

# The Healing of Single- and Double-Row Stapled Circular Anastomoses

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The healing of anastomoses performed by single- or double-row circular stapling instruments is analyzed in the dog colon. Mucosal healing is better in single-row stapled anastomoses. Apposition of the outer intestinal layers is superior in double-row stapled anastomoses. Bursting pressure and circular wall tension values are identical in both anastomotic types except at 24 hours after surgery when the strength of a double-row stapled anastomosis is superior. A cost-benefit analysis is still in favor of single-row circular instruments. In our opinion, adequate preoperative bowel preparation and a thorough surgical technique, when preparing the cut edges to be anastomosed and placing purse-string sutures, are infinitely more important than making a choice between single- or double-row stapling machines. [Key words: Colon and rectal surgery; Suture techniques; Surgical staplers; Wound healing]

MANY FACTORS influence intestinal wound healing.<sup>1</sup> One of these factors is the surgical technique. The basic principle of a suture technique which inverts the cut edges of the gut is based on experimental studies<sup>2-5</sup> and on a controlled clinical trial.<sup>6</sup> However, it still remains controversial whether one or two layers of sutures have to be placed especially for colorectal anastomoses.<sup>7-9</sup>

Recently, much interest has been shown in the use of circular stapling instruments in colorectal surgery. Clinical experience with Russian types of circular stapling instruments, firing a single row of staples, demonstrated that anastomotic dehiscence occurs less frequently after stapled than after hand sutured anastomoses in rectal surgery, and that circular staplers enable an anastomosis to be made at a lower rectal level than would be possible by hand suturing through the abdomen.<sup>10-12</sup> Since 1966, several types of circular Russian suture guns have been used in our department for low anterior resection as well

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as in total gastrectomy. In 1979, American versions, firing a double row of staples, became available.<sup>13</sup> Although the Russian suture gun had been described as an attractive instrument technically easy to use,<sup>11</sup> anastomoses made with American stapling machines, firing a double row of staples, were claimed to be more secure.<sup>14,15</sup> The controversy whether an intestinal anastomosis should be performed in one or two layers then extended to the use of circular automatic suturing machines.

Some authors published clinical experience with both types of circular staplers,<sup>11,16,17</sup> but an objective prospective clinical trial is rather difficult to perform from an ethical point of view as the surgeon might prefer to place additional seromuscular reinforcing sutures in some cases as a matter of precaution. Since an experimental study comparing both stapler types has not been published, this study deals with the healing of single- and double-row stapled circular anastomoses performed in scientifically ideal circumstances on the dog colon.

## Materials and Methods

Fifty-six female dogs weighing between 12 and 25 kg were anesthetized with 30 mg sodium pentobarbital per kg intravenously. Preoperative preparation consisted only of a 24-hour fast, a single dose of 500 mg ampicillin intramuscularly, and colonic irrigation with 2 liters of tap water followed by 1 liter of povidone 1 per cent solution in water (Isobetadine®, Laboratoria Belgana, Brussels). Using an aseptic technique, the mid-colon was delivered through a midline hypogastric incision. The arteriovenous branches of a 2- to 3-cm segment were ligated close to the intestinal wall. The colonic diameter

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and wall thickness were measured at this level using a disposable tissue measuring device (Proximate TMD, Ethicon Inc., Somerville, NJ). A circular stapling instrument with a diameter just inferior or identical to the measured intestinal diameter was chosen and inserted through the anus. Stapling guns firing either a single row of staples (SPTU-21, PKS-25 or SPTU-29, Medexport, Brussels) or a double row of staples (Proximate Disposable Intraluminal Stapler PDIS, Ethicon Inc., Somerville, NJ) were used. The technical characteristics of the circular stapling instruments used in this study are compared in Table 1. At the level of the prepared colonic segment, the head of the instrument was moved away about one inch from the shoulder piece. Without opening the gut, the midportion of the segment was tied to the circular rod. Then the head was approximated again to the shoulder piece until the distance between them was identical to the measured wall thickness. After performing the anastomosis the instrument was opened and removed without undue traction on the anastomosis. The abdominal wall was closed in layers. Only one end-to-end circular anastomosis was allowed in each animal. Totally, 28 single-row stapled circular anastomoses and 28 double-row stapled anastomoses were performed.

**Morphologic and Histologic Examination:** Twenty dogs were sacrificed at different times after operation. Specimens containing the sutures were resected and opened longitudinally on the antimesenteric side. The contents were removed by gentle washing. After 15 minutes of fixation in formalin, the sutures were examined carefully using a stereo-microscope and photographed. After overnight fixation the staples were gently removed and biopsies were taken perpendicularly through the anastomotic site. They were embedded in paraffin and semiserial sections were stained with hematoxylin and eosin, and Masson's trichrome.<sup>18</sup>

**Measurement of Bursting Pressure and Circular Wall Tension:** Thirty-six dogs were sacrificed either immediately after performance of the anastomosis (12 dogs) or 1, 2, 4 or 7 days later (each time 6 dogs). A 10-cm colonic segment with the anastomosis in its midportion was excised without removal of eventual adhesions at the suture line. The strength of the anastomosis was assessed in a segment of 6 cm collapsed length, immersed in a saline bath, by inflating the lumen with air at a rate of 50 ml/min until leakage occurred. At that time the intraluminal bursting pressure was recorded as well as the external anastomotic diameter. Circular wall tension was calculated according to La Place's law.<sup>19</sup> The measured diameters were converted to internal bowel radii by division by two and subtraction of the wall thickness as measured with the tissue measuring device (ranging from 1.2 to 1.6 mm).

### Results

**Macroscopic Examination:** Profile sections of 12 anastomoses examined at low magnification, one or two days after surgery, showed an evident unevenness protruding in the lumen. This was due to the inverting nature of the suture. Gross examination of specimens revealed no major differences between the two types of stapled anastomoses. Superficial necrosis of the anastomosis on the luminal side was always present. On the serosal side no granulation tissue was observed but the continuity was relatively better established in the double-row stapled anastomosis than in the single-row group (Fig. 1). A schematic representation of cross sections through single- and double-row stapled anastomoses is given in Figure 2.

In four specimens, obtained four days after surgery, the anastomosis was almost completely covered by a smooth epithelial layer when a single-row stapled anastomosis

TABLE 1. Comparison Between Single- and Double-Row Circular Stapling Machines\*

	SPTU-21	ILS21	PKS-25	ILS25	SPTU-29	ILS29
Outer Diameter (O.D.) of instrument working part (1)†	21.0	21.0	25.0	25.0	29.0	29.0
Diameter of knife (2)	14.0	12.5	16.5	16.5	19.0	20.0
Distance from						
O.D. to outer layer of staples	1.0	1.0	1.0	1.0	1.0	1.0
O.D. to inner layer of staples (3)	—	2.0	—	2.0	—	2.0
Distance from knife to outer layer of staples	2.5	3.25	3.25	3.25	4.0	3.5
$\frac{[(1)-2 \times (3)]-(2)}{2}$						
Number of staples on circumference						
Outer layer	10.0	8.0	12.0	10.0	14.0	12.0
Inner layer	—	8.0	—	10.0	—	12.0
Distance between staples (outer layer)	2.0	3.5	2.0	3.5	2.0	3.5
Width of staples	4.0	4.0	4.0	4.0	4.0	4.0
Diameter of rod	6.0	6.5	5.0	6.5	6.0	6.5
Length of instrument working part	180.0	195.0	175.0	195.0	180.0	195.0

\*All dimensions are given in millimeters.

†(1), (2), and (3) refer to O.D., diameter of knife, and distance from O.D. to outer layer of staples, respectively.

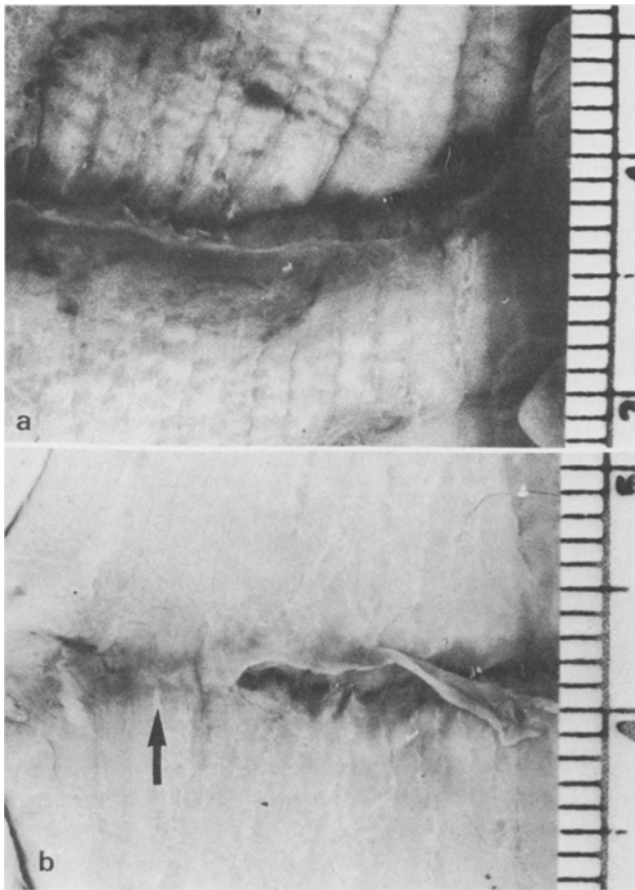


FIG. 1. Gross examination of the serosal side of the anastomosis reveals reestablishment of continuity (arrow) in a double-row stapled anastomosis (b) as compared with a single-row stapled specimen (a). Operative specimens obtained at two days after surgery.

had been performed, whereas areas of necrosis and granulation tissue separated by normal mucosal islands were seen in cases where a double-row stapled anastomosis had

been performed (Fig. 3). In both types of anastomoses the serosal side was continuous and smooth.

In four specimens, obtained seven days after surgery, a complete epithelialization of the anastomosis was found in single-row stapled anastomoses whereas granulation tissue was still present in anastomoses performed with a double row of staples. The serosal side was completely healed in both anastomotic types.

**Microscopic Examination:** In all specimens we found the formation of a crest which protruded into the lumen owing to the folded muscular layer and to the granulomatous process due to mucosal necrosis which was present early after performing the anastomosis. Indeed, we observed necrosis of the glandular epithelium, the muscularis mucosae and part of the submucosa in all sections from specimens obtained one day after surgery. In some specimens a few isolated mucosal islands were observed but, in most areas, the mucosa was replaced by granulation tissue. The circular muscular layers were well approximated at the anastomotic line in both groups. Only a widening of the intercellular spaces due to local edema was observed. For the longitudinal muscle layer a better apposition was achieved with a double row of staples.

After four days the epithelium had healed almost completely in single-row stapled anastomoses. The glandular ramifications remained incomplete and irregular and the lamina propria contained a rich cellular infiltrate with extravasated red blood cells. In sections from anastomoses with a double row of staples the surface was still covered by a vascular granulation tissue.

In specimens obtained seven days postoperatively, similar features were observed. The healing and cleaning process was still in course in both types of anastomoses although it was far more advanced in sutures which had been performed with a single row of staples. Although the

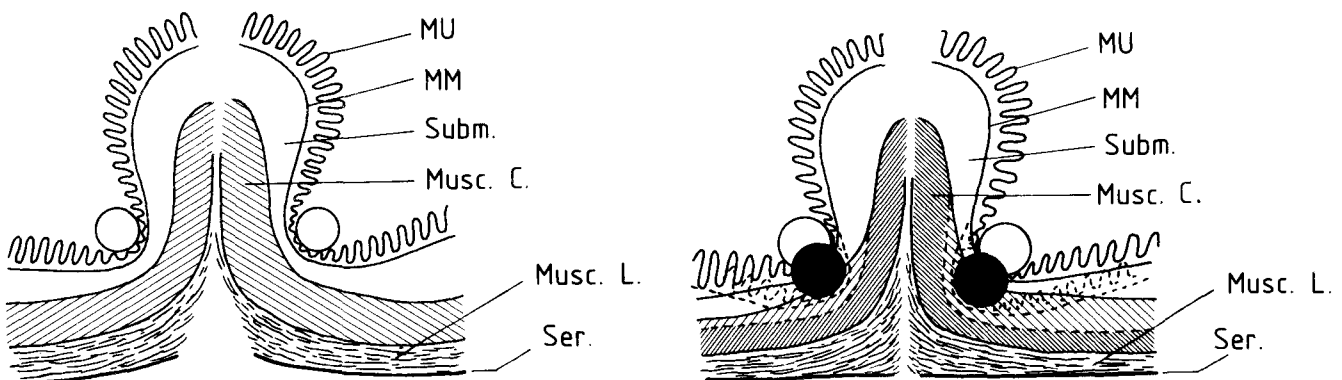


FIG. 2. Schematic representation of a single-row (left) and a double-row stapled anastomosis (right) early after surgery. Apposition of the inner layers of the intestinal wall is good in both types of anastomoses. In the single-row anastomosis, a gap is observed at the serosal side between the serosal and longitudinal muscular layers. This gap is absent in a double-row stapled anastomosis. MU: mucosa, MM: muscularis mucosae, Subm.: submucosa, Musc. C.: circular muscle layer, Musc. L.: longitudinal muscle layer, Ser.: serosa, O: cross section through staples.

glandular layer was continuous and of equal thickness when a single row of staples had been used, the seromuscular gap had not yet healed completely; fibroconnective bridges could be observed between the two suture edges.

**Bursting Pressure and Circular Wall Tension:** No dog in any of the groups died. Leakage of the anastomosis was never observed. A comparable degree of adhesion formation was found in both groups. The results of analyzing the intraluminal forces producing leakage or bursting are summarized in Figures 4 and 5. Three anastomoses of each type were tested after 1, 2, 4 and 7 days. Six anastomoses of each type were tested immediately after performance, as it is evident that this should be the most vulnerable moment for a single-row stapled anastomosis compared with a double-rowed one. Bursting pressure and the calculated bursting circular wall tension were comparable in both anastomotic types, except at one day after operation. At that time double-row stapled anastomoses proved to be superior to single-row stapled anastomoses ( $P < 0.01$ ).

**Discussion**

The main goal of our study was to compare the healing strength of single- and double-row stapled circular anastomoses performed in surgically ideal circumstances, i.e., avoiding as much as possible those factors which adversely influence wound healing. We feel this goal was reached in our experimental study. Local and systemic factors as well as surgeon-related variables were identical in both groups. Peroperative peritoneal soiling and placement of purse-string sutures, which are of great importance in clinical practice, were completely avoided as the gut was not opened. The surgical procedure was standardized, the only variable being that in one group single-row and in the other group double-row stapled anastomoses were performed. Moreover, by peroperative measurement of the intestinal diameter the appropriate size of stapling

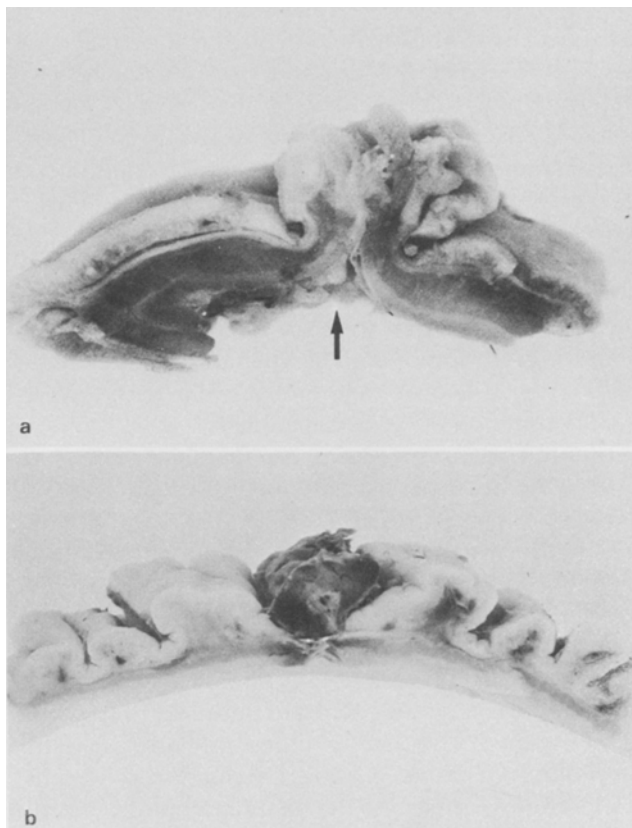
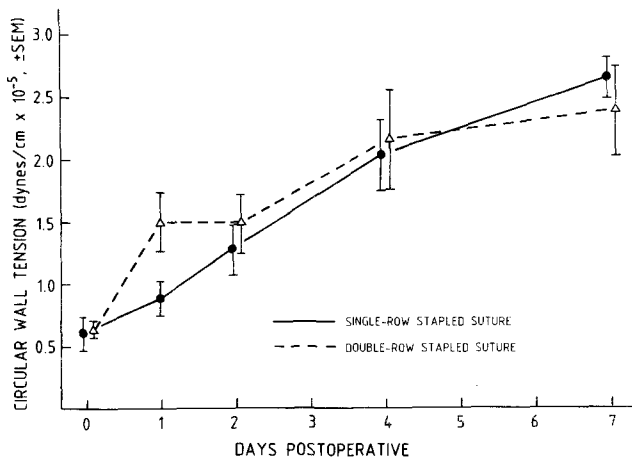
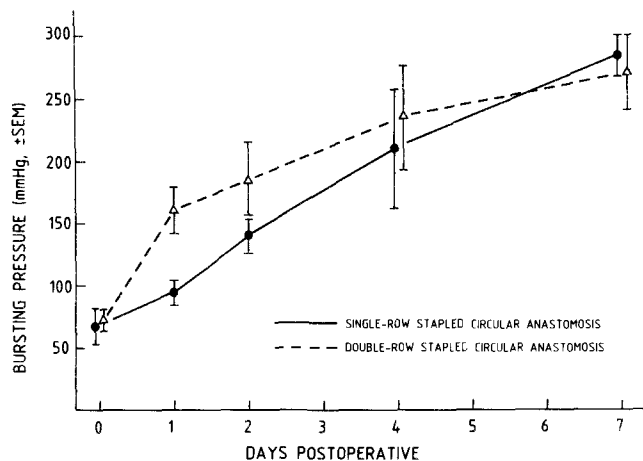


FIG. 3. Section through the anastomotic site showing well-vascularized tissue at the luminal side of a single-row stapled anastomosis (a) and necrotic tissue at the luminal side of a double-row stapled anastomosis (b). Serosal apposition is good in (b), whereas in (a) the seromuscular gap (arrow) is filled up with fibrin coagulum and collagen. Specimens obtained four days after surgery.

instrument was always chosen, avoiding any significant problem, especially undue traction and manipulation at the anastomosis during removal of the stapler. Also the gap between head and shoulder piece of the stapling



FIGS. 4 and 5. Evolution of bursting pressure and circular wall tension in single- and double-row stapled circular anastomoses of the dog colon. Mean values ± SD.

instrument was always adapted to the intestinal wall thickness measured by a special device (TMD).

Morphologic analysis showed that recovery of the mucosa was achieved early and easily in single-row stapled anastomoses. In double-row stapled anastomoses the mucosal necrosis was much more extensive. This is probably related to a higher degree of mucosal ischemia due to the double row of staples which overlap each other. In both types of anastomoses the apposition of the inner layers of the intestinal wall was good. Healing of the submucosa, the importance of which for the strength of healing is well known<sup>20</sup> and probably due to the hierarchic organization of the collagen fibers,<sup>21,22</sup> was comparable in the various specimens. Another major difference between the two types of anastomoses was found on the serosal side.

The influence of the serosal coat on intestinal anastomotic healing has already been studied by others.<sup>23</sup> In single-row anastomoses the apposition of the serosal tissue was poor, whereas apposition was good and healing achieved quickly in double-row stapled anastomoses. Indeed, in these sutures serosal continuity was partly restored within 24 hours after surgery probably as a result of a process of primary healing. On microscopic examination fibrosis mixed with an inflammatory, mostly leukocyte, infiltrate was found. This was even more pronounced after 48 hours; however, from that time, the larger serosal gap in a single-row stapled anastomosis also became filled up, so that the serosal continuity became similar to that of double-row stapled anastomoses. Apposition of intact serosal surfaces may not be so important since minimal trauma triggers fibroblast proliferation and fibrin secretion. This fibrin acts as an adhesive between the inverting ends of the intestine and increases the rupture strength of the anastomosis. In single-row stapled anastomoses serosal healing and adhesion reveal slightly protracted times probably due to the greater gap and to the less good apposition of the outer muscular layer.

Bursting pressure and circular wall tension measurements performed on fresh single- or double-row stapled anastomoses were found to be identical. This is in contrast with the generally propagated and, at first sight, acceptable opinion that a double-row stapling instrument would produce a safer, i.e., a more hermetic, anastomosis from the start. At one day postoperatively, the tensile strength of a double-row stapled anastomosis proved to be superior. In our opinion this finding has to be related to the fact that restoration of the seromuscular continuity is achieved earlier in this type of circular stapling due to better apposition. However, a difference in bursting pressure of approximately 60 mm Hg at 1 day postoperatively might be of no practical importance since an intraluminal pressure of 90 mm Hg probably does not

occur at that time due to postoperative ileus; the highest "physiologic" colonic pressure observed in patients is 140 mm Hg.<sup>24</sup> At two days postoperatively and, later on, when the larger seromuscular gap in single-row stapled anastomoses was completely filled up with new collagen, the tensile strength of both anastomotic types was comparable again.

It has to be emphasized that Russian surgeons always recommend reinforcement of a stapled circular anastomosis in clinical practice, although their experimental work indicates the adequacy of stapled closure alone.<sup>25</sup> Reinforcing sutures through the outer intestinal layer may improve the early strength of single-row stapled anastomoses as they result in a smaller seromuscular gap which consequently can be filled up more rapidly with fibrin coagulum and collagen.

When comparing both types of circular stapling machines not only the clinically very important aspect of anastomotic safety has to be considered but also the cost-benefit aspect. Although \$100, or even more, is a small price for avoiding a definitive stoma in patients with rectal cancer, it has to be emphasized that the price-relationship between a Russian and an American suture gun is at least 1 versus 10.

Since the healing process and development of tensile strength in single- and double-row stapled circular anastomoses are quite comparable, and since their bursting pressure values at two days after performance are equal or superior to the highest intracolonic pressure values that have been recorded in humans, it becomes clear that adequate preoperative bowel preparation, optimal blood supply, and absence of tension at the anastomotic site, as well as a thorough surgical technique when preparing the cut edges to be anastomosed and placing purse-string sutures, are infinitely more important than making a choice between single- or double-row stapling machines.

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#### Announcements

##### SYMPOSIUM ON PREVENTION AND DETECTION OF CANCER

The Sixth International Symposium on Prevention and Detection of Cancer will be held November 26-29, in Vienna, Austria. The Symposium is sponsored by the International Society for Preventive Oncology, the World Health Organization, the Austrian Cancer Society-Austrian Cancer League, and the Association of Clinical Scientists-USA. The program includes overview lectures, panels, poster sessions, scientific exhibits, and special workshops designed for critical appraisal of current data. Discussions are to concentrate on actions to be taken and on the implementation of existing knowledge for effective cancer control by primary and secondary prevention. Reports are to present progress in multifactorial etiology of oncogenesis, molecular biology, identification of high risk groups, tumor susceptibility, and clinical and laboratory manifestations of cancer including tumor markers. Participants include clinicians, epidemiologists, pathologists, experimental oncologists, immunologists, socioeconomists, educators and members of the health care team. Abstracts of presentations are invited by June 15, 1984. Abstracts and program appear in *Cancer Detection & Prevention* 1984;7(6). Award(s) for outstanding investigation(s) presented by the International Society for Preventive Oncology. The symposium accredited for 32 CME credit hours. For more information write; Prevention & Detection of Cancer, AMEX POB #790459, Dallas, Texas 75379 or call toll-free in USA: 1-800-527-0297, outside Europe: (USA-214) 392-3663, in Europe: (Austria 43-222) 52-0544.

##### THE AMERICAN SOCIETY FOR GASTROINTESTINAL ENDOSCOPY THIRD ANNUAL POSTGRADUATE COURSE II "TECHNIQUES IN GASTROINTESTINAL ENDOSCOPY"

"Techniques in Gastrointestinal Endoscopy," the third annual postgraduate course II of the American Society for Gastrointestinal Endoscopy, will be held at the Boston Marriott-Copley Place in Boston, January 24-26, 1985. The Course Director is Bennett E. Roth, M.D. For further information, contact ASGE/PG, Thirteen Elm Street, Manchester, Massachusetts 01944 or telephone (617) 927-8330.