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The use of component separation during abdominal wall reconstruction in contaminated fields: A case-control analysis

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ABSTRACT

Background: Component separation technique (CST) allows fascial medialization during abdominal wall reconstruction (AWR). Wound contamination increases the incidence of wound complications, which multiplies the incidence of repair failure. The aim of this study was to compare the impact of CST on AWR outcomes in contaminated fields in comparison to those operations without CST.
Methods: A prospective, single institution hernia database was queried for patients undergoing AWR with CST and contamination. A case control cohort was identified using propensity score matching.
Results: There were 286 CSTs performed in contaminated cases. After propensity score matching, 61 CSTs were compared to 61 No-CSTs. These groups were matched by defect area (CST:287.1 ± 150.4 vs No-CST:277.6 ± 218.4 cm^2, $p = 0.156$), BMI (32.0 ± 7.0 vs 32.2 ± 6.0 kg/m^2, $p = 0.767$), diabetes (26.2% vs 32.8%, $p = 0.427$), and panniculectomy (52.5% vs 36.1%, $p = 0.068$). Groups had similar rates of wound complications (42.6% vs 40.7%, $p = 0.829$) and recurrence (4.9% vs 13.1%, $p = 0.114$).
Conclusions: The use of CST in the face of contamination is not associated with an increase in wound complications, mesh complications, or recurrence.

Introduction

Ventral hernia repair (VHR) remains one of the most common surgeries in the United States with over 350,000 cases performed yearly.[1] Achievement of fascial re-approximation, mesh reinforcement, reduced incidence of wound complications, and the avoidance of bridging meshes have all been demonstrated to reduce recurrence rates.[2–9] When the fascial defect is large and there is loss of domain, component separation techniques (CST) may be required to allow for medialization of the linea alba and approximation of the fascia in the midline. The term CST was coined by Ramirez et al., in 1990 when they described the release of the external oblique (EOR) combined with posterior rectus sheath release.[10] However, the use of fascial division to allow for "tension relief" to assist in repair of ventral hernias was described by Young in the early 1960s.[11] Perhaps the greatest challenge of these operations, especially EOR with large skin flap dissection, is the increased risk of wound complications.[12] Given this and the musculo-fascial division required as part of CST, the performance of CST versus a bridging technique might be questioned. In a recent meta-analysis, Holihan et al. examined CST versus a bridging mesh repair and demonstrated that CST was associated with a decrease in recurrence rate.[7] In a more recent study examining 775 CSTs, our group demonstrated similar findings.[13]

Surgical wound class defined by the level of contamination has been well delineated by the Center for Disease Control (CDC). The CDC Wound Class from 1 to 4 correlates directly with an increasing risk of surgical site occurrences (SSO), especially infection, in VHR,[14] and often results in an alteration in the controversial and much debated mesh selection for these cases.[15–20] Wound complications in abdominal wall reconstruction (AWR) increase hernia recurrence by 3–5 times compared to those operations without these complications.[13,21,22] Thus, the combination of CST used in a contaminated field could potentially pose a marked increased risk of wound complications, which may offset the benefits attributable to CST.

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The purpose of this study was to be one of the first to examine the outcomes of CST AWR in the setting of CDC class 2, 3, and 4 wounds as compared to similar cases that did not involve CST.

Materials and methods

Study population

All CST were performed at the Carolinas Medical Center in Charlotte, North Carolina. The majority of patients were referred from other centers, frequently with recurrent hernias and most had co-morbidities. All open AWR utilizing CST were examined, including incisional, ventral, and flank hernias. A propensity match was performed for case control.

Study design

After Institutional Review Board approval, an institutional, prospectively-maintained, hernia-specific database was queried for all CST between 2006 and 2018. Emergent operations were excluded. Only cases involving preperitoneal mesh in defects greater than 100 cm^2 were included.[23] Data were collected on a prospective basis by dedicated, trained abstractors, independent from clinical duties, and without surgeon review to prevent the introduction of bias. Demographic, operative, and post-operative information were obtained for each case. Mesh type was categorized into biologic, absorbable synthetic (2 in the No-CST group and 3 in CST group), or permanent synthetic material. The CST group involved either an anterior components separation technique (ACST) [external oblique release with posterior rectus sheath release (PRSR)] or posterior components separation technique (PCST) [PRSR most often with a tranversus abdominus release (TAR)].[13,24] Wound classification was determined by CDC Wound Class and placed in operative documentation at the end of every case. The primary outcome of interest was hernia recurrence. Secondary outcomes included wound complications, mesh infections, length of stay, 30-day readmissions, charges, and mortality. Wound complications were defined as seroma requiring intervention, cellulitis requiring antibiotics, wound breakdown (superficial), wound infection requiring antibiotics, fascial dehiscence, and fistula. Patients having multiple wound complications such as wound breakdown and cellulitis are classified as 1 total wound complication.

Propensity matching

Propensity-score nearest neighbor matching was performed for comparison of patients undergoing OVHR in the setting of CDC class 2, 3, and 4 wounds that did not involve component separation based on logistic regression analysis, generating 1:1 closely matched pairs for comparison. Patients were matched based on BMI, sex, and defect size. Selection of propensity-matching variables was based on statistical and clinical significance between groups.

Skin closure management

Patients within this cohort often underwent delayed primary closure.[25] At the time of initial surgery, a vacuum dressing is applied to the subcutaneous space, including tracking in any skin flaps. This is changed at the bedside every 2 days until the patients wound is ready for closure, typically five to seven days. The patient then returns to the operating room for delayed primary closure with subcutaneous drain placement.

Statistical analysis

Descriptive statistics were reported as means with corresponding standard deviations for continuous variables and percentages for categorical variables. Categorical variables were evaluated using Pearson's chi-squared and Fisher's exact test where appropriate. Continuous and ordinal variables were evaluated using Wilcoxon-Mann-Whitney and the Kruskal-Wallis tests. Odds-ratios with corresponding 95% confidence intervals were used to report the Results of the logistic regression and Cox proportional hazards regression models. Statistical significance was set at $p < 0.05$, and all reported p values were two-tailed. All data were analyzed using Statistical Analysis Software, version 9.4 (SAS Institute, Inc., Cary, NC).

Results

There were 286 CSTs performed in contaminated cases. After applying exclusion criteria, there were 186 CSTs analyzed for matching with 63 No-CST cases. After propensity score matching, there were 61 cases with CST matched to 61 cases without CST for comparison.

A subset analysis was performed initially to compare the anterior CST and the posterior CST that were included after matching. Twenty patients received anterior CST and 41 received posterior techniques. These two groups differed in terms of BMI (29.7 − anterior vs 33.0 kg/m^2 − posterior, $p = 0.046$) and defect size (359.9 vs 251.6 cm^2, $p = 0.011$). Two recurrences were seen in the anterior group and 1 in the posterior group ($p = 0.248$). Comparing wound complications showed 50% of anterior patients had a wound complication and 39.0% of posterior patients ($p = 0.416$). One mesh infection occurred in the anterior group and 0 in the posterior group ($p > 0.05$). Based on the similar outcomes, the anterior and posterior groups were combined for further analysis versus the No-CST group.

Patient characteristics were similar between the CST group and the No-CST group (Table 1). Comorbidities that were similar include BMI, diabetes, history of smoking, age, and ASA score. The groups had an equal number of patients with recurrent hernias. Despite propensity score matching, there were some factors that differed between the groups. These included mean number of previous hernia repairs and history of COPD.

Operative characteristics for the two groups are shown in Table 2. The CST and No-CST groups had similar hernia characteristics. The hernias were ventral in location, and a similar number were incarcerated. Ventral Hernia Working Group[26] hernia grade and CDC wound class were also similar. The size of the hernia was very large in both groups, and they were reconstructed with very large mesh implants. As per the study parameters, all hernias were repaired with a preperitoneal mesh. Biologic or absorbable biosynthetic mesh were used in the majority of both groups (55.7% vs 50.8%, $p = 0.586$), and when synthetic mesh was used, it was during CDC Class II cases only.

Surgical outcomes are demonstrated in Table 3. Over equal lengths of follow-up (CST 16.7 ± 20.8 vs non-CST 23.8 ± 24.2 months, $p = 0.074$), the primary outcome of hernia recurrence was not significantly different between groups (CST 4.9% vs non-CST 13.1%, $p = 0.114$). The rates of successful complete fascial closure were similar between the two groups (91.8% vs 83.6%, $p = 0.220$), as were wound complications. There were no differences in complications, length of stay, or thirty-day readmissions (all p values > 0.05). The most common complication in the CST group was superficial wound breakdown (27.9%), and in the No-CST group it was seroma requiring intervention (19.7%). When comparing ACST to No-CST there was not a difference in wound complications

Table 1
Patient characteristics during OVHR in case control sample.

Patient Characteristics			
	CST n = 61 (%)	No-CST n = 61 (%)	p-value
Age (years)	60.4 ± 9.3	56.7 ± 11.9	0.094
Female	33 (54.1)	33 (54.1)	1.00
BMI (kg/m^2)	32.0 ± 7.0	32.2 ± 6.0	0.767
Mean previous hernia repairs	2.4 ± 2.7	2.7 ± 1.6	0.042
Comorbidity			
COPD	1 (1.6)	8 (13.1)	0.032
Coronary artery disease	10 (16.1)	6 (9.8)	0.283
Current steroid use	7 (11.9)	6 (9.8)	0.721
Current anticoagulant use	7 (11.8)	7 (11.8)	1.00
Diabetes	16 (26.2)	20 (32.8)	0.427
Hypertension	36 (59.0)	35 (57.4)	0.854
Peripheral vascular disease	0 (0)	1 (1.6)	1.00
History of smoking	12 (19.7)	13 (22.0)	0.750
ASA Score			0.843
I	0 (0)	1 (1.7)	
II	18 (30.5)	20 (33.3)	
III	40 (67.8)	39 (65.0)	
IV	1 (1.7)	0 (0)	

COPD: Chronic obstructive pulmonary disease; ASA: American Society of Anesthesiologists.

Table 2
Operative characteristics during OVHR in case control sample.

Operative Characteristics			
	CST n = 61 (%)	No-CST n = 61 (%)	p-value
Recurrent Hernia	46 (75.4)	40 (65.6)	0.234
Incarcerated	22 (36.7)	25 (41.0)	0.626
Type of Hernia Repaired			1.00
Ventral/Incisional	61 (100)	61 (100)	
Hernia Grade			0.710
1	0 (0)	0 (0)	
2	2 (3.3)	1 (1.6)	
3	51 (83.6)	49 (80.3)	
4	8 (13.1)	11 (18.0)	
CDC Wound Class			0.336
1	0 (0)	0 (0)	
2	40 (65.6)	45 (73.8)	
3	12 (19.7)	7 (11.5)	
4	9 (14.7)	9 (14.7)	
Panniculectomy	32 (52.5)	22 (36.1)	0.068
Average Hernia Defect Size (cm^2)	287.1 ± 150.4	277.6 ± 218.4	0.156
Average Mesh Size (cm^2)	818.3 ± 343.7	786.2 ± 297.1	0.409
Total Operative Time (min)	252.4 ± 87.5	199.1 ± 71.4	<0.001
Estimated Blood Loss (mL)	187.6 ± 142.9	125.3 ± 111.7	0.003

($p = 0.402$). In the CST group, there were 12 patients with multiple wound complications (4 had ACST). There were no intra-abdominal abscesses seen in the study population, and there was one mesh infection in the CST group. In the patients without complete closure, the majority of the fascia was closed, leaving a small defect that was bridged. Overall the rate of recurrence in bridging mesh patients was 16.7%. When examining only patients with fascial closure there was no difference in hernia failure ($p = 0.297$).

A subset analysis was performed for those that were CDC class 2 wounds. Forty-five patients in the No-CST group and 40 patients in the CST group were identified. Synthetic mesh was used in 60% of both groups. There were 4 recurrences in the No-CST group (8.9%) and 2 in the CST group (5.0%), $p = 0.68$. Wound complications were also similar in this group (32.6 vs 40.0%, $p = 0.481$).

Another subset analysis was performed examining patients with CDC class 3 and 4 wounds combined. There were 16 patients in the No-CST group and 21 patients in the CST group. Biologic mesh was utilized in over 85% of cases. There were 3 recurrences in the No-CST group (18.6%) and 1 in the CST group (4.8%), which was in a class 4 wound ($p = 0.287$). Wound complications were found in 56.3% of No-CST patients and 47.7% of CST patients ($p = 0.463$).

Examination based on mesh type was performed. Synthetic mesh was utilized in 30 cases in the No-CST group and 27 cases in the CST group. Synthetic mesh was primarily used in class 2 wounds with 93.1% and 88.9% of synthetic meshes used in class 2 cases respectively. Biologic mesh was used in 31 cases in the No-CST group and 34 in the CST group, and 40.0% of class 2 cases received biologic mesh in both groups. The recurrence rate for synthetic mesh was 13.3% in No-CST and 3.7% in CST ($p = 0.356$), and in biologic mesh was 12.9% versus 5.9% ($p = 0.413$). There was no difference in recurrence between the synthetic and biologic mesh repairs. Wound complications were observed in 35.7% - No-CST and 51.9% - CST when utilizing synthetic mesh ($p = 0.282$). When cases involved biologic mesh the rates of wound complications were 45.2% vs 35.3% ($p = 0.456$).

Quality of life (QoL) is routinely assessed utilizing the Carolinas Comfort Scale (CCS).[27] Both groups of patients had high rates of pre-operative pain (84.2% in No-CST and 80.0% in CST). The use of

Table 3
Outcomes after OVHR in case control sample.

Outcomes	CST n = 61 (%)	No-CST n = 61 (%)	p-value
Length of Stay	8.3 ± 5.0	7.5 ± 4.8	0.206
In-hospital complications			
Acute kidney injury	3 (5.9)	2 (4.6)	0.340
Deep vein thrombosis	1 (1.8)	1 (1.8)	1.000
Pneumonia	1 (1.8)	2 (3.5)	0.618
Pulmonary embolism	0 (0)	0 (0)	1.000
Respiratory insufficiency	3 (5.2)	1 (1.8)	0.618
Wound Complications	26 (42.6)	24 (40.7)	0.829
Seroma requiring intervention	6 (9.8)	12 (19.7)	0.692
Superficial wound breakdown	17 (27.9)	6 (9.8)	0.011
Wound cellulitis	5 (8.2)	4 (6.6)	0.257
Wound infection	12 (19.7)	11 (18.0)	0.270
Fascial dehiscence	0 (0)	1 (1.6)	1.000
Fistula	1 (1.9)	0 (0)	0.495
Intra-abdominal Abscess	0 (0)	0 (0)	1.000
Mesh Infection	1 (1.7)	0 (0)	1.000
Readmission (30 days)	13 (21.7)	11 (18.3)	0.648
Operative Charges (USD)	20813.1 ± 10297.0	17490.3 ± 10608.0	0.083
Total Hospital Charges (USD)	104061.5 ± 62759.4	93201.3 ± 65327.8	0.240
Hernia Recurrence	3 (4.9)	8 (13.1)	0.114
Average Follow-up (months)	16.7 ± 20.8	23.8 ± 24.2	0.074
Mortality	0 (0)	1 (1.8)	0.496

CST did not negatively impact QoL. There were no differences in ideal QoL at both short (2–4 weeks) and long term follow up (2 years) with increasing rates of ideal quality of life over time in both groups.

Discussion

This study examined patients undergoing open ventral hernia repair in a contaminated setting and compared outcomes based on performance of CST. This allowed for applicable comparisons in AWR in the setting of CDC class 2, 3, and 4 wounds. The two groups identified have similar pre-operative characteristics with few exceptions, which were limited to COPD and the mean number of previous VHRs. The CST and No-CST groups had very similar hernias, including an equal number of patients in the various wound classes, very similar defect sizes, and equivalent number of patients with recurrent hernias. The mesh types and sizes of the mesh utilized for the repair were equal, and they were all placed in the preperitoneal space. The current study demonstrated that the addition of a CST in contaminated cases did not negatively impact complications or recurrence rates and would be appropriate for use in these complex patients. With an average of 20 months of follow-up, the AWR recurrence rate was 9% in these large contaminated hernias. Indeed, the patients undergoing a CST had a recurrence rate of 4.9%. Indeed, the use of CST in these large complex hernias also did not negatively impact patient quality of life at 6 months and 2 years of follow-up.

Recurrence has been the traditional outcomes measure for VHR given that permanent abdominal wall re-approximation is the goal of most of these procedures. Recurrences are costly both to patients and the health care system and drive up the incidence of complications and failures in future repair operations.[1,28,29] The impact of fascial closure as a key element in AWR, as opposed to a bridging mesh, has been studied. In a recent meta-analysis, Holihan et al. examined CST versus a bridging mesh repair and demonstrated that CST was associated with a significant decrease in recurrence rates.[7] In a more recent study examining 775 CSTs, the authors of the current study demonstrated that midline approximation resulted in more than a 5-fold reduction in hernia recurrence (16.1% versus 2.5%) in large defects.[13] These data have been confirmed by others with fascial closure being a predominant factor impacting failure following a mesh-based repair.[3,23] Fascial closure has also been shown to be associated with a reduction in overall wound complications and mesh infection.[5,13]

Wound complications are a predictor of hernia recurrence. Surgical site occurrences (SSO) increase the risk of AWR failure by greater than 3 fold.[21,23,30] Perhaps the greatest challenge in operations employing CST, especially ACST with large skin and subcutaneous flap dissection, is the increased risk of wound dehiscence, seroma and infection.[12,23] The generation of large subcutaneous flaps may devascularize skin and subcutaneous tissue, and allows space for fluid to accumulate. In a systematic review by *Cornette* et al., they found a SSO rate of 33.4%.[31] The perceived rate of wound complications has been one of the driving forces for the acceptance of the PCST. In a study of anterior versus PCST, there was a higher wound complication rate in the ACST group (48.2% vs 25.5%),[32] which was supported by a large, inclusive CST study (42.9% versus 31.2%).[13] However, in these patients, the ACST hernia defects were markedly larger and more panniculectomies, which may add to the wound complexity. The current study found no difference in ACST to PCST, which may have been secondary to contributions of the contaminated wound class of all patients. This may have led to a higher complication rate in general, which may mask the issues caused by skin flaps. This may have also been impacted by the size of the study sample.

Given 1) the increase in wound complications in AWR when using a CST to close the abdomen; 2) that patients described in the current study have contaminated, high risk wounds and large hernias; and 3) that wound complications increase AWR failure, surgeons might make the case to forego a CST in these cases and simply perform a bridging biologic or absorbable synthetic mesh repair or close the skin over the hernia and plan for a hernia recurrence. This would allow the surgeon to “come back to fight again another day” and allow the use of a CST, which is difficult to do a second time, for the next operation. While this is supportable, the incidence of fistula formation can be as high as 22% with the use of an absorbable synthetic, such as vicryl, when it is placed in contact with the bowel. This may also allows for the formation of a larger, often massive abdominal wall defect.[33,34] Indeed, of those patients who present with a contaminated hernia and had an operation allowing the formation of a deliberate hernia requiring reoperation, there is little data documenting how many of those patients will return for another AWR. In a recent study examining 78 mesh fistula patients, of those patients with a planned re-repair of their hernia, only 34% of the patients consented for the definitive repair. Two-thirds chose to live with the on-going issues of a recurrent hernia rather than have another attempt at AWR.[35] Given this information combined with the outcomes of this study, the use of a mesh repair and CST in contaminated cases should be at least considered. It should be stressed that mesh selection should be strongly deliberated, and that placement of a permanent synthetic mesh in a Class 3 or 4 wound might result in a marked increase in mesh infection.[36]

In an effort to decrease the incidence of wound complications, the authors began to perform a "VAC-assisted" delayed primary closure (DPC) of the abdominal subcutaneous tissues and skin in contaminated cases, starting in 2008. In 87 cases, a VAC was placed at the time of surgery, changed every 2 days, and the wound was debrided as needed and closed in the operating room over drains an average of 5.4 days post-operatively. This was typically just prior to discharge. The patients were highly comorbid with contaminated wounds with an estimated wound complication rate of 68.4% according the CeDAR app.[37] The overall failure rate of DPC was 9.3%. This outcome compares to sending patients home with a VAC dressing where the wounds took an average of 129 days to heal. In the current study, DPC was used in 31.6% of patients in the CST group and 26.9% of patients in the No-CST group. The use of VAC-assisted DPC may be one way to aid in the prevention of complications and subsequent failure in complex or contaminated AWR.

As our population appears to continue to grow increasingly more comorbid, the ability to counsel patients and optimize them for surgery has become a priority in the authors' hernia center. These include not operating on active smokers by open techniques, decreasing HgbA1C in diabetic patients to 7.2 or less, and encouraging patients with a BMI of 30 or greater to lose weight.[13,23] We have also instituted operative changes, such as DPC, as described above, and the use of perforator sparing ACST and PCST instead of ACST when possible. Since 2013, the combination of these factors has resulted in a decrease in overall complications by 50% and recurrence by more than 60% when all open hernia repairs were examined. This is despite an overall increase in the size of the hernia defects during that time.[13,37]

Limitations of this study include the small sample size in the No-CST group. This does leave the chance for a Type II error in this study. While the defect sizes were equal, an inherent assumption could be made that the patients in the CST group had greater loss of abdominal domain or abdominal wall stiffness and thus required a musculo-fascial advancement flap to reapproximate the linea alba.[38] However, we were able to provide a quite similar match for the majority of the No-CST patients within the CST group in order to generate cohorts for comparison. While recurrence data was not significantly different, longer follow-up time could change these findings.

Conclusions

The use of CST in the face of contamination is not associated with an increase in wound complications, mesh infection, or recurrence. These results demonstrate that the use of CST in contaminated fields during preperitoneal open ventral hernia repair is safe and effective.

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Declaration of competing interest

Drs. Maloney, Oma, Schlosser, and Sing have nothing to disclose. Ms. Prasad has nothing to disclose. Dr. Kercher is on the speakers' bureau at Bard, Ethicon, and W.L. Gore.

Dr. Colavita is on the speakers' bureau at Allergan.

Dr. Augenstein is on the speakers' bureau at Allergan, Intuitive, Acelity, and W.L. Gore.

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