuff. Furthermore, the air inflation test proved it far stronger than the Navy because the serosa-to-serosa proved in our hands to be a much stronger approximation than mucosa-to-mucosa. Whether, though less secure than the Gambée, the Navy anastomosis is still secure enough, is a question which can only be settled by clinical trial. Is the risk involved in the more treacherous colonic and esophageal anastomoses justified when there is little to be gained by the everting anastomosis?

Our studies show that the double row in-

version of the Standard, generally regarded as giving it greater security, is probably the very factor which, by jeopardizing arterial supply and venous and lymphatic return, render it more prone to avascular necrosis and abscess formation. At the same time, the extensive inverted cuff constitutes an obstruction hazard. Getzen and co-workers⁴ point out that the necessarily wider area of cleanoff of bowel ends to be joined and the marked angulation of the wall in suturing render technics with wide cuff inversion more subject to critical ischemia and congestion. Also, Buchin and Van Geertruyden¹ report more tissue necrosis and microscopic abscesses in two-layer than in one-layer anastomoses. These, as well as our own histologic studies, would explain the unexpected tendency to adhesion formation and necrosis of the Standard anastomosis.

The Gambee anastomosis has a further advantage over other methods when carried out in an awkward position, such as deep in the pelvis, since back row sutures are taken from the inside and there is no need for twisting or manipulating the bowel ends.

The Halsted anastomosis, though slightly stronger than the Gambee in air inflation tests, still results in much greater inverted cuff. From the foregoing considerations then, the Gambee in our estimation emerges as the most desirable of the four open anastomoses studied. That its stitches pierce through the bowel wall produces no demonstrable harm.

We realize that some experiments notably by Waltzer and Altemeier¹⁰ and by Cohn and associates⁸ reveal that in the dog and rabbit, tumor implantation is considerably less after closed than after open anastomosis. Likewise, Ravitch⁹ devised a clamp which may eventually render suture methods obsolete. For the present we think that the open anastomosis is the most reliable and accurate method available and

that tumor implantation in the human is far less common than in the experimental animal.

Summary

Animal experiments together with a limited clinical experience seem to show that the more time-consuming and difficult Standard anastomosis because of its double row is actually less rather than more secure than the Gambee, and it has a further serious drawback in a marked turn-in. The Halsted, slightly stronger than the Gambee anastomosis, has nearly as great an obstructing turn-in as the Standard. The Navy anastomosis, though simple and quickly performed, and devoid of obstructing cuff, has such low leak pressures with air inflation, that we hesitate to use it for any critical anastomosis, especially of colon or esophagus. In short, our investigations and clinical experience seem to show the Gambee to be superior to other anastomoses tested, and it is becoming our procedure of choice.

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Announcement

Jane Nugent Cochems Competition

The University of Colorado School of Medicine announces the Sixth Annual Cochems Competition, funds for which were provided in the will of the late Mrs. Jane Nugent Cochems. A prize of \$2500 will be awarded to the author of the best paper in the field of "Thrombophlebitis and Basic Vascular Problems." Basic vascular problems under consideration in this instance should be concerned with the underlying mechanisms or processes of vascular disease, particularly those associated with thrombosis, but not necessarily restricted to it.

The competition is open to all persons holding the doctorate degree and entries must be received in triplicate, including all charts, illustrations and photographs, on or before *November 15, 1967*. For income tax reasons, eligibility is limited to those physicians who are subject to U. S. income tax regulations.

The Colorado National Bank of Denver, Trustees under the will of Jane Nugent Cochems, has requested the Dean of the University of Colorado School of Medicine to conduct the competition. The judges appointed by the Dean are Dr. Sol Sherry, Professor of Medicine, Washington University School of Medicine in St. Louis, and Dr. Michael E. De Bakey, Professor and Head of the Department of Surgery, Baylor University College of Medicine. Decisions of the judges are final, and they may elect at their discretion not to award the prize.

Papers submitted in the competition may not be published until after the winner has been announced early in 1968. At that time, the winning paper and all others may be published at the discretion of individual authors. It should be noted, however, that sponsors and judges of the competition will not assume any responsibility for submitting manuscripts for publication nor for any costs incident thereto. The winning paper, if published, must carry the designation, "Awarded the Jane Nugent Cochems Prize."

No entry blank or application form is required. There are no restrictive rules regarding length or format of the manuscript, joint authorship, or inclusion of such materials as pictures, charts, figures, etc. It is not required that the paper include results of original experimental work, nor that it be based on personal clinical experience. All manuscripts must be typed with double spacing and each copy together with accompanying illustrations, etc., must be submitted in a folder or cover. On request, the original copy of the manuscript will be returned if accompanied by a stamped, addressed envelope. Papers will be judged on originality, content, clarity, and critical value.

Inquiries regarding the competition and all manuscripts should be submitted to Dr. John J. Conger, Vice President for Medical Affairs and Dean, School of Medicine, University of Colorado Medical Center, 4200 E. Ninth Avenue, Denver, Colorado 80220.