Hernia (2025) 29:8
https://doi.org/10.1007/s10029-024-03195-6

ORIGINAL ARTICLE

Delayed vs single-staged abdominal wall reconstruction in contaminated ventral hernia

Sara M. Maskal[1] · Raha Al Marzooqi[1] · Ouen Mali[1] · Li-Ching Huang[2] · Ryan C. Ellis[1] · Kimberly Woo[1] · Daphne Remulla[1] · Benjamin T. Miller[1] · Lucas R. A. Beffa[1] · Clayton C. Petro[1] · Ajita S. Prabhu[1] · Michael J. Rosen[1]

Received: 10 August 2024 / Accepted: 13 October 2024

Abstract

Introduction When faced with contaminated ventral hernia repairs, surgeons must decide to repair the defect in a single-stage or delay the definitive repair until a clean scenario has been achieved. We sought to compare wound complications, long-term hernia recurrence and quality of life for patients who underwent delayed versus single-staged abdominal wall reconstruction (AWR) in the setting of clean-contaminated and contaminated wounds.

Methods The Abdominal Core Health Quality Collaborative was used to identify adult patients at our institution who underwent open AWR with retromuscular synthetic mesh placement between January 2014 and August 2023. The delayed group included patients who underwent clean-contaminated or contaminated abdominal operation in the setting of a ventral hernia without placement of permanent synthetic mesh, then underwent AWR with permanent synthetic mesh placement in a separate operation. The single-staged group had clean-contaminated or contaminated wounds concomitant with AWR. Outcomes of the AWR were compared.

Results 63 patients underwent a delayed AWR and 375 patients underwent a single-staged AWR with a median(IQR) follow-up of 3(2,5)years. Most common concomitant procedures involved small intestine(30%) or hepatobiliary(30%). Most common index operations in delayed AWR were ileostomy(52.4%) and colostomy(14.2%) reversals. Median(IQR) time between initial operation and definitive AWR was 1.0 (0.7, 1.9)years. Median(IQR) hernia width was 11.35(8.4, 15.0)cm at initial operation and 16.0(15.0,20.0)cm at AWR for the delayed group($p < 0.001$). Three patients (19%) in the delayed group and 14(12%) in the single-staged underwent wound debridement within 30-days($p = 0.46$); a single patient in each required partial mesh excision within 30-days($p = 0.098$). Wound morbidity, reoperation and hernia recurrence were similar ($p > 0.05$).

Conclusion In patients with a ventral hernia and separate indication for abdominal operation with a clean-contaminated or contaminated wound, either delayed or single-stage approaches to AWR may be viable.

Keywords Abdominal wall reconstruction · Contaminated hernia repair · Synthetic mesh · Staged hernia repair

Introduction

Surgeons frequently encounter patients presenting with a large ventral hernia and a separate indication for a clean-contaminated or contaminated abdominal operation. In these cases, surgeons must choose between performing a single-staged operation to correct both pathologies or addressing the intraabdominal process upfront and returning later to repair the hernia. Historically, definitive repair of a large ventral hernia with permanent synthetic mesh was considered relatively taboo in the setting of wound contamination [1], but there is growing contemporary evidence to support the durability of ventral hernia repair with synthetic mesh in select contaminated cases, though at the cost of significant wound morbidity [2–4]. While staging the hernia repair theoretically decreases the risk of wound morbidity [5, 6], the counterargument is that the hernia may enlarge and become more complex in the interim as well as requiring

✉ Sara M. Maskal
Maskals2@ccf.org

[1] Center for Abdominal Core Health, Cleveland Clinic, 2049 E 100th St, Desk, A-100, Cleveland, OH 44106, USA

[2] Vanderbilt University Medical Center, Nashville, TN, USA

Published online: 16 November 2024

a second operation and convalescence for the patient who had a clean contaminated or contaminated repair.

There is a knowledge gap in the literature comparing a planned delayed approach versus single-staged abdominal wall reconstruction in the setting of clean-contaminated and contaminated cases (CDC class II-III) with regards to patient outcomes, quality of life, recurrence, and cost to the healthcare system. We aim to compare the short- and long-term wound complications, long-term hernia recurrence, total cost of, and quality of life for patients who underwent delayed repair of a ventral hernia versus single-staged repair in the setting of clean-contaminated and contaminated wounds.

Methods

After obtaining Institutional Review Board approval, the Abdominal Core Health Quality Collaborative (ACHQC) database was queried to identify adult patients who underwent open abdominal wall reconstruction (AWR) with transversus abdominis release (TAR) and permanent macroporous synthetic retromuscular mesh placement at our institution between January 2014 and August 2023. The ACHQC is a surgeon-entered, prospectively collected database that includes granular data regarding patient characteristics, operative details, clinical outcomes, and patient reported [7]. Additional chart review of those patients who underwent AWR was used to identify patients who had previously undergone a clean-contaminated or contaminated (CDC class II-III) operation in the setting of a ventral hernia followed by a planned "delayed" AWR, excluding patients with permanent stomas, temporary diverting stomas matured during the initial operation, or permanent mesh placement during the initial operation. Patients who underwent AWR in a single-staged fashion with retromuscular synthetic mesh at the time of a clean-contaminated or contaminated operation were identified as a comparator group. We excluded patients with a permanent stoma as these cases would inevitably remain contaminated in future procedures, CDC class IV wounds, those with a temporary loop stoma as we typically do not reconstruct those patients at the primary operation due to challenges associated with stoma takedown through a retromuscular mesh, and those who were missing follow up at 30 days postoperatively.

Primary outcomes of interest were wound events, including surgical site infection (SSI), surgical site occurrence (SSO), and surgical site occurrence requiring procedural intervention (SSOPI) within 30 days postoperatively of the AWR with synthetic mesh [8]. Secondary outcomes included reoperation, hernia recurrence based on a pragmatic definition, abdominal wall-specific quality of life, and pain, all measured relative to the definitive AWR with synthetic mesh placement for both groups. The pragmatic definition accounts for radiographic, clinical exam, and patient-reported assessments for hernia recurrence. For example, the pragmatic definition considers a patient-reported "bulge" on the Hernia Recurrence Inventory (HRI) as a recurrence, though a negative clinical or radiographic assessment may outweigh this [9]. Abdominal wall-specific quality of life was measured utilizing the HerQLes survey, which is scored from 0 to 100 with higher scores indicating better quality of life and a minimum clinically important difference of 15.6 [10, 11]. Pain was measured using the NIH PROMIS 3a Pain Intensity Scores, which is scored from 30.7 to 71.8 with lower scores indicating less pain and a lowest possible score on the PROMIS 3a scale of 30.7 indicating "no pain" [12]. Direct costs for both the initial surgery and definitive AWR for the delayed group and for the definitive AWR in the single-stage group as well as all associated hospital admissions were obtained from our institution. Our institution does not allow us to publish actual costs; as such, costs are presented as a ratio of the lower cost.

Continuous data was analyzed using Wilcoxon tests and categorical data was analyzed using Pearson tests. A multivariable logistic regression was performed for the outcomes of SSI, SSO, and SSOPI within 30 days accounting for the following covariates: single-staged versus delayed AWR, diabetes, sex, BMI, history of inflammatory bowel disease, and intraoperative complications. Significance was set at $p < 0.05$.

Results

A total of 63 patients who underwent a delayed AWR and 375 patients who underwent a single-staged AWR with clean-contaminated or contaminated wounds were identified (Fig. 1). Median(IQR) age was 61 (52,68) years for the entire cohort. The delayed group had a lower median(IQR) BMI (31[28,34] vs. 33 [29,36], $p = 0.036$), more male patients (56% vs. 41%, $p = 0.035$), fewer patients with diabetes (11% vs. 28%, $p = 0.004$), and had more patients with inflammatory bowel disease (13% vs. 6%, $p = 0.047$). Patient demographics are summarized in Table 1.

Operative details: initial operations in the delayed group

Most ($n = 62$ (98%)) of the initial operations in the delayed group were elective cases and 28 (44.4%) were recorded as clean-contaminated and the rest were contaminated. Index operations for this group included: ileostomy takedown ($n = 33$ (52.4%)), colostomy reversal ($n = 9$ (14.3%)),

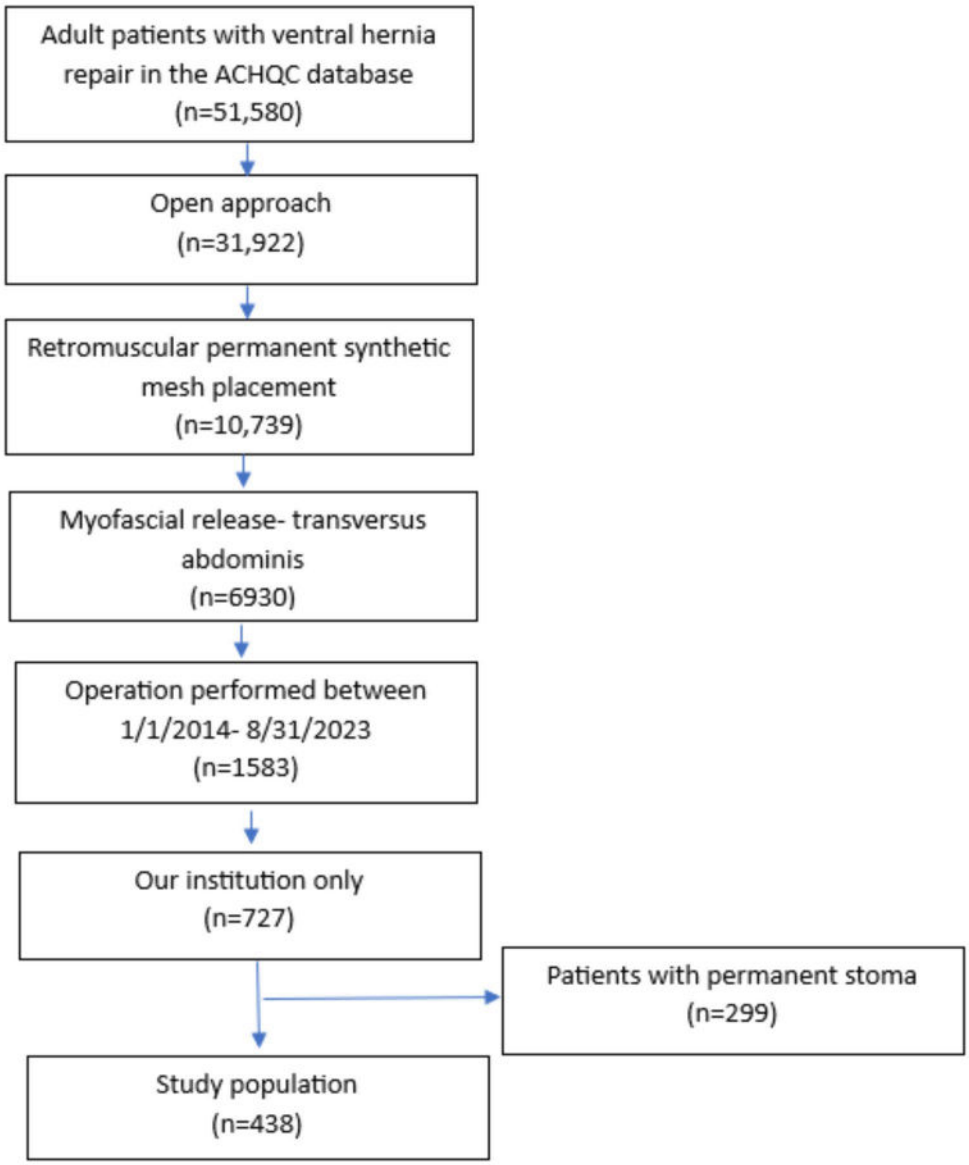

Fig. 1 Diagram of inclusion and exclusion criteria

gastrointestinal/genitourinary fistula takedown ($n=6$ (9.52%)), bowel/colon resection ($n=4$ (6.35%)), hernia repair aborted for enterotomy ($n=4$ (6.35%)), foregut anastomosis ($n=2$ (3.17%)), and foreign body removal ($n=2$ (3.17%)). Median (IQR) time between initial operation and definitive AWR was 1.0(0.7, 1.9) years. Median (IQR) BMI at initial operation was 30.9 (26.3,33.1) kg/m^2 and at AWR was 30.7 (28.6,34.3) kg/m^2 ($p=0.50$). Median (IQR) hernia width was 11.3(8.4, 15.0) cm at initial operation and 16.0(15.0,20.0) cm at time of AWR for the delayed group ($p<0.001$). In 55 (85.93%) of these index cases the fascia was closed with suture alone, though three of these were loop ileostomy closures with midline hernias that had previously bridged with absorbable synthetic (2) or biologic mesh (1) fascial bridges. There were 6 cases with absorbable synthetic and 1 additional case with biologic mesh used to bridge the fascial defect. Postoperatively 12 patients experienced cellulitis, skin dehiscence or wound drainage and were treated with oral antibiotics, 5 patients experienced superficial wound infections requiring wound opening and packing only, 2 patients required reoperation for wound debridement (one for wound necrosis requiring skin graft and the other for retained packing), one patient required percutaneous drainage of an abdominal wall abscess, and one patient developed a small intraabdominal abscess requiring antibiotics.

Operative details: definitive abdominal wall reconstruction

The majority (99%) of cases were elective. Operative time was more likely to be less than two hours in the delayed

Table 1 Demographics

Characteristic	Delayed ($n=63$)	Single-stage ($n=375$)	p-value
Age (years), median(IQR)	61 (52, 68)	61 (52, 67)	0.94
Female, n(%)	28 (44)	220 (59)	0.035
Race, n(%)			0.57
White	56 (89)	330 (88)	
Non-white	6 (10)	45 (12)	
BMI (kg/m^2), median(IQR)	31 (28, 34)	33 (29, 36)	0.036
Current smoker, n(%)	4 (6)	28 (7)	0.75
Hypertension, n(%)	22 (35)	230 (61)	0.57
Diabetes Mellitus, n(%)	7 (11)	105 (28)	0.004
Inflammatory bowel disease, n(%)	8 (13)	22 (6)	0.047
Hepatic Insufficiency or Liver Failure, n(%)	0	2 (1)	0.56
Dialysis, n(%)	1 (2)	2 (1)	0.35
Chronic Obstructive Pulmonary Disease, n(%)	5 (7.9)	53 (14)	0.18
Anti-platelet medications, n(%)	6 (9.5)	35 (9)	0.96
Anti-coagulation medications, n(%)	5 (7.9)	20 (5)	0.41
Immunosuppressants, n(%)	6 (9.5)	24 (6)	0.36
History of abdominal wall SSI, n (%)	25 (40)	141 (38)	0.75
Currently active infection, n (%)	0	34 (9)	0.013

Table 2 Operative characteristics

Characteristic	Delayed ($n=63$)	Single-stage ($n=375$)	p-value
Elective case, n(%)	62 (98)	371 (99)	0.72
Mesh width(cm), median (IQR)	30 (30, 50)	30 (30, 50)	0.84
Mesh length(cm), median (IQR)	30 (30, 42)	30 (30, 50)	0.47
Hernia width (cm), median (IQR)	16 (15, 20)	15 (12, 20)	0.29
Hernia length (cm), median (IQR)	25 (23,28)	25 (21,20)	0.38
Operative time (minutes), n(%)			<0.001
0–59	0	0	
60–119	9 (14)	7 (2)	
120–179	12 (19)	66 (18)	
180–239	19 (30)	103 (27)	
>240	23 (37)	199 (53)	
Wound status, n(%)			<0.001
Clean	56 (89)	0 (0)	
Clean-contaminated	4 (6)	240 (64)	
Contaminated	3 (5)	135 (36)	
Intraoperative complication, n(%)	4 (6)	84 (22)	0.003
Bowel preparation, n(%)	0	31 (8)	0.018
Stoma present, n(%)	0	45(12)	0.004
Fascial closure, n(%)	53 (84)	343 (91)	0.067

Table 3 30-day complications

Characteristic	Delayed ($n=63$)	Single-stage ($n=375$)	p-value
Length of stay (days), median (IQR)	5 (4,6)	6 (5,8)	0.001
Readmission, n (%)	9 (14)	46 (12)	0.66
SSI, n(%)	7 (12)	64 (17)	0.36
Superficial (n)	2	34	
Deep, (n)	5	31	
Organ Space, (n)	0	1	
SSO, n(%)	11 (19)	69 (18)	0.87
SSOPI, n(%)	8 (14)	69 (18)	0.66
Reoperation, n(%)	2 (3)	7 (2)	0.5
Pulmonary embolism, n(%)	1 (9)	6 (5)	0.55
Sepsis, n(%)	0	2 (2)	0.67
Acute renal failure, n(%)	0	4 (3)	0.76
Pneumonia, n(%)	1 (9)	14 (11)	0.81

group compared to the concomitant group ($n=9$(14.29%) vs. $n=7$(1.87%), $p<0.001$) and had a lower rate of intraoperative complications ($n=4$(6.35%) vs. $n=84$(22.40%), $p=0.003$), which included three enterotomies and one gastric injury during adhesiolysis. The most common additional procedures in the single staged group were hepatobiliary ($n=78$ (20.80%)), small intestine ($n=79$(21.07%)), and colorectal ($n=59$ (15.73%)). There were stomas present in ($n=8$ (12.70%)) of the patients in the single-staged group, all of which were taken down during the operation. Macroporous uncoated polypropylene mesh was used in all cases. Most ($n=56$ (88.89%)) of the operations in the delayed group were considered clean and heavyweight mesh was more commonly placed in this group (42.86% vs. 22.13%, $p<0.001$) (Table 2).

Short term outcomes

Length of stay after AWR was shorter for the delayed group (5 [4, 6] vs. 6 [5, 8] days, $p=0.001$). There were no anastomotic leaks in either group. There were no differences in wound or medical complications (Table 3). Three patients (19%) in the delayed group and 14(12%) in the single-staged underwent wound debridement within 30-days($p=0.46$); a single patient in each required partial mesh excision within 30-days($p=0.098$). On multivariable analysis, increasing BMI was associated with increased risk of SSI within 30 days postoperatively (OR 1.44, 95%CI 1.04-2.0, $p=0.028$), but there was no association with group (single-staged versus delayed) for SSI (OR 1.20, 95%CI 0.51–2.86,$p=0.68$), SSO (OR 0.86, 95%CI 0.41–1.80, $p=0.69$), or SSOPI (1.26, 95%CI 0.56–2.86, $p=0.58$).

Long term outcomes

Median clinical and radiographic follow-up was 2 (1,3) years and patient reported outcomes were available for a median of 3 (2,5) years for both groups from the time of definitive AWR. Sixteen (4.27%) patients in the single-staged group had a known radiographic recurrence at a mean (SD) follow-up of 2.36(±1.95) years. Two (3.17%) patients had known radiographic recurrence in the delayed group at a mean (SD) follow-up of 2.13(±1.73) years. Sixty-nine (18.40%) patients had a known hernia recurrence based on the pragmatic definition in the single-staged group at a mean follow-up of 2.25 (±1.40) years. Nineteen (30.16%) patients had a known hernia recurrence based on the pragmatic definition in the delayed group at a mean follow-up of 1.82(±1.27) years. Hernia recurrence over time can be seen in Fig. 2. Twenty patients underwent reoperation for hernia recurrence in the single-staged group at a mean time of 2.32 (±1.90) years; reoperation probability was 0.05% (95% CI 0.02–0.08%). Three patients underwent reoperation for hernia recurrence in the delayed group at a mean time of 1.78 (±1.37) years; reoperation probability for hernia recurrence was 0.04% (95% CI 0.00–0.09%). There was no difference in HerQLes or PROMIS scores between the groups at any timepoint (Fig. 3).

Cost

The ratio of median direct cost for the hospitalization related to the delayed group including both index operation and subsequent definitive repair was 1.55 (IQR 1.14,2.09) compared to the AWR for the concomitant surgery group (median 1.0 [IQR 0.79,1.31])($p < 0.001$).

Discussion

In this retrospective cohort study, there were no differences in wound complications, or quality of life between single-staged AWR patients and those undergoing a delayed AWR. Despite a higher direct cost and increase in hernia width in the delayed group, patients with a delayed AWR had a shorter operative time, LOS, and similar pragmatic hernia recurrence compared to a single-staged AWR.

Most surgeons have historically been reluctant to place a permanent synthetic in the setting of contamination based on the risk of developing a chronic infection of the prosthetic. Prospective trials of biologic and absorbable synthetic mesh in contaminated settings demonstrated acceptable wound complication rates but higher long-term hernia recurrence rates when compared to synthetic mesh [3, 13]. Following animal model studies and retrospective cohort studies suggesting that monofilament polypropylene was able to clear bacterial contamination [14–16], Rosen et al. conducted a multicenter randomized control trial of biologic versus mediumweight polypropylene mesh for retromuscular ventral hernia repair which demonstrated durability and cost advantage with synthetic mesh and similar wound complication profiles [2]. This was consistently shown in subsequent randomized trials, supporting a movement towards increased surgeon comfort with AWR in the setting of contamination [17]. While these trials have demonstrated the safety and efficacy of mediumweight polypropylene mesh when utilized in the contaminated setting, they did not evaluate a staged or delayed approach. This option would be potentially most beneficial in the setting of a case in which the subsequent operation would be in a clean setting, with theoretically less wound morbidity risks. No

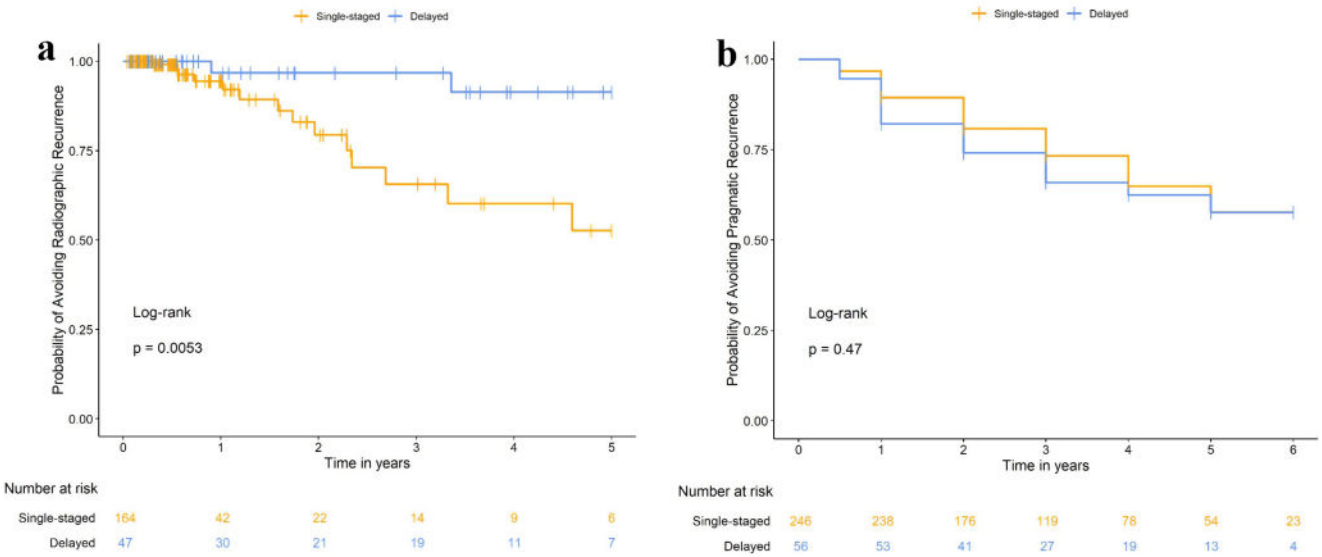

Fig. 2 Kaplan-Meier curve for radiographic (**a**) and pragmatic (**b**) hernia recurrence over the first 6 years postoperatively

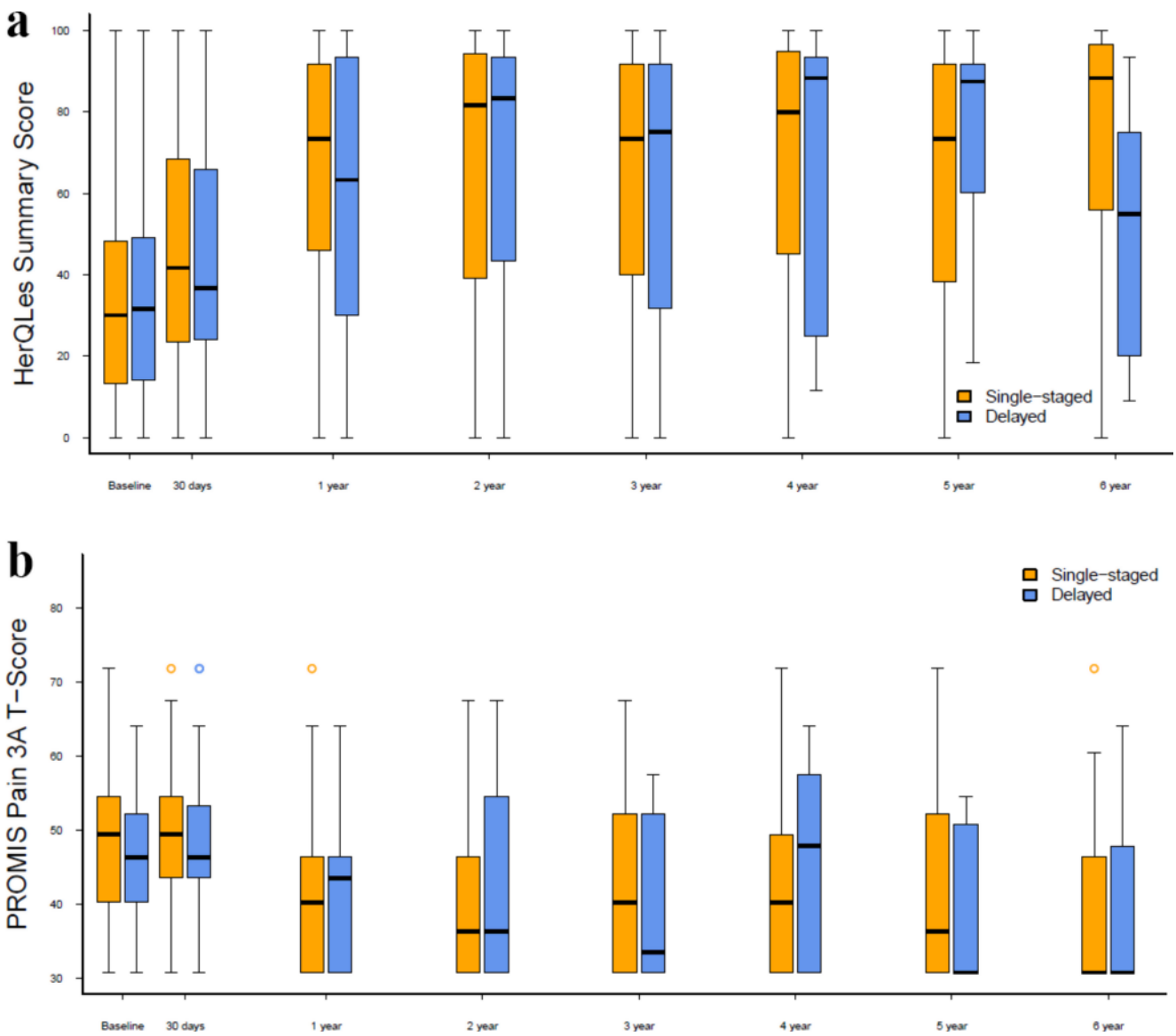

Fig. 3 Abdominal wall specific quality of life (HerQLes) (**a**) and pain (PROMIS) (**b**) scores over the first 6 years postoperatively

randomized controlled trials have evaluated this treatment option to date. This prompted our group to evaluate our outcomes by comparing a planned delayed reconstruction versus a single-staged reconstruction for patients undergoing contaminated ventral hernia repairs.

Our data demonstrates pros and cons to both a single-staged or delayed abdominal wall reconstruction in the setting of clean-contaminated or contaminated wounds with respect to short-term wound morbidity or long-term durability of the repair, which suggests that both are viable options in selected patients. Delaying AWR was associated with a slight increase in the size of the hernia, which was not clinically or statistically significant, and slightly increased costs but had an advantage in radiographically detected hernia recurrence. These results should be interpreted with the understanding that the operating surgeons chose to delay hernia repair or perform the reconstruction in a single-stage in this cohort based on their experience and judgment. When patients present with an intraabdominal pathology and a large ventral hernia, surgeons must evaluate their options and individualize operative approach based on the specific scenario.

Our institutional algorithm to approaching hernia repair in the setting of contamination has been previously published [18]. There are some advantages to single-stage surgery for patients, so our surgeons commonly perform single-stage AWR in low-risk contaminated settings such as elective cholecystectomy or hysterectomy. In a hemodynamically unstable patient with gross infection or contamination, most surgeons would choose not to perform a definitive hernia

repair with synthetic mesh placement. However, not every scenario is clear cut. In the absence of randomized data, this decision-making relies primarily on surgeon judgment. We want to acknowledge that there are scenarios which may benefit, at least philosophically, from delaying definitive AWR to favor a clean operative field. For our group, some of those common scenarios include the anticipated need for bridging of the anterior fascia, preference for heavyweight polypropylene mesh, and high-risk anastomoses (for patient-specific reasons or operative concerns). These considerations are difficult to capture in a retrospective review but should be accounted for clinically.

The intraoperative complication rate being higher in the single-stage group is partially a reflection of selection bias in the inclusion criteria, for example some cases were considered contaminated (single-stage) due to the presence of an intraoperative enterotomy or bladder injury in which the surgeon felt comfortable continuing on with the reconstruction, so interpretation should be tempered. Our institution is liberal about performing abdominal wall reconstruction with permanent synthetic mesh in the setting of contamination, which suggests that there is an unavoidable selection bias influencing the surgeons' decision to concomitantly perform the abdominal wall reconstruction versus staging which affects both cohorts. Along that line, if there is a concern that a patient is at high risk of anastomotic leak, the surgeons would generally bring up a loop ileostomy and those cases would have been excluded from this study. Retrospective chart review is also limited by reporting bias and there may have been additional reasoning behind the timing of AWR that is not captured. The selection criteria for the study cohort also excluded patients whose hernia operation was planned to be completed in a staged manner, but never followed up to the AWR and therefore cannot comment on outcomes for those patients. Because our institution does not routinely create ACHQC database records for patients until a "definitive" repair is performed, there is no reliable method to identify these patients or track their hernia-related outcomes. Regarding generalizability, our data is also most relevant to surgeons who currently perform abdominal wall reconstruction, have the capabilities of managing the complex postoperative needs of these patients, and who have some comfort using permanent mesh in contaminated settings. Finally, the cost data does not capture indirect costs, charges, and does not capture the cost of reoperations or outpatient healthcare costs.

Conclusion

Delayed and single-staged abdominal wall reconstruction are both viable approaches to treating patients with large ventral hernias and separate intraabdominal pathology requiring operation, and surgeons should consider the relative risks and benefits of both on an individualized basis.

Funding This study received no funding.

Declarations

Competing interests Dr. Prabhu is on the advisory board for Surgimatix and CMR Surgical. Dr. Petro serves as an Advanced Medical Solutions, Bard-Davol, and Surgimatix Consultant, and has received research grants from the American Hernia Society, the Central Surgical Association, and the Society of American Gastrointestinal and Endoscopic Surgeons. Dr. Rosen serves as the medical director of the ACHQC and receives salary for this position, received a grant to his institution for research from Telabio and has stock options with Ariste. Dr. Miller received a research grant from the American Hernia Society and research funding for his institution from Integra. Dr. Maskal accepted a Resident Research Grant from the Abdominal Core Health Quality Collaborative and honoraria from Momentis Surgical. Dr. Ellis and Dr. Woo accepted honoraria from Momentis Surgical. Mr. Mali, Dr. Beffa, Dr. Al Marzooqi, Dr. Huang and Dr. Remulla have no disclosures.

References

1. Ventral Hernia Working Group, Breuing K, Butler CE, Ferzoco S, Franz M, Hultman CS, Kilbridge JF et al (2010) Incisional ventral hernias: review of the literature and recommendations regarding the grading and technique of repair. Surgery 148(3):544–558. https://doi.org/10.1016/j.surg.2010.01.008
2. Rosen MJ, Krpata DM, Petro CC et al (2022) Biologic vs synthetic mesh for single-stage repair of contaminated ventral hernias: a Randomized Clinical Trial. JAMA Surg 157(4):293–230. https://doi.org/10.1001/jamasurg.2021.6902
3. Itani KM, Rosen MJ, Vargo D et al (2012) Prospective study of single-stage repair of contaminated hernias using a biologic porcine tissue matrix: the RICH study. Surgery 152(3):498–505. https://doi.org/10.1016/j.surg.2012.04.008
4. Olivarria OA, Bernardi K, Dhanani NH (2021) Synthetic versus biologic mesh for Complex Open ventral hernia repair: a pilot randomized controlled trial. Surg Infect (Larchmt) 22(5):496–503. https://doi.org/10.1089/sur.2020.166
5. Choi JJ, Palaniappa NC, Dallas KB et al (2012) Use of mesh during ventral hernia repair in clean-contaminated and contaminated cases: outcomes of 33,832 cases. Ann Surg 255(1):176–180. https://doi.org/10.1097/SLA.0b013e31822518e6
6. Ortega G, Rhee DS et al (2012) An evaluation of Surgical Site infections by wound classification system using the ACS-NSQIP. J Surg Res 174(1):33–38. https://doi.org/10.1016/j.jss.2011.05.056
7. Poulose BK, Rosen MJ (2018) The role and impact of registries on Abdominal Wall Reconstruction. Plast Reconstr Surg 142. https://doi.org/10.1097/PRS.0000000000004878. 197S-200S
8. Kanters AE, Krpata DM, Blatnik JA, Novitsky YM, Rosen MJ (2012) Modified hernia grading scale to stratify surgical site occurrence after open ventral hernia repairs. J Am Coll Surg 215(6):787–793. https://doi.org/10.1016/j.jamcollsurg.2012.08.012

9. Baucom RB et al (2016) Patient reported outcomes after incisional hernia repair-establishing the ventral hernia recurrence inventory. Am J Surg 212(1):81–88. https://doi.org/10.1016/j.amjsurg.2015.06.007
10. Krpata DM et al (2012) Design and initial implementation of HerQLes: a hernia-related quality-of-life survey to assess abdominal wall function. J Am Coll Surg 215(5):635–642. https://doi.org/10.1016/j.jamcollsurg.2012.06.412
11. Renshaw SM, Gupta A, Poulose BK (2022) Establishing the minimal clinically important difference for the hernia-related quality of Life Survey (HerQLes). Am J Surg 223(2):245–249. https://doi.org/10.1016/j.amjsurg.2021.06.018
12. Instrument PROMIS Pain Intensity - Short Form 3a v1.0| NIDA CTN Common Data Elements. Accessed: Dec. 20, 2022. [Online]. Available: https://cde.nida.nih.gov/instrument/0a481bfb-a5e6-3c84-e050-bb89ad43314d
13. Rosen MJ et al (2017) Multicenter, prospective, longitudinal study of the recurrence, Surgical Site infection, and Quality of Life after contaminated ventral hernia repair using Biosynthetic Absorbable Mesh: the COBRA Study. Ann Surg 265(1):205–211. https://doi.org/10.1097/SLA.0000000000001601
14. Engelsman AF, van Dam GM, van der Mei HC et al (2010) In vivo evaluation of bacterial infection involving morphologically different Surgical meshes. Ann Surg 251(1):133–137. https://doi.org/10.1097/SLA.0b013e3181b61d9a
15. Blatnik JA, Krpata DM, Jacobs MR, Gao Y, Novitsky YW, Rosen MJ (2012) In vivo analysis of the morphologic characteristics of synthetic mesh to resist MRSA Adherence. J Gastrointest Surg 16(11):2139–2144. https://doi.org/10.1007/s11605-012-1992-5
16. Campanelli G, Nicolosi FM, Pettinari D, Avesani EC (2004) Intestinal resection and multiple abdominal hernia mesh repair: is the combination safe and feasible? Chir Ital 56(6):839–842
17. Harris HW et al (2021) Preventing recurrence in clean and contaminated hernias using Biologic Versus Synthetic Mesh in ventral hernia repair: the PRICE randomized clinical trial. Ann Surg 273(4):648–655. https://doi.org/10.1097/SLA.0000000000004336
18. Petro CC, Rosen MJ (2018) Fight or flight: the role of staged approaches to Complex Abdominal Wall Reconstruction. Plast Reconstr Surg 142(3):38S–44S. https://doi.org/10.1097/PRS.0000000000004847