



Complex abdominal wall hernia repair with biologic mesh in elderly: a propensity matched analysis

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Abstract

Background Complex abdominal wall reconstruction (CAWR) has become a common surgical procedure both in non-elderly and elderly patients.

Objective The aim of this study is to analyze the outcomes of the elderly compared to nonelderly undergoing CAWR using propensity score matching.

Methods All patients who underwent CAWR using porcine-derived, non-crosslinked acellular dermal matrix (ADM) (Strattice™) between January 2014 and July 2017 were studied retrospectively. Propensity matched analysis was performed for risk adjustment in multivariable analysis and for one-to-one matching. The outcomes were analyzed for differences in post-operative complications, reoperations, mortality, hospital length of stay and adverse discharge disposition.

Results One hundred-thirty-six patients were identified during the study period. Non-elderly (aged 18–64 years) constituted 70% ($n=95$) and elderly (aged ≥ 65 years) comprised 30% of the overall patient population ($n=41$). Seventy-three (56.7%) were females. After adjustment through the propensity score, which included 35 pairs, the surgical site infection ($p=1.000$), wound necrosis ($p=1.000$), the need for mechanical ventilation ($p=0.259$), mortality ($p=0.083$), reoperation rate ($p=0.141$), hospital length of stay ($p=0.206$), and discharge disposition ($p=0.795$) were similar.

Conclusion Elderly patients undergoing CAWR with biological mesh have comparable outcomes with non-elderly patients when using propensity matching score.

Keywords Hernia · Complex abdominal wall reconstruction · Biologic mesh · Elderly · Posterior component release · Outcomes · Complications · Propensity matching

Introduction

In the USA by 2050, the population aged 65 and over is projected to be 83.7 million, double the estimated number of 43.1 million in 2012 [1]. This demographic shift in the population will have implications in terms of a higher proportion of elderly undergoing major surgery.

A ventral hernia is one of the most common consequences after laparotomy and often require complex abdominal wall reconstruction (CAWR) [2–4]. Yet, studies on outcomes after complex abdominal wall reconstruction (CAWR) in the elderly populations are very limited. There is evidence that postoperative morbidity and mortality is higher in elderly as compared to non-elderly and

increasing age itself remains an independent risk factor for postoperative morbidity and mortality [5]. The world health organization (WHO) consider the chronological age of 65 years as an ‘elderly’ or older person [6]. Similarly, in the United States also age ≥ 65 is considered elderly [7]. The biologic mesh has been suggested in the contaminated field or high-risk patients [8–10] undergoing CAWR. We use non-cross linked acellular porcine dermal matrix (Strattice™) in all patients at high-risk for infections and those with contaminated field undergoing CAWR. Our initial results of CAWR with Strattice™ were encouraging hence this particular mesh type was utilized [11].

This study aimed to analyze the outcomes of the elderly compared to non-elderly undergoing CAWR using biological mesh as reinforcement by utilizing propensity score matching.

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Methods

We performed a retrospective cohort review of all patients aged ≥ 18 years who underwent CAWR using a porcine-derived acellular dermal matrix (Strattice™) for complex abdominal wall hernia at Westchester Medical Center, Valhalla, NY from 2014 to 2016. The patient population was divided into two groups; non-elderly aged 18–64 years and elderly aged ≥ 65 years. Before designing the study, classification for primary and incisional abdominal wall hernias proposed by Muysoms et al., and criteria for CAWD outlined by Slater et al., was used to establish the inclusion criteria [12]. The study was approved by the Institutional Review Board.

Inclusion criteria

Patients aged ≥ 18 years who underwent CAWR with biological mesh falling into the criteria proposed by the consensus group [8].

Exclusion criteria

Patients with age < 18 years, use of synthetic mesh, simple incisional hernia closed primarily.

Variables and outcomes

The data were collected for patient demographics, etiology of hernia, past surgical history, and comorbid conditions. Intraoperative variables included the surgical approach (type of incision), lysis of adhesions, type of component separation (anterior, posterior or combined), mesh type, size, and placement technique, and associated procedures (intestinal resection, stoma/fistula takedown, panniculectomy, and redundant skin excision), and finally number of drains. Propensity scores were calculated using a logistic regression model using the following variables: age, sex, body mass index, modified frailty index, hypertension, diabetes mellitus, chronic obstructive pulmonary disease (COPD), chronic kidney disease, ischemic heart disease, cirrhosis, malignancy, dementia, obesity, arthritis, psychiatric disorder, patient functionality, peripheral vascular disease, type of prior surgery, mesh size and number of drains.

The outcome measures were mortality, hospital length of stay, intensive care length of stay, need for mechanical ventilation, surgical site infection, seroma, need for reoperation and adverse discharge disposition.

Surgical site infections were defined using the US Centers for Disease Control and Prevention criteria for superficial and deep incisional SSI. These criteria require the patient to have at least one of the following: (1) purulent drainage from the superficial or deep (fascia or muscle) incision but not from within the organ or space component of the surgical site; (2) pain or tenderness, localized swelling, redness, heat, or fever, or several of these symptoms, and the incision is opened deliberately or spontaneously dehisces; or (3) abscess within the wound (clinically or radiologically detected) [13, 14]. Post-operative seroma, if present, was defined according to the classification proposed by Morales et al. [15] Adverse discharge disposition was defined as the discharge to an acute or sub-acute rehabilitation center. The modified frailty index (mFi) score was calculated based on Velanovich et al. [16], while the uniformity in reporting the outcome results after abdominal wall repair was ensured using the recommendations from Muysoms et al. at EuraHS Working Group (European Registry of Abdominal Wall Hernias) [17].

Surgical technique

The choice of mesh to strengthen the reconstruction of the abdominal wall in all the patients was an acellular porcine dermal matrix (Strattice™). Mesh placement techniques employed in our patient population were: sublay (retro-rectus), underlay (intraperitoneal), onlay or bridge. However, since 2017 our group has changed the mesh placement technique from intraperitoneally (underlay) and anterior component separation [18, 19] to posterior component separation (PCS) with or without transversus abdominis release (TAR) and sublay (retro-rectus) mesh placement [20–22]. During PCS we ensure the sparing of all neurovascular bundles.

The linea alba is closed over the mesh whenever possible. During the closing of the abdominal wall, we measure airway peak pressure. The increase of up to 5 cm H₂O change from the open state to closed linea alba is deemed acceptable. We place two or three 19-french Blake drains below the fascia-adipocutaneous flaps.

Statistical analysis

Summary statistics are presented as frequencies and percentages for the categorical variable. The continuous data are presented as mean and standard deviation. The data were compared using the independent student *t* test for continuous variables and the Chi-squared test for categorical variables before matching; after matching, $p < 0.05$ was considered significant. We performed one-to-one pair propensity score matching using nearest neighbor matching with no replacement (a single participant could not be selected multiple

times). Propensity scores were predicted probabilities of the logistic regression equation for individual covariate patterns. Tolerance for matching was set at 0.2. The analysis was conducted using SPSS 25 software (IBM, Inc., Armonk NY, USA). The study report complies with the STROBE criteria [23].

Results

During the study period, we included 136 patients who underwent CAWR with biological mesh from January 2014 to July 2017. Non-elderly (aged 18–64 years) constituted 70% ($n=95$) and elderly (aged ≥ 65 years) were 30% ($n=41$). There were 73 females (56.7%) and 63 males (46.3%).

After one to one propensity matching, we created 35 pairs of elderly and non-elderly (age 18–64 years). Thus, six elderly patients lacked matches within the tolerance threshold and were not included in the analyses in the PSM group.

Baseline characteristics

As shown in Table 1, the significant variables in elderly were: age (75.7 ± 6.8 years in elderly vs. 49.4 ± 11.3 years in non-elderly, $p < 0.001$), frailty (24.4% vs. 9.5%, $p = 0.02$), presentation to the hospital with small bowel obstruction (22% vs. 9.5%, $p = 0.049$), and comorbidities such as hypertension (82.9% vs. 51.6%, $p = 0.001$), and malignancy (39.0% vs. 13.7%, $p = 0.00$). The nonelderly group had a higher percentage of hernia as chief complaint (83.2% vs. 61.0%, $p = 0.005$). Elderly were more dependent on caregivers or family members for the activities of daily living (ADL) (47.5% vs. 23.4%, $p = 0.006$).

After PSM, two pairs of 35 patients were obtained. An analysis of the baseline characteristics was performed to evaluate the accuracy of the method, as shown in Table 1. There were no significant differences between the two matched groups regarding patient baseline characteristics. The groups were similar in terms of age, frailty, presentation, and comorbidities after controlling for confounders.

Operative characteristics

Table 2 shows that before PSM, the type of incision, intestinal resection rate (20.0% vs. 20.2%, $p = 0.977$), ECF take down (4.9% vs. 7.4%, $p = 0.7228$) and stoma take down (7.3% vs. 10.6%, $p = 0.753$) were statistically similar in both age groups. Similarly, retro-rectus mesh placement (64.1% in elderly vs. 63.7% in non-elderly), and bridge mesh placement (17.9% in elderly vs. 19.8% in non-elderly) were comparable in both age groups. However, the underlay

technique was used more commonly in the elderly (17.9% vs. 5.5%, $p = 0.026$) and onlay technique was more common in the non-elderly (11.0% vs. 0%, $p = 0.026$). The Center for Disease Control (CDC) wound class II, III, IV were similar for both groups (43.9% in elderly vs. 48.4% in non-elderly, $p = 0.628$). The panniculectomy rates (2.4% in elderly vs. 5.3% in non-elderly, $p = 0.667$), mean mesh size (544.81 ± 580.9 cm² in elderly vs. 449.8 ± 257.5 cm² in non-elderly, $p = 0.241$) and number of drains placed (2.21 ± 1.1 in elderly vs. 1.99 ± 1.3 in non-elderly, $p = 0.355$) were also similar.

After PSM, as shown in Table 2, the difference between mesh placement techniques was found to be non-significant for all placement locations ($p = 0.255$). All other major operative characteristics including type of operative approach, CDC wound class II/III/IV ($p = 0.632$), panniculectomy rates ($p = 1.000$), excision of redundant skin ($p = 0.062$), primary wound closure rates ($p = 1.000$), mesh size ($p = 0.377$) and the number of drains placed ($p = 0.235$) remained statistically similar.

Post-operative outcomes

The postoperative outcomes for the two groups before and after PSM are depicted in Table 3. Overall intraoperative complication rate (4.9% in elderly vs. 1.1% in non-elderly, $p = 0.216$), surgical site infection rate (7.3% in elderly vs. 6.4% in non-elderly, $p = 1.000$), wound necrosis (2.5% vs. 3.2%, $p = 1.000$) and need for a wound VAC (22.0% in elderly vs. 21.1% in non-elderly, $p = 0.907$) were comparable.

The postoperative need for mechanical ventilation was significantly higher in the elderly as compared to the non-elderly (22.0% in elderly vs. 5.0% in non-elderly, $p = 0.006$). A higher proportion of the elderly was discharged to skilled nursing facilities (16.2% in elderly vs. 4.3% in non-elderly, $p = 0.024$) and subacute rehabilitation centers (in elderly 18.9% vs. 14.1% in nonelderly, $p = 0.024$). The statistically higher number of non-elderly patients were discharged home as compared to the elderly (77.8% vs. 56.8%). The in-hospital mortality (7.3% in elderly vs. 1.1% in non-elderly, $p = 0.083$), the reoperation rate (12.2% in elderly vs. 23.2% in non-elderly, $p = 0.141$) and the hospital length of stay (17.49 ± 26.84 days in elderly vs. 12.79 ± 14.44 days in non-elderly, $p = 0.206$) were statistically similar in both groups.

After PSM, as shown in Table 3, the need for postoperative mechanical ventilation was statistically similar between the two groups (17.1% in elderly vs. 5.7% in non-elderly, $p = 0.259$).

The discharge disposition was also similar. A statistically similar percentage of elderly were discharged to home (67.7% vs. 76.5% non-elderly, $p = 0.795$), to skilled nursing facilities (12.9% vs. 5.9% non-elderly, $p = 0.795$) and to

Table 1 Baseline characteristics of elderly vs non-elderly patients undergoing complex abdominal wall reconstruction with acellular porcine dermal matrix

	Overall series			Propensity-matched series		
	Non-elderly, N=95 (%)	Elderly, N=41 (%)	p value	Non-elderly, N=35 (%)	Elderly N=35 (%)	p value
Age (years)	49.4±11.3	75.7±6.8	<0.001*	53.7±9.1	75.5±6.7	<0.001*
Gender			0.025*			0.053
Male	50 (52.6%)	13 (31.7%)		19 (54.3%)	11 (31.4%)	
Female	45 (47.4%)	28 (68.3%)		16 (45.7%)	24 (68.6%)	
Body mass index (BMI Kg/m ²)	32.2±10.3	31.0±6.9	0.52	32.0±9.1	31.1±6.4	0.607
Frailty (mFI 3+)	9 (9.5%)	10 (24.4%)	0.02*	6 (17.1%)	6 (17.1%)	1.00
Presentation						
Hernia	79 (83.2%)	25 (61.0%)	0.005*	25 (71.4%)	22 (62.9%)	0.445
Enterocutaneous fistula	9 (9.5%)	2 (4.9%)	0.504	5 (14.3%)	1 (2.9%)	0.198
Small bowel obstruction	9 (9.5%)	9 (22.0%)	0.049*	6 (17.1%)	7 (20.0%)	0.749
Prior predisposing condition						
Trauma	14 (14.7%)	4 (9.8%)	0.432	2 (5.7%)	4 (11.4%)	0.673
Elective intraabdominal surgery	45 (47.4%)	17 (41.5%)	0.526	14 (40.0%)	16 (45.7%)	0.732
Diverticulitis	10 (10.5%)	4 (9.8%)	1.000	4 (11.4%)	4 (11.4%)	1.000
Other colonic surgery	7 (7.4%)	5 (12.2%)	0.511	1 (2.9%)	4 (11.4%)	0.356
Small bowel obstruction	6 (6.3%)	2 (4.9%)	1.000	4 (11.4%)	2 (5.7%)	0.673
Urologic surgery	4 (4.2%)	3 (7.3%)	0.430	2 (5.7%)	3 (8.6%)	1.000
Obstetric/gynecologic	13 (13.7%)	6 (14.6%)	0.883	4 (11.4%)	6 (17.1%)	0.734
Cancer	8 (8.4%)	6 (14.6%)	0.356	8 (22.9%)	5 (14.3%)	0.356
Solid organ transplant						
Heart transplant	3 (3.2%)	0	0.554	1 (2.9%)	0	1.000
Liver transplant	10 (10.5%)	2 (4.9%)	0.510	5 (14.3%)	2 (5.7%)	0.428
Kidney transplant	8 (8.4%)	1 (2.4%)	0.277	2 (5.7%)	0	0.493
Open abdomen management	15 (15.8%)	8 (19.5%)	0.595	4 (11.4%)	7 (20.0%)	0.324
Setting						
Elective	68 (71.6%)	24 (58.5%)	0.136	24 (68.6%)	22 (62.9%)	0.615
Urgent/emergent	27 (28.4%)	17 (41.5%)		11 (31.4%)	13 (37.1%)	
Comorbidity						
Congestive heart failure	3 (3.2%)	2 (4.9%)	0.637	0	1 (2.9%)	1.000
Dialysis	3 (3.2%)	3 (7.3%)	0.365	1 (2.9%)	2 (5.7%)	1.000
Acute renal failure	2 (2.1%)	0	1.000	2 (5.7%)	0	0.493
Chronic steroid use	13 (13.7%)	3 (7.3%)	0.390	5 (14.3%)	3 (8.6%)	0.710
Cardiac disease	12 (12.6%)	10 (24.4%)	0.087	5 (14.3%)	8 (22.9%)	0.356
Hypertension	49 (51.6%)	34 (82.9%)	0.001*	23 (65.7%)	28 (80.0%)	0.179
COPD	11 (11.6%)	6 (14.6%)	0.621	3 (8.6%)	5 (14.3%)	0.710
Cirrhosis	8 (8.5%)	5 (12.2%)	0.533	2 (5.7%)	5 (14.3%)	0.428
Smoking	16 (17.0%)	6 (14.6%)	0.729	4 (11.4%)	6 (17.1%)	0.734
Alcohol abuse	16 (17.0%)	2 (4.9%)	0.056	3 (8.6%)	2 (5.7%)	1.000
Drug abuse	5 (5.3%)	1 (2.4%)	0.667	0	1 (2.9%)	1.000
Malignancy	13 (13.7%)	16 (39.0%)	0.001*	13 (37.1%)	12 (34.3%)	0.803
Diabetes	26 (27.4%)	17 (41.5%)	0.104	15 (42.9%)	14 (40.0%)	0.808
Obesity	45 (48.4%)	18 (43.9%)	0.631	16 (45.7%)	16 (45.7%)	1.000
Arthritis	6 (6.3%)	3 (7.3%)	1.000	2 (5.7%)	2 (5.7%)	1.000
Psychiatric disorder	17 (17.9%)	3 (7.3%)	0.109	8 (22.9%)	3 (8.6%)	0.101
Patient functionally dependent	22 (23.4%)	19 (47.5%)	0.006*	10 (28.6%)	14 (40.0%)	0.313
Altered sensorium	6 (6.7%)	5 (12.5%)	0.314	2 (5.7%)	4 (11.8%)	0.428

Table 1 (continued)

	Overall series			Propensity-matched series		
	Non-elderly, N=95 (%)	Elderly, N=41 (%)	p value	Non-elderly, N=35 (%)	Elderly N=35 (%)	p value
Peripheral vascular disease	5 (5.3%)	5 (12.2%)	0.168	4 (11.4%)	4 (11.4%)	1.000

*Significant at $p < 0.05$

Table 2 Comparison of operative characteristics of elderly vs non-elderly patients undergoing complex abdominal wall reconstruction with acellular porcine dermal matrix

	Overall series			Propensity-matched series		
	Non-elderly, N=95 (%)	Elderly, N=41 (%)	p value	Non-elderly, N=35 (%)	Elderly N=35 (%)	p value
Type of incision						
Midline	73 (77.7%)	31 (75.6%)	0.794	25 (71.4%)	27 (77.1%)	0.584
Flank	2 (2.1%)	1 (2.4%)	1.000	0 (0.0%)	1 (2.9%)	1.000
Para median	5 (5.3%)	4 (9.8%)	0.453	2 (5.7%)	4 (11.4%)	0.673
Left lower quadrant	0	2 (4.9%)	0.090	0	1 (2.9%)	1.000
Left upper quadrant	3 (3.2%)	1 (2.4%)	1.000	3 (8.6%)	0	0.239
Right upper quadrant	5 (5.3%)	0	0.322	2 (5.7%)	0	0.492
Right lower quadrant	2 (2.1%)	1 (2.4%)	1.000	0	1 (2.9%)	1.000
Bilateral subcostal	7 (7.4%)	1 (2.4%)	0.434	3 (8.6%)	1 (2.9%)	0.614
Lysis of adhesions	73 (76.8%)	27 (65.9%)	0.182	28 (80.0%)	22 (62.9%)	0.112
Intestinal resection	19 (20.2%)	8 (20.0%)	0.977	9 (25.7%)	6 (17.6%)	0.417
Fistula take down	7 (7.4%)	2 (4.9%)	0.722	4 (11.8%)	1 (2.9%)	0.198
Stoma take down	10 (10.6%)	3 (7.3%)	0.753	4 (11.4%)	3 (8.6%)	1.000
Lateral component separation	36 (37.9%)	16 (39.0%)	0.900	13 (37.1%)	15 (42.9%)	0.625
Mesh placement technique						
Sublay (retro-rectus)	58 (63.7%)	25 (64.1%)	0.026*	25 (75.8%)	20 (60.6%)	0.255
Onlay	10 (11.0%)	0		3 (9.1%)	0	
Bridge	18 (19.8%)	7 (17.9%)		5 (15.2%)	6 (18.2%)	
Underlay	5 (5.5%)	7 (17.9%)		0	7 (21.2%)	
Wound class II/III/IV	46 (48.4%)	18 (43.9%)	0.628	18 (51.4%)	16 (45.7%)	0.632
Panniculectomy	5 (5.3%)	1 (2.4%)	0.667	1 (2.9%)	1 (2.9%)	1.000
Excision of redundant skin	14 (14.7%)	11 (26.8%)	0.094	3 (8.6%)	10 (28.6%)	0.062
Primary wound closure	78 (82.1%)	34 (82.9%)	0.908	30 (85.7%)	30 (85.7%)	1.000
Mesh size (cm ²)	449.8 ± 257.5	544.81 ± 580.9	0.241	457.55 ± 268.7	571.19 ± 626.4	0.377
Number of drains	1.99 ± 1.3	2.21 ± 1.1	0.355	1.91 ± 1.1	2.24 ± 1.1	0.235

*Significant at $p < 0.05$

subacute rehabilitation centers (16.1% vs. 11.8% nonelderly, $p = 0.795$).

The intraoperative complication rate (2.9% in elderly with 0 in non-elderly, $p = 1.000$), the need for wound VAC utilization (22.9% in elderly vs. 14.3% in non-elderly, $p = 0.356$), wound infection rate (8.6% in elderly vs. 5.7% in non-elderly, $p = 1.000$), wound necrosis rate (2.9% in elderly vs. 0% in non-elderly, $p = 0.493$), hospital mortality rate (2.9% in elderly vs. 2.9% in nonelderly, $p = 1.000$), the reoperation rate (11.4% in elderly vs. 14.3% in non-elderly, $p = 1.000$) and the hospital length of stay (13.16 ± 13.06 days in elderly

vs. 11.58 ± 11.53 days in nonelderly, $p = 0.606$) remained statistically similar.

Discussion

We have demonstrated that, when controlling for confounding variables with propensity score matching, abdominal wall reconstruction in the elderly population is not associated with greater complications than in non-elderly. There were no significant differences in operative

Table 3 Comparison of post-operative outcomes of elderly vs non-elderly patients undergoing complex abdominal wall reconstruction with acellular porcine dermal matrix

	Overall series			Propensity-matched series		
	Non-elderly, N=95 (%)	Elderly, N=41 (%)	<i>p</i> value	Non-elderly, N=35 (%)	Elderly N=35 (%)	<i>p</i> value
Intraoperative complications	1 (1.1%)	2 (4.9%)	0.216	0	1 (2.9%)	1.000
Need for wound VAC	20 (21.1%)	9 (22.0%)	0.907	5 (14.3%)	8 (22.9%)	0.356
Wound infection	6 (6.4%)	3 (7.3%)	1.000	2 (5.7%)	3 (8.6%)	1.000
Wound necrosis	3 (3.2%)	1 (2.5%)	1.000	0	1 (2.9%)	0.493
Mechanical ventilation required	5 (5.3%)	9 (22.0%)	0.006*	2 (5.7%)	6 (17.1%)	0.259
Discharge disposition						
Home	71 (77.2%)	21 (56.8%)	0.024*	26 (76.5%)	21 (67.7%)	0.795
Skilled nursing facility	4 (4.3%)	6 (16.2%)		2 (5.9%)	4 (12.9%)	
Subacute rehabilitation	13 (14.1%)	7 (18.9%)		4 (11.8%)	5 (16.1%)	
Acute care hospital	2 (2.2%)	0		1 (2.9%)	0	
Discharged home with the drain	58 (65.9%)	22 (62.9%)	0.749	24 (70.6%)	18 (60.0%)	0.373
Death	1 (1.1%)	3 (7.3%)	0.083	1 (2.9%)	1 (2.9%)	1.000
Reoperation	22 (23.2%)	5 (12.2%)	0.141	5 (14.3%)	4 (11.4%)	1.000
Hospital Length of stay (days)	12.79 ± 14.44	17.49 ± 26.84	0.206	11.58 ± 11.53	13.16 ± 13.06	0.606

VAC vacuum-assisted closure

*Significant at $p < 0.05$

technique. Post-operative complications, ventilator utilization, and hospital and /ICU length of stay were similar. The type and frequency of discharge disposition were also similar for the two groups. These results are in concordance with those reported by Giordano et al. [24].

In our practice, we use biologic mesh for all patients who had an open abdomen management, multiple comorbidities and are high risk for infection (Hernia Working Group class 3, and 4) [25], complex re-operative surgery for recurrent hernia, patient on immunosuppressive medication or those who undergo CAWR in the acute setting. The main operative technique that we currently use is the posterior component separation with or without transversus abdominis release (TAR) and sublay (retro-rectus) mesh placement [20–22]. On occasions we may perform the anterior component separation. The use of synthetic mesh in complex cases and those associated with high risk for infection is associated with higher rates of complications such as infections, fistulas and need for explantation [10].

The elderly population has more chronic conditions, and thus it is expected that this may lead to a higher rate of postoperative morbidity and mortality [26]. One of the most feared complications after CAWR is wound infections [17]. Surgical site infection (SSI) is associated with a longer postoperative hospital stay, additional surgical procedures or stay in the intensive care unit and often higher mortality

[18]. In our study, the incidence of SSIs was comparable between the two groups and was associated with a statistically similar rate of reoperations before and after PSM. All the reoperations were for wound debridement only, and no mesh required explantation. The biological nature of the mesh offers this distinct advantage of mesh salvage in high-risk cases.

Post-operative mechanical ventilation (MV) is often required in the aging population and leads to higher rates of morbidity and increased healthcare costs [27, 28]. In the current study, however, the need for MV was not significantly different from the non-elderly population. It has been reported that 45% of elderly patients require services such as home health care, skilled nursing facilities, and inpatient rehabilitation after elective surgery [29]. In our study, after adjusting for baseline characteristics with PSM, we did not find disposition in the elderly to be any different from the non-elderly.

Advanced age and comorbidities are often interrelated [30]. As expected in our study the comorbidities and frailty were more prevalent in the elderly but after PSM analysis this effect was found not to be significant. This may explain the lack of significant post-operative outcomes differences between our two age groups. The plausible explanation is that because of changing lifestyle and increased longevity the distribution of comorbidities is gradually becoming

more uniformly distributed. This area remains to be explored further.

Importantly, old age, high burden of comorbidities and frailty have negative impact on decision making and proper access to surgery [31]. The strategy of ‘prehabilitation’ to increase functional capacity prior to a surgical procedure represents an ideal opportunity to identify modifiable risk factors, and introduce interventions to reduce the negative effect of comorbidity on the postoperative outcomes [32]. The key components of this multimodality strategy are medical optimization, preoperative physical exercise, nutritional support, and stress/anxiety reduction [33]. Several studies have shown that the favorable outcome can be achieved after employing prehabilitation in various types of surgeries. The CAWR specific prehabilitation, yet to be developed, may further improve the outcomes in this group of patients.

There are a number of strengths of this study. The main one is the use of propensity score matching allowing for controlling the confounders. The strict study design and the use of frailty as one of the co-dependent factors used to analyze outcomes after CAWR with biological mesh in the elderly are other strengths.

However, there are few study limitations as well, including the retrospective nature of our study and lack of data on recurrence rate and quality of life after CAWR. The number of patients in each group limits the statistical power to detect medium or small differences between groups. Furthermore, unlike randomized control trials, the introduction of unmeasured characteristics and confounders is one of the other potential limitations of PSM.

Conclusions

Outcomes after CAWR with a biological mesh did not differ between elderly and non-elderly patients and advanced age did not translate into poor outcome as compared to the non-elderly. Based on these findings, advanced age should not be regarded as an absolute or relative contraindication to CAWR.

Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

Ethical approval The study was approved by the Institutional Review Board.

Human and animal rights The study including human participants has been performed in accordance with the ethical standards of the Declaration of Helinski and its later amendments.

Informed consent Informed Consent was obtained from patients prior to all surgical procedures.


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