Effects of Low-dose Preoperative Irradiation on Low Anterior Anastomosis in Dogs*

ROBERT M. SCHAUER, M.D.,* MELVIN P. BUBRICK, M.D.,† DANIEL A. FEENEY, D.V.M.,‡ GARY R. JOHNSTON, D.V.M.,‡ ERIC S. ROLFSEMEYER, M.D.,* ROBERT L. STROM, M.D.,§ CLAUDE R. HITCHCOCK, M.D., PH.D.†


Twenty mongrel dogs underwent preoperative radiation therapy to the colon and rectum using the Nominal Standard Dose Equation to simulate treatment with 2000 rads. Each dog then underwent anterior resection of the rectosigmoid, and reconstruction was randomized into two groups consisting of either handsewn or EEA-stapled anastomoses. Anastomoses were examined digitally and radiographically on the day of surgery and on the seventh postoperative day. There were three radiographic leaks among the ten dogs having the handsewn anastomoses and one radiographic leak among the ten dogs having the EEA-stapled anastomoses. There was one clinically significant leak which occurred in a dog having an EEA-stapled anastomosis and was associated with peritonitis and death. The overall leak rate was 30 percent among dogs having handsewn anastomoses and 20 percent among dogs with stapled anastomoses. The data suggest that an anterior resection in low colorectal anastomosis can be done safely after low-dose radiation using either handsewn or stapling techniques. [Key words: Anastomosis; Carcinoma; Colon; Radiation therapy; Rectum; Stapling device]

Preoperative irradiation has been used widely in the treatment of colorectal carcinoma. Since the first case description by Symonds in 1914,1 numerous
treatment protocols have been established.2-7 Doses have ranged from a “low dose” of 2000 rads to the “high dose” techniques of 4500 to 5500 rads, with no general agreement as to which regimen is optimal. Five-year survival statistics have suggested improved survival with either dosage range.3,5,6

The current operative treatment of rectal and rectosigmoid carcinoma involves a trend toward rectal sphincter-sparing resection,9 with increasing use of low anterior anastomotic techniques. In the past, surgery following irradiation therapy to the rectum or rectosigmoid has been limited to abdominoperineal resection, presumably to avoid the risks of performing a low anastomosis in an irradiated field.10 Recent reports, however, suggest that small-bowel as well as colonic anastomoses can be performed safely following irradiation therapy utilizing both handsewn and stapling techniques.3,5,7,11
With this in mind, an animal study was designed (1) to assess the safety of performing an extraperitoneal colorectal anastomosis following low-dose irradiation and (2) to compare the efficacy of handsewn and stapling techniques under these circumstances.

Methods and Materials

Twenty mongrel dogs, weighing 40 to 54 pounds, underwent preoperative irradiation to the rectum, using a 250 kVp, 15 mA orthovoltage x-ray unit. Surface source distance (SSD) was 50 cm. The half-value layer of the x-ray beam was 2.6 mm of copper (mm Cu). The radiation dose was measured utilizing a "thimble" radiation chamber (Victoreen R meter Model 500 and thimble chamber Model 550-6A, Victoreen, Inc., Cleveland, Ohio) placed in the rectum with the sensitive volume in the center of the x-ray beam. Plastic tubing was placed in the rectum to protect the R meter from damage due to peristalsis or feces. While radiation was administered, the accumulated dose was monitored for each portal to allow accurate dosimetry.

Ventral dorsal right-to-left and left-to-right oblique portals were used to administer 915 to 920 rads to a 4-cm length of the rectum in one dose. The x-ray beam was centered along a line perpendicular to the long axis of the body, 7 cm anterior to the anus. Each portal exposed an area 4 × 6 cm on the surface of each dog's skin on the side of the x-ray tube, and each portal was used to administer one-half of the above-mentioned depth dose. No surface overlap was used. The angle (off vertical) for each portal was determined specifically for each animal depending on body weight and shape.

Calculations were planned to simulate a 2000 rad, 12-day, ten-fraction low-dose protocol for preoperative radiation therapy using the nominal standard dose equation (NSD) as follows: 

\[
\text{NSD} = \text{dose (total)} \times (\text{days on treatment})^{-0.11} \times (\text{number of fractions})^{-0.24}
\]

According to the NSD equation, a total dose of 875.6 rads was to be delivered by two portals (437.8 rads per portal). A 5 per cent increase in depth dose was administered to compensate for absorption of the plastic tubing on the dorsal side of the R meter.

After a three-week resting period, the dogs were randomly assigned to one of two operative groups. All dogs underwent mechanical bowel cleansing, and each dog was given 6 g carbenicillin (Geopen®) in divided doses over a four-hour perioperative period.

Surgery was done under aseptic technique through a vertical midline incision, and anesthesia was by intravenous administration of sodium thiopental. At operation, the sigmoid was dissected free of its peritoneal attachments. The rectum was mobilized anteriorly and posteriorly, and both lateral rectal stalks were divided. A 5-to-10 cm segment of rectosigmoid was then resected, and end-to-end anastomosis was done between the proximal sigmoid and extraperitoneal rectum using one of the two anastomotic techniques.

Group I dogs underwent a handsewn inverting two-layer anastomosis. The inner layer consisted of a continuous full-thickness 3-0 chromic catgut suture utilizing the Connell stitch anteriorly to secure circumferential mucosal inversion. The outer layer consisted of interrupted Lembert-type sutures of 4-0 silk. Group II dogs underwent a stapled anastomosis using the EEA stapling device (Autosuture Company, Division of United States Surgical Corp., Stanford, Connecticut). Proximal and distal bowel loops were secured to the stapling device with 2-0 Prolene continuous full-thickness suture, and a complete inner ring of resected bowel wall was obtained from both colonic and rectal segments after the stapling device had been fired. Each anastomosis was evaluated by digital examination on the operating table. Immediate postoperative barium-enema examinations were performed using a volume sufficient to outline the rectum, proximal colon, and anastomotic site, as described by Goligher et al. A second barium-enema examination was performed on the seventh postoperative day and then once weekly if a leak was demonstrated.

The level of anastomosis was evaluated by digital examination at the time of the barium-enema examination on the seventh postoperative day. This level was measured and recorded. The abdominal wound was also inspected at this time. All dogs were killed one to two months postoperatively and were examined for anastomotic dehiscence, perianastomotic abscess, and intraperitoneal abscess.

Results

Effects of Irradiation: The irradiation was tolerated well by all dogs. Some evidence of skin damage and alopecia was noted in all 20 animals. Grossly, no radiation changes were seen at the level of the rectosigmoid, proximal colon, or small bowel. Histologically, all resected specimens of small bowel were found to have some changes consistent with irradiation effect. Some were more severe than others. The spectrum of findings noted included (1) diminished mucosal height, (2) abnormal mucosal architecture, (3) plasma cell mucosal infiltration, (4) ectatic mucosal and submucosal vessels, (5) increase in mitoses in the mucosa, (6) thickening of the submucosa, (7) rem-