ORIGINAL ARTICLE

Impact of Mesh Use on Morbidity Following Ventral Hernia Repair With a Simultaneous Bowel Resection

Dimitrios Xourafas, MD; Stuart R. Lipsitz, ScD; Paolo Negro, MD; Stanley W. Ashley, MD; Ali Tavakkolizadeh, MD

Objective: To evaluate the impact of mesh use on outcomes following ventral hernia repairs and simultaneous bowel resection.

Design: Retrospective review.

Setting: Teaching academic hospital.

Patients: We studied 177 patients who underwent a ventral hernia repair with a bowel resection between May 1, 1992, and May 30, 2007. A prosthesis was used in 51 repairs (mesh group), while 126 repairs were primary (mesh-free group).

Main Outcome Measures: Demographic characteristics, comorbidities, mesh type, bowel resection type (colon vs small bowel), defect size, drain use, and length of hospital stay were compared between groups with Fisher exact test and multivariate analysis.

Results: There were no statistically significant differences between patient characteristics and relevant comorbidities. The incidence of postoperative infection (superficial or deep) was 22% in the mesh group vs 5% in the mesh-free group ($P=.001$). Other complications (fistula, seroma, hematoma, bowel obstruction) occurred in 24% of patients in the mesh group vs 8% of patients in the mesh-free group ($P=.009$). Focusing on the patients who developed an infection, prosthetic mesh use was the only significant risk factor on multivariate regression analysis, irrespective of drain use, defect size, and type of bowel resection.

Conclusions: We recommend caution in using mesh when performing a ventral hernia repair with a simultaneous bowel resection because of significantly increased postoperative infectious complications. Drain use, defect size, and bowel resection type did not influence outcomes.

Arch Surg. 2010;145(8):739-744

Author Affiliations:
Department of Surgery, Brigham and Women's Hospital and Harvard Medical School, Boston, Massachusetts (Drs Xourafas, Lipsitz, Ashley, and Tavakkolizadeh); and Department of Surgery, Policlinico Umberto I, Rome, Italy (Drs Xourafas and Negro).

VENTRAL HERNIA REPAIR IS one of the most common surgical procedures, with 4% to 11% of patients who undergo major abdominal surgery eventually developing a ventral hernia.[1-3] More than 100 000 repairs are carried out annually in the United States.[4] Since the introduction of prosthetic meshes in the early 1960s, the surgical approach to hernia repairs has evolved from primary suture to tension-free repairs, with a corresponding significant improvement in outcomes.[5]

Successful repair of large and complex ventral hernias remains a formidable surgical challenge, sometimes requiring a simultaneous bowel resection. In these circumstances, the use of a prosthetic mesh is generally avoided owing to a presumed increase in infectious complications. Few clinical studies, however, have quantified this risk. Clearly, lack of mesh use puts these patients at higher risk for developing a recurrence.[3,6-11] Recent use of biological meshes in these cases has been associated with significant cost and suboptimal results with postoperative laxities and bulges, which have required further intervention.[12,13] Quantification of prosthetic mesh–related complications in such patients is therefore important to help develop a suitable treatment algorithm for these complex cases.

The primary goals of this study were to evaluate the outcomes of ventral hernia repairs using a mesh following a simultaneous bowel resection and to compare these with the outcomes of primary suture repairs. Furthermore, we set out to identify risk factors associated with development of postoperative complications in these cases.

METHODS

After Brigham and Women's Hospital Institutional Research Committee approval, an electronic research patient database was searched using relevant *International Classification of Diseases, Ninth Revision* and Current Procedural Terminology codes to identify an initial group of 188 patients. After reviewing the operative reports of these patients, we selected 177 adult pa-

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Table 1. Patient Characteristics and Perioperative Data

Characteristic	Mesh + Bowel Resection (n=51)	Mesh-Free + Bowel Resection (n=126)	*P* Value
Age, mean (range), y	59 (17-93)	61 (30-89)	.36
Male/female, No.	26/25	53/73	.32
BMI >30, %	57	53	.74
Diabetes, %	25	23	.70
Tobacco use, %	20	18	.83
Defect size, cm, %			<.001
1-3	6	61	
>3	94	39	
Operation, %			>.99
Elective	92	93	
Emergency	8	7	
Preoperative antibiotic use, %	100	100	>.99
Type of bowel resected, %			<.001
Small bowel	76	42	
Colon	24	58	
Gangrenous bowel, %	4	6	>.99
Drain, %	71	30	<.001
Discharged with a drain, %	25	5	.05
Length of hospital stay, mean (range), d	13 (2-71)	11 (1-72)	.49

Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).

tients who met our inclusion criteria of having a ventral hernia repair with a simultaneous bowel resection during the same surgery at our institution between May 1, 1992, and May 30, 2007. Eleven patients with an inguinal or femoral hernia at the time of their bowel resection were excluded. Patients were divided into 2 groups: those who underwent a ventral hernia repair with a simultaneous bowel resection using a mesh (mesh group), and those with suture repair of the ventral hernia after the bowel resection (mesh-free group). The following preoperative and intraoperative parameters were recorded by reviewing individual discharge summaries, imaging studies, and operative reports: age, sex, body mass index (BMI; calculated as weight in kilograms divided by height in meters squared), relevant comorbidities such as diabetes and tobacco use, history of previous hernia repair, antibiotic prophylaxis, type of surgery (elective vs emergency), and the indication for the simultaneous bowel resection. Hernia defect size, type of prosthetic mesh implanted, type of bowel resection performed (colon vs small bowel), nature of resected bowel (gangrenous vs viable), use of a drain, and patients discharged with a drain were also recorded for all cases. Postoperative parameters including length of hospitalization, infectious and noninfectious complications, and recurrence rates were compared between the groups.

The hernia defect sizes were assessed based on operative reports and grouped into small (≤3 cm) or large (>3 cm) hernia defects. This division by defect size was based on previous studies recommending use of mesh in all hernias with a defect of 3 cm or larger.[14] Patients with multiple defects (Swiss cheese) were classified as having small hernia defects (≤3 cm) based on the measure of the largest singular defect and not on its multiplicity.

Postoperative infections were divided into superficial (wound and subcutaneous tissue) or deep when a subfascial abscess was noted. Noninfectious complications including seroma, hematoma, enterocutaneous fistula, and postoperative bowel obstruction or ileus were recorded.

Follow-up visits were also reviewed for patients when possible to look for evidence of hernia recurrence. Recurrence was defined as a defect in the abdominal wall appearing at or close to the site of the previous hernia. Clinical examinations, radiological imaging, and subsequent reoperations were evaluated to assess for recurrences.

Table 2. Indications for the Simultaneous Bowel Resection

Indication	Patients, %		*P* Value
	Mesh	Mesh-Free	
Bowel obstruction	51	29	.009
Cancer	12	34	.002
Cancer + bowel obstruction	2	5	.67
Other	35	32	.72

Categorical patient characteristics (such as sex) were compared between surgical arms (mesh vs mesh-free groups) or infection status (yes vs no) with Fisher exact test.[15] Continuous patient characteristics (such as BMI) were compared between groups with the Wilcoxon rank sum test.[16] Survival curves were estimated by the Kaplan-Meier method,[17] with differences assessed by the log-rank test.[18] To accommodate for the small numbers of events (infections), exact multivariate logistic regression[19] was used to compare the surgery groups, with adjustment for possible confounders.

RESULTS

We identified 51 patients in the mesh group and 126 patients in the mesh-free group. Patient demographic characteristics and comorbidities are summarized in **Table 1**. There were no statistically significant differences with respect to age, sex, BMI, diabetes, and tobacco use between the groups. There were no in-hospital mortalities in either group. Twenty-four patients in the mesh group vs 19 in the mesh-free group had previous ventral hernia repairs.

All procedures were performed open and under general anesthesia. The majority of cases (86%) were performed by 23 surgeons during the 15-year study period. More than 90% of the repairs were performed electively. Four patients in the mesh group and 9 in the mesh-free group required an emergency procedure for bowel perforation or strangulation. All 177 patients received prophylactic intravenous antibiotics prior to their surgery. A first- or third-generation cephalosporin was most commonly used.

We observed statistical disparities between patients in the mesh group and those in the mesh-free group in terms of hernia defect size ($P<.001$), bowel resection type ($P<.001$), and drain use ($P<.001$). Most patients in the mesh group had larger defects than those in the mesh-free group and underwent a small-bowel resection rather than a large-bowel resection. Drains were also placed more frequently in the mesh group. No differences were observed in terms of length of hospital stay, with mean hospitalizations of 13 days (range, 2-71 days) for the mesh group and 11 days (range, 1-72 days) for the mesh-free group (Table 1).

The indications for bowel resection (bowel obstruction vs malignant neoplasm) differed significantly between the 2 groups (**Table 2**). More patients in the mesh group had undergone intestinal resection secondary to bowel obstruction, while in the mesh-free group, the most

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Table 3. Type of Mesh Material Used and Incidence of Infections for Each Type

Prosthesis	Type of Mesh Used, % of Overall Mesh Use	Infection Incidence, % Within Each Mesh Type Group
Polypropylene	74	24
Biological	10	0
Absorbable	8	25
Polytetrafluoroethylene	2	0
Polyester	2	0
Xerophyllum	2	0
Not specified	2	100

common indication for bowel surgery was an underlying malignant neoplasm.

The choice of mesh type was surgeon driven and varied over time. Although different surgeons performed the operations during the 15-year period of this study, the technique consisted mainly of an underlay placement of the mesh. The majority (74%) of meshes used were heavyweight polypropylene (20 cases with Prolene [Ethicon, Inc, Somerville, New Jersey], 17 with Sepramesh [Genzyme Corp, Cambridge, Massachusetts], and 1 with Marlex [Chevron Phillips Chemical Co LLC, The Woodlands, Texas]). In 5 complicated cases associated with strangulated bowel, rectovaginal fistula, abdominal wall dehiscence, and removal of infected Gore-Tex mesh (Gore Medical, Flagstaff, Arizona), a biological prosthesis was used (4 cases with Alloderm [LifeCell Corp, Branchburg, New Jersey], 1 with Surgisis [Cook Biotech, West Lafayette, Indiana]). **Table 3** summarizes the distribution of prosthetic materials in the mesh group and the percentage within each group that became infected. More than 20% of the patients who had a polypropylene mesh developed a postoperative infection.

The incidence of postoperative infection was 22% in the mesh group vs 5% in the mesh-free group ($P=.001$) (**Table 4**). Of 11 patients with infections in the mesh group, 4 (36%) had a superficial infection and 7 (64%) had a deep infection. Of the 6 patients with infections in the mesh-free group, 5 (83%) had a superficial infection and 1 (17%) had a deep infection. *Enterococcus* and *Staphylococcus aureus* were responsible for most of both superficial and deep infections.

Other significant complications such as seroma, hematoma, enterocutaneous fistula, and postoperative bowel obstruction occurred in 12 patients (24%) in the mesh group vs 10 (8%) in the mesh-free group ($P=.009$). These postoperative infections and complications obligated 14 patients (27%) in the mesh group and 12 patients (10%) in the mesh-free group to undergo a reoperation ($P=.004$) (Table 4). Seven of 9 patients in the mesh group had mesh removal after deep infections. Two patients in the mesh group required a débridement of their superficial wound infection and takedown of an enterocutaneous fistula. Most patients in the mesh-free group underwent a débridement for superficial infection and takedown of a fistula.

We were able to review 148 of the 177 records for follow-up, ranging from 1 month to 10 years (mean, 22 months; median, 7 months) of follow-up. Eleven patients (22%) in the mesh group and 30 (24%) in the mesh-free group developed a recurrence ($P=.85$).

In both groups, the majority of infections (82% in the mesh group, 100% in the mesh-free group) and postoperative complications (67% in the mesh group, 70% in the mesh-free group) presented in the first year after surgery. In contrast, recurrences occurred more commonly after the first year of surgery. In particular, 5 patients (45%) in the mesh group and 22 patients (73%) in the mesh-free group presented with a recurrent ventral hernia after the first year of surgery. **Table 5** illustrates the relationship between the postoperative period and adverse outcomes (infection, other complications, and recurrence). The Kaplan-Meier analysis in the **Figure** provides a visual summary of these data.

In our series, 134 patients presented with a primary ventral hernia, while 43 had had 1 or more previous her-

Table 4. Postoperative Infection, Other Complications, and Long-term Outcomes

Outcome	Mesh + Bowel Resection (n=51)	Mesh-Free + Bowel Resection (n=126)	*P* Value
Infection, %	22	5	.001
Superficial	36	83	
Deep	64	17	
Bacteria, %			.99
Enterococcus	45	50	
Staphylococcus aureus	45	33	
Staphylococcus epidermidis	10	0	
Klebsiella	0	17	
Other complications, %	24	8	.009
Fistula	58	70	
Seroma	17	10	
Hematoma	0	10	
Bowel obstruction	25	10	
Reoperation, %	27	10	.004
Mesh removal	64	NA	
Débridement	14	92	
Bowel obstruction	22	8	
Follow-up, mean (median), mo	21 (7)	23 (7)	.79
Recurrence, %	22	24	.85

Abbreviation: NA, not applicable.

Table 5. Time Between Operation and Outcomes

Outcome	Patients With Outcome, %	
	Mesh + Bowel Resection (n=51)	Mesh-Free + Bowel Resection (n=126)
Infection		
<12 mo	82	100
>12 mo	18	0
Other complications		
<12 mo	67	70
>12 mo	42	30
Recurrence		
<12 mo	55	27
>12 mo	45	73

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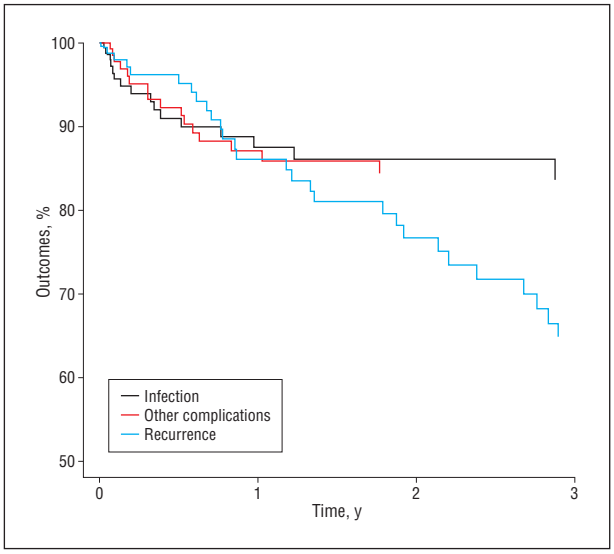

Figure. Kaplan-Meier curves of all outcomes (infection, other complications, and recurrence) over time. Infection and other complications occur most commonly in the first postoperative year in both the mesh and mesh-free groups. In contrast, recurrences occur throughout the postoperative period.

Table 6. Previous Ventral Hernia Repairs and Recurrence

Hernia	Recurrence After Surgery, %	*P* Value
Primary (n=134)	19	.02
Previous repairs (n=43)	37	

nia repairs before the index case. The patients with previous hernia repairs had a significantly higher recurrence rate compared with those who had a primary hernia repair ($P=.02$) (**Table 6**).

Because there were differences in hernia size, type of bowel resection, and drain use in the mesh and mesh-free groups, we performed univariate and multivariate subgroup analyses to identify significant factors for infection. We compared 17 patients with infection vs 160 patients without infection. There were no statistically significant differences between patient characteristics and relevant comorbidities (**Table 7**). Although patients with infection had a significantly higher BMI than patients without infection on univariate and multivariate analysis (mean BMI, 36.1 vs 30.1, respectively; $P=.02$), there were no differences in the percentage of obese patients (BMI >30). The use of prosthetic mesh was the only significant factor associated with increased postoperative infections on univariate ($P=.001$) and multivariate ($P=.02$) analyses. Cause and type of bowel resection, hernia defect size, use of a drain, being discharged with a drain, and presence of intestinal necrosis at the time of surgery did not influence infection rates. Related data are summarized in Table 7.

Moreover, infection was an important predictive factor for other major complications ($P<.001$) and subsequent reoperation ($P<.001$). Fifty-nine percent of patients with infection developed a postoperative complication, and 88% of them required a reoperation. Interestingly, a significantly higher rate of patients with infection had undergone previous hernia repairs compared with those without infection (59% vs 21%, respectively; $P=.001$).

Table 7. Detection of Risk Factors for Postoperative Infection

Risk Factor	Infection (n=17)	Infection-Free (n=160)	*P* Value
Age, mean (range), y	58 (40-89)	61 (17-93)	.19
Male/female, No.	8/9	71/89	>.99
BMI >30, %	76	51	.07
Diabetes, %	18	22	.77
Tobacco use, %	6	19	.32
Operation, %			.36
Elective	88	93	
Emergency	12	7	
Preoperative antibiotic use, %	100	100	>.99
Type of bowel resected, %			.31
Small bowel	65	51	
Colon	35	49	
Gangrenous bowel, %	12	4	.21
Reason for bowel resection, %			.23
Bowel obstruction	35	36	
Cancer	12	29	
Bowel obstruction + cancer	0	4	
Other	53	31	
Defect sizes, cm, %			.07
1-3	24	48	
>3	76	52	
Prosthesis, %	65	25	.001/.02[a]
Drain use, %	59	40	.20
Length of hospital stay, mean (range), d	15 (2-44)	11 (1-72)	.58
Discharged with a drain, %	20	14	.29
Other major complications, %	59	18	<.001
Fistula	60	58	
Bowel obstruction	30	17	
Seroma	10	8	
Hematoma	0	8	
Reoperations, %	88	6	<.001

Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).
[a]The *P* value by univariate analysis is .001; the *P* value by multivariate analysis is .02.

COMMENT

The use of prosthetic mesh constitutes the gold standard for repair of complex ventral hernias, with a significant reduction in the recurrence rates compared with primary suture repair.[3,20-25] To help quantify the risk of infection associated with mesh use in cases of ventral hernia repair with a simultaneous bowel resection, we carried out this study, which has clearly shown a higher incidence of infectious and noninfectious complications with mesh use without any advantageous outcomes on the recurrence rates. These complications increase the need for reoperation, which in turn increases the risk of a hernia recurrence and which we believe explains the similar recurrence rate observed in our mesh and mesh-free groups.

Previous publications and established surgical principles have generally advised against the use of mesh or other foreign bodies after a bowel resection. However, several recent publications, all based on small series of patients, had questioned this dogma and proposed the

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use of a prosthetic material in these settings to achieve a lower hernia recurrence rate. Birolini et al[26] performed prosthetic repair of incisional hernias following colonic surgery in 20 patients, reporting a mesh-related morbidity of 15.8% in the first year and 23.1% within the first 2 years. Machairas et al[27] concluded that prosthetic repair of incisional hernias can be safely performed following colonic operations, despite 10% of meshes having to be removed secondary to infections and a recurrence rate of 16%. None of these studies, however, compared the outcome of their mesh group with the outcome of a mesh-free group. Our study of 177 patients, representing the largest published series to our knowledge, allows comparison of outcomes between similar patient groups who underwent mesh or primary repairs. The data further support the conservative approach of avoiding mesh use in a contaminated or clean-contaminated field. To further define potential risk factors that may influence the adverse outcome of meshes in these circumstances, we looked at several specific factors.

We had anticipated that the type of bowel resection (colonic vs small bowel) would have an effect on postoperative outcomes owing to the differences in luminal bacterial load between the 2 regions as well as the differences in anastomotic leak rates. However, on univariate and multivariate analyses, the type of bowel resection is not an independent risk factor for postoperative infection.

Another contentious topic is the role of the surgical drains. Suction drains are frequently used after ventral hernia repairs to close the dead space in the subcutaneous tissue. More than 50% of surgeons performing open ventral mesh repairs use such drains routinely in an attempt to reduce the infectious risk of these procedures.[28] However, a recent Cochrane meta-analysis concluded that there was insufficient evidence to determine whether drain placement after incisional hernia repair is associated with better outcomes.[28] Our study provides further support that the use of drains, even in complex repairs that require bowel resection, offers no benefit to the patient.

We observed that more than 90% of complications, excluding recurrences, presented within the first postoperative year. This time line should be borne in mind when developing a follow-up schedule for these patients. The time line for development of these complications was similar between the mesh and mesh-free groups (Figure). On the contrary, recurrence rates continued to increase after the first year of surgery. In this study, we had no statistically significant differences in the recurrence rates between the 2 groups. This may seem paradoxical because mesh use is thought to be associated with reduced recurrence. However, infectious complications are a known risk factor for recurrence,[3,29] and we believe the higher rate of infectious complications as well as the need for further surgical intervention in the mesh group have counterbalanced the benefit of the mesh.

Our study confirms previous reports that recurrent hernia repairs are associated with higher recurrence rates.[30] We found that the recurrence rate is higher in those who have undergone a previous hernia repair compared with those who have undergone primary repair (37% vs 19%, respectively; $P = .02$). Interestingly, we also observed that patients who had undergone previous ventral hernia repairs had a significantly higher incidence of postoperative infection. This result suggests that a previous hernia repair is a factor not only for recurrence but also for postoperative infection.

Most of the meshes used in this series were heavyweight polypropylene, which is likely a reflection of the surgical practice during the study period. Twenty-four percent of these meshes became infected. Five patients had undergone a ventral hernia repair using a biological prosthesis, and none developed a postoperative infection. Although our numbers and the heterogeneity of the groups do not allow for any firm conclusions, we agree that the new biological meshes may constitute an innovative alternative for the treatment of complex ventral hernias, especially in a surgical field at risk for infection.[31-33] There is an increasing diversity of such materials on the market, and although there are clear indications for their use in hernia surgery, some caution is advised. Other than the high cost, studies have indicated that biological prostheses may lead to a higher hernia recurrence rate or to laxity of the abdominal wall associated with bulges that may require further intervention.[34] To help define the role of biological prostheses in hernia surgery, the European Hernia Society has recently initiated a voluntary database for clinicians to register the use of biological prostheses with the intention of evaluating their outcomes following hernia repairs in the setting of contaminated surgical fields.[35] These results may contribute to new protocols for the treatment of complex ventral hernias associated with bowel resection.

To our knowledge, this is the largest study in the literature to analyze ventral hernia repairs with a simultaneous bowel resection, and it provides new insight into factors to be considered when dealing with these challenging cases. The retrospective nature of the data, however, has limited the collection and evaluation of some results. The brief follow-up period with a median of 7 months in addition to the fact that our recurrence rates are based on record review provided a suboptimal method to evaluate hernia recurrence. A prospective study with longer follow-up is needed for more accurate information on this outcome.

In conclusion, this study demonstrates that the use of prosthetic meshes significantly increases the risk of infectious and noninfectious complications in patients undergoing ventral hernia repair and a simultaneous bowel resection. Other surgical factors such as the use of a surgical drain, hernia defect size, type of bowel resection, being discharged with a drain, or an ischemic or gangrenous nature of the resected bowel have no impact on developing postoperative complications. Use of prosthetic mesh and infection were both predictors of other complications that significantly increase the risk of subsequent reoperation and mesh removal. History of previous ventral hernia repairs also constituted an important risk factor for postoperative infection and recurrence. We recommend caution in using mesh when performing a ventral hernia repair with a simultaneous bowel resection because of the significantly higher risk of complications and reoperations.

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Accepted for Publication: June 17, 2009.
Correspondence: Ali Tavakkolizadeh, MD, Department of Surgery, Brigham and Women's Hospital, 75 Francis St, Boston, MA 02115 (atavakkoli@partners.org).
Author Contributions: Drs Xourafas and Tavakkolizadeh had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Xourafas and Tavakkolizadeh. *Acquisition of data:* Xourafas. *Analysis and interpretation of data:* Xourafas, Lipsitz, Negro, Ashley, and Tavakkolizadeh. *Drafting of the manuscript:* Xourafas, Lipsitz, Negro, and Tavakkolizadeh. *Critical revision of the manuscript for important intellectual content:* Ashley. *Statistical analysis:* Xourafas and Lipsitz. *Study supervision:* Ashley and Tavakkolizadeh.
Financial Disclosure: None reported.
Previous Presentations: This paper was presented at the Third Annual Academic Surgical Congress; February 15, 2008; Huntington Beach, California; and at the Fourth Annual Academic Surgical Congress; February 6, 2009; Fort Myers, Florida.
Additional Contributions: Anne Burgess, MSHI, BSN, assisted with data collection and use of the electronic database.

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