Healing of the right and left colon
An experimental study


Summary
An experimental study investigated the relative healing properties of the unprepared right and left colon of the baboon. Colonic healing was assessed in three ways: anastomotic leakage, hydroxyproline concentration and breaking strength. The results suggest that healing on the two sides of the colon is similar.

It is generally believed that primary repair or resection and anastomosis in right colon injuries is safe, while a colostomy is recommended for the majority of left colon injuries. However, in a recent retrospective clinical study we suggested that both sides of the colon heal similarly and that they should therefore be treated similarly. Healing in the right and left colon was compared under experimental controlled conditions.

Materials and methods
Ten adult male baboons of approximately the same weight (18-20 kg) were used, and each one acted as its own control. They were subjected to laparotomy without any bowel preparation. Cultures of colonic material were obtained from both sides of the colon by means of needle aspiration. A 3 cm-long segment from the right colon and another 3 cm segment from the left colon were resected and the continuity of the bowel was restored by a two-layer repair (interrupted 3/0 polyglycolic sutures). A single dose of 1 g cefoxitin was given intra-operatively. Postoperatively the animals were given a sugar solution for 3 days and thereafter their normal diet.

The resected colonic segments were used as control specimens to measure breaking strength and hydroxyproline concentrations. The baboons were sacrificed 10 days later and the anastomotic healing was assessed in three ways: leakage, breaking strength and hydroxyproline concentration.

The breaking-strength tests were performed at a temperature of 23°C, with a custom-built, motor-driven, tensometer. From each colonic specimen three longitudinal strips (8 x 4 mm) from between the taenia were prepared with the help of a double-bladed scalpel. The tests were done at an extension rate of 107 x 10-6 m/s. The resulting force-time curves were transformed to their corresponding stress-strain relationships to obtain engineering values of strength. The hydroxyproline concentrations were estimated from biopsy specimens taken between the taenia. In the presence of an anastomosis the biopsies were obtained from the anastomotic site. Three biopsies were taken from each side of the colon. The specimens were stored at 20°C until analysis. The hydroxyproline tests were performed randomly using a modification of the Woessner technique. The tissue was hydrolysed with 6N HCl at 110°C for 20 hours and the determination of hydroxyproline was performed on a Technicon AutoAnalyzer II.

Results
There was 1 death 7 days after operation caused by an anastomotic leak from the right colon. The remaining 9 baboons had an uneventful postoperative course until sacrificed. The anastomoses on both sides of the colon were intact in all animals. In 2 of them,
there was a small amount of bloody fluid in the peritoneal cavity, which was sterile on culture.

The faecal cultures taken at the first operation showed that both the left and right colons were populated by Escherichia coli, faecal Streptococci, Bacteroides fragilis, and Clostridium welchii in all baboons. Proteus mirabilis, Klebsiella and Pseudomonas were isolated in some of the animals.

The breaking strength in the intact right colon was $0.158 \pm 0.022 \text{ N/mm}^2$ (28 tests) and in the intact left colon $0.164 \pm 0.014 \text{ N/mm}^2$ (28 tests). The difference in the two sides of the colon was not significant ($t$-test; $P > 0.05$). The hydroxyproline concentrations were $5.83 \pm 1.61 \mu g/mg$ (30 tests) and $5.92 \pm 1.85 \mu g/mg$ (30 tests) respectively ($t$-test; $P > 0.05$; NS). The breaking strength of the anastomosis was $0.080 \pm 0.005 \text{ N/mm}^2$ for the right colon (25 tests) and $0.076 \pm 0.009 \text{ N/mm}^2$ (25 tests) for the left colon (NS). The hydroxyproline concentrations were $4.48 \pm 1.37 \mu g/mg$ (27 tests) and $4.51 \pm 1.28 \mu g/mg$ (27 tests) respectively (NS). The breaking strength and the hydroxyproline concentrations in the intact colon were significantly higher than in the anastomosis ($P < 0.005$). This applied for both right and left colon. Fig. 1 shows the hydroxyproline concentrations in individual baboons.

Discussion

Colonic healing was assessed by the presence or absence of leakage, breaking strength, and hydroxyproline concentrations. Breaking strength is considered superior to the bursting pressure in assessing the mechanical strength of the anastomosis.4,10 The presence of sutures has no effect on the test after the first few days and there is no need for their removal.11 This test gives direct information on the anastomotic strength in testing colonic anastomoses because it is considered to be more representative of the physiological strain in the bowel than breaking strength. However, it is reliable only during the first few days.12 After the first week the bowel ruptures away from the anastomosis.12,11 The value of hydroxyproline concentration as a biochemical indicator of the healing process is well documented. This amino acid is almost exclusively found in collagen in tissues of vertebrates, thus making it a useful marker for collagen synthesis and healing.14 Its concentrations correlate well with the breaking strength.9

The management of civilian colonic injuries is a controversial issue. The general belief that primary repair or resection and anastomosis in the unprepared bowel is safer in the right colon than in the left colon, is based on theoretical grounds (different anatomy, physiology, faecal contents) rather than on clinical criteria. There is no convincing clinical or experimental evidence to support this approach. In a study of 134 patients with colon injuries, our results suggested that both sides of the colon heal similarly.9 The present findings support this view. The dangers of extrapolation from the experimental to the human situation are well recognised. However, the choice of the baboon as an experimental animal makes our conclusions more meaningful because of the close similarity of the anatomy and microbiology of the colon of the baboon and the human colon.

In conclusion, using the criteria referred to, the present study suggests that in the unprepared bowel, healing on the two sides of the colon is the same. These findings are supported by our reported clinical experience.

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References