



Open repair of large abdominal wall hernias with and without components separation; an analysis from the ACS-NSQIP database



Nirav K. Desai, I. Michael Leitman*, Christopher Mills, Valentina Lavarias, David L. Lucido, Martin S. Karpeh Jr.

Department of Surgery, Mount Sinai Beth Israel, Icahn School of Medicine at Mount Sinai, New York, NY, USA

HIGHLIGHTS

- The repair of large abdominal wall hernias is more frequently performed using components separation.
- While this technique appears to reduce recurrence, morbidity has not been previously studied.
- When compared to a large cohort, components separation has a higher complication rate than traditional open hernia repair.

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ABSTRACT

Background: Components separation technique emerged several years ago as a novel procedure to improve durability of repair for ventral abdominal hernias. Almost twenty-five years since its initial description, little comprehensive risk adjusted data exists on the morbidity of this procedure. This study is the largest analysis to date of short-term outcomes for these cases.

Methods: The ACS-NSQIP database identified open ventral or incisional hernia repairs with components separation from 2005 to 2012. A data set of cohorts without this technique, matched for preoperative risk factors and operative characteristics, was developed for comparison. A comprehensive risk-adjusted analysis of outcomes and morbidity was performed.

Results: A total of 68,439 patients underwent open ventral hernia repair during the study period (2245 with components separation performed (3.3%) and 66,194 without). In comparison with risk-adjusted controls, use of components separation increased operative duration (additional 83 min), length of stay (6.4 days vs. 3.8 days, $p < 0.001$), return to the OR rate (5.9% vs. 3.6%, $p < 0.001$), and 30-day morbidity (10.1% vs. 7.6%, $p < 0.001$) with no increase in mortality (0.0% in each group).

Conclusions: Components separation technique for large incisional hernias significantly increases length of stay and postoperative morbidity. Novel strategies to improve short-term outcomes are needed with continued use of this technique.

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1. Introduction

Open ventral abdominal hernia repair is one of the most common procedures performed in general surgery [1]. Ramirez and colleagues introduced the components separation technique (CST) in 1990 as a new method for abdominal wall reconstruction in ventral hernia repair [2]. By separating layers of the abdominal wall, this technique allows for increased mobilization of the rectus

abdominis muscles to the midline [3]. This technique has been suggested for larger hernia defects when fascial closure may lead to excess tension, resulting in a greater risk of failure or respiratory compromise. While several studies have shown successful results and improved recurrence rates with this technique, they have not all been consistent [5–10]. There have also been increased wound healing complications seen with this technique, though this finding has also not been consistent in comparison studies [9–12]. There is minimal literature discussing the incidence of complications or additional costs that might result from use of this technique [3,5,8] when compared to more traditional repairs of large abdominal wall hernias. Further, almost all reported data is based on a single

* Corresponding author. Mount Sinai Beth Israel, 10 Union Square East, Suite 2M, New York, NY, 10003, USA.

E-mail address: Mleitman@chpnet.org (I.M. Leitman).

surgeon or institution's experience.

The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) provides a large multi-center database allowing for risk stratification from analysis of post-operative outcomes. While components separation may reduce the incidence of recurrent hernia in patients with large fascial defects, does this result in a greater morbidity or cost? The NSQIP database presents a useful tool to look at both surgical and medical morbidity by creation of a cohort of patients undergoing prosthetic repair of abdominal wall hernias with and without components separation [12,13].

2. Methods

2.1. Population

The Human Research Committee approved this study (IRB# 023-14). The 2005–2012 ACS-NSQIP participant use data files were accessed on February 1, 2014. These files were queried to identify all patients undergoing ventral hernia repair (VHR). Current procedural terminology (CPT) codes were used to identify the following inpatient open hernia repairs: 49,560, 49,561, 49,565, and 49,566. Concurrent use of components separation technique (CST) was identified with CPT code 15,734. Patients undergoing repair of small abdominal wall hernias without prosthetic reinforcement and emergency surgery were excluded. The participant user file (PUF) was used to identify all patients undergoing abdominal wall hernia repair with and without components separation (last accessed February 24, 2014).

In 2012, over 250 academic and community hospitals participated in ACS-NSQIP throughout the country. Trained clinical reviewers collect data on patient demographics, medical history, laboratory values, operative, and post-operative data points. Patients are contacted in writing or by telephone for complete 30-day follow-up. Data is collected on randomly assigned patients and entered online in a HIPAA-compliant, secure, web-based platform. Each variable is defined in the NSQIP manual and ACS monitors data collections stringently with periodic random audits to ensure accuracy and standardization.

2.2. Independent variables

NSQIP variables for analysis of the two groups were selected to include demographics, baseline health characteristics, pertinent comorbidities, American Society of Anesthesiologists (ASA) class, wound class, and case complexity via CPT code. Demographics selected were age, gender, and BMI. Baseline health characteristics included current smoking within one year of operation, functional health status and level of dyspnea. Comorbidities selected were diabetes on oral medications or insulin, hypertension requiring medication, dialysis requirement, ascites within 30 days of surgery, chronic use of steroids, and medical history of chronic obstructive pulmonary disease, congestive heart failure, and myocardial infarction. These groups and their characteristics are identified in Table 1.

2.3. Matched cohort

Matching was done to minimize selection bias given the non-randomization for use of CST in a given abdominal wall hernia repair. Variables were identified that are most significant in producing a set of VHR patients similar to patients undergoing concurrent CST. These variables were used to develop a propensity score for each patient enabling creation of a cohort of 2245 matched pairs. The independent variables were analyzed again to

Table 1
Population comparison.

Independent variable	VHR	# of cases	CST	# of cases	P value
Total# of cases		66,194		2245	
Male	42.5%	28,132	45.2%	1015	0.011*
Female	57.5%	38,062	54.8%	1230	0.011*
Age					
(20–29)	23.5%	15,556	21.4%	480	0.019*
(30–39)	24.1%	15,953	25.3%	568	0.193
(40–49)	24.3%	16,085	26.9%	604	0.005*
(50–59)	18.1%	11,981	19.7%	442	0.056
(60–69)	8.5%	5626	6.1%	137	0.000*
(70–79)	1.4%	927	0.6%	13	0.001*
BMI					
Underweight	0.8%	530	0.6%	13	0.42
Normal	17.1%	11,319	11.4%	256	0.000*
Overweight	28.5%	18,865	26.6%	597	0.047*
Obese	24.1%	15,953	26.5%	595	0.009*
Very Obese	28.6%	18,931	34.5%	775	0.000*
Diabetic	16.0%	10,591	19.9%	447	0.009*
HTN	49.8%	32,965	53.9%	1210	0.000*
Smoker	21.0%	13,901	22.6%	507	0.07
Dialysis	1.0%	662	0.8%	18	0.413
COPD	5.1%	3376	7%	157	0.000*
CHF	0.3%	199	0.1%	2	0.069
Previous MI	0.1%	66	0%	0	0.461
Steroid use	3.2%	2118	2.7%	61	0.176
Ascites	0.5%	331	0.3%	7	0.188
Level of dyspnea		66,260			
None	90.8%	60,104	89%	1998	0.006*
With exertion	8.7%	5759	10.4%	233	0.004*
At Rest	0.6%	397	0.6%	13	0.99
Functional status					
Independent	98.1%	64,936	98%	2200	0.645
Partially dependent	1.6%	1059	1.7%	38	0.599
Totally dependent	0.2%	132	0.1%	2	0.296
ASA class					
1	6.4%	4236	2.2%	49	0.000*
2	49.8%	32,965	42.7%	959	0.000*
3	41.0%	27,140	52.3%	1174	0.000*
4	2.7%	1787	2.7%	61	0.897
Wound class					
Clean	88.2%	58,383	78.7%	1767	0.000*
Clean-contaminated	8.6%	5693	12.8%	287	0.000*
Contaminated	1.5%	993	4.1%	92	0.000*
Dirty	1.7%	1125	4.4%	99	0.000*
CPT code					
Initial	77.7%	51,433	55.9%	1255	0.000*
Recurrent	22.3%	14,761	44.1%	990	0.000*
Incarcerated	23.9%	15,820	27.4%	615	0.000*

* = statistically significant value, VHR = patients receiving ventral hernia repair, CST = patients receiving concurrent component separation technique, # = number of cases, BMI = body mass index, HTN = hypertension requiring medication, COPD = past medical history of chronic obstructive pulmonary disease, CHF = history of congestive heart failure, MI = myocardial infarction, ASA = American Society of Anesthesiologists, CPT = current procedural terminology.

ensure an adequate match and identify differences that may have persisted (Table 2). A primary outcome analysis was performed to identify differences in operative duration, hospital length of stay, surgical length of stay, 30-day morbidity and mortality (Table 3). A secondary analysis was performed to identify differences in the 21 NSQIP- defined post-operative occurrences. These include superficial and deep incisional surgical site infections, organ/space surgical site infection, wound disruption, pneumonia, unplanned intubation, pulmonary embolism, presence of mechanical ventilation greater than 48 h, progressive renal insufficiency, acute renal failure, urinary tract infection, stroke/CVA with neurological deficit, presence of coma greater than 24 h, peripheral nerve injury, cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, administration of blood transfusion, graft/prosthesis/flap failure or loss, deep vein thrombosis or thrombophlebitis, sepsis,

Table 2
Matched cohort comparison.

Independent variable	VHR	# of cases	CST	# of cases	P value
Total# of cases		2245		2245	
Male	45.4%	1019	45.2%	1015	0.857
Female	54.6%	1226	54.8%	1230	0.857
Age					
(20–29)	20.8%	467	21.4%	480	0.661
(30–39)	25.8%	579	25.3%	568	0.707
(40–49)	27.3%	613	26.9%	604	0.814
(50–59)	19.6%	440	19.7%	442	0.94
(60–69)	6%	135	6.1%	137	0.9
(70–79)	0.5%	11	0.6%	13	0.694
BMI					
Underweight	0.9%	20	0.6%	13	0.235
Normal	14.4%	323	11.4%	256	0.003*
Overweight	25.7%	577	26.6%	597	0.519
Obese	23.9%	537	26.5%	575	0.043*
Very obese	33.8%	759	34.5%	775	0.615
Diabetic	19%	427	19.9%	447	0.474
HTN	52.1%	1170	53.9%	1210	0.209
Smoker	23.9%	537	22.6%	507	0.323
Dialysis	0.7%	16	0.8%	18	0.491
COPD	6.1%	137	7%	157	0.228
CHF	0.4%	9	0.1%	2	0.021*
Previous MI	0%	0	0%	0	0.317
Steroid use	2.5%	56	2.7%	61	0.779
Ascites	0.4%	9	0.3%	7	0.796
Level of dyspnea					
None	89%	1998	89%	1998	0.962
With exertion	10.2%	229	10.4%	233	0.806
At rest	0.8%	18	0.6%	13	0.287
Functional status					
Independent	98.3%	2207	98%	2200	0.438
Partially dependent	1.4%	31	1.7%	38	0.396
Totally dependent	0.2%	4	0.1%	2	0.479
ASA class					
1	2%	45	2.2%	49	0.6
2	42.7%	959	42.7%	959	0.976
3	53.1%	1192	52.3%	1174	0.611
4	2.3%	52	2.7%	61	0.387
Wound class					
Clean	79.1%	1776	78.7%	1767	0.742
Clean-contaminated	13.3%	299	12.8%	287	0.595
Contaminated	3.7%	83	4.1%	92	0.396
Dirty	3.9%	88	4.4%	99	0.454
CPT code					
Initial	55.9%	1255	55.9%	1255	0.952
Recurrent	44.1%	990	44.1%	990	0.952
Incarcerated	27.6%	620	27.4%	615	0.92

* = statistically significant value, VHR = patients receiving ventral hernia repair, CST = patients receiving concurrent component separation technique, # = number of cases, BMI = body mass index, HTN = hypertension requiring medication, COPD = past medical history of chronic obstructive pulmonary disease, CHF = history of congestive heart failure, MI = myocardial infarction, ASA = American Society of Anesthesiologists, CPT = current procedural terminology.

Table 3
Primary analysis.

Primary outcome	VHR	CST	Difference	P value
Return to the OR	3.70%	5.90%		0.000*
Total hospital LOS	3.76 days	6.36 days	2.6 days	0.000*
Total surgical LOS	4.22 days	6.94 days	2.72 days	0.06
Operative duration	105.2 min.	187.8 min.	82.6 min.	0.000*
Estimated 30-day morbidity	7.6%	10.1%	2.5%	0.000*
Estimated 30-day mortality	0.3%	0.3%	0.1%	0.003*
Actual 30-day morbidity	11.09%	23.96%	12.87%	0.000*
Actual 30-day mortality	0.5%	0.8%	0.3%	0.255

* = statistically significant value, VHR = matched cohort receiving ventral hernia repair, CST = matched cohort receiving concurrent component separation technique, OR = Operating Room, LOS = length of stay.

and septic shock (Table 4).

2.4. Statistical analysis

Independent variables were analyzed in both populations before and after matching using z-tests as continuous variables were separated into distinct components for analysis. P-values were determined to be significant at a level lower than 0.05. Z-test and t-tests were used to analyze differences in the selected outcomes between the two groups. A secondary analysis was performed on 30-day morbidity outcomes using Pearson's chi-squared tests in a family-wise manner. P-values for all tests measuring outcomes were determined as significant if less than 0.05.

3. Results

A total of 68,439 VHR cases were identified in the ACS-NSQIP PUF database from 2005 to 2012. 2245 VHR cases were identified where components separation was performed. 66,194 VHR cases were identified without components separation as a comparison. Comparisons between these two groups seen in Table 1 reveal differences in several categories. Patients undergoing concurrent separation were more often male, between the ages of 30 and 60, obese (BMI>30), and with a higher ASA class. These patients have proportionately higher rates of COPD, hypertension requiring medication, diabetes on oral agents or insulin, and dyspnea on exertion. Patients undergoing components separation had more complex abdominal wall hernias with a greater proportion being recurrent and incarcerated. Their wounds had higher proportions in the clean-contaminated, contaminated, and dirty categories. After creating a cohort of 2245 matched pairs, these cases still had a higher proportion of obese patients and a lower proportion of normal patients though other categories of BMI now showed comparable proportions.

Primary outcome analysis highlights several important differences (Table 3). A significantly higher proportion of patients undergoing concurrent CST required a return to the operating room (VHR: 3.7% vs. CST: 5.9%, $P < 0.001$). Hospital length of stay was increased by 2.6 days with CST. (VHR: 3.8 vs. CST: 6.4, $p < 0.001$) Operative duration was also significantly longer by 82.6 min (VHR: 105.2 vs. CST: 187.8, $p < 0.001$).

Secondary evaluation was performed using a family-wise analysis (Table 4). We found a significant increase in deep incisional SSI (VHR: 1.8% vs. CST: 4.8%, $p < 0.001$), organ/space SSI (VHR: 0.8% vs. CST: 2.7%, $p < 0.001$), and wound disruption or dehiscence (VHR: 0.45% vs. CST: 1.87%, $p < 0.001$). We also found a difference in superficial SSI that approached significance (VHR: 5.0% vs. CST: 7.1%, $p < 0.064$).

Our analysis reveals differences of 0.1% in estimated 30-day mortality ($p < 0.004$) and 2.5% in estimated 30-day morbidity. (VHR: 7.6% vs CST: 10.1%, $p < 0.001$) These estimated probabilities are derived by NSQIP for each individual case from pre-existing conditions using an algorithm for hierarchical regression analysis. They are calculated using the previous 12 months of data so that both the algorithm and data change over time. In comparison, we found differences of 0.30% in actual 30-day mortality ($p = 0.255$) and 12.87% in actual 30-day morbidity (VHR: 11.1% vs CST: 24%, $p < 0.001$).

We did find a significant difference in the following respiratory complications: pneumonia (VHR: 1.2% vs. CST: 3.7%, $p < 0.001$), unplanned intubation (VHR: 0.8% vs. CST: 3.3%, $p < 0.001$), and dependency on mechanical ventilation for greater than 48 h (VHR: 1.0% vs. CST: 3.9%, $p < 0.001$). The following complications were also increased in patients undergoing CST: progressive renal insufficiency (VHR: 0.1% vs. CST: 1.2%, $p < 0.001$), myocardial infarction

Table 4
Morbidity analysis.

Secondary outcome	VHR	# of cases	CST	# cases	P value
Total number of cases		2245		2245	
Superficial SSI	4.99%	112	7.08%	159	0.063
Deep incisional SSI	1.83%	41	4.77%	107	0.000*
Organ/space SSI	0.80%	18	2.67%	60	0.000*
Wound disruption	0.45%	10	1.87%	42	0.000*
Pneumonia	1.20%	27	3.70%	83	0.000*
Unplanned intubation	0.80%	18	3.30%	74	0.000*
Pulmonary embolism	0.27%	6	0.89%	20	0.112
Ventilator>48 hours	0.98%	22	3.92%	88	0.000*
Progressive renal insufficiency	0.13%	3	1.16%	26	0.000*
Acute renal failure	0.27%	6	0.67%	15	0.634
Urinary tract infection	1.74%	39	2.98%	67	0.112
Stroke/CVA w/neurological deficit	0%	0	0.18%	4	0.605
Coma>24 Hours	0	0	0	0	–
Peripheral nerve injury	0.04%	1	0	0	1
Cardiac arrest requiring CPR	0.27%	6	0.53%	12	0.967
Myocardial infarction	0.09%	2	0.67	15	0.031*
Presence of blood transfusion	48.82%	1096	71.31%	1601	0.000*
Graft/prosthesis/flap failure	0.04%	1	0.18%	4	0.981
DVT/Thrombophlebitis	0.62%	14	1.34%	30	0.266
Sepsis	1.87%	42	4.90%	110	0.000*
Septic Shock	0.62%	14	1.78%	40	0.007*

* = statistically significant value, # = number of cases, SSI = superficial site infection, CVA = cerebrovascular accident, CPR = cardiopulmonary resuscitation, DVT = deep vein thrombosis.

(VHR: 0.1% vs. CST: 0.7%, $p = 0.031$), presence of blood transfusion (VHR: 49.8% vs. CST: 71.3%, $p < 0.001$), sepsis (VHR: 1.9% vs. CST: 4.9%, $p < 0.001$), and septic shock (VHR: 0.6% vs. CST: 1.8%, $p = 0.007$).

4. Discussion

Abdominal wall hernia repair is one of the most common surgical procedures. The decision of how to repair a complex ventral hernia is a difficult one, and there are few evidence-based guidelines that guide pre-operative decision-making and risk counseling. Components separation is a significant technical advancement that allows for improved myofascial mobilization in the midline repair of large hernias. This technique most commonly involves anterior abdominal wall dissection with transection of the external oblique aponeurosis allowing for medialization of the rectus abdominal muscles. Several variations in its technique have also been described including a posterior technique with separation of the posterior rectus sheath, retrorectus dissection, release of the transversus abdominis; peri-umbilical perforator sparing technique in anterior dissection; and endoscopic separation [11,14,15]. Physiological changes have been identified as a result of this technique with hypertrophy of abdominal wall musculature on follow-up CT scans [16]. Anatomical studies have found progressive decrease in tension with release of each muscle layer [17]. Significantly improved recurrence rates have been reported when components separation allows for primary fascial closure [9]. Despite its potential long-term benefits in hernia repair, morbidity from the technique has not been fully described. Previous studies reporting morbidity focused primarily on wound complications and in non-controlled settings [18,19].

The ACS-NSQIP database provides risk-adjusted early outcome data following.

common surgical procedures [20]. We used this national, multi center database to characterize the population undergoing concurrent components separation technique and appropriately select a comparable cohort of patients for outcome analysis. The population of patients undergoing concurrent components separation has a greater proportion of medical comorbidities, which has been

independently shown to contribute to worse post-operative outcomes [12]. More patients receiving components separation are obese. Obesity is itself a costly, pervasive risk factor associated with numerous complications, specifically in hernia repair [4,21]. The population undergoing components separation has greater proportions of contaminated wounds and complex hernia cases. Contaminated wounds have been shown to lead to increased post-operative surgical site occurrences [22,23].

By creating a matched cohort of ventral hernia repair patients using a propensity model, we attempted to control for the inherent selection bias present in repairs undergoing components separation technique. Our cohort ultimately consists of patients from the VHR group that would be expected to have received components separation based on similarities in pre-operative and operative characteristics to patients in the CST group.

While the difference in mortality is not significant, we report a large, significant difference in morbidity. Our results confirm that NSQIP estimates can help predict the likelihood of post-operative events. However, when using components separation technique, these estimates may under predict adverse events. The actual morbidity in our CST group was much higher than that predicted by the NSQIP model.

Our data on the risk of surgical infection is corroborated by single-institution studies showing similar increased results of wound complications [18,19]. Our results suggest that the increased morbidity from this technique is predominately composed of deeper wound infections in line with components separation technique involving a deeper flap-based dissection. Fischer et al. [21] have previously reported respiratory complications in components separation. However, in their analysis, they report obesity as the predominant contributing factor. We report an independent association between concurrent CST and respiratory events. Further, we found significant differences in renal insufficiency, myocardial infarction, need for blood transfusion, sepsis and septic shock that have not previously been reported.

Components separations' risk for wound complications has been well documented in the literature. Our results indicate significant medical complications in addition from this technique. The dissection needed for flap creation with resultant ischemia of

abdominal wall layers cannot be discounted in the short-term as this presents a significant strain on a patient's physiological system. The healing consequent to this type of surgical procedure requires increased metabolism with the potential for wound complications if healing is disrupted or host factors are inadequate. This may further predispose to medical morbidity during recovery.

Increased operative time has been independently shown to increase morbidity. Procter et al. found that with each additional half hour of operating time, infectious complications increased by almost 2.5% and length of stay by 6% [24].

Returns to the OR result in additional costs. These cases are done on an urgent/emergent basis and require use of additional medical personnel during nonscheduled hours. Increased post-operative events cause an additional financial burden. Each additional day in the hospital carries a significant cost and the increased length of stay associated with CST (2.6 days) was significant.

The present study has some key limitations. First, this analysis and patient selection rely exclusively on the retrospective, multi-institutional data entry into the NSQIP database. One potential problem is that the patient populations might have intrinsic differences, factors predisposing to or the result of a large, complex hernia. The decision to use components separation is a surgeon's preference typically dependent on the patient's health status and the nature of their hernia. Our initial demographic analysis indicates component separation is used more frequently in contaminated cases and with recurrent, incarcerated cases. Wound class and case complexity are the primary attributes of case presentation our analysis will account for. By matching, we are able to control for a number of factors but only these selected demographics and characteristics, our analysis cannot account for other intrinsic differences not tracked by NSQIP such as the size or nature of the hernia defect. NSQIP has begun recording mesh and hernia defect size data in 2013, which could potentially act as an appropriate surrogate in a future study. Other hidden, untracked variables with differences between our cohort populations may exist. While our analysis excludes emergencies, some of these cases are performed on an urgent basis and subsequent repairs after failed attempts may be planned in an elective fashion. Further, even after matching, some differences may persist in the dataset. In our matched cohort, patients in the CST group were still more often obese. As mentioned previously, obesity has been shown to be a risk factor for increased complications of any type, which may confound our results to a degree.

Second, we are unable to distinguish between different methods of components separation. As previously discussed, beyond an anterior dissection for components separation, a posterior component separation can be performed with retrorectus dissection, release of the posterior rectus fascia, and release of the transversus abdominis muscle layer [25]. Posterior techniques minimize anterior dissection and creation of large lipocutaneous flaps; they have been reported to reduce wound complications as well. Krpata et al. found improved recurrence rates from 14% to 3% ($p = 0.09$) and decreased wound complications from 48% to 26% ($p = 0.01$) using posterior CST [8]. Peri-umbilical perforator sparing technique releases the external oblique superiorly and inferiorly minimizing flap creation and similarly has shown decreased wound complications [14,25,26]. Currently, unless the technique is performed laparoscopically, these would all be coded similarly and included in the present study. We believe that their potential inclusion actually further strengthens the reported data. These techniques aim to minimize morbidity; thus, the persistence of significant differences emphasizes the results.

While the study points to inherent morbidity resulting from use of components separation, the improved recurrence rates and potential for enhanced abdominal wall physiology in hernia repair

should not be overlooked. Novel techniques to limit the amount of dissection, flap and resultant dead space creation are being investigated and should be analyzed for associated outcomes. Fox et al. found an improvement to 6% of wound complications from 27% when comparing laparoscopic to open CS [27]. Other studies have also identified decreased wound-healing complications with minimally invasive techniques [28,29]. Giurgius et al. found a decrease in wound complications using endoscopic technique [11].

When using a clinical algorithm to determine the best technique for hernia repair, significantly decreased recurrence rates and wound complications have been reported with components separation [30,31]. Clinical algorithms that help indicate the most appropriate method of repair might allow for an individualized approach that could produce better outcomes. Further investigation should be performed to determine if medical morbidity is also reduced with these approaches. Consensus guidelines might be developed from further analysis that could assist surgeons in the choice of repair, patient selection and pre-operative planning.

5. Summary

While components separation may offer long-term advantages in hernia repair, an analysis of propensity-score matched patients shows that use of this technique might increase the cost and morbidity when compared to more traditional ventral hernia repair. Innovative strategies should be investigated with continued use to guide the selection of abdominal wall hernia repair and improve both early and long-term patient outcomes.

Ethical approval

Mount Sinai Beth Israel Human Research Committee approved this study (IRB# 023-14).

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Author contribution

Study concept and design – Leitman, Desai, Karpeh, Lucido.

Data collection – Desai, Lavarias.

Data analysis and interpretation – Desai, Leitman, Karpeh, Mills, Lucido.

Writing the paper. Desai, Leitman.

Conflicts of interest

None.

Guarantor

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