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The impact of preoperative anemia and malnutrition on outcomes in paraesophageal hernia repair

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Abstract

Background Patients with a paraesophageal hernia may experience gastroesophageal reflux symptoms and/or obstructive symptoms such as dysphagia. Some patients with large and complex paraesophageal hernias unintentionally lose a significant amount of weight secondary to difficulty eating. A subset of patients will develop Cameron's erosions in the hernia, which contribute to anemia. Given the heterogeneous nature of patients who ultimately undergo paraesophageal hernia repair, we sought to determine if patients with anemia or malnutrition suffered from increased morbidity or mortality.

Methods The American College of Surgeons National Surgical Quality Improvement Program datasets from 2011 to 2015 were queried to identify patients undergoing paraesophageal hernia repair. Malnutrition was defined as preoperative albumin < 3.5 g/dL. Preoperative anemia was defined as hematocrit less than 36% for females and 39% for males. Thirty-day postoperative outcomes were assessed.

Results A total of 15,105 patients underwent paraesophageal hernia repair in the study interval. Of these patients, 7943 (52.6%) had a recorded preoperative albumin and 13.9% of these patients were malnourished. There were 13,139 (87%) patients with a documented preoperative hematocrit and 23.1% met criteria for anemia. Both anemia and malnutrition were associated with higher rates of complications, readmissions, reoperations, and mortality. This was confirmed on logistic regression. The average postoperative length of stay was longer in the malnourished (6.1 vs. 3.1 days when not malnourished, $p < 0.0001$) and anemic (4.1 vs. 2.8 days without anemia, $p < 0.0001$).

Conclusion Malnutrition and anemia are associated with increased morbidity and mortality in patients undergoing paraesophageal hernia repair, as well as a longer length of stay. This information can be used for risk assessment and perhaps preoperative optimization of these risk factors when clinically appropriate.

Keywords Paraesophageal hernia · Anemia · Malnutrition · Outcomes · Frailty

Hiatal hernias are very common in North America, with an estimated prevalence of 10% to up to 80% of adults [1]. Paraesophageal hernias (PEHs) account for 5% of all hiatal hernias and are increasingly common in advanced age [2, 3]. PEHs enlarge with time, and the annual incidence of acute symptoms requiring urgent or emergent surgery is estimated to be 0.7–7% per year [4]. Symptoms related to the presence of a PEH include dysphagia, postprandial epigastric and/or chest pain, retching and vomiting, early satiety, and unintentional weight loss. Surgery is indicated for symptomatic PEHs and in urgent/emergent circumstances such as incarceration and volvulus leading to obstruction or ischemia [5].

In some patients, most often in elderly and frail patients, a known PEH will become gradually more symptomatic with escalating dysphagia, postprandial pain, or early satiety. These patients will modify their diet, often avoiding solid foods, eating less at each meal, or less often. Unintentional weight loss and ultimately malnutrition can result. Cameron's lesions are found in 29–42% of anemic patients with PEHs. Surgical repair of a PEH has been demonstrated to lead to resolution of these erosions in 88% of patients [6]

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and resolution of anemia in 60–70% [7]. Patients without preoperative Cameron's lesions have still demonstrated a 50% resolution of anemia [8].

The impact of malnutrition and anemia on outcomes following surgical procedures such as joint replacement and inflammatory bowel disease resection has been well described [9, 10]. The relationship between malnutrition and anemia on outcomes following paraesophageal hernia repair has not been studied on a large scale. We sought to determine the impact of anemia or malnutrition on perioperative morbidity and mortality in paraesophageal hernia repair using a national surgical dataset.

Materials and methods

The American College of Surgeons National Surgical Quality Improvement Program (NSQIP) datasets from 2011 to 2015 were queried to identify patients undergoing paraesophageal hernia repair. Inclusion criteria were a primary surgical procedure with a CPT code consistent with PEH repair. All open, laparoscopic, thoracic, and thoracoabdominal procedures were included (Table 1).

Preoperative anemia was defined as a hematocrit less than 36% for females and 39% for males based on the World Health Organization's definition of anemia [11]. Malnutrition was defined as preoperative albumin < 3.5 g/dL, consistent with previous publications using hypoalbuminemia as a marker of malnutrition [12–14]. All preoperative lab values in NSQIP are attained within 90 days of surgery. Patients were excluded from individual analyses of anemia- and malnutrition-related outcomes if they were missing a preoperative hematocrit or albumin lab value. Postoperative outcomes evaluated included surgical site infection (SSI), urinary tract infection (UTI), venous thromboembolism (VTE), myocardial infarction (MI), acute kidney injury (AKI), pneumonia, reoperation, readmission, mortality, and length of stay. All outcomes were limited to 30 days postoperatively.

Categorical variables were analyzed using Chi-square tests. Continuous variables were analyzed using independent samples *t* tests. Binary logistic regression was used to evaluate if preoperative anemia or malnutrition, as well as if the combination of both conditions, was predictive of morbidity and mortality. Patients with both conditions were compared to patients with neither condition. Multivariate logistic regressions were used to control for cases performed emergently as well as for the type of procedure by CPT code. Statistical analysis was performed using SPSS version 24 with a significance level of $p < 0.05$. Our Institutional Review Board determined that this study did not require full IRB approval given the de-identified nature of the data, the fact that it is publicly available, and that this work does not mean criteria for human subject research.

Results

A total of 15,105 patients underwent a surgical procedure with a primary CPT code for PEH repair in the study interval. The cohort was predominantly female (70.9%) with a median age of 63 years. There were 13,139 patients with a recorded preoperative hematocrit (87%). Of these, 3040 patients (23.1%) met our criteria for preoperative anemia. A total of 7943 patients had a recorded preoperative albumin (52.6%). Of these patients, 13.9% met our definition of malnutrition prior to surgery. Only 4.5% of the sample ($N = 682$) had both anemia and malnutrition. The study population and their comorbidities are characterized in Table 2.

Within our sample, the majority of patients (88.8%) underwent laparoscopic PEH repair. The remaining patients underwent open (9.2%), thoracic (1.0%), and thoracoabdominal (1.0%) repairs. Overall, 542 patients (3.6%) underwent emergency surgery. The emergency surgery cohort was missing preoperative albumin values in 21.4% ($n = 116$) and preoperative hematocrit levels in 2.4% ($n = 13$). Patients undergoing emergent repair were more likely to be anemic than patients having elective repair (29.6% emergent vs.

Table 1 CPT procedure codes

CPT code	Description	Percent of cohort (%)
43,281	Laparoscopy, surgical, repair of paraesophageal hernia, without mesh	54.2
43,282	Laparoscopy, surgical, repair of paraesophageal hernia, with mesh	34.5
43,332	Open, repair of paraesophageal hiatal hernia, via laparotomy, without mesh	6.7
43,333	Open, repair of paraesophageal hiatal hernia, via laparotomy, with mesh	2.5
43,334	Thoracic repair, repair of paraesophageal hiatal hernia, via thoracotomy, without mesh	0.8
43,335	Thoracic repair, repair of paraesophageal hiatal hernia, via thoracotomy, with mesh	0.2
43,336	Repair of paraesophageal hiatal hernia, via thoracoabdominal incision, without mesh	0.7
43,337	Repair of paraesophageal hiatal hernia, via thoracoabdominal incision, with mesh	0.3

Table 2 Comparison of patient characteristics

	Anemic ($N=3040$)	Not anemic ($N=10,099$)	Malnourished ($N=1106$)	Not malnourished ($N=6837$)
Age (mean)	66.3	61.4	69.7	61.7
Sex				
Female	2103 (69.2%)	7276 (72.0%)	787 (71.2%)	4914 (71.9%)
Male	937 (30.8%)	2823 (28.0%)	318 (28.8%)	1921 (28.1%)
Hispanic	149 (4.9%)	508 (5.0%)	53 (4.8%)	381 (5.6%)
Emergent case	196 (6.4%)	333 (3.3%)	126 (11.4%)	300 (4.4%)
ASA				
1 No disturbance	22 (0.7%)	156 (1.5%)	4 (0.4%)	85 (1.2%)
2 Mild disturbance	997 (32.8%)	4939 (48.9%)	237 (21.4%)	3105 (45.4%)
3 Sever disturbance	1800 (59.2%)	4766 (47.2%)	721 (65.2%)	3445 (50.4%)
4 Life-threatening disturbance	216 (7.1%)	227 (2.2%)	142 (12.8%)	193 (2.8%)
5 Moribund	2 (0.1%)	3 (0.0%)	2 (0.2%)	4 (0.1%)
Procedure type				
Laparoscopic	2572 (84.6%)	8963 (88.8%)	870 (78.7%)	5958 (87.1%)
Open	392 (12.9%)	924 (9.1%)	199 (18.0%)	739 (10.8%)
Thoracic	31 (1.0%)	114 (1.1%)	15 (1.4%)	67 (1.0%)
Thoracoabdominal	45 (1.5%)	98 (1.0%)	22 (2.0%)	73 (1.1%)
Smoker (within 1 year)	234 (7.7%)	970 (9.6%)	81 (7.3%)	637 (9.3%)
Diabetes mellitus	399 (13.1%)	871 (8.6%)	148 (13.4%)	698 (10.2%)
Dyspnea	474 (15.6%)	1243 (12.3%)	168 (15.2%)	826 (12.1%)
Congestive heart failure	36 (1.2%)	28 (0.3%)	29 (2.6%)	24 (0.4%)
Ventilator dependent	19 (0.6%)	8 (0.1%)	16 (1.4%)	7 (0.1%)
COPD	263 (8.7%)	537 (5.3%)	125 (11.3%)	402 (5.9%)
Ascites	2 (0.1%)	1 (0.0%)	1 (0.1%)	1 (0.0%)
Hypertension	1852 (60.9%)	5142 (50.9%)	677 (61.2%)	3629 (53.1%)
Dialysis	18 (0.6%)	5 (0.0%)	9 (0.8%)	7 (0.1%)
Disseminated cancer	18 (0.6%)	13 (0.1%)	5 (0.5%)	19 (0.3%)
Open wound	27 (0.9%)	17 (0.2%)	15 (1.4%)	13 (0.2%)
Chronic steroids	192 (6.3%)	364 (3.6%)	91 (8.2%)	297 (4.3%)
Weight loss	111 (3.7%)	190 (1.9%)	66 (6.0%)	142 (2.1%)
Bleeding disorder	160 (5.3%)	187 (1.9%)	76 (6.9%)	167 (2.4%)
Transfusion of PRBCs within 72 h of surgery	73 (2.4%)	10 (0.1%)	51 (4.6%)	19 (0.3%)

22.9% elective, $p=0.01$). These patients were also more likely to be malnourished (37.1% emergent vs. 12.3% elective, $p\leq0.0001$). The majority of emergent cases were still performed laparoscopically (56.8%). The remaining emergent cases were open abdominal in 37.3%, thoracic in 1.8%, and thoracoabdominal in 4.0%.

Anemic patients were significantly more likely to experience a complication including UTI, VTE, MI, or pneumonia (Table 3). Patients with preoperative anemia also experienced higher rates of readmission and reoperation. Length of stay was longer in patients with preoperative anemia (4.1 vs. 2.8 days in non-anemic patients; $p<0.0001$). On logistic regression, preoperative anemia increased the risk of postoperative MI, the greatest at 4.29-fold (Fig. 1). The risk of 30-day mortality was significantly increased in patients with preoperative anemia (odds ratio [OR] 4.00, 95% confidence interval [CI] 2.78–5.76, $p<0.0001$). This risk decreased to 3.57 (95% CI 2.47–5.16, $p<0.0001$) when controlling for emergent repair. When controlling for emergent cases, all other analyzed postoperative events remained statistically significant with small (<0.5) decreases in odds ratios. When controlling for CPT code, all analyzed postoperative events remained statistically significant with only small changes to each odds ratio and confidence interval.

Patients who met our definition of preoperative malnutrition were more likely to develop multiple complications including postoperative SSI, UTI, VTE, MI, AKI, and pneumonia (Table 4). Preoperative malnutrition was also

Table 3 Incidence of morbidity and mortality in anemic patients compared to patients without anemia undergoing paraesophageal hernia repair

	Anemia/no anemia	*p* value
Surgical site infection	2.2%/1.7%	0.059
Urinary tract infection	2.3%/1.4%	0.001*
Venous thromboembolism	1.7%/0.9%	< 0.0001*
Myocardial infarction	1.1%/0.2%	< 0.0001*
Acute kidney injury	0.6%/0.4%	0.153
Pneumonia	4.4%/1.9%	< 0.0001*
Reoperation within 30 days	3.7%/2.5%	0.001*
Readmission within 30 days	9.4%/6.2%	< 0.0001*
30-day mortality	2.1%/0.5%	< 0.0001*

*Statistically significant, $p < 0.05$

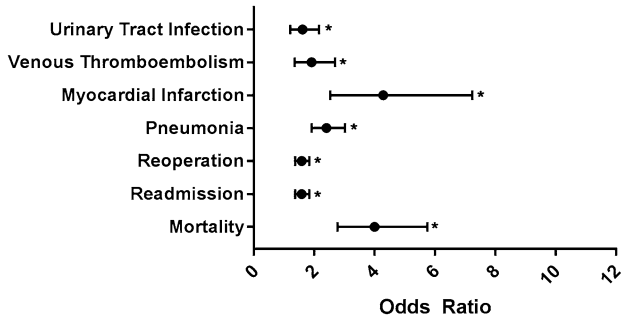

Fig. 1 Morbidity and mortality in the setting of anemia. *$p < 0.05$

Table 4 Incidence of morbidity and mortality in malnourished patients compared to patients without malnutrition in paraesophageal hernia repair

	Malnutrition/no malnutrition	*p* value
Surgical site infection	4.2%/1.5%	< 0.0001*
Urinary tract infection	3.3%/1.7%	< 0.0001*
Venous thromboembolism	2.2%/1.1%	0.004*
Myocardial infarction	1.1%/0.3%	< 0.0001*
Acute kidney injury	1.1%/0.4%	0.001*
Pneumonia	7.3%/2.1%	< 0.0001*
Reoperation within 30 days	4.9%/2.6%	< 0.0001*
Readmission within 30 days	11.2%/6.9%	< 0.0001*
30-day mortality	4.2%/0.6%	< 0.0001*

*Statistically significant, $p < 0.05$

associated with higher rates of readmission and reoperation. The average postoperative length of stay was longer in patients with preoperative malnutrition (6.1 vs. 3.1 days in those not malnourished, $p < 0.0001$). On logistic regression, preoperative malnutrition increased the risk of all morbidity and mortality, with the greatest risk being mortality (OR 7.76, 95% CI 5.03–11.99, $p < 0.0001$) as depicted in Fig. 2. Mortality risk remained significantly increased in those with preoperative malnutrition when controlling for repair being done emergently (OR 6.71, 95% CI 4.31–10.45, $p < 0.0001$). When controlling for emergent cases, all other analyzed postoperative events remained statistically significant with small (< 0.5) decreases in odds ratios. When controlling for CPT code, all analyzed postoperative events remained statistically significant with only small changes to each odds ratio and confidence interval.

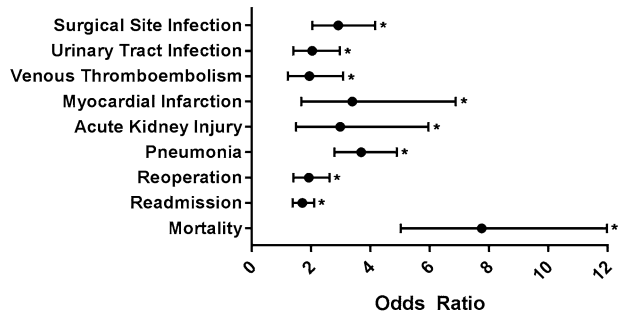

Fig. 2 Morbidity and mortality in setting of malnutrition. *$p < 0.05$

Table 5 Incidence of morbidity and mortality in patients with both anemia and malnutrition compared to patients with neither condition undergoing paraesophageal hernia repair

	Anemia and malnutrition/neither	*p* value
Surgical site infection	4.1%/1.4%	< 0.0001*
Urinary tract infection	4.3%/1.6%	< 0.0001*
Venous thromboembolism	2.2%/1.0%	0.004*
Myocardial infarction	1.5%/0.1%	< 0.0001*
Acute kidney injury	1.3%/0.4%	< 0.0001*
Pneumonia	8.8%/1.9%	< 0.0001*
Reoperation within 30 days	5.6%/2.5%	< 0.0001*
Readmission within 30 days	12.6%/6.5%	< 0.0001*
30-day mortality	5.6%/0.5%	< 0.0001*

*Statistically significant, $p < 0.05$

Patients with both preoperative anemia and malnutrition had an increased rate of all six included complications as well as increased rates of reoperation, readmission, and 30-day mortality (Table 5). Patients with both preoperative anemia and malnutrition remained in the hospital longer than patients with neither condition (6.7 vs. 3.0 days, $p < 0.0001$). The greatest increase risk in morbidity for these patients was a tenfold increase in myocardial infarction risk (OR 10.07, 95% CI 3.96–25.60, $p < 0.0001$) as depicted in Fig. 3. Patients with both anemia and malnutrition were 12.7 times more likely to experience a complication than patients with

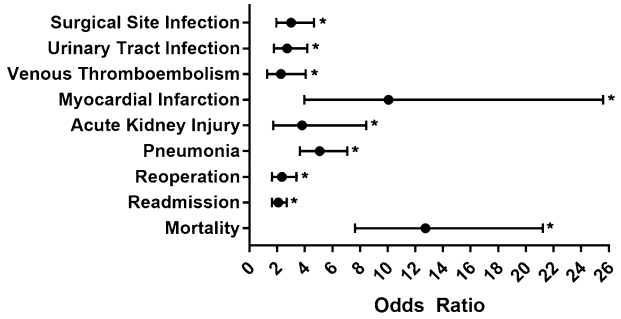

Fig. 3 Morbidity and mortality in the setting of anemia and malnutrition. *$p < 0.05$

neither condition (95% CI 7.64–21.23, $p < 0.0001$). When controlling for CPT code, all analyzed postoperative events remained statistically significant with only small changes to each odds ratio and confidence interval.

Discussion

Using a large national clinical surgical database, we have demonstrated that patients who undergo PEH repair are often either anemic or malnourished. Anemic and malnourished patients have higher rates of morbidity and mortality as well as an increased length of stay following surgery. The combination of both anemia and malnutrition was associated with an even higher risk of these adverse outcomes. A small portion (3.6%) of patients undergo emergent repair, and these patients are most likely to suffer from preoperative anemia or malnutrition.

Studies published nearly 50 years ago by Skinner and Belsey [15] and Hill [16] led many surgeons to prophylactically repair all paraesophageal hernias when identified in order to prevent the life-threatening complications of obstruction and strangulation. More recent studies have challenged this notion, and now paraesophageal hernias are often not repaired unless they are associated with symptoms [5]. Unfortunately, long-standing paraesophageal hernias often first become symptomatic in elderly and frail patients in whom surgery may be poorly tolerated [17, 18]. The morbidity of paraesophageal hernia repair has decreased dramatically over the past 20 years or more. Contemporary mortality rates after emergent PEH repair are estimated to be 5.4–8% and 0.8–1.4% after elective PEH repair [5, 19, 20]. The decrease in mortality incidence has largely been attributed to the widespread adoption of laparoscopy (88% in elective cases in our study) and advances in perioperative care. A better understanding of the risks for morbidity and mortality following PEH repair may inform future quality improvement and risk reduction efforts.

Anemia has been associated with increased postoperative morbidity following several types of procedures. A study of major non-cardiac surgeries revealed that preoperative anemia was independently associated with increased rates of 30-day postoperative morbidity and mortality [21]. Patients with preoperative anemia had a higher rate of complications, mortality, and longer length of stay when undergoing joint arthroplasty procedures [9]. In another study evaluating outcomes following hepatectomy, preoperative anemia was associated with a 20% increased risk of complications [22]. In patients with inflammatory bowel disease, anemia was associated with complications and increased length of stay [10]. It has proven difficult to demonstrate that the correction of anemia prior to surgery leads to improved rates of morbidity and mortality [23]. One recently published study revealed that a systematic approach to optimizing hemoglobin before hip or knee arthroplasty and to limiting blood loss was associated with improved outcome up to 90 days after discharge, including fewer readmissions and shorter length of stay [24]. A randomized controlled trial in patients with preoperative anemia undergoing major abdominal surgery demonstrated that perioperative intravenous iron supplementation decreased blood transfusion and length of hospital stay but had no impact on morbidity or mortality [25]. Another trial in patients with non-metastatic colorectal adenocarcinoma randomized patients to intravenous or oral iron supplementation in the 2 weeks prior to surgery. Intravenous iron did not reduce the blood transfusion requirement but was more effective than oral iron at treating preoperative anemia and iron deficiency in patients undergoing colorectal cancer surgery [26]. When opportunity allows, it is our opinion that severely anemic patients undergoing PEH repair should undergo preoperative optimization of hemoglobin and iron stores, although the benefit of this strategy has not been determined. This study is not designed to assess the impact of optimization of either anemia or malnutrition on outcomes.

Serum albumin is the main protein of human blood plasma. It binds ions such as calcium, hormones, bilirubin, and certain medications. Albumin plays a primary role in the oncotic pressure of blood. Hypoalbuminemia is a potent surrogate marker for malnutrition, and its relationship with adverse surgical events is well described. Hypoalbuminemia has been associated with poor outcomes in urological [13], gastrointestinal [10, 27, 28], and orthopedic [9] procedures. A recently published review of 16 major types of procedures using the NSQIP dataset revealed that hypoalbuminemia was an independent predictor of overall complications in 12 of the procedures examined and 30-day mortality in 11 of the procedures [14]. The administration of intravenous albumin prior to surgery in patients with hypoalbuminemia has not been demonstrated to impact surgical outcomes [29]. Preoperative evaluation and correction of nutritional status

may have a significant impact on the odds of adverse postoperative outcomes. A recently published Cochrane meta-analysis supports preoperative nutritional optimization in gastrointestinal surgery as a strategy to decrease perioperative morbidity [30]. A Nutrition-Focused Quality Improvement Program consisting of routine nutritional screening, assessment, and optimization was associated with a 50% relative risk reduction for readmissions and a 29% decreased length of stay in surgical patients [31]. Nutritional optimization prior to major surgery is recommended by both the American (ASPEN) and European (ESPEN) Societies for Parenteral and Enteral Nutrition [32, 33]. In non-emergent situations when malnutrition is identified preoperatively, nutrition should be optimized prior to proceeding with PEH repair when possible for these reasons.

It is interesting to note that the incidence of hypoalbuminemia and anemia in patients presenting emergently is much higher than that in patients who present for elective PEH repair. We feel that these findings are likely related to a combination of two possible causes. First of all, the natural history of most paraesophageal hernias is that they are symptomatic (sometimes severely symptomatic with dysphagia and early satiety) for a period of time before the need to address the hernia surgically becomes emergent [34]. Unintentional weight loss is a common finding in these patients. Our second hypothesis relates to the fact that albumin is a 'negative' acute phase protein that decreases in the setting of inflammation and acute illness [29]. Hemoglobin may be decreased in anemia of inflammation and anemia of chronic disease. Older patients are especially susceptible to these phenomena. Low albumin and low anemia in these patients may therefore be a reflection of the acute inflammatory response associated with an emergent PEH presentation.

There are a number of limitations to this study. The size and complexity of the paraesophageal hernia and the nature of the symptoms cannot be determined from these data. It is possible some of these patients were undergoing a hiatal hernia repair for the primary indication of gastroesophageal reflux. NSQIP hospitals self-select to participate in this quality improvement program and therefore outcomes may not be representative of care throughout the United States, especially when it comes to a complex operation such as PEH repair. There are many missing lab values, especially for albumin. Despite these shortfalls, we feel we have provided additional evidence to a steadily growing body of literature that both anemia and malnutrition are associated with increased rates of morbidity and mortality following gastrointestinal surgery, in this case following paraesophageal hernia repair. Preoperative correction of severe anemia and optimization of nutrition when clinically appropriate is recommended. Anemia and malnutrition are important risk factors for complications that may be useful in benchmarking complication rates. This knowledge may also help inform patients and families about the risks associated with surgical repair of paraesophageal hernias, especially in cases where anemia and/or malnutrition are present prior to surgery.

Disclaimer The American College of Surgeons-National Surgical Quality Improvement Program (ACS-NSQIP) and the hospitals participating in the ACS-NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

Compliance with ethical standards

Disclosures Dr. Gould is a consultant for Torax Medical. Dr. Goldblatt is a consultant for Gore, Medtronic, and Allergan. He receives research support from Davol and Merck. Drs. Clark, Lak, Higgins, Kastenmeier, and Kindel and Ms. Helm have no conflicts of interest or financial ties to disclose.

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