Experience of General Surgery Residents in the Creation of Small Bowel and Colon Anastomoses

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BACKGROUND: With the introduction of stapling devices (SDs), the proportion of hand-sewn (HS) intestinal anastomoses (IAs) has declined. As more IAs are constructed with SDs, there are fewer opportunities for general surgery residents (GSRs) to acquire the skills for HS techniques during their training.

STUDY DESIGN: Data for this study were extracted from an existing database of all IAs performed at the Department of Surgery of the Morristown Medical Center since 2003. For the purposes of this study, a 5.5-year timeframe was used between July 2006 and 2011, which contained 1659 IA operations on adult patients with resident involvement. GSRs of the 5-year general surgery residency program were grouped by postgraduate year (PGY) for further analysis.

RESULTS: The number of all IAs created by each resident during the 5-year training was 67.2 on average. Most of these operations were done in the last 2 years of the training: 45.1% of all IAs in PGY5 and 37.3% of all IAs in PGY4. Of all, 1659 IAs performed in the study period, 711 (42.9% of total) were done laparoscopically and 948 (57.1% of all IAs) were done as open operations. Laparoscopic operations had a proportionally higher rate of SD use when compared to open cases (90.9% vs 82.4%). On average, each resident constructed 9.4 HS IAs (13.98% of all IAs) and 57.8 SD IAs (86.02% of total). Out of all anastomoses, ostomy reversals (30.7%) had the highest percentage of HS suturing followed by right colectomies (27.5%), ileal pouch-anal anastomoses and total colectomies and proctocolectomies (23.3%), small bowel resection (17.0%), and left colectomies (5.5%). Regardless of the location of the operation, stapled and sutured anastomoses had similar outcomes measured by the rate of anastomotic leaks. Residents used significantly more SDs in the creation of anastomoses than HS suturing in the PGY3, PGY4, and PGY5 years. We also documented that attending surgeons who are older more often used HS suturing than their younger colleagues when creating IAs.

CONCLUSIONS: The experiences of GSRs in IA operations are heavily weighted toward the use of SDs. There are select cases, however, when HS suturing can have an advantage over stapler use in anastomosis creation. Therefore, we believe that GSRs should continue learning, perfecting, and using the both techniques. (J Surg Ed 73:844-850. © 2016 Published by Elsevier Inc. on behalf of the Association of Program Directors in Surgery)

KEY WORDS: general surgery residency, surgical training, alimentary tract surgery, anastomosis operation, hand-sewn and stapled intestinal anastomoses created by residents

COMPETENCIES: Medical Knowledge, Professionalism, Practice-Based Learning and Improvement, Patient Care, Systems-Based Practice

INTRODUCTION

The creation of an intestinal anastomosis (IA) is an essential skill for general surgeons.[1,2] Although a successful intestinal anastomosis is often lifesaving, a failed intestinal anastomosis can lead to serious complications, including death.[3,4] IA operations only became safe and effective by the turn of the 19th century when various pioneers of modern surgery described techniques for suturing of the intestine.[5] Through the 20th century, surgeons developed various suturing techniques to tailor IAs to specific clinical situations.[6] With the introduction of stapling devices (SDs) in the late 1960s, anastomosis creation became possible in anatomic locations that were beyond the reach of suturing before, such as very

This study was presented by Rolando H. Rolandelli, MD, FACS, at the 2014 Annual Congress of the American College of Surgeons as a Poster of Exceptional Merit.

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  1931-7204/$30.00 http://dx.doi.org/10.1016/j.jsurg.2016.04.011

low anterior resections of the rectum.[7] Chassin et al.[8] reported that stapling procedures were used in a much higher percentage of those operations, which were performed under emergency conditions or in the presence of intraabdominal sepsis, intestinal obstruction, and carcinomatosis. The use of SDs has evolved from applying them to cases where sutures could not be used to becoming the preferred method of IAs.[9]

When compared to hand-sewn (HS) techniques, SDs offer the great advantage of expedience in the creation of IAs.[10] Since the short-term outcomes of IAs are similar using either surgical method, HS suturing is usually left to special situations where SDs are not suitable for a safe and effective anastomosis creation. These situations are found in pediatric surgery and in emergencies with abnormalities in the bowel wall or connections of the intestine to other structures such as the biliary tree and the pancreas.[11] Unfortunately, these cases involve serious risks, making them less than ideal for the general surgery residents (GSRs) to gain skills in IA operations.

The creation of an IA with HS sutures requires skills that are learned, practiced, and further developed with experience. Alignment of the 2 sides of intestine, placement, handling, and tying of sutures requires precision that comes with the repeated performance of these maneuvers.[6] Experience gives the trainee confidence in using a particular technique until he/she eventually achieves mastery. Both confidence and mastery require a certain minimum number of procedures that is proportional to the complexity of the technique. Once the skills are acquired, their periodic use allows for perfection of the technique.

Although the exact minimum number of cases needed to master the skills of IA creation with HS suturing has not been well defined, it has been documented in recent years that the cumulative operative experience of residents is decreasing during general surgery residency.[12] The prevalence of open cavitary procedures continues to decline even more so than the overall downward trend in total number of major operations during general surgery training.[12-15] These trends could point toward a newer training environment that offers fewer opportunities for GSRs to learn and practice the surgical skills and techniques required to properly perform HS intestinal anastomosis operations.[12,15-17]

These observations prompted us to study the characteristics and trends of general surgery resident training, practice, and experience regarding anastomosis operation. For this purpose, we analyzed and compared the operative experience of GSRs in creating IAs by either HS sutures or using SDs through the 5 years of their training.

METHODS

Morristown Medical Center is a tertiary teaching hospital with a free-standing general surgery residency program, approved by the Accreditation Council for Graduate Medical Education (ACGME) to graduate 5 surgical residents per year.[18] The Department of Surgery includes a Level 1 Trauma Center, accredited by the American College of Surgeons. The department performs approximately 10,000 operations per year out of a total volume of 20,000 procedures performed in the 27 main operating rooms of the Medical Center. Since 2003, the Department of Surgery has maintained a database that includes all IA operations performed by its members with a specific focus on colorectal procedures. This database includes all preoperative, intraoperative, and postoperative data collected by the American College of Surgeons National Surgical Quality Improvement Program. Furthermore, several additional surgical parameters are documented in every IA operation according to our Institutional Review Board–approved study protocol. Resident involvement in the surgery and other related information was also collected in every case.

For the purposes of this study, a 5.5-year timeframe was used between July 2006 and 2011 from our database, which consisted of 1659 IAs with resident involvement. GSRs from each year were grouped by postgraduate year (PGY) level. First, the total numbers of IA operations were compared for each PGY of the 5-year residency program. In addition, we compared data on IAs completed with HS suturing or SD where residents were involved in each PGY level. Furthermore, we analyzed the surgical procedures in terms of the location of the IA operation and made comparisons between the 2 techniques of IA creation, such as HS vs SD. We made several additional observations regarding the attending physician involved in IA cases including the specialization, age, and methodological preferences of the surgeon. The IA technique, either HS or performed with a SD, was recorded. If the surgeon used a SD and then sewed over the staple line, it was considered a stapled IA. In addition, all IA operations were classified as either open, which included cases that were converted from laparoscopic to open, or laparoscopic that included cases in which a hand port was used.

For statistical analysis of the data we used GraphPad Prism and Micrsoft Excel. Statistical significance was accepted at the $p < 0.05$ level using student t test, Wilcoxon, one-way analysis of variance, or Fisher's exact test.

RESULTS

Comparison of the Numbers of IA Operations With GSR Involvement in Each Year of the 5 Years of General Surgery Training

GSRs experienced a total of 1659 IA operations from July 2006 to December 2011. These cases included small bowel resections (SBR), right side colectomies (RC), left side colectomies (LC), ostomy reversals (OSR), and ileal pouch-anal anastomosis combined with total colectomies and proctocolectomies (IPTPC). Of all, 1659 IAs

TABLE. Summary of Open and Laparoscopic IA Operations Divided Into Hand-Sewn and Stapled Groups

IA Operations	Total (1659)	Hand-sewn (232)	Stapled (1427)
Open	948	167	781
Laparoscopic	711	65	646

performed in the study period, 711 (42.9% of total) were done laparoscopically, and 948 (57.1% of all IAs) were done as open operations (Table). In the distribution of IAs, the most common procedures were LC, followed by RC and SBR (Fig. 1). We calculated the average numbers of these operations done by each resident in every PGY of residency training. The number of all anastomoses created by each resident during the 5-year training was 67.2 on average, including the average 27.9 IA cases in PGY5 year alone. Out of the 3 most often performed of those procedures for PGY5, the average number of IAs done by each resident was 12.5 for LC, as well as 6.4 for RC, and 4.0 for SBR (Fig. 1). In addition, the overall numbers of these operations were significantly higher in the past 2 years of the training program when compared to those in the first 2 years (Fig. 1).

The Percentage Distributions of IA Operations Show Significantly Higher Involvement of Residents in the Second Half of Residency, Especially in PGY5

Next, we analyzed the overall percentage distribution of all IA operations throughout the 5 years of residency training, assigning 100% to the total number of 1659 of all such procedures with resident involvement. Most of these operations were done in the past 2 years of the training; 45.1% of all IAs in PGY5 and 37.3% in PGY4 (Fig. 2). The percentage distributions of IAs were significantly higher in PGY5, PGY4, and even in PGY3 when compared to PGY1 (Fig. 2). These findings indicate a significantly higher activity and involvement of residents in the operating room acquiring real-life surgical experience during the second half of the general surgery residency training.

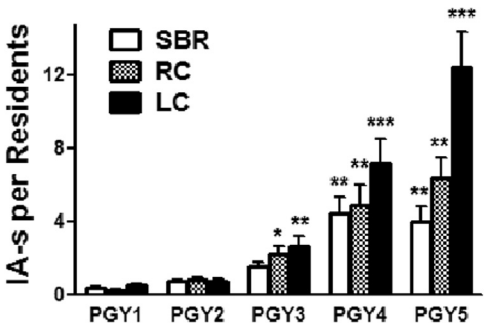

FIGURE 1. Comparison of the numbers of the 3 most often performed types of IA procedures with GSR involvement in each year of the 5 years of general surgery training. The average numbers of small bowel resections (SBR), right side colectomies (RC), and left side colectomies (LC) created by residents are shown for each year of the training. The numbers of these operations were significantly higher in PGY4 and PGY5 years of the training program when compared to those done in the first 2 years. *p < 0.05, **p < 0.01, and ***p < 0.001 vs PGY1 and PGY2. All data are represented as mean ± SEM. SEM, standard error of the mean.

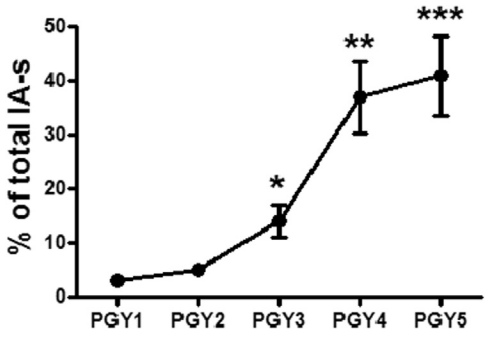

FIGURE 2. The percentage distributions of IA operations show significantly higher involvement of residents in the second half of residency, especially in PGY5. The percentage numbers of all IA operations are show for each PGY year of training. The percentage distribution was significantly higher in PGY3, PGY4, and PGY5 when compared to the first 2 years of training. *p < 0.05, **p < 0.01, and ***p < 0.001 vs PGY1 and PGY2. All data are represented as mean ± SEM. SEM, standard error of the mean.

Residents Practice and Experience Significantly More IA Operations Created by SD Than HS Sutures Throughout the Entire Residency Program

Next, we analyzed the surgical techniques used in the creation of the 1659 IA operations documented in this study. We compared the numbers of IA operations created

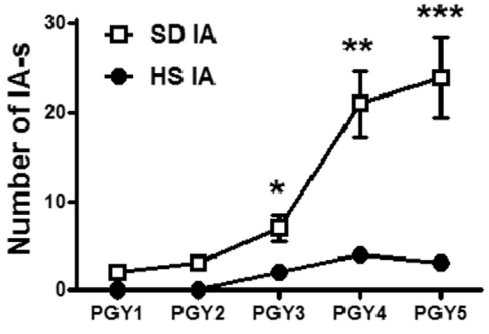

FIGURE 3. Residents practice and experience significantly more IA operations created by SDs than HS suturing throughout the entire residency program. The average number of HS IAs and SD IAs created by each resident is shown in each year of the 5-year training program. The number of IA operations with SDs significantly increased in the past 3 years of training when compared to the first 2 years while the distribution of HS IA operations did not change significantly over the years and remained relatively low throughout the entire residency program. *p < 0.05, **p < 0.01, and ***p < 0.001 vs PGY1 and PGY2. All data are represented as mean ± SEM. SEM, standard error of the mean.

by residents using SDs or HS sutures in each year of the 5 years of the general surgery training program. Residents were found to use SDs significantly more frequently than HS sutures in PGY3, PGY4, and PGY5 years of their training (Fig. 3). The differences in the application of these 2 major techniques of IA creation were the greatest in PGY5. Accordingly, the trend was the most evident on the graph by PGY5, the last year of the training program (Fig. 3).

IA Operations on the Left Colon Have the Highest Percentage Rate of SD Use

Next, we aimed to analyze the types of IA operations in relation to the use of SDs vs the HS technique. In this respect we analyzed 615 LC, 462 RC, 288 SBR, 251 OSR, and 43 IPTPC anastomosis operations. As Figure 4A shows, OSR had the highest percentage of HS suturing (30.7% of all IAs), followed by RC (27.5%), IPTPC (23.3%), and SBR (17.0%). Interestingly, HS suturing was used in the lowest proportion in the creation of anastomoses in LC cases (5.5%) cases (Fig. 4A). It is clear that in LC operations surgeons overwhelmingly prefer using staplers. However, in other surgical locations, probably because of the more challenging anatomical situations or pathophysiological conditions, surgeons tend to use the HS suturing method in about 20% to 30% of the cases (Fig. 4A).

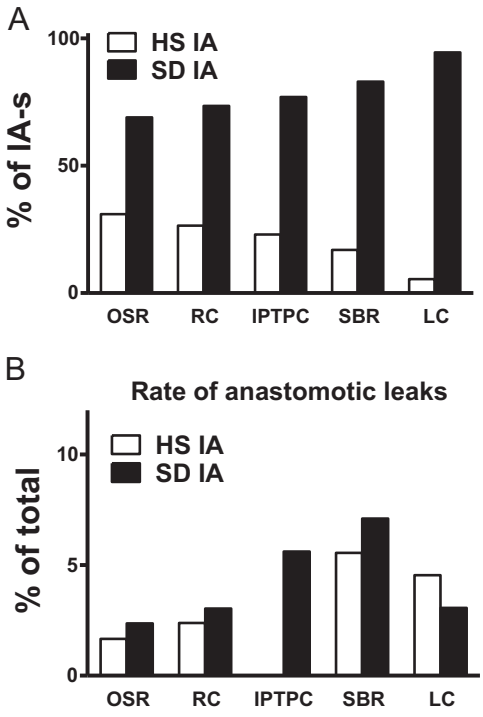

FIGURE 4. (A) IA operations on the left side of the colon have the highest percentage rate of SD use. Different types of IA operations have various rates of SD use when compared to HS suturing. The percentage distributions of HS IAs and SD IAs are shown in 5 different types of anastomoses. OSR operations show the highest percentage of HS suturing (30.7% of all IAs), followed by RC (27.5%), IPTPC (23.3%), and SBR (17.0%). Interestingly, HS suturing was used least in the creation of anastomoses in LC cases (5.5%) corresponding with an overwhelming use of SDs in 94.5% of IA operations on the left side of colon. (B) Stapled and hand sutured anastomoses have similar outcomes measured by the rates of anastomotic leaks. The percentages of anastomotic leaks of HS IAs and SD IAs are show in the figure. When the actual numbers of clinical anastomotic leaks were compared between HS and SD anastomoses in any of these types of IA operations we did not find significant differences. Using Fisher's exact test, the $p > 0.05$ for each type of anastomosis.

Regardless of the Location of the Operation, Stapled and Sutured Anastomoses Have Similar Outcomes Measured by the Rate of Anastomotic Leaks

We also analyzed if there were differences in outcomes of anastomoses created by either SDs or HS technique in any type of IA operation represented in Figure 4A, including OSR, RC, IPTPC, SBR, and LC anastomoses. There is no significant difference in terms of anastomotic leak rates between SD and HS anastomoses in any of these types of operations (Fig. 4B). These findings corroborate previous publications documenting similar outcomes for stapled and sutured anastomoses.[4,19,20]

The Comparison of Average Percentage Distribution of HS Suturing Among Surgeons of Different Ages

HS sutured anastomoses represent the older technique while the use of SDs is a newer method. We analyzed whether the newer technique is more often used by younger surgeons in the early stage of their career. We plotted the frequency of HS use as the percentage of all IAs in relation to the age of the surgeons in our study. Each dot represents 1 of the 10 most active general or colorectal surgeons in the study with at least 25 individually performed IAs out of the 1659 operations analyzed in this cohort (Fig. 5). The graph shows that older surgeons tended to use and teach residents the HS suturing more often when creating an anastomosis than their younger colleagues (Fig. 5).

DISCUSSION

We found that SDs are used much more frequently by residents throughout the 5 years of the training program than the HS technique. Interestingly, this dominance of SD use applies to all types and locations of IAs. On average, this leaves GSRs with an experience of only 9.4 sutured IAs per resident in the 5-year period of training compared to the average number of 57.8 stapled IAs. This corresponds with recent observations describing the shrinking number of attending surgeons preferring HS IAs.[20-23] This is especially

FIGURE 5. The comparison of average percentage distribution of the use of HS suturing among surgeons of different ages. This figure shows that older surgeons tend to use HS suturing more often than their younger colleagues. Each dot represents 1 surgeon in this study, showing the distribution of HS IAs as the percentage of all IAs performed by the given surgeon.

true in laparoscopic and emergency operations, during which SD is the technique of choice for most IAs.[10,24]

ACGME requires a minimum of 72 surgical operations of the alimentary tract performed by each resident during the general surgery residency program. This category includes all esophagus, stomach, small bowel, large bowel, and anorectal procedures. In this study, we wanted to specifically focus on IAs from the perspective of colorectal surgery. As we were able to include 1659 operations, we felt that this would be a sufficient sample for meaningful statistical analyses within this area of focus; therefore upper GI operations were not included in this study. According to the ACGME Report for Residents Graduating in years 2012 to 2013, the average number of cases in the alimentary tract category for the total GSR experience nationwide is 248. Of these, only 18 were enterectomies (17 open and 1 laparoscopic) and 57 were colectomies (37 open and 20 laparoscopic). This gives GSRs nationwide an opportunity to create approximately 75 IAs during their entire training.

In the current study, when experience in pediatric surgery is added to the 67.2 average number of cases, the GSRs' experience at Morristown Medical Center is very much in line with the experience of GSRs in the USA. One difference between the national averages and our data in IA creation is the ratio of open:laparoscopic operations, which is 85:15 nationally and 57.1:42.9 for Morristown Medical Center (Table). In general surgery training, the trend toward more laparoscopic operations nationwide and an even higher number of cases in community hospitals has been well documented.[17,25]

There are technical challenges resulting from surgeons performing IAs only with SDs in almost all patients. There are clinical scenarios where the bowel wall is edematous or unevenly inflamed where a SD cannot reliably ensure proper sealing of an anastomosis. The use of SDs also forces surgeons to create side-to-side anastomoses in SBRs.[26-29] These "functional" end-to-end anastomoses in the small bowel are associated with small bowel bacterial overgrowth. This is well tolerated in most patients but can lead to blind loop syndrome in others.[30]

There is no doubt, however, that the use of SDs has enabled surgeons to reconstruct the intestine in situations where there is no better alternative.[26,27] Such situations include coloproctostomies post-sigmoidectomy or low anterior resection, ileoanal anastomoses, anal sphincter preservation, laparoscopic enteroenterostomies, and ileocolostomies or colocolostomies when done intracorporeally. It is also well understood that if IAs are to be created in a multitrauma patient, SDs allow for expediency.[28,29] However, there is no advantage of using SDs for enteroenterostomies or colocolostomies in open surgery or in laparoscopic operations if the IA is done extracorporeally.[28] In fact, there is some scientific evidence that anastomoses formed by end-to-end anastomosis staplers can be potentially detrimental, leading to rectal tears and anastomotic defects.[31]

In the trauma and emergency general surgery patient population, higher leak rates of stapled anastomoses have been reported when compared to HS anastomoses.[29,32,33] However, most of literature documents similar outcomes for both the techniques of anastomosis creation and the benefits, safety, and efficacy of SDs for IAs have been overwhelmingly shown in multiple studies.[4,7-9,15,26,28,34]

The ability to properly create IAs with SDs is an essential surgical skill. It requires knowledge of the various techniques and the types of SDs available. There are important technical elements to be learned when creating stapled anastomoses, which lead to important judgmental decisions. Creating HS IAs requires similar judgmental decisions, and most importantly, requires additional hand skills that are crucial to the outcome of the operation. These include the handling of the bowel edges with forceps, the placement of sutures at proper distances and angles, the handling of the suture material, and the cinching and tying of the sutures.

Although our experience in this study has suggested that training in HS anastomoses is becoming rarer, we believe that it is still important to be well-versed in hand suturing as well as stapling. Therefore we suggest these specific steps to be taken as potential solutions to the problem: (1) All IA cases believed beforehand to include a HS anastomosis should have resident involvement so as not to miss out on this rarer experience. (2) Bioskills training programs involving accurate models of HS anastomosis formation, either using pig gut or commercially available artificial lifelike single layer bowel tissue specimens, can provide invaluable additional suturing experience. (3) A concerted effort by attending surgeons employing the HS technique in favorable situations such as the reversal of loop ileostomies and colostomies would allow surgeons and residents to practice and maintain the skills of sewing IAs.

A tool has been developed and validated for the assessment of competence in creating simulated IAs in the laboratory called the objective structured assessment of

technical skills method.[35] It has been shown that including the creation of HS IAs in the simulation curriculum is effective in acquiring the necessary skills and in gaining confidence with the relevant techniques.[36,37] However, in addition to simulation, GSRs should be exposed to both elective and emergency surgery cases for learning and practicing in live clinical scenarios as much as possible.

In summary, the current practice in creation of IAs is heavily weighted toward the use of SDs. Overall, SDs are effective and safe, as several studies documented no significant difference in morbidity and mortality between stapled and HS IAs. However, there are select cases when HS suturing can have an advantage over SD use in anastomosis creation. Therefore, we believe that GSRs should continue learning, perfecting, and using both techniques.

AUTHOR CONTRIBUTIONS

Study conception and design: Rolandelli, Lazar, Nemeth.

Acquisition of data: Paglinco, Nemeth, Hicks, Barratt-Stopper.

Analysis and interpretation of data: Nemeth, Paglinco, Lei, Rolandelli, Hicks.

Drafting of manuscript: Nemeth, Rolandelli.

Critical revision: Rolandelli, Lazar, Lei.

ACKNOWLEDGMENTS

This research study was funded by the Department of Surgery, Morristown Medical Center, Morristown, NJ.

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