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When the Mesh Goes Away: An Analysis of Poly-4-Hydroxybutyrate Mesh for Complex Hernia Repair

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Background: Mesh reinforcement is a cornerstone of modern ventral hernia repair (VHR); yet, complications with synthetic mesh and cost of biologic have created a need for alternative options. Biosynthetic mesh is a resorbable scaffold that theoretically leverages the benefits and minimizes deficiencies of existing mesh types. This study evaluates 2-year outcomes following poly-4-hydroxybutyrate (P4HB) mesh reinforcement for complex VHR.

Methods: A retrospective review of all consecutive VHR with P4HB (n = 70) was conducted from 2015 to 2018 by a single surgeon. Clinical outcomes, quality of life (QoL; and cost were assessed.

Results: Seventy patients were included with an average age and body mass index of 58.6 years and 33 kg/m^2, respectively. High-risk comorbidities included hypertension (59%), and smoking history (50%). Cases were primarily modified Ventral Hernia Working Group class 2 (50%), or 3 (36%), with average defect size of 323 cm^2 (25–972 cm^2). P4HB was placed in the retromuscular (80%) or onlay (20%) plane. Mean follow-up was 24 months (12.2–41 months). Hernia recurrence rate was 5.7% (n = 4) and occurred an average of 285 days (209–368 days) post-repair. Of the 21 surgical site occurrences (SSO), 5 (7%) required surgical intervention. A significant improvement in overall QoL ($P = 0.001$) was noted following repair. Defect size and SSOPI were independently associated with increased direct cost.

Conclusions: P4HB mesh for complex VHR is associated with favorable 2-year clinical outcomes, acceptable hernia recurrence rate, and a significant improvement in QoL. This study supports the use of biosynthetic mesh as an effective biomaterial for complex VHR. *(Plast Reconstr Surg Glob Open 2019;7:e2576; doi: 10.1097/GOX.0000000000002576; Published online 27 November 2019.)*

INTRODUCTION

One in 8 patients will develop an incisional hernia after abdominal surgery.[1] In the United States, approximately 350,000 hernia repairs are performed annually, with an estimated cost expenditure of $7 billion.[2,3] The advent of mesh reinforcement has successfully reduced the risk of hernia recurrence and currently serves as the gold standard for an effective, modern ventral hernia repair (VHR).[4–9] However, despite these advancements, significant risks are associated with long-term permanent mesh implantation including infection, chronic pain, mesh erosion, and reoperation.[10–12] The inherent trade-off balances between the risk of mesh infection, or mesh-related complications, and the opportunity to obtain a successful hernia repair.[13]

Permanent synthetic mesh has been demonstrated to provide long-term biomechanical support and reliably reduce the risk of hernia recurrence.[14–16] Yet, due to the inherent permanence, long-term complications are common, including chronic pain, inflammation, mesh erosion, and infection. Thus, surgeons are oftentimes reluctant to implant a foreign material if there is a potential risk for a chronic infection.[11,17] Biologic mesh serves as a solution

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for many complex hernias by providing rapid revascularization and bacterial resistance.[18–20] However, the significant cost burden and variable long-term outcomes have led surgeons to search for alternative biomaterials.[21–23]

Resorbable biosynthetic biomaterials have evolved in an attempt to leverage the advantages of synthetic and biologic mesh, by providing short-term mechanical support and clearance of bacterial burden, respectively.[24–26] Resorbable biosynthetic products are composed of synthetic polymers that serve as a scaffold for host tissue ingrowth, where native collagen slowly replaces the mesh as it degrades over time.[27] Poly-4-hydroxybutyrate (P4HB) (Phasix Mesh; C.R. Bard Inc., Warwick, RI) is a type of biosynthetic mesh and consists of a monofilament scaffold, that fully resorbs in 12–18 months.[26,28] Early evidence suggests that bioresorbable mesh may provide a clinical advantage over permanent devices and a cost advantage over biologic mesh in complex VHR.[25,29,30] The purpose of this study was to evaluate the clinical outcomes, quality of life (QoL), and cost associated with P4HB mesh reinforcement for VHR.

METHODS

Study Design

A retrospective review of patients undergoing ventral hernia repair with P4HB mesh was performed by a single surgeon (JPF) from October 2015 to January 2018. Adult patients (>18 years) undergoing single-stage VHR/incisional hernia repair with biosynthetic P4HB (Phasix Mesh) mesh were included in the study. Seventy patients out of 120 were chosen based on exclusion criteria (27-month inclusion). Patients were excluded if P4HB was used for prophylactic laparotomy reinforcement, parastomal hernia repair, more than 1 piece of mesh was used, or if patients had less than 12 months of clinic follow-up. This study was reviewed and approved by the Institutional Review Board at the University of Pennsylvania (Protocol # 832515). All HIPAA (Health Insurance Portability and Accountability Act of 1996) compliant mechanisms were followed to ensure confidentiality.

Outcomes and Data Collection

Data collection was performed using the secure web-based platform, REDCap.[31] Patient demographics and comorbidities were analyzed for all patients including age, sex, body mass index (kg/m^2), diabetes, hypertension, chronic obstructive pulmonary disease, and number of previous abdominal hernia repairs. Perioperative variables and hernia characteristics included American Society of Anesthesiologists status, Centers for Disease Control (CDC) wound classification, modified Ventral Hernia Working Group (VHWG), defect size (cm^2), and size of P4HB (cm^2).[32,33] Defect size was measured intraoperatively based on hernia width and length (cm^2) following lysis of adhesions and before component separation. Mesh size (cm^2) was recorded based on product dimensions before implantation.

Postoperative outcomes consisted of hernia recurrence, surgical site occurrence (SSO), surgical site infection (SSI), and SSO requiring surgical intervention (SSOPI). Any patient with a described or clinically present bulge was evaluated with a computed tomography (CT) scan. Hernia recurrence was defined as present if a palpable defect was noted on examination during supine or standing, or if a defect was identified on CT imaging. SSO, SSI, and SSOPI were defined according to the classification by DeBord et al.[34] SSO was defined as delayed healing, seroma, hematoma, wound dehiscence, or wound necrosis. SSI was categorized into superficial, deep, or organ space infections as defined by the CDC.[32,35] Delayed healing was described as a nondehisced wound that did not require a surgical intervention. Primary endpoints included hernia recurrence, SSOs, and SSIs. Secondary endpoints included QoL and cost.

Extended follow-up was collected through telephone interviews for patients who were beyond 16 months from VHR and were unable to follow up in clinic for at least 6 months. Telephone evaluation was performed using a validated, standardized questionnaire.[36] Any positive answer on the questionnaire was considered a hernia recurrence until proven otherwise by physical examination or advanced imaging. Patients with any complaints related to the hernia repair returned to the clinic for examination.

The University of Pennsylvania Department of Finance provided financial data for the index VHR, and any subsequent emergency department visit, reoperation, or readmission, pertaining to the initial P4HB hernia repair.

Surgical Technique

General criteria for P4HB use are patient preference (preoperatively determined) for nonpermanent synthetic mesh, (intraoperatively determined) presence of contamination, high-risk clean cases, and onlay. All hernias were closed primarily, with slow absorbing monofilament 1-Maxon (Medtronic, Minneapolis, MN) sutures. Onlay mesh placement was chosen when the posterior layers of the abdominal wall were not amenable to retrorectus/preperitoneal mesh placement. Onlay mesh reinforcement began by raising skin flaps, closing the defect as described and fixating P4HB with at least 5 cm of overlap, with partial thickness trans-fascial-U stitches. Retromuscular repair began by fully mobilizing the rectus complex and the posterior rectus sheath. The addition of a transversus abdominis release (TAR) or external oblique release was performed when necessary. All external oblique releases were completely released onto the chest wall, as a myocutaneous flap of the abdominal wall, with significant medial advancement of the midline rectus complex. All TARs were performed as described by Novitsky et al[37] and utilized when the posterior rectus sheath was unable to be closed. In these cases, a top-down, pretransversalis technique was preferred. Mesh fixation was performed with either trans-fascial sutures, in the presence of anterior fascial tension, or fibrin glue-based fixation (TISSEEL Fibrin Sealant, Baxter Healthcare Corp, Deerfield, IL, USA). in the absence of anterior fascial tension.[38]

QoL

QoL was prospectively collected both preoperatively and throughout the postoperative follow-up period using the Hernia-related Quality-of-Life Survey.[39] QoL was retrospectively assessed and analyzed based on follow-up intervals of 0–3, 3–6, 6–12, 12–18, 18–24, and >24 months. QoL scores were averaged for patients with more than 1 QoL response within the same postoperative time interval. All QoL scores were converted using the Rasch model to fit a 0-to-100 scale, with a higher score indicating better QoL.

Statistical Analysis

Descriptive statistics, paired *t* tests, and multivariate regression analyses were performed. Multivariate logistic regression was used to measure effects of these independent variables on the total direct cost due to hernia repair. Factors demonstrating significant association for all outcomes of interest were defined by $P < 0.05$. All analyses were performed using STATA (Stata Corporation, College Station, TX).

RESULTS

Demographics and Operative Characteristics

A total of 70 patients underwent VHR with P4HB mesh, with an average postoperative follow-up of 24 months (12.2–41 months). Average age of our cohort was 58 years (23–81 years), more commonly male (n = 37, 53%), and presented with an average body mass index of 33.0 kg/m² (20.3–53.3 kg/m²) (Table 1). Thirty-six percent presented with a recurrent ventral/incisional hernia. Patients were primarily American Society of Anesthesiologists physical status 3 (n = 38, 55%). Overall, patients were at high risk for SSOs according to the modified VHWG grading system, consisting of 14% (n = 10) class 1, 50% (n = 35) class 2, and 36% (n = 25) class 3 defects (Table 2). According to CDC wound classification, defects were most commonly clean (n = 45, 64%), or clean contaminated (n = 18, 26%), and contaminated (n = 4, 6%), or dirty/infected (n = 3, 4%). Average hernia defect size was 323 cm² (25–972 cm2), and average size of P4HB before implementation was 469 cm² (80–875 cm²).

TABLE 1. Patient Demographics, Comorbidities, and Preoperative Variables

Total No. Patients	70
Age, y (range)	58.6 (23.2–81)
Sex (male), n (%)	37 (52.8)
Body mass index, kg/m² (range)	33.0 (20.3–53.3)
Previous open abdominal surgery	66 (94)
Average previous open abdominal surgeries, n (range)	2.7 (0–12)
Recurrent hernia repaired, n (%)	25 (36%)
Comorbidities	
Obesity (kg/m²; ≥ 30), n (%)	41 (59)
Hypertension, n (%)	41 (59)
Diabetes, n (%)	16 (23)
Smoking history, n (%)	35 (50)
Previous wound infection, n (%)	8 (11)
COPD, n (%)	4 (6)

COPD, chronic obstructive pulmonary disease.

TABLE 2. Perioperative Variables and Hernia Characteristics: CDC Wound Classification and Mean Defect Size

Total No. Patients	70
ASA class, n (%)	
1	1 (1)
2	31 (44)
3	38 (55)
Modified VHWG, n (%)	
1	10 (14)
2	35 (50)
3	25 (36)
CDC wound classification, n (%)	
Clean	45 (64)
Clean contaminated	18 (26)
Contaminated	4 (6)
Dirty/infected	3 (4)
Mean defect size, cm² (range)	323 (25–972)
Mean hernia width, cm (range)	17 (5–35)
Mean hernia length, cm (range)	19 (5–37)
Mean biosynthetic mesh size, cm² (range)	469 (80–875)

ASA, American Society of Anesthesiologists.

Intraoperative details are described in Table 3. The retromuscular plane (n = 56, 80%) was most commonly used for P4HB placement, followed by onlay (n = 14, 20%). Anterior component separation was performed in 19 patients and included unilateral (5.7%), and bilateral (21%) releases. TAR was performed in 17 patients and consisted of both unilateral posterior component separation (4%) and bilateral posterior component separation (20%). Concurrent panniculectomy was performed in 33 patients (47%).

Postoperative Outcomes

Postoperative outcomes are detailed in Table 4. Mean length of stay was 4 days (0–38 days). Four patients were identified with a hernia recurrence, for a rate of 5.7%. Mean time to hernia recurrence was 285 days (209–368 days) from initial P4HB repair, and 75% (n = 3) of the identified hernia recurrences underwent additional repair. Hernia recurrence occurred in the retromuscular plane (n = 4); however, no statistically significant difference was noted compared to onlay repairs ($P = 0.303$). One patient presented with an abdominal bulge, which was not clinically significant and not determined to be a hernia recurrence after CT imaging. All

TABLE 3. Intraoperative Details, Including Plane of Mesh Placement, Component Separation, and No. Drains

Total No. Patients	70
Operative time, min (range)	211 (60–581)
Anatomic plane of P4HB placement, n (%)	
Retromuscular	56 (80)
Onlay	14 (20)
Mesh fixation technique, n (%)	
Suture	51 (73)
Fibrin glue	19 (27)
Component separation, n (%)	
Unilateral anterior component separation	4 (5.7)
Bilateral anterior component separation	15 (21)
Unilateral posterior component separation	3 (4)
Bilateral posterior component separation	14 (20)
TAR + EOR	1 (1.4)
Concurrent panniculectomy, n (%)	33 (47)
Average no. drains	2 (1–4)
Mean days to drain removal, n (range)	20 (6–63)

EOR, external oblique release.

TABLE 4. Postoperative Outcomes, n (%), Including Hernia Recurrence, SSO, SSI, and SSOPI

Total No. Patients	70
Average follow-up, mo (range)	24 (12.2–41)
Length of stay, d (range)	4 (0–38)
Hernia recurrence	4 (5.7)
Retromuscular, n	4
Onlay, n	0
Time to hernia recurrence, d (range)	285 (209–368)
Repair of hernia recurrence	3 (75)
SSO, n (%)	21 (30)
Delayed wound healing	11 (16)
Seroma	6 (8)
Cellulitis	2 (3)
Fascial dehiscence	2 (3)
SSI, n (%)	6 (8)
Superficial infection	6 (8)
SSOPIs, n (%)	5 (7)
IR drainage	3
Debridement	2
Rate of reoperation, n (%)	8 (11)
Pulmonary embolism	3 (4)
Deep vein thrombosis	1 (1)
Bowel perforation	0 (0)
Postoperative mesh infection	0 (0)
Mesh explantation	0 (0)

hernia recurrences were clinically evaluated by the senior author and confirmed through CT imaging. SSOs occurred in 21 patients (30%), which included delayed healing (n = 11, 16%), seroma (n = 6, 8%), cellulitis (n = 2, 3%), and wound dehiscence (n = 2, 3%) (Table 5). Overall reoperation rate (n = 8, 11%) consisted of repair of hernia recurrence (n = 3) and SSOPIs (n = 5). Notably, there were no cases of postoperative mesh infection or mesh explantation during the follow-up period.

QoL Assessment

Patients reported a significant improvement in overall QoL compared to baseline ($P < 0.00001$) (Table 6). Additionally, there was a significant improvement throughout the 6-month postoperative follow-up intervals ($P < 0.005$) when compared to the average preoperative score: 0–6 months (72, n = 53, $P < 0.005$), 6–12 months (71.2, n = 28, $P < 0.005$), 12–18 months (73, n = 14, $P < 0.005$), and 18–24+ months (72, n = 15, $P < 0.005$). Patients who experienced an SSO ($P = 0.008$) and received more than 2 drains ($P = 0.003$) had a significantly lower QoL at the 3–6 and >24 months (SSO, $P = 0.026$; >2 drains, $P = 0.030$) postoperative windows (Table 7). Figure 1 demonstrates the increase in QoL in comparison to the time that P4HB undergoes hydrolysis, and distinct time points for when hernia recurrence occurred for the 4 patients in our cohort. Additionally, the minimal clinical strength required for a repair is shown, as identified by Deeken and Matthews and Deeken et al.[18,24] A comparison of QoL in patients with and without recurrences (Fig. 2) identified no significant difference in disease-specific QoL throughout the postoperative follow-up intervals.

Cost Analysis

Total direct costs for the index procedure, and any subsequent readmission or reoperation costs, were collected for all patients (Table 8). The average total direct cost for a P4HB repair in our cohort was $23,994 ± $13,372. Through multivariate regression analysis, administration of intraoperative blood ($P < 0.05$), hernia defect size ($P < 0.05$), and postoperative SSOPI ($P < 0.05$) were independently associated with higher total direct costs.

TABLE 5. Comparison of No. Previous Repairs, Wound Class, and VHWG, to Clinical Outcomes (Hernia Recurrence, SSO SSOPI, and SSI)

		No. Previous Hernia Repairs			Wound Class			VHWG			
	All (n = 70)	0 Repairs (n = 45)	≥1 Repairs (n = 25)	*P*	Clean (n = 45)	Contaminated (n = 25)	*P*	1 (n = 10)	2 (n = 35)	3 (n = 25)	*P*
HR	4 (5.7)	3 (6.7)	1 (4.0)	0.645	2 (4.4)	2 (8.0)	0.539	0 (0.0)	2 (5.7)	2 (8.0)	0.654
SSO	21 (30.0)	10 (22.2)	11 (44.0)	0.057	10 (22.2)	11 (44.0)	0.057	2 (20.0)	8 (22.9)	11 (44.0)	0.160
SSOPI	5 (7.1)	2 (4.4)	3 (12.0)	0.240	3 (6.7)	2 (8.0)	0.836	1 (10.0)	2 (5.7)	2 (8.0)	0.879
SSI	6 (10.0)	4 (8.9)	2 (8.0)	0.899	2 (4.4)	4 (16.0)	0.098	0 (0.0)	2 (5.7)	4 (16.0)	0.216

HR, hernia recurrence.

TABLE 6. Average Pre- and Post-Quality of Life, with the Net Percent Change in Scores Throughout the 24-mo Study Period

		Postoperative QoL (Mean)					
	Baseline (Mean)	0–6 mo	6–12 mo	12–18 mo	18–24+ mo	Average Postoperative QoL	*P*
HerQLes (n = 59)	45.6	72	71.2	82	73	72	<0.00001

HerQLes, Hernia-related Quality-of-Life Survey.

TABLE 7. Comparison of Pre- and Post-Quality of Life in Patients with and without SSO, More Than 1 Previous Hernia Repair, and More Than 2 Drains

	Baseline	Postoperative HerQLes (*P*)					
	Preoperative	0–3 mo	3–6 mo	6–12 mo	12–18 mo	18–24 mo	24+ mo
<1 previous hernia repair vs >1 previous hernia repair	0.327	0.7998	0.917	0.9895	0.393	0.3833	**0.0258**
No SSO vs SSO	0.0016	0.142	**0.008**	0.442	0.792	0.663	**0.0260**
<2 drains vs >2 drains	0.0057	0.2922	**0.0029**	0.5548	0.2593	0.4816	**0.0303**

HerQLes, Hernia-related Quality-of-Life Survey.

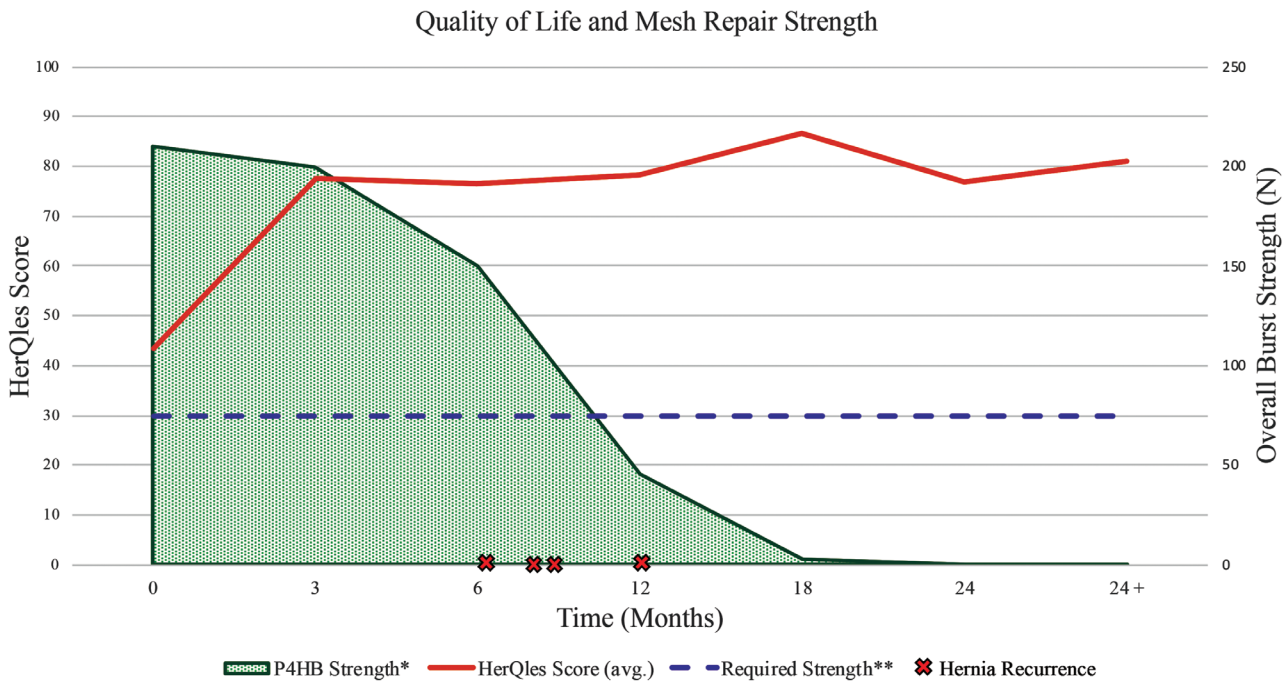

Fig. 1. Average QoL (HerQLes) scores for all patients and the hydrolysis of P4HB over 24 months is shown, as well as the minimal clinical strength requirement for a repair (*, **derived from preclinical data in the studies by Deeken and Matthews, Deeken et al, and Wolloscheck et al[18,24,40]). Specific time points of when hernia recurrence occurred are also noted. Strength = determined by calculating area under the curve in Newtons (bursh strength) versus kDa (molecular weight). HerQLes, Hernia-related Quality-of-Life Survey.

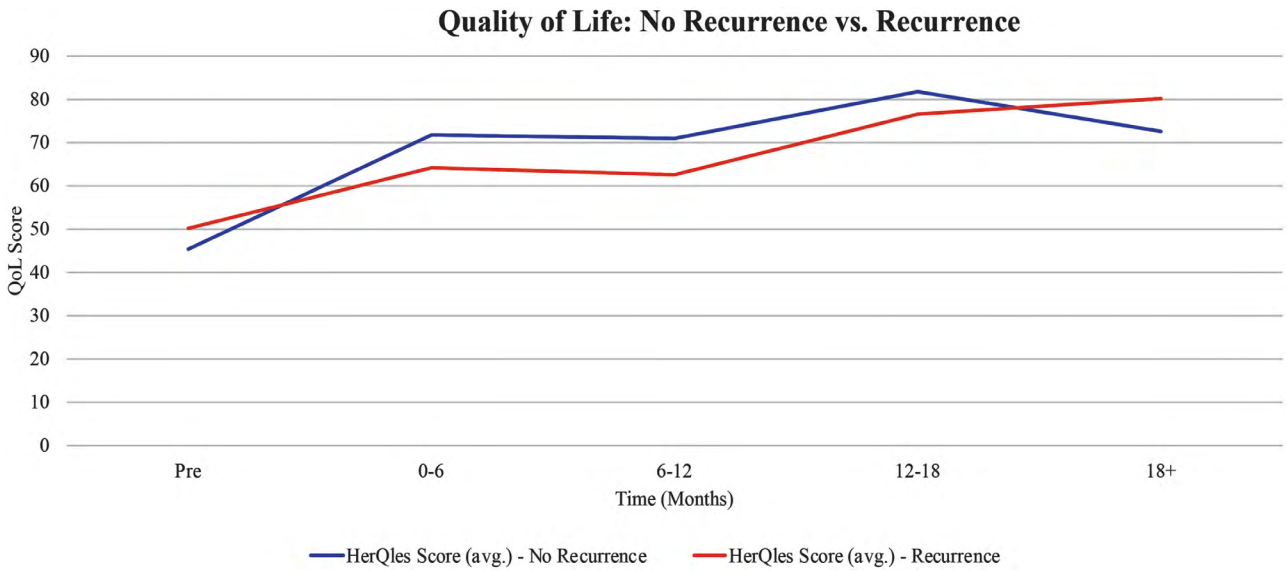

Fig. 2. QoL over 6-month postoperative intervals comparing patients with and without hernia recurrence.

DISCUSSION

An established goal of modern VHR is to restore abdominal wall anatomy and function, while improving long-term QoL. Although improvements in surgical technique and the emergence of mesh reinforcement have enhanced outcomes in VHR, advancements in biomaterials can potentially further improve results for patients. In a recent article from *JAMA*, Kokotovic et al[11] identified that although permanent mesh can effectively prevent hernia recurrence, the long-term benefits are in part offset by mesh-related complications. Biologic mesh has been utilized as an alternative due to its resorbable nature and ability to resist infection for complex hernias[20]; however, there is a significant increase in cost compared to synthetic mesh,[23] with substantial variability in long-term clinical outcomes.[41]

TABLE 8. Analysis of Total Direct Cost for All Patients and Comparison of Costs with HR, SSO, SSOPI, and SSI

	Total Direct Costs	*P*
All patients (n = 69)	$23,994 ± 13,372	–
No HR (n = 65)	$23,517 ± 13,263	0.234
HR (n = 4)	$31,759 ± 14,659	
No SSO (n = 49)	$20,534 ± 7,438	0.0005*
SSO (n = 20)	$32,472 ± 19,840	
No SSOPI (n = 64)	$22,533 ± 10,225	0.0008*
SSOPI (n = 5)	$42,702 ± 30,354	
No SSI (n = 63)	$23,406 ± 13,491	0.239
SSI (n = 6)	$30,170 ± 11,175	

Costs include index operation and admission plus any additional readmissions or reoperations. Cost data were unavailable for 1 patient.
HR, hernia recurrence.

In this study, we analyzed 2-year clinical outcomes, disease-specific QoL, and cost following VHR with P4HB biosynthetic mesh. Overall, the current study's primary endpoint of hernia recurrence was 5.7%, with a significant improvement in QoL and no cases of mesh infection or removal. P4HB (Phasix Mesh) is a naturally derived monofilament scaffold, that incorporates through hydrolysis and hydrolytic enzymatic degradation, achieving full resorption in 12–18 months.[26,28] By-products of carbon dioxide and water are rapidly metabolized, with minimal effect on local wound pH. P4HB has been evaluated in various preclinical studies, indicating its potential to provide structural support to the abdominal wall and its aptitude to overcome a bacterial burden.[18,42,43] Furthermore, preclinical models have demonstrated increased resistance to bacterial contamination with 4-hydroxybutyrate, compared to polypropylene mesh, and 4-hydroxybutyrate's ability to induce noncytotoxic effects and increase the expression of antimicrobial peptides (cramp and B-defensin-4).[43,44] Although, preclinical data have shown P4HB resorption by 2 years, we recognize that additional human studies are needed to fully assess the performance of P4HB and the possibility of recurrences to occur after several years. In the authors' opinion, P4HB handles similar to that of a synthetic mesh, but behaves akin to a biologic device with its ability tolerate contaminated fields.

Limited clinical studies have evaluated the use of P4HB for VHR, with long-term outcomes and an analysis of disease-specific QoL. Roth et al prospectively analyzed P4HB (Phasix Mesh) in CDC class I/high-risk VHR and incisional hernia repair with 18 months of follow-up.[25] In their series of 121 patients, a 9% hernia recurrence rate and 9% SSI rate were identified. Additionally, the COBRA[30] study prospectively examined outcomes with biosynthetic mesh (Gore Bio-A), in 104 patients with clean-contaminated or contaminated ventral hernias, where 87 (84%) achieved 24-month follow-up. Authors concluded a hernia recurrence rate of 17%, and SSIs in 18%, and an improvement in QoL. Our experience with P4HB mesh demonstrates promising results with a significant increase in QoL, low hernia recurrence rate of 5.7%, and acceptable 2-year complication rate with no mesh removals despite a 30% incidence of SSO. As 80% of hernia recurrences occur within 2 years after repair, we believe that achieving 2-year average follow-up was critical to evaluate the success of a VHR.[45] Additionally, as incorporation of P4HB is complete in 12–18 months,[26,43] our average follow-up period of 2 years allows for an appropriate evaluation of the utility of P4HB mesh in VHR. The average time to hernia recurrence, in our study of 285 days (9.4 months), further addresses the importance of achieving follow-up beyond the 12–18-month hydrolysis period of P4HB.

In a high-risk patient population with complex ventral hernias, our results are comparable to other studies evaluating bioresorbable P4HB mesh, and other mesh types in a similar patient population.[25,46] Specifically, Roth et al[25] and the COBRA study,[30] as previously discussed. In comparison with synthetic mesh, Cobb et al[47] demonstrated a recurrence rate of 16.9% over a mean follow-up of 17 months. Additionally, Carbonell et al[16] evaluated 100 cases of clean-contaminated and contaminated VHRs with permanent polypropylene mesh and reported a 7% recurrence rate and 14% rate of SSI at less than 1-year follow-up. When evaluating CDC class II and III wounds in our series, results identified a recurrence rate of 9%, with an average defect size of 345 cm^2 and 24 months of follow-up.

Although a majority of our cohort were clean cases, 86% of patients were modified VHWG class II or III; thus, a significant percentage of our cohort was at risk for postoperative wound events. A head-to-head comparison identified a trend toward significance for higher rates of SSOs when patients were more operatively complex and in the setting of contamination. However, we believe our results show that biosynthetic mesh can serve as a viable biomaterial for repair of CDC class II–IV defects, which represents 36% (n = 25) of our cohort, an average defect size of 380 cm^2, 2 hernia recurrences, 11 SSOs, 16% SSI rate, 8% SSOPI, and no mesh removals. Notably, no significant difference was identified in hernia recurrence, SSOPI, SSI, or QoL when compared to clean repairs. Literature reports have shown that in the setting of postoperative wound events following permanent mesh placement for VHR, there is a reported 69% risk of mesh explantation and, similarly, a 6-fold increase in mesh explanation risk if prosthetic mesh is used when contamination is present. In the current study, no cases of P4HB infection or explantation were noted. These results are promising compared to a 35% SSI rate and 31.3% hernia recurrence rate with biologic mesh[22] in complex (VHWG III/IV) patients, and a 7% recurrence rate with permanent polypropylene mesh.[16]

An increase in total direct costs was identified with postoperative SSO ($P = 0.0005$) and SSOPI ($P = 0.0008$). Additionally, intraoperative blood transfusions ($P < 0.05$), hernia defect size ($P < 0.05$), and SSOPI ($P < 0.05$) were predictive of higher direct costs. These results are supported throughout the literature, where postoperative complications can significantly increase costs.[48–50] However, due to the limited number of recurrences in this study, further research is needed to evaluate the true impact of hernia recurrence on cost and QoL.

In studies with long-term follow-up, the benefits attributable to permanent mesh reinforcement are offset in part by mesh-related complications.[11] Acknowledging

the patients with the highest risk for mesh-related complications is critical to mitigate the associated clinical burdens and provide the most optimal repair. P4HB's antimicrobial benefits and long-term resorption properties may be helpful when exposed to bacteria in contaminated or high-risk cases where wound events and mesh infection are more likely to occur.[43,44] With the mesh completely hydrolyzed by 18 months, the chances of infections and hernia recurrence beyond 2 years are possible, but extremely low.[26,45] P4HB for VHR provides surgeons with a biomaterial that leverages the benefits and improves the deficiencies of both currently available mesh types.[43] Based on this 2-year study, reliable results are demonstrated in both the retromuscular (n = 56) and onlay plane (n = 14) as well as across clean, high-risk clean, and contaminated defects.

Limitations of this study include the lack of a comparison arm to evaluate outcomes with other mesh types. Second, this is a single-surgeon, retrospective review. Furthermore, we are aware our cost analysis can only be representative of the cost expenditure at our institution; however, we believe these results can provide insight for future analysis on biosynthetic mesh. Future prospective studies are needed to analyze long-term outcomes comparing biosynthetic mesh to synthetic and biologic mesh, and different types of biosynthetic mesh.

Collectively, these results reflect the principles of our clinical practice, including primary fascial closure, meticulous soft tissue management, optimal mesh plane placement, and the use of biosynthetic mesh in complex hernia repair. We present one of the largest single-surgeon retrospective reviews of P4HB for VHR in a challenging patient population, with no cases of mesh infection or explantation and a significant improvement in patient QoL, that remains consistent, even after the mesh has gone away.

CONCLUSIONS

So, what happens when the mesh goes away? It seems that nothing happens, which is exactly what one would hope for. P4HB mesh is an effective, versatile, biomaterial for complex VHR, associated with low 2-year recurrence, and significant improvements in QoL. Importantly, when the mesh has completely hydrolyzed, there is not an increase in recurrence or deterioration in QoL.

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