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Reconstructive

Concurrent Panniculectomy With Abdominal Wall Reconstruction: A Propensity-scored Matched Study of Quality Improvement Outcomes

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Background: Concurrent panniculectomy with abdominal wall reconstruction (CP-AWR) as a single-stage operation has reported increased complications, but constant quality improvement can improve results. This study describes outcomes for 21 years, impacted by evidence-based-practice changes.

Methods: Prospectively maintained database was reviewed for CP-AWR and separated by surgery date: "early" (2002–2016) and "recent" (2017–2023). A 1:1 propensity-scored matching was performed based on age, tobacco use, body mass index (BMI), American Society of Anesthesiologists (ASA) score, wound class, and defect size.

Results: Of 701 CP-AWRs, 196 pairs matched. Match criteria were not significantly different between early and recent groups, except for BMI (34.6 ± 7.2 versus 32.1 ± 6.01 kg/m^2; $P = 0.001$). Groups were comparable in sex and diabetes, but recent patients had fewer recurrent hernias (71.4% versus 56.1%; $P = 0.002$). Recent patients had more biologic (21.9% versus 49.0%; $P < 0.001$) and preperitoneal mesh (87.2% versus 97.4%; $P = 0.005$). Readmission and reoperation did not significantly differ, but length of stay (8.3 ± 6.7 versus 6.5 ± 3.4 d; $P = 0.001$) and wound complications decreased over time (50.5% versus 25.0%; $P < 0.001$). Hernia recurrence rates improved (6.6% versus 1.5%; $P = 0.019$), but follow-up was shorter (50.9 ± 52.8 versus 22.9 ± 22.6 months; $P < 0.0001$).

Conclusions: Despite patient complexity, outcomes of CP-AWR improved with implementation of evidence-based-practice changes in preoperative optimization, intraoperative technique, and postoperative care. This large dataset demonstrates the safety of a single-stage repair that should be part of hernia surgeons' repertoire.
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INTRODUCTION

Performing a concurrent panniculectomy with abdominal wall reconstruction (CP-AWR), which has been considered to increase complications,[1–3] improves hygiene; alleviates panniculitis; allows for better operative exposure; removes redundant, poorly perfused skin; offloads the weight putting undue tension on the hernia repair; and combines 2 procedures into 1 anesthetic load.[3–6] Prior work from this institution demonstrated that of patients who underwent abdominal wall reconstruction (AWR) via laparotomy after being denied panniculectomy by insurance, 71% developed cellulitis under their pannus and 14% required salvage panniculectomy secondary to wound complications or chronic seroma.[7] As such, removing excess pannus is not exclusively cosmetic but is frequently medically appropriate for a durable repair.[5,8,9]

However, panniculectomy, whether performed as a concurrent procedure or not, has historical drawbacks such as increased operative time and higher rates of postoperative complications, particularly wound morbidity.[2]

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Detractors argue that concurrent panniculectomy is associated with an unacceptable risk of wound complications, which is quoted as high as 20%–40% in some literature.[4,10,11] In our own initial CP-AWR cohort from 2007 to 2018, rate of seroma requiring intervention was 20% and superficial wound breakdown was 24%,[5] whereas other studies determined that the benefits outweigh the risk of CP-AWR.[1–3,12–14] CP-AWR did not impair quality of life (QOL) and may actually enhance patient satisfaction.[5,13,15–17] When individual surgical site occurrences (SSO) are examined, the associated morbidity is often limited and may be outweighed by the improved recurrence rates seen in some patients who underwent CP-AWR.[5,9] This leads many to conclude that wound morbidity is inherent to the panniculectomy, and this patient population thus should not preclude a concurrent hernia repair.[8,18]

In a pursuit of continuous quality improvement and improved hernia care, the Carolinas Hernia Center has adopted numerous evidence-based practice changes for the past 21 years as a result of recurring, self-examination of our outcomes.[19–22] The principles of panniculectomy have remained largely consistent over this timeframe, but our evidence-based directives in preoperative optimization, perioperative management, and postoperative complication prevention, as outlined in Figure 1, have improved abdominal wall reconstruction (AWR) outcomes and may have impacted panniculectomy outcomes too.[19] This study intended to provide a general institutional overview of the effect of these evidence-based changes on CP-AWR outcomes for the last 21 years.

Takeaways

Question: Have evidence-based practice changes and quality improvement initiatives at a tertiary hernia center improved outcomes after concurrent panniculectomy and abdominal wall reconstruction?

Findings: This observational study demonstrated that implementation of evidence-based practice changes in preoperative optimization, intraoperative technique, and postoperative care improved outcomes after concurrent panniculectomy and abdominal wall reconstruction over the last 21 years. Specifically, length of stay, wound complications, and hernia recurrence decreased over time.

Meaning: The implementation of evidence-based practice changes and continuous quality improvement improved outcomes and made concurrent panniculectomy with abdominal wall reconstruction a safe single operation.

METHODS

Evidence-based Practice Changes

The evidence-based practice changes have included preoperative, intraoperative, and postoperative measures since the inception of the Carolinas Hernia Center. Most of these have been previously described.[19]

Preoperatively, "prehabilitation" and patient optimization have been implemented to improve abdominal wall reconstruction (AWR) outcomes, as demonstrated in our work and others'.[23,24] In 2006, smoking cessation was required for 4 weeks before surgery.[18] More recently, our group has demonstrated that smoking cessation negated the increased risk of tobacco use and lowered the risk of wound complications to that of never smokers.[25] In 2010, weight loss was strongly encouraged for obese patients with body mass index (BMI) more than 35 kg/m^2 with data demonstrating that every point of BMI, down to 26 kg/m^2, decreased the incidence of wound complications. In an ongoing study of 256 patients with obesity, preoperative weight loss averaged 26 lbs per patient. In 2012, glucose control in patients with diabetes before surgery was implemented with a target hemoglobin A1c less than 7.2%.[23,24,26]

In 2019, a review of penicillin-allergic patients demonstrated higher rates of surgical site infection (SSI), readmission, and hernia recurrence with non-beta-lactam antibiotic prophylaxis when compared with first-line beta-lactam prophylaxis.[27] In response, a penicillin allergy protocol was instituted that stratified patients' risk of anaphylaxis, which led to an increase in first-line antibiotic administration and an associated decrease in SSI in patients allergic to penicillin. In 2020, a partnership was established with geriatric medicine to provide comprehensive evaluations, assist in preoperative counseling, and manage geriatric-specific risks.[28] Aside from preoperative optimization, a practice shift in 2015 included the use of preoperative abdominal wall botulinum toxin A injections to facilitate tension-free fascial closure, potentially avoid the need for a component separation or a bridging repair, and decrease wound complications.[29–31]

Intraoperatively, the preperitoneal hernia technique benefits wider mesh overlap and excludes the viscera from the prosthetic mesh implant.[18,32] In 2011, vacuum-assisted negative-pressure wound therapy followed by operative delayed primary closure was implemented for patients with high infectious complication risk to decrease wound complications.[33] In moving away from synthetic mesh in Centers for Disease Control and Prevention (CDC) class III–IV wounds and other high-risk patients, the use of biologic mesh has decreased mesh infection rates to less than 1%.[34–37] In 2017, a closing tray protocol was adapted to abdominal wall reconstruction (AWR), which demonstrated a decrease in wound complications by 67% on time series analysis.

Postoperatively, in 2018, the use of closed incision negative-pressure therapy further decreased wound complications, particularly in patients who underwent CP-AWR.[38] See Figure 1 for timeline of evidence-based practice changes.

Study Design and Patient Selection

After this study was approved by the institutional review board (IRB00083110), a prospectively maintained institutional database was queried for all patients who underwent CP-AWR between September 2002 and May 2023 at a high-volume tertiary referral hernia center. Written consent

Year	Practice Change
2006	Smoking cessation >4 weeks before surgery - Part of this institution's preoperative optimization program to improve patient risk factors for complications
2010	Preoperative weight loss - Part of this institution's preoperative optimization program to improve patient risk factors for complications
2010	Remove deep fascial drain at discharge - An effort to decrease the exposure of mesh to improve mesh infection risk
2011	Vacuum-assisted delayed primary closure - Another effort to decrease wound complications and surgical site infections
2011	Full mesh excision for infected mesh - Efforts to excise the entire infected mesh outweighed the risk of leaving pieces of infected mesh within the abdominal wall
2012	Glucose optimization to HbA1c <7.2 - Part of this institution's preoperative optimization program to improve patient risk factors for complications
2013	Elimination of synthetic mesh in CDCIII-IV - Use of biologic mesh in complex cases further decreased wound complications in contaminated and dirty cases
2013	CeDAR app to estimate cost of complications - Mobile app that calculates patients' risk of complications and associated cost 1-year postop based on comorbidities
2013	Elimination of lightweight mesh in the ventral abdomen - Data demonstrated unacceptably high rates of mesh fracture and hernia recurrence with lightweight mesh
2015	Perforator-sparing anterior CST - Efforts to decrease wound complications by preserving perfusion to subcutaneous flaps
2016	Closing tray protocol - Antibiotic irrigation, exchanging of instruments, gloves, and new drapes decreased infectious and wound complications
2016	Botulinum toxin A injections - Chemical denervation facilitates fascial closure, avoids possible component separation, decreases wound complications
2017	TAP blocks with liposomal bupivacaine - Long-lasting local anesthetic improved postoperative pain and decreased need for opioid pain medications
2018	Closed-incision negative pressure wound therapy - Routine skin vac therapy further decreased wound complication rates, particularly in panniculectomy patients
2018	Patient opioid education program - Increased patient education, counseling that decreased postoperative opioid use and improved multimodal pain regimen
2019	Penicillin allergy protocol - Stratified patients' allergy risk, increased administration of 1st line beta-lactam prophylaxis, decreased surgical site infection
2019	Vacuum-assisted French-fry technique - Modified negative pressure wound vac closure for high-risk patients with history of wound infections, mesh infections
2020	Geriatric service partnership - Geriatricians attend the abdominal wall reconstruction clinic to provide comprehensive preoperative evaluation, counseling

*AWR: abdominal wall reconstruction; HbA1c: hemoglobin A1c; CeDAR: Carolinas Equation for Determining Associated Risks; CST: component separation techniques; TAP: transversus abdominis plane

Fig. 1. Timeline of evidence-based practice changes at Carolinas Medical Center.

was obtained from all patients or relevant persons before enrollment in the database preoperatively, and their outcomes were tracked and documented by trained research analysts retrospectively. Attending surgeons do not have access to the data to prevent any bias in the data entry. All patients were operated on by surgeons affiliated with Carolinas Laparoscopic and Advanced Surgery Program. This study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology Reporting guidelines.[39]

Patients were stratified by surgery date into the "early" group from 2002 to 2016 and "recent" group from 2017 to 2023. The cutoff date was determined by the evidence-based practice changes that had been implemented up to that point. The date was also determined by the transition from primarily plastic surgeon performed panniculectomies to abdominal wall reconstruction (AWR) surgeon performed panniculectomies after adequate training and observation by plastic surgery. Abdominal wall reconstruction (AWR) surgeons were general surgeons who were fellowship trained in minimally invasive surgery and abdominal wall reconstruction. Patient demographics, preoperative clinical information, operative details, and postoperative outcomes were reported. The primary outcome was the incidence of wound complications, which included cellulitis, wound infection, wound breakdown, seroma requiring intervention, and hematoma.

Propensity Matching

Propensity-scored matching was performed to compare CP-AWR patients in the early and recent groups. This

Table 1. Demographic and Clinical Information of CP-AWR Propensity-scored Match

	Early: 2002–2016 (n = 196)	Recent: 2017–2023 (n = 196)	*P*
Age (ye)*	57.6 ± 11.4	57.4 ± 11.6	0.975
Female	150 (76.5)	143 (73.0)	0.416
Race			**0.002**
White	179 (91.3)	155 (79.1)	
African American	13 (6.6)	33 (16.8%)	
Other races	4 (2.0)	8 (4.1)	
Tobacco use*			>0.999
Never smoker	121 (61.7)	121 (61.7)	
Former smoker	66 (33.7)	66 (33.7)	
Current smoker	9 (4.6)	9 (4.6)	
COPD	16 (8.2)	15 (7.7)	0.852
BMI (kg/m^2)*	34.6 ± 7.2	32.1 ± 6.0	**0.001**
Diabetes	70 (35.7)	59 (30.1)	0.237
No. comorbidities	4.6 ± 2.3	5.0 ± 2.5	0.142
ASA score*			0.407
I	1 (0.5)	4 (2.0)	
II	64 (32.7)	53 (27.0)	
III	125 (63.8)	133 (67.9)	
IV	6 (3.1)	6 (3.1)	
Wound class*			>0.999
Clean	137 (69.9)	137 (69.9)	
Clean-contaminated	25 (12.8)	25 (12.8)	
Contaminated	24 (12.2)	24 (12.2)	
Dirty-infected	10 (5.1)	10 (5.1)	
Recurrent hernia	140 (71.4)	110 (56.1)	**0.001**
Defect size (cm^2)*	264.4 ± 260.4	272.2 ± 207.5	0.301

Values in boldface indicate statistical significance.
Data are presented as n (%) or mean (±SD).
*Propensity-scored match criteria.
COPD: chronic obstructive pulmonary disease.

generated a 1:1 ratio match based on age, tobacco use, BMI, American Society of Anesthesiologists (ASA) score, CDC wound classification, and defect size. Tobacco use and wound class were exact matches.

Statistical Analysis

Early and recent patients and their outcomes were compared in a retrospective cohort study and institutional review. Data were analyzed by a trained statistician using Statistical Analysis Software (SAS Version 9.4). Descriptive data were reported using frequency and percentage for categorical variables and mean and SD for continuous variables. Pearson chi-square and Fisher exact tests were applied to compare categorical variables, and Kruskal-Wallis test was utilized to compare continuous variables. Multivariable logistic regression was also performed to identify independent predictors of wound complications. Statistical significance was set at a *P* value less than 0.05, and reported *P* values are 2-tailed.

RESULTS

Propensity-scored Match

Of 701 total patients with CP-AWR, there were 436 patients in the early group and 236 in the recent group; 196 patients were matched per group, and outcomes were reported as early versus recent. Match criteria, including age (57.6 ± 11.4 versus 57.4 ± 11.6 y; $P = 0.975$), tobacco use (4.6% versus 4.6% active smokers; $P > 0.999$), ASA score (63.8% versus 67.9% ASA III; $P = 0.407$), wound class (69.6% versus 69.9% clean; $P > 0.999$), and defect size (264.4 ± 260.4 versus 272.2 ± 207.5 cm^2; $P = 0.301$) were not significantly different between early and recent groups, respectively; however, recent patients had a lower average BMI (34.6 ± 7.2 versus 32.1 ± 6.01 kg/m^2; $P = 0.001$). Early versus recent groups were comparable in sex (76.5% versus 73.0% female; $P = 0.416$) and diabetes (35.7% versus 30.1%; $P = 0.237$), but the recent group had more African American patients (6.6% versus 16.8%; $P = 0.002$) and fewer recurrent hernias (71.4% versus 56.1%; $P = 0.002$). See Table 1 for match criteria and demographic results.

Intraoperative techniques differed somewhat between groups. Recent patients had more biologic (21.9% versus 49.0%; $P < 0.001$) and preperitoneal mesh (87.2% versus 97.4%; $P = 0.005$). Biologic mesh was chosen for patients with CDC II–IV wounds, those at greater risk of infectious complications, and often in patients requiring long-term immunosuppression. Fascial closure rates increased over time (94.9% versus 99.5%; $P = 0.006$), whereas operative time decreased (220.8 ± 83.0 versus 170.8 ± 69.0 min; $P < 0.001$). There was no statistical difference in the rate of component separation (42.9% versus 37.8%; $P = 0.284$) or delayed primary closure (6.6% versus 9.2%; $P = 0.349$). See Table 2 for full analysis.

Table 2. Intraoperative Details and Postoperative Outcomes of CP-AWR Propensity-Scored Match Analysis

	Early: 2002–2016 (n = 196)	Recent: 2017–2023 (n = 196)	P
	Intraoperative details		
Mesh type			**<0.001**
Synthetic	152 (77.6)	100 (51.0)	
Biologic	43 (21.9)	96 (49.0)	
No mesh	1 (0.5)	0 (0.0)	
Mesh location			**0.005**
Preperitoneal	171 (87.2)	191 (97.4)	
Retrorectus	8 (4.1)	4 (2.0)	
Intraperitoneal	11 (5.6)	1 (0.5)	
Onlay	2 (1.0)	0 (0.0)	
Inlay	2 (1.0)	0 (0.0)	
Component separation	84 (42.9)	74 (37.8)	0.284
Fascial closure	186 (94.9)	195 (99.5)	**0.006**
Delayed primary closure	13 (6.6)	18 (9.2)	0.349
Operative time (min)	220.8 ± 83.0	170.8 ± 69.0	**<0.001**
	Postoperative outcomes		
Transfers to ICU	38 (19.4)	25 (12.8)	0.067
Length of stay (d)	8.3 ± 6.7	6.5 ± 3.4	**0.001**
Total hospital charges (USD)	$89,810 ± 81,974	$105,235 ± 71,020	**<0.001**
Overall wound complications*	99 (50.5)	49 (25.0)	**<0.001**
Cellulitis	31 (15.8)	15 (7.7)	**0.012**
Wound infection	44 (22.4)	13 (6.6)	**<0.001**
Wound breakdown	43 (21.9)	10 (5.1)	**<0.001**
Seroma requiring intervention	39 (19.9)	19 (9.7)	**0.004**
Hematoma	9 (4.6)	12 (6.1)	0.501
Mesh infection	5 (2.6)	1 (0.5)	0.215
Intraabdominal abscess	14 (7.1)	9 (4.6)	0.283
Enterocutaneous fistula	5 (2.6)	2 (1.0)	0.449
Reoperation	6 (3.1)	4 (2.0)	0.751
Readmission	32 (16.3)	29 (14.8)	0.741
Recurrence	13 (6.6)	3 (1.5)	**0.019**
Follow-up (mo)	50.9 ± 52.8	22.9 ± 22.6	**<0.001**

Values in boldface indicate statistical significance.
ICU, intensive care unit; USD, US Dollar.
Data are presented as n (%) or mean (±SD).
*Overall wound complications: cellulitis, wound infection, breakdown, seroma, and hematoma.

Postoperatively, there was no difference in the number of patients transferred to the intensive care unit (19.4% versus 12.8%; $P = 0.067$), but length of stay decreased in the recent group (8.3 ± 6.7 versus 6.5 ± 3.4; $P = 0.001$). Overall wound complications decreased over time (50.5% versus 25.0%; $P < 0.001$), as did individual wound complications such as cellulitis (15.8% versus 7.7%; $P = 0.012$), wound infection (22.4% versus 6.6%; $P < 0.001$), wound breakdown (21.9% versus 5.1%; $P < 0.001$), and seroma requiring intervention (19.9% versus 9.7%; $P = 0.004$). Readmission (16.3% versus 14.8%; $P = 0.741$) and reoperation (3.1% versus 2.0%; $P = 0.751$) did not differ between early and recent groups, but hernia recurrence rates improved over time (6.6% versus 1.5%; $P = 0.019$). As expected, follow-up was shorter in the recent group (50.9 ± 52.8 versus 22.9 ± 22.6 mo; $P < 0.001$) (Table 2). See Figures 2 and 3 for preoperative and postoperative photographs. As an institutional review, see **Supplemental Digital Content 1** for data on the entire CP-AWR cohort over time (**http://links.lww.com/PRSGO/D696**).

Multivariable Logistic Regression

A multivariable logistic regression for wound complications was performed. When controlling for BMI, tobacco use, wound class, component separation, delayed primary closure, mesh location, and operative time, only diabetes (odds ratio = 2.098, 95% confidence interval: 1.310–3.360; $P = 0.002$) and early group classification (odds ratio = 2.543, 95% confidence interval: 1.576–4.103; $P < 0.001$) were independent predictors of wound complications. See Table 3 for full analysis.

DISCUSSION

For 21 years of continuous quality improvement, outcomes after CP-AWR have improved and demonstrated the safety of performing a single-stage operation. This institutional review, consisting of 196 propensity matched pairs, found decreased length of stay as well as a decrease in overall wound complications by almost 50%. Specifically, 55% of the early and 25% of the recent patients experienced wound complications with continued downward trajectory over time. Furthermore, individual wound complications, such as cellulitis, wound infection, wound breakdown, and seroma, requiring intervention decreased by as many as 4 times, and recurrence rates statistically improved from 6.6% to 1.5%.

Over time, measures put into place not only improved wound complications in our patients who underwent

Fig. 2. Preoperative and postoperative images of a CP-AWR patient. A, Preoperative clinic photograph taken from the patient's side. B, Preoperative clinic photograph taken from the patient's front. C, Postoperative follow-up clinic photograph taken from the patient's front. D–E, Postoperative follow-up clinic photographs taken from the patient’s sides.

abdominal wall reconstruction (AWR) but also those who underwent concomitant panniculectomy. Over the course of the study period, patients remained complex, as demonstrated by their obesity, large hernia defect size, high rate of prior failed hernia repairs, use of component separation, and necessary measures to combat infectious complications postoperatively. Yet, despite these risk factors, patients had low rates of wound morbidity and postoperative complications.

These data additionally straddled other published cohorts. In their 2017 article, Giordano et al[3] described 27.6% of CP-AWR patients with SSO, 19.3% with dehiscence, 3.7% with seroma, and 9.9% requiring reoperation, whereas in their 2019 study, Hutchison et al[16] described 29% of patients who underwent CP-AWR with SSO, and a meta-analysis concluded a 27.9% rate of SSO after CP-AWR.[10] Although other literature suggested a significant increase in QOL measures after panniculectomy, historically, surgeons were reluctant to offer concomitant panniculectomy due to the fear of wound complications and resultant risk of hernia repair failure.[13,15–17,40–42] Through our institution’s data, we documented a 5.5 times increased risk of hernia recurrence in those patients with wound complications.[43] Thus, risk reduction is both beneficial and necessary for patients to have a durable outcome.

Traditionally, the longer incision, larger dissection, ligation of deep epigastric perforators, and increased dead space of the panniculectomy was thought to increase wound complications. As a result, both plastic and general surgeons have sought data to understand the safety of CP-AWR.[2,3,12–14] In a single-institutional study, the rate of overall SSO was significantly higher in patients who underwent CP-AWR

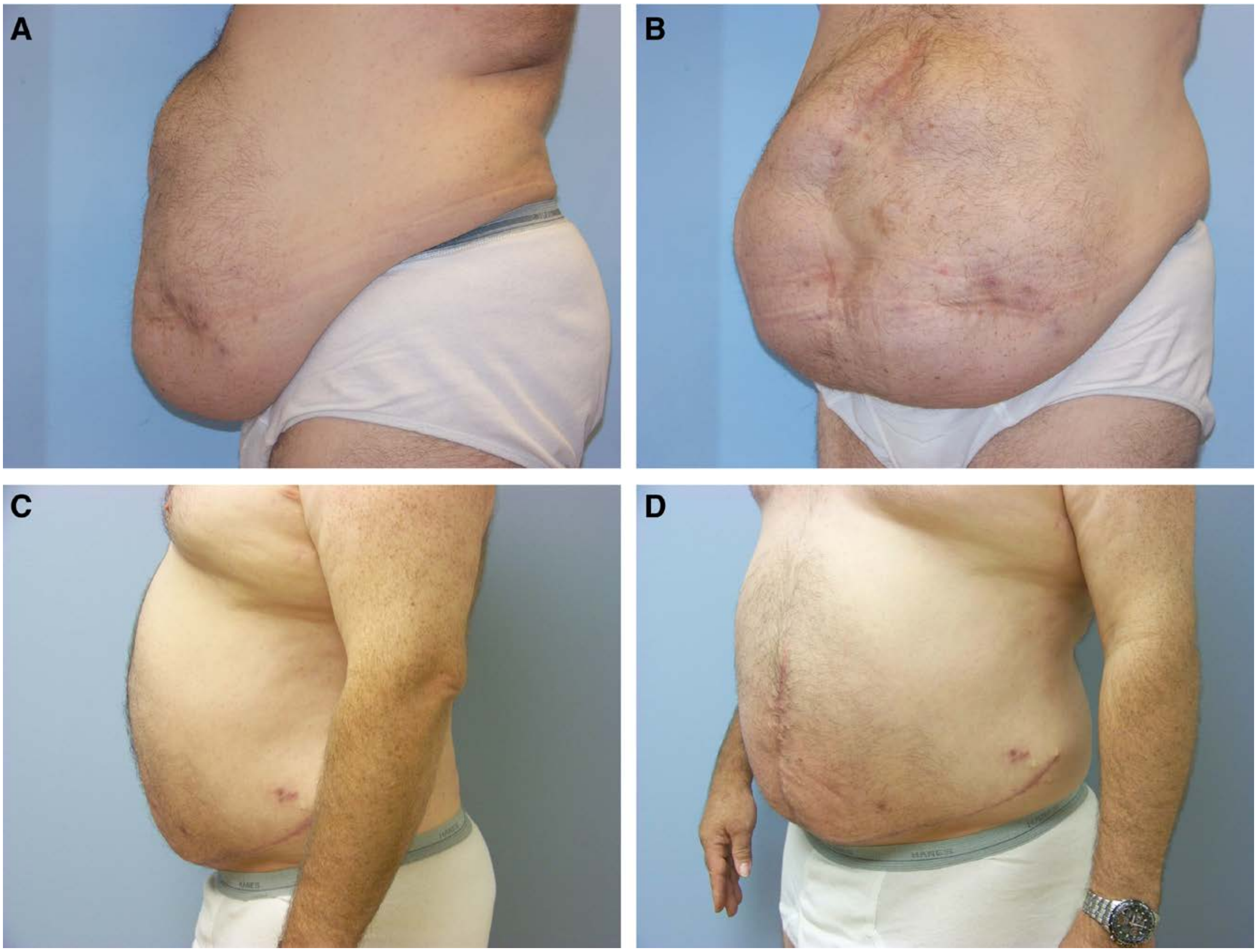

Fig. 3. Preoperative and postoperative images of a CP-AWR patient. A–B, Preoperative clinic photographs taken from the patient's side and front. B–C, Postoperative follow-up clinic photographs taken from the patient's side and front.

Table 3. Multivariable Regression for Wound Complications in Patients Who Underwent CP-AWR

	OR	95% CI	*P*
Early vs recent	2.543	1.576–4.103	**<0.001**
BMI (kg/m^2)	1.017	0.982–1.053	0.352
Diabetes	2.098	1.310–3.360	**0.002**
Smoking status			
Never		Reference	
Former	0.736	0.450–1.203	0.236
Current	1.213	0.416–3.534	0.521
Wound class			
Clean		Reference	
Clean-contaminated	0.856	0.410–1.787	0.172
Contaminated	1.437	0.666–3.099	0.747
Dirty/infected	2.356	0.799–6.951	0.145
Component separation	1.009	0.626–1.628	0.969
Delayed primary closure	1.858	0.740–4.665	0.187
Mesh location			
Preperitoneal		Reference	
Retrorectus	0.909	0.253–3.267	0.237
Intraperitoneal	1.706	0.478–6.093	0.721
Onlay	7.829	0.181–338.846	0.431
Inlay	4.562	0.102–204.246	0.656
Operative time	1.001	0.998–1.005	0.378

Values in boldface indicate statistical significance.
CI, confidence interval; OR, odds ratio.

compared with ventral hernia repair alone; however, when stratified, individual SSO rates and SSI rates were not significantly worse with CP-AWR.[14] Interestingly, in a study comparing CP-AWR to panniculectomy alone rather than hernia repair alone, wound complication rates were not statistically different. This redemonstrated an inherent risk with panniculectomy that is not exacerbated by concurrent hernia repair, suggesting that there is no benefit to performing the procedures separately.[4] In a randomized controlled trial where patients were randomized to isolated incisional hernia repair or CP-AWR, the concomitant procedure expectedly required longer operative time, but again there were no differences in early or late morbidity, which were defined as seroma, skin necrosis, wound infections, or pain after 6 months, umbilical stenosis, and hernia recurrence with 1 year of follow-up.[41] In our own prior work, overall wound occurrence in CP-AWR reached 44.6%, which was statistically higher than abdominal wall reconstruction (AWR) alone patients, but individually, only rate of superficial wound breakdown was significantly increased with panniculectomy.[5]

Within this institution, continuous evaluation has resulted in constant quality improvement in both our patients who underwent abdominal wall reconstruction (AWR) and CP-AWR. Our group has published on many of these changes. Particularly, these included preoperative optimization, including smoking cessation; glucose control; weight loss; changes in our intraoperative technique, which largely consisted of moving towards preperitoneal mesh placement; implementing the penicillin allergy and closing tray protocols; and improved postoperative management such as the use of closed incision negative-pressure therapy.

Patient optimization has been the predominant and most successful impact on abdominal wall reconstruction (AWR) outcomes. Well documented in the literature, increasing BMI and other preventable comorbidities have a strong correlation with operative time, wound complications, and eventual hernia recurrence.[35,44–46] At our institution, advancements in patient "prehabilitation" have successfully mitigated these risks conferred by tobacco use, uncontrolled diabetes, and obesity. In our 2006 study of preperitoneal ventral hernia repairs, smoking was the leading predictive factor in wound complications, but this study evidenced a loss of significance for these variables on regression analysis of the recent cohort.[18] In addition to controlling diabetes and elimination of smoking, our hernia center has recommended preoperative weight loss for patients with obesity since its inception.[47] Frequently, there is large overlap between patients with complex abdominal wall hernias and obesity.[48] Within our own patient population, during the course of 18 years, the mean BMI of complex open preperitoneal hernia repairs was 32.8 ± 7.6 kg/m^2.[19] Indeed, for every point of BMI greater than 26 kg/m^2, there is an increase in wound-related complications by 1.006 times, which was again confirmed in the current study.[43] We use the offer of performing a panniculectomy to motivate patients to lose weight. Thus, preoperative weight loss may not only improve patient QOL but also decrease postoperative risk and was sustainable in our patients over 3.5 years of follow-up, in a study pending review. We also transitioned to performing botulinum toxin A injections to decrease the need for further alteration of the abdominal wall and reduce overall wound complications.[31] Intraoperatively, caution is taken to limit subcutaneous flap undermining and preserve perforator vessels if possible. Both a penicillin allergy protocol and closing tray protocol have decreased infectious complications, particularly in this high-risk panniculectomy patient population.[49,50] Finally, utilization of closed incision negative-pressure therapy decreased the risk of postoperative wound complications, particularly superficial wound breakdown, and lessened the need for wound-related reoperation.[38,51,52]

This study intended to provide a broad overview of the effect of evidence-based changes on CP-AWR outcomes, and ultimately, these data supported our continued efforts to decrease wound complications without compromise to hernia recurrence. It is through the cumulation of these interventions that CP-AWR is a safe and effective single-stage repair.

Limitations exist in this study. As this is not a randomized controlled trial, a potential confounder is patient selection over time, making it difficult to compare early and recent groups. As arduous documentation requirements exist for insurance to reimburse the panniculectomy procedure, selection bias may be introduced into this cohort, as only the most obese and comorbid patients are offered panniculectomy. Our goal was to evaluate how practice changes within a single institution have contributed to CP-AWR over time; however, certainly, there are numerous factors which affect outcomes. The benefit of a single institution is a higher degree of homogeneity in perioperative care and hernia repair compared with studies which pool results from multiple studies or hospitals, but the disadvantage is the inability to completely control for confounding, concomitant changes within our practice, as exhibited by the differences in prehabilitation, BMI, and preperitoneal mesh placement between early and recent groups. This limitation was mitigated by the use of multivariable logistic regression, but it is impossible to control for all external influences of SSI in this time period.

CONCLUSIONS

Despite the complexity, implementation of evidence-based interventions and patient prehabilitation has significantly improved wound complications, hernia recurrence, mesh infection, length of stay, and 30-day readmission among patients who underwent CP-AWR for the last 21 years. This large set of patients demonstrates the safety of a single-stage repair that should be part of hernia surgeons' repertoire.

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DISCLOSURES

Dr. Augenstein is a consultant for Medtronic and Vicarious Surgical and is a speaker for Allergan, Bard, and Pacira. Dr. Heniford is a surgical research grant recipient and speaking *honorarium for WL Gore. The other authors have no financial interest to declare in relation to the content of this article.*

PATIENT CONSENT

Patients provided written informed consent to participate in this study and be enrolled in our prospectively maintained database, but no ethics committee meeting was indicated for completion of this study.

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ETHICAL APPROVAL

This study was approved by the institutional review board at Carolinas Medical Center.

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