

Single-layer mass closure of major laparotomies by continuous suturing¹

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Introduction

Sutures break, knots slip and tissues tear. These are the three causes of wound failure after laparotomy closure. The first two have been completely eliminated by the abandonment of catgut, but tissues still tear, either because each stitch is not deep enough, or because tissue is destroyed by infection or tight suturing. The suture-holding capacity of tissues depends on three variables: first, the direction of the fibres (sutures inserted at right angles are held more securely); secondly, the distance from the cut edges at which the sutures have been inserted (the deeper the bite the stronger the hold); and thirdly, the bulk of the tissue embraced by the sutures (the larger the more secure).

We all pay lip service to the need for a secure hold of suture on tissue, but it was Jenkins (1976) who applied simple arithmetic to this need. From 1957 to 1973, using two layers of continuous monofilament nylon (Jenkins, personal communication), he closed 1505 major laparotomies and had only one burst abdomen. He inserted sutures at 1.1 to 1.3 cm intervals (observing the principle of the deep bite) and, by measuring the unused lengths of nylon and the length of the wound, found that the ratio of suture length to wound length varied between 3.5 and 5.3 to 1. Each stitch, therefore, required from 4 to 6 cm of material, confirming that bites of 1 to 1.5 cm had been taken. In 7 patients not in the series, 3 with burst abdomens and 4 with incisional hernias, he found that the ratio of suture length to wound length was less than 2 to 1 indicating that the sutures had been inserted too near the cut edges.

One of the attractions of this arithmetical approach is that it enables surgeons in training to monitor their performance, but it can only be done with a continuous suture method. Therefore, although interrupted mass suturing had given satisfactory results in our hands (an incidence of burst abdomen of 0.56%), we changed to a continuous technique. As we had previously found no significant disadvantage in using monofilament steel, monofilament nylon or braided polyglycolic acid (PGA) (Leaper *et al.* 1977), we continued to use these three materials on a randomly allocated basis.

Methods

Three hundred and five consecutive patients under the care of one surgeon, undergoing emergency or elective major laparotomy, were randomly allocated to have their musculo-aponeurotic incisions closed by either steel (29 gauge monofilament stainless steel wire), polyglycolic acid (Dexon no. 1 BPC) or nylon (no. 1 BPC monofilament). The following categories of incision were excluded: gridiron muscle-splitting for appendicectomy, Pfannenstiel for prostatectomy, lumbar for exposure of the kidney or for sympathectomy, and those through pre-existing incisional hernias.

Smoking habits were recorded and cardiac and respiratory condition assessed preoperatively. Nutrition was judged to be good if haemoglobin, blood urea, serum proteins and bilirubin were within normal limits. Blood loss during operations was measured and blood transfusions noted. Postoperative respiratory condition was allotted a score (Leaper *et al.* 1977) and one of four or more denoted severe complications.

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The technique of continuous mass abdominal wall closure was identical with all suture materials, which were carried on Moynihan 5/8 circle hand-held needles, 11.5 cm in total length. 'Deep bites' (intended to be not less than 1 cm from the cut edges) were taken through musculo-aponeurotic layers including peritoneum at approximately 1 cm intervals, and knots were formed by three square throws. The number of stitches was counted and the unused ends of suture material measured. This figure subtracted from the original length gave the total length of suture material per stitch. During each operation the length of incision and the thickness of subcutaneous fat were measured with a sterile ruler, and obesity was defined as a thickness of subcutaneous fat greater than 2.5 cm. All data were entered on forms and transferred to coded punch cards for analysis.

Any discharge from the wound within a month of operation was regarded as sepsis unless it was of clear sterile serum. Surviving patients were seen not less than six months after their operations, and an incisional hernia was diagnosed when straining produced a visible bulge deep to the scar, associated with a palpable defect in the musculo-aponeurosis.

The protocol contained no escape clause and the only patients rejected from analysis were 11 who died within a week of operation (none of whom had a burst abdomen).

Statistical analysis of the significance of differences was by the χ^2 test, and a *P* value of <0.05 was accepted as significant.

Results

Two hundred and ninety-four patients survived for longer than a week and their records were analysed. Those in each of the three suture material groups were well-matched (Table 1).

Table 1. Comparability of the series

	Steel	PGA	Nylon
Male	41	41	40
Age 60+	58	61	62
Malignant	27	34	32
Incision - midline	54	58	55
- transverse	42	41	44
Incision length 18 cm+	8	10	12
Obese	31	41	34
Consultant closing	51	56	42
Blood transfusion	11	12	16
Jaundice	8	6	5
Emergency operation	12	21	22
Length of operation <60 min	48	51	44
60 min +	48	48	55
Total	96	99	99

There were no burst abdomens. The overall incidence of major and minor wound sepsis was 29%, ranging from 16% for operations on the upper gastrointestinal and biliary tracts (low risk) to 52% for colorectal operations (high risk). The incidence of sepsis was lower in wounds sutured with PGA than in those sutured with either steel or nylon but the differences were not statistically significant; in low risk operations there were 7 out of 57 (12%) with PGA, compared with 10 out of 69 (14%) with steel and 13 out of 60 (22%) with nylon. After ileocolorectal operations, wound sepsis was found in 20 out of 42 (48%) with PGA, 16 out of 28 (57%) with steel and 20 out of 38 (53%) with nylon.

Young people had a lower incidence of wound sepsis (19%) than those over the age of 60 (35%), but this reflected only the greater number of colorectal operations in the elderly.

The length of suture material per stitch varied from 3 to 10 cm (Figure 1), mean 5.90, standard deviation 1.46, and was independent of the direction of the incision (vertical or transverse) and of the status of the surgeon (consultant or surgeon in training). Less suture

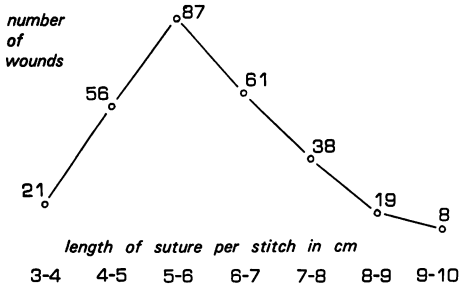


Figure 1. Variations in length of suture material per stitch

material was, however, used in thin patients (subcutaneous fat < 1.0 cm thick) than in those of normal (1.0–2.4 cm) or obese (2.5 cm or over) build; 20 out of 37 thin patients (54%) required less than 5 cm of material per stitch, compared with 23% of the rest ($\chi^2 = 16.18, P < 0.001$).

More material was used in the 26 patients who developed incisional hernias than in the 214 who did not (6.58 ± 1.90 and 5.81 ± 1.39 ; $t = 2.53, P < 0.02$).

Incisional hernias were sought not less than six months postoperatively in 240 surviving patients; 26 were found (11%). Nine occurred after 83 steel closures (11%), 11 after 83 PGA (13%) and six after 74 nylon (8%). There are no significant differences among these figures (Table 2).

Table 2. Some factors not significantly associated with incisional herniation

	No. of patients	Hernias No. (%)
Consultant closure	122	9 (7%)
Registrar closure	118	17 (14%)
Jaundice	16	1 (6%)
No jaundice	224	25 (11%)
Midline incision	133	17 (13%)
Transverse incision	107	9 (8%)
Obese	97	10 (10%)
Not obese	143	16 (11%)
Good nutrition	143	15 (10%)
Poor nutrition	97	11 (11%)
Suture material: Steel	83	9 (11%)
PGA	83	11 (13%)
Nylon	74	6 (8%)

Several factors did appear to influence the rate of herniation (Table 3), and significant among these were wound sepsis, male sex, postoperative chest complications, long incisions, operations lasting more than 60 minutes, postoperative distension, blood transfusion and old age. (The last is probably associated with wound sepsis after colorectal operations.)

Steel sutures had to be removed from 5 patients, 3 for pain and 2 for persistent stitch sinuses. One nylon suture was removed from a persistent sinus. No such complications were found after suture with PGA.

Table 3. Factors significantly associated with incisional herniation

	No. of patients	Hernias No. (%)	χ^2	P
Wound sepsis	66	17 (26%)	20.99	<0.001
No wound sepsis	174	9 (5%)		
Men	91	19 (21%)	15.31	<0.001
Women	149	7 (5%)		
Severe postoperative chest complications	54	13 (24%)	12.65	<0.001
No severe postoperative chest complications	186	13 (7%)		
Incision length 18 cm +	26	8 (31%)	12.00	<0.001
Incision length < 18 cm	214	18 (8%)		
Postoperative distension	101	18 (18%)	8.82	<0.01
No postoperative distension	139	8 (6%)		
Length of operation 60 min +	122	20 (16%)	7.94	<0.01
Length of operation < 60 min	128	6 (5%)		
Blood transfusion	28	7 (25%)	6.59	<0.02
No blood transfusion	212	19 (9%)		
Age 60 +	137	20 (15%)	4.68	<0.05
Age < 60	103	6 (6%)		

Discussion

Many authors have analysed the unavoidable causes of wound failure (Halasz 1968, Keill *et al.* 1973) and it is now well established that male sex, old age, malnutrition, blood transfusion, and postoperative coughing and distension are associated with a higher than average incidence of burst abdomens. Gynaecological operations, on the other hand, are singularly immune (Mills 1972, Baggish & Lee 1975).

Technique, however, is fundamental. Norris (1939) reported an incidence of 0.56% burst abdomens in 2318 laparotomies (including gridiron incisions) and made the famous statement that 'The elimination of postoperative wound dehiscence is entirely within the jurisdiction of the operating surgeon'. He advocated the 'greater utilization of smaller sizes of tanned catgut in a meticulous manner, i.e. interrupted sutures with small tissue bites'. He did, however, recommend the addition of 'an adequate number of non-absorbable retention sutures which have been placed through all the layers at an optimum distance from the wound margins to insure their holding power'.

Early attempts to exploit the greater tensile strength and knot security of non-absorbable sutures were thwarted by the frequency with which stitch sinuses occurred when natural non-absorbables were used. This problem was overcome by the use of monofilament stainless steel wire, and Jones *et al.* (1941) reported three contemporary – but not randomly selected – series of operations on the biliary tract. The burst abdomen rate was 11% when incisions were sutured with two layers of catgut, 7% when sutured with catgut for the peritoneal layer and interrupted steel wire for the anterior rectus sheath, whereas only one burst abdomen occurred in 81 operations after steel closure with interrupted mass far-and-near sutures. This (the Smead-Jones method) has been widely adopted as the standard for mass closure. In spite of the cogent theoretical (Dudley 1970) and practical (Irvin *et al.* 1977) arguments in favour of mass musculo-aponeurotic closure, many surgeons still close laparotomies in layers and rates of burst abdomen of 3% or more are not uncommon (Ellis 1977).

Using the Smead-Jones interrupted mass closure technique with monofilament steel (Irvin *et al.* 1977, Leaper *et al.* 1977), monofilament nylon (Dudley 1975) or polypropylene (Hermann 1974), wound dehiscence occurs in less than 1% of laparotomies. Polyglycolic acid sutures used in the same way are equally effective (Leaper *et al.* 1977, Bentley *et al.* 1978), but even the mass closure technique does not prevent burst abdomens when catgut is used (Leaper *et al.* 1976) because it breaks and the knots come undone.

The principle underlying the success of the Smead-Jones suture is the 'deep bite' for the musculo-aponeurotic layers, which affords greater suture-holding power than layered suturing (Seidel *et al.* 1974). Deep bites can only be achieved satisfactorily by the use of a Moynihan hand-held needle. Needles requiring holders are too short to encompass the bulk of tissue necessary. Our surprising finding of a significantly greater length of suture material per stitch in those patients who developed incisional hernias has yet to be explained. Is there, perhaps, an optimal depth of bite?

An alternative method of mass closure is by a continuous suture (Kirk 1972, Martyak & Curtis 1976) and we have used this method with some success in this series.

As for the type of suture material, there seems to be nothing to choose among steel, PGA and nylon. We have, however, given up using stainless steel wire, partly because surgeons and nurses do not like handling it, and partly because of the occasional necessity for late removal of the sutures on account of pain or sinuses.

Whereas with this method of mass suturing the freedom from wound dehiscence is encouraging, the problem of late incisional hernias remains, and our incidence of 11% is too high. Though some were due to technical inadequacies, many patients had suffered postoperative wound sepsis, largely due to inefficient antibacterial bowel preparation (we were at the time testing two single agents, metronidazole and tetracycline, neither of which was satisfactory). Further reduction in the rate of herniation must depend on better methods of prevention of sepsis.

Summary

Surgeons who close major laparotomy incisions in a single layer (excluding skin) usually put interrupted sutures of non-absorbable monofilament material. In 305 consecutive patients we have, instead, used continuous deep-bite mass sutures with satisfactory results. The suture material, chosen at random, was either monofilament nylon, monofilament stainless steel wire or polyglycolic acid (PGA). The length of material used was measured, and this figure divided by the number of bites to give the mean distance from the cut edges at which the needle had been inserted. The ratio of length of suture material to number of bites ranged from 3–10 cm (mean 5.90, s.d. 1.46).

There were no burst abdomens, but 26 incisional hernias were detected within six months of operation; these were significantly associated with male sex, old age, long incisions, long operations, postoperative coughing and distension, blood transfusion and wound sepsis. Steel sutures were removed from 5 patients because of pain or sinuses, and nylon sutures from one.

We conclude that laparotomy closure by a single continuous layer of sutures is satisfactory, and that there is little to choose among nylon, PGA and steel. The incidence of incisional hernias would be reduced by the elimination of wound sepsis.

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