Comparative study of biological versus synthetic prostheses in the treatment of ventral hernias classified as grade II/III by the Ventral Hernia Working Group

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Short title: Bioprostheses & Ventral Hernias VHWG II/III

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Summary

AIM OF THE STUDY: The implantation of biological prostheses in an at-risk environment has seen increasing use. Their markedly higher cost compared to synthetic prostheses makes it important to analyze their usefulness in terms of actual benefit and cost-effectiveness. This study aims to examine the relevance of bioprostheses during surgical repair of Grade II/III ventral hernias as classified by the Ventral Hernia Working Group (VHWG).

MATERIALS AND METHODS: This study analyzed the data of 119 patients requiring non-emergency repair of VHWG II/III grade hernias between 2010 and 2017. The results of patients who were treated with a bioprosthesis (n = 59) were compared to those receiving a synthetic prosthesis (n = 60). The primary outcome was surgical site infection (SSI) at 90 days. The secondary endpoints were hernia recurrence rate, cost of the prosthesis, duration of hospital stay and re-hospitalization rate.

RESULTS: The two groups were shown to be comparable by analysis of demographic, pre- and intra-operative data. The SSI rate was significantly higher in the bioprosthesis group (20% *vs.* 7%; p = 0.010), as was the recurrence rate (56% *vs.* 28%; p = 0.003) with a median follow-up of 40.15 months. The cost of the bioprosthesis was significantly higher than that of the synthetic prosthesis (€ 3363 *vs.* € 249; p <0.010).

CONCLUSION: In this retrospective study, the use of a bioprosthesis for repair of VHWG II/III ventral hernias was associated with a higher rate of both SSI and hernia recurrence at a cost 13 times greater than the use of a synthetic prosthesis.

Keywords: Biological prosthesis, Parietal reconstruction, Grade II/III ventral hernia, SSI, Recurrence

Essential points

- The management of ventral hernia in patients at risk of septic complications is poorly codified.
- The most important risk after prosthetic repair of abdominal wall hernia is surgical site infection (SSI).
- The development of bioprostheses has offered hope of decreasing the risks of SSI or recurrence in contaminated, clean-contaminated or at-risk of contamination, operative settings, but at a very high cost.
- The results of our study showed bioprostheses to have a low efficacy in preventing SSI in patients at septic risk and they are associated with a significant medium-term risk of recurrence.
- The use of bioprostheses must be reconsidered and should probably be limited to exceptional situations which must be defined in terms of patient and societal benefit.

Introduction

The surgical management of ventral hernias is a complex issue that has led to the evaluation of the benefit of the prophylactic placement of a prosthesis during the closure of a midline laparotomy in at-risk patients (1). The many surgical techniques and multiple available types of synthetic and biological prostheses have led to heterogeneous studies with contradictory results (2,3). There is currently no consensus on the management of ventral hernias, and treatment methods vary among surgeons. In 2008, the Cochrane Database published a systematic review analyzing the different repair techniques, with or without prosthesis, as well as the different implantation sites, and was unable to issue a formal recommendation (4). The only point of consensus is that repair with prosthesis implantation reduces the rate of late hernia recurrence (5,6). Some teams go so far as to question the value of surgical management compared to simple monitoring (7). The most feared post-operative complication is infection of the prosthesis, whose prevalence varies between 5 and 10% in some studies, or even more than 30% depending on the presence of contamination or intra-operative infection (8-12). Biological prostheses constructed from porcine or bovine dermis with or without collagen cross-linking (reticulation) have been developed and marketed with the aim of reducing the incidence of prosthetic infection. The initial concept was that their matrix of biological origin would be integrated into the native tissue and allow better resistance to bacterial contamination. Clinical trials in animals supported this hypothesis, showing better bacterial clearance compared to polytetrafluoroethylene (PTFE) prostheses (13). Their use has increased in recent years, mainly for implantation in a contaminated or clean-contaminated environment, or when the risk of infection is considered high. In 2010, the Ventral Hernia Working Group published recommendations for hernia repair techniques tailored to their four grades of classification shown in Figure 1. These recommendations, based on studies with a low level of evidence, proposed use of biological prostheses for Grade II (patients with co-morbidities) [3]. Like many recommendations, even though they

are of weak scientific evidence, they have been widely referenced and have been followed in clinical practice. However, studies have shown conflicting results on their benefit in preventing SSI, as well as their long-term effectiveness in preventing the risk of hernia recurrence (14,15). In view of their cost, which is markedly higher than that of PTFE prostheses, it is important to rigorously analyze their usefulness in terms of actual benefit for the patient and for society. The objective of this study was to compare the post-operative results after implantation of a biological versus synthetic prosthesis during ventral hernia repair in patients at risk of septic complication (VHWG Grade II and III) (3,16).

Patients and Method

This is a retrospective, monocentric, comparative cohort study, based on the type of prosthesis implanted (biological or synthetic) during ventral hernia repair at the two digestive surgery departments of the University Hospital of Montpellier between January 1, 2010 and December 31, 2017. This study was conducted as part of an assessment of professional practices in our operating rooms. Only patients with a ventral hernia at increased risk of infection, VHWG grade II or III (3,16) were included. The data of patients who were treated with a biological prosthesis (Pbio group) or synthetic (Psyn group) were compared. Patients with grade I or IV ventral hernia and those undergoing emergency surgery were excluded. Data collection was carried out retrospectively after approval by the establishment's ethics committee (IRB no. 2019_IRB-MTP_06-09), using the data available in the patient's computerized medical file *via* our institution's software (Dx Care®). Demographic data (age, sex, BMI, ASA score) as well as medical history (diabetes, COPD, smoking, alcohol consumption, immunosuppressive treatment, type of initial intervention, context of recurrent ventral hernia) were collected and compared.

Surgeries

The surgical data were collected from the operative report: the type of hernia surgery (midline, subcostal, transverse, peristomal), the diameter in cm of the hernia neck, the type and size of prosthesis used and the type of repair (onlay, sublay, underlay and inlay). The choice of the type of prosthesis was left to the discretion of the operating surgeon since there was no defined treatment protocol at our center. Drains were placed according to the surgeons' preferences, and generally removed between the third and fifth post-operative day if drainage was less than 50cc/24h. All procedures were performed by laparotomy in these VHWG II/III patients.

Post-operative follow-up

Follow-up data were obtained from the various consultation letters and examination results available. Data concerning duration of stay and the rate of unscheduled re-hospitalization were collected.

Morbidity and mortality data were collected up to 90 days after the operation, and classified according to Clavien-Dindo (17). Typically, follow-up consisted of a systematic follow-up visit with the surgeon at one month and at three months after the operation.

Recurrence was assessed by clinical examination, possibly confirmed by an imaging study in case of clinical doubt (ultrasound or uninjected abdomino-pelvic CT). For patients who were not available for follow-up visit, a telephone interview was carried out at the time of the study to find out whether they had developed a recurrence and, if so, its time to onset and whether it had required surgery.

The costs for prosthetic implants were provided by the pharmacist of the service.

Outcome measures

The primary outcome measure was the rate of SSI at 90 days after the operation, defined by the presence of a local infection around the prosthesis resulting in abscess, generalized sepsis or purulent discharge from the wound.

Secondary endpoints included the hernia recurrence rate, the cost of the prosthesis, duration of stay and re-hospitalization rate.

Statistical analysis

Statistical analysis was carried out by the Department of Medical Information of the University Hospital of Montpellier using SAS® Version 7.12 HF4 software. Quantitative variables were described by their number with mean and standard deviation, or by their median with 1st and 3rd quartiles and range (minimum and maximum). Qualitative variables were described by their frequency and the percentage of patients in each category. Missing data was not considered in the calculation of the percentages.

Two groups were studied: the biological prosthesis (PBio) group and the synthetic prosthesis (PSyn) group. Comparison between the groups was established by the Chi-square or Fisher's tests for qualitative variables and by the Student's or Wilcoxon and Mann-Whitney tests for quantitative variables. The results for the primary endpoint, SSI, were analyzed using a univariable and multivariable logistic regression model. They are expressed as Odds Ratio with 95% confidence interval, adjusted for the ASA score and the type of prosthesis. All statistical tests were two-tailed with a Type I error of 0.05. Recurrent hernia and interval to recurrence were represented according to the Kaplan-Meier method and compared between the two groups according to the Log Rank test.

Results

Descriptive analysis of populations and surgical interventions

Between January 1, 2010 and December 31, 2017, 563 patients underwent ventral hernia repair with placement of a parietal prosthesis at the University

Hospital of Montpellier. Among them, 441 patients received a synthetic prosthesis (78.3%) and 122 received a biological prosthesis (21.6%). In our study, 119 patients who met the inclusion criteria were analyzed. For these patients, 59 patients received a biological prosthesis (PBio group) and 60 patients received a synthetic prosthesis (PSyn group). The flow diagram is summarized in Figure 2. The distribution by VHWG Grade was similar between the two groups, including the patients classified VHWG II (28 (47.5%) versus 29 (48.3%); p = 0.924) and the patients classified VHWG III (31 (52.5%) versus 31 (51.7%); p = 0.924). Patient demographics, co-morbidities and surgical characteristics of the procedures were analyzed and compared between the two groups. Apart from the ASA score, which was significantly higher in the PBio group compared to the PSyn group (3 [1-3] versus 2 [1-4]; p <0.010), the other demographic data were comparable in the two groups. Co-morbidity data showed no statistically significant difference between the two groups (Table 1). In the overall population studied, the two predominant indications for the initial surgery from which the ventral hernia stemmed were inframesocolic surgery in 70 patients (58.8%), 48 of whom had peristomal hernia (40%), followed by liver transplantation in 37 patients (31%). There was no significant difference between the two groups regarding the indications for the initial surgery.

The anatomical characteristics of the ventral hernia and the intra-operative data are detailed in Table 2. No statistically significant difference was found in the mean size of the hernia neck between the two groups (7.75 cm ± 5.25 versus 8.36 cm ± 7.10; p = 0.790). In contrast, the surface area of the prosthesis used (in cm^2) was significantly larger in the Pbio group (519.6 ± 404.1 *vs.* 334.24 +/- 241; p = 0.032). There was no statistically significant difference between the two groups regarding the association of the ventral hernia repair with another intervention, including colectomy, cholecystectomy and stomal transposition. The positioning of the prosthesis was comparable between the two groups, mainly in the retromuscular position (35 (63.6%) *vs.* 39 (65%); p = 0.890), and intraperitoneal (17 (30.9%) *vs.* 20 (33, 3%); p = 0.780). Regarding details of surgical technique, there was no statistically significant difference in terms of the

use of a component separation technique, implantation of a bridging prosthesis, drainage, or placement of a compression bandage. Note that there were more bridging prostheses in the PBio group although this was not statistically significant (3 (5.45%) versus 0 (0%); p = 0.106). Three types of biological prostheses were used (CELLIS® (reticulated porcine dermis, Mecellis-La Rochelle- France; n = 38), PERMACOL® (reticulated porcine dermis, Covidien / Medtronic-Minneapolis, USA; n = 12), TUTOMESH® (non-retriculated bovine pericardium, Novomedics-Metz- France; n = 9)). Nine types of synthetic prosthesis were used in this study (PROLENE® n = 17; PHYSIOMESH® n = 17; PARIETEX® n = 9; VENTRAL PATCH® n = 5; PROGRIP® n = 5; PROCEED® n = 3; TIMESH® n = 2; PROMESH® n = 1; ABSOLIGHT® n = 1).

Post-operative results

The post-operative results are detailed in Table 3. There was no statistically significant difference in parietal complications in terms of hematoma, seroma, skin necrosis and evisceration. There was more wound dehiscence in the PBio group (8 (13.5%) *vs*. 0 (0%); p = 0.030). The severity of complications was greater in the PBio group, with more Clavien 3-4 complications (14 (23.7%) *vs.* 4 (6.6%); p = 0.009). More of the complications in the PSyn group underwent simple monitoring than in the PBio group (5 (45.4%) *vs.* 1 (5%); p = 0.013).
Other types of management (revisional surgery, antibiotic therapy, radiological drainage, local wound care or VAC therapy) were not statistically significantly different in the two groups.

Primary endpoint results
The SSI rate was significantly higher in the PBio group (12 (20.3%) *vs.* 4 (6.6%); p = 0.014). In multivariable analysis (Table 4), the variables that were independently associated with SSI were: diabetes (OR: 4.127 (1.009-16.875); p = 0.048), use of a biological prosthesis (OR: 4.585 (1.167–18.001); p = 0.029) and

performance of a colectomy in association with the ventral hernia repair (OR: 38.381 (2.186-673.843); p = 0.01).
Retromuscular positioning of the prosthesis was a protective factor (OR: 0.287 (0.089-0.925); p = 0.03).

Secondary endpoint results

Duration of stay and cost of the prosthesis
The total duration of stay was significantly longer in the PBio group (median 7 days [1-28] *vs.* 5 days [1-29]; p = 0.001). The length of stay in intensive care or continuing care was not statistically different in the two groups. The readmission rate was statistically significantly higher in the PBio group (10 (16.9%) *vs.* 2 (3.3%); p = 0.013). The average cost of the prosthesis was statistically significantly higher in the PBio group (€ 3,363.34 (± € 2,355.08) *vs.* €249.44 (± € 187.76); p <0.001).

Recurrent ventral hernia
After a median follow-up of 36.5 months (3-105 months) with five patients lost to follow-up (one in the PSyn group, four in the PBio group), 48 patients developed recurrence of their ventral hernia (40%) within a median interval of ten months (1-30 months). The number of recurrences was statistically significantly greater in the PBio group compared to the PSyn group (31 (56.36%) *vs.* 17 (28.8%); p = 0.002).
These results were confirmed by analysis of recurrence-free survival, which was significantly lower in the PBio group (p = 0.001) (Figure 3). Among these patients, 23 (48%) were re-operated, including 11 in the PBio group and 12 in the Psyn group.

Discussion

This study leads us to express strong cautions about the effectiveness of biological prostheses in patients with VHWG Grade II/III hernias, in view of the higher rate of SSI (20%), with longer hospital stay, higher rehospitalization rate and medium-term recurrence rate (> 50%) compared to patients who had implantation of a synthetic prosthesis. When these disappointing results are coupled to an additional material cost 13 times greater than that of synthetic material, we must question the medico-economic interest of continuing to use bioprosthetic material. The short and medium term results of this study are in agreement with other data available in the literature (18,19).

In 2015, Abdelfatah *et al.* published a study reporting the long-term results of Permacol® bioprostheses with a follow-up of more than five years. The surgical site infection rate in their series was 20% for all VHWG classes combined, with a 66% overall rate of clinically confirmed recurrence (18).

In 2016, Majmunder *et al.* conducted a retrospective multicenter comparative study comparing biological and synthetic prostheses with regard to infection risk and recurrence rate (19). Their results also demonstrated a higher SSI rate in the PBio group (31.9% *vs.* 12.3%, $p = 0.01$), as well as a higher 1-year recurrence rate compared to the PSyn group (26.3% *vs.* 8.9%, $p = 0.039$).

More recently, Baldan *et al.* published a retrospective multicenter study to present the results of biological prostheses in northeastern Italy (20). Although there was no comparison with synthetic prostheses, they showed SSI rates of only 8.9% and 14.3% in VHWG II and III classes respectively. This infection rate seems low compared to our study and the other studies discussed above. Since their definition of infection was not precisely explained in their methodology and was perhaps more restrictive than the one we used, it is possible that this explains the complication rates of 32.4% and 36.6% in the VHWG II and III groups, respectively, including hematomas, seromas and enterocutaneous fistulas; this is lower than in our experience.

Their study has the theoretical advantage of its multicenter nature, but there appears to be a significant evaluation bias. In fact, the data was collected by each center and then sent to the center performing the study, which centralized

the results received and requested additional information by e-mail if necessary. It is therefore possible that the complications were underestimated.

In our study, which is an evaluation of professional practices, the rate of active smoking in the population was high (43.3% in the PSyn group *vs.* 49% in the PBio group, no statistically significant difference). However, active smoking is a known risk factor for SSI due to decreased tissue oxygenation and interference with the healing process (21-23). Several randomized trials and a meta-analysis have demonstrated that smoking cessation at least four weeks before surgery is beneficial in reducing the number of post-operative infections (24-26). Tobacco usage and obesity (21) are the only modifiable risk factors pre-operatively and the surgeon must address them before proposing parietal repair in order to improve results.

With regard to hernia recurrence, we found a high recurrence rate in our study regardless of the type of prosthesis used (56.36% *vs.* 28.81%, p = 0.029), which is probably related to the SSI rate. In fact, the vicious circle of "wall repair, complication, recurrence, re-operation" is well described in the literature, and it is known that SSI doubles the risk of hernia recurrence (27). On the other hand, other facts that may explain our high recurrence rate include the fact that

(i) our population included –a large number of hepatic and/or renal transplant patients on immunosuppressants that may promote recurrence, as well as patients with peri-stomal hernia whose management is complex and often a source of recurrence,

(ii) the evaluation of recurrence was somewhat subjective for patients who were lost to follow-up or who were not seen in follow-up consultation due to lack of symptoms. These patients were queried by telephone regarding hernia recurrence; for this reason, interpretation of this rate is subject to caution. Our high recurrence rate, regardless of the repair technique, reflects a reality that is supported by the publication of an international multicenter prospective cohort study that included 1075 patients and revealed a recurrence rate at two years of 27.7% (28). Risk factors identified were a past history of hernia repair, lateral

herniation, concomitant intestinal surgery, the occurrence of post-operative complications and the absence of a prosthesis.

This study has several limitations.

Our cohort study is retrospective and monocentric but the limited number of patients makes any matching difficult, even though–the numbers were large compared to other studies on the subject. This cohort remains heterogeneous, including patients with several types of prostheses, associated surgical procedures, different sites of herniation and different techniques of hernia repair. The fact that the ASA score is higher in the PBio group may call into question whether the two groups are truly comparable, due to patient selection bias. ASA score assessment remains subjective and variable depending on the anesthesiologist's interpretation. In order to reduce this potential bias, multivariable analysis with adjustment of the Odds-Ratio calculation on the ASA score was performed and still found a statistically significant difference in the SSI risk depending on the type of prosthesis.

We also emphasize that the only independent protective factor for SSI is implantation of the prosthesis in the retromuscular position. The pre-operative choice of parietal repair technique and evaluation of its feasibility remains essential for the success of surgical management.

Our evaluation of economic impact considers only the cost of the prosthetic patch without considering other associated hospital costs. Yet, duration of stay as well as the number of readmissions were also higher in the PBio group. These results call into question whether use of a bioprosthesis is indicated in VHWG Grade II/III patients. It is very likely that the septic risk of hernia repairs with synthetic prosthesis was overestimated in these patients, especially in those where only the site-related risk factors were retained. Only the results of ongoing randomized trials (SIMBIOSE, MEMBO) will allow us to assess the role of bioprostheses in our therapeutic arsenal (29). In addition, the communication of our results within our center has directly impacted our clinical practices by decreasing our indications for the placement of biological prostheses, which are currently reserved only for situations where there are no other alternatives.

Finally, the occurrence of SSI within 90 post-operative days after placement of a biological prosthesis should probably not
be considered a complication in itself. While biological prostheses were placed for curative purposes in this study, they could also be reconsidered as a delaying tactic or first stage treatment in these high-risk patients. The PBio participates in the healing of chronic parietal infection before re-operation using a non-absorbable synthetic prosthesis. The role of PBio in the arsenal of prostheses would therefore be similar to absorbable synthetic prostheses, *i.e.* Vicryl®, which are, however, much less expensive. In this setting, the need to remove the prosthesis remains low and local care of infection is often sufficient (30). The development and marketing of slowly resorbable biosynthetic prostheses (6-36 months), which are designed, in principle to disappear and be eventually replaced by solid fibrous tissue similar to neo-fascia has reopened the debate. The multicenter, prospective COBRA study, which included 104 patients with large eventrations, has shown the effectiveness of these prostheses for repairs in clean-contaminated and contaminated environments with a 2-year hernia recurrence rate of 17% (31). These very encouraging results were also found in a French prospective study concerning complex parietal repairs with a one-year recurrence rate of 10.3%, equivalent to the results of synthetic prostheses in a clean environment (32).

Conclusion

The results of this study reinforce other studies the literature and provide additional arguments for limiting the use of bioprostheses to exceptional situations where there is a severe risk of infection (VHWG grade 4). It appears that bioprostheses are not as effective as hoped in preventing SSIs and are also associated with high medium-term recurrence rates. The ongoing development of absorbable biosynthetic prostheses, currently under evaluation, could provide an attractive alternative in our surgical arsenal in terms of cost-effectiveness.

Declaration of links of interest: The authors declare that they have no links of interest

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Tables

Table 1: Demographic data and characteristics of ventral hernias

Variables	Synthetic prosthesis (n=60)	Biologic prosthesis (n=59)	*P* value
Age, mean ± SD	58.22 ± (12.2)	59.80 (± 12.4)	0.430
Sex			
Female	21 (36%)	22 (37%)	_
Male	76 (64%)	37(63%)	0.800
BMI, mean ± SD	28 (± 6)	27 (± 6)	0.290
ASA Score			0.017
1	5 (8.3%)	1 (1.7%)	
2	36 (60%)	21 (35.6%)	
3	19 (31.7%)	36 (61%)	
4	0 (0%)	1 (1.7%)	
Past medical history			
Alcohol abuse	9 (15%)	16 (27.1%)	0.105
Active smoking history	26 (43.3%)	29 (49.2%)	0.524
Diabetes	10 (16.7%)	9 (15.3%)	0.833
Immunosuppression	29 (48.3%)	24 (40.7%)	0.401
Inflammatory bowel disease	8 (13.3%)	5 (8.5%)	0.396
Cirrhosis	2 (3.3%)	7 (11.9%)	0.095
Chronic renal insufficiency	6 (10%)	6 (10.2%)	0.976
Obesity	18 (30%)	18 (30.5%)	0.952
Chronic obstructive pulmonary disease	16 (26.7%)	14 (24.1%)	0.753
Cardiovascular risk factors	60 (100%)	59 (100%)	0.407
Malnutrition	0 (0%)	1 (1.7%)	0.496
VHWG grade			
Grade II	29 (48.3%)	28 (47.5%)	_
Grade III	31 (51.7%)	31 (52.5%)	0.924
Risk factors for infection			
Peristomal hernia	24 (40.0%)	24 (40.7%)	0.941
Past history of liver transplantation	19 (31.7%)	18 (30.5%)	0.891
Past history of renal transplantation	6 (10%)	3 (5.1%)	0.491
Associated cholecystectomy	4 (6.7%)	3 (5.1%)	1.000

Ventral hernia with transposition of stoma	3 (5.00)	0 (0%)	0.244
Associated colectomy	2 (3.3%)	1 (1.7%)	1.000

SD: Standard Deviation; BMI: Body Mass Index; ASA: American Society of Anesthesiologists; VHWG: Ventral Hernia Working Group

Table 2: Intra-operative data

Intra-operative data	Synthetic prosthesis (n=60)	Biologic prosthesis (n=59)	*P* value
Type of ventral hernia			
Midline incisional hernia	21 (35%)	16 (27%)	0.353
Sub-costal incisional hernia	13 (21%)	18 (30%)	0.272
Transverse incisional hernia	7 (11%)	3 (5%)	0.322
Hernia dimensions			
Hernia neck (cm), mean ± SD	7.8 (±5.3)	8.4 (±7.1)	0.787
Size of prosthesis (cm^2), mean ± SD	334.24 (±241)	519.6 (±404)	**0.032**
Localization of prosthesis placement			
Onlay	0 (0%)	1 (1.8%)	0.478
Sublay	39 (65%)	35 (63.6%)	0.879
Underlay	20 (33.3%)	17 (30.9%)	0.781
Inlay	1 (1.6%)	0 (0%)	1.000
Cost of prosthesis (Euros), mean ± SD	€ 249 (±188)	€ 3363 (±2355)	**<0.0001**

Table 3: Post-operative results

Complications	Synthetic prosthesis (n=60)	Biologic prosthesis (n=59)	*P* value
Local complications	11 (18.3%)	20 (33.9%)	0.062
Hematoma	4 (6.7%)	2 (3.4%)	0.679
Wound dehiscence	0 (0%)	8 (13.6%)	**0.003**
Skin necrosis	0 (0%)	4 (6.7%)	0.057
Seroma	4 (6.7%)	3 (5.1%)	1.000
Evisceration	2 (3.3%)	1 (1.7%))	1.000
Surgical site infection	4 (6.6%)	12 (20.3%)	**0.030**
Superficial infection	1 (1.67%)	2 (3.3%)	1.000
Deep abscess	3 (5%)	10 (16.9%)	**0.037**
Surgical re-intervention	3 (5%)	6 (10.1%)	0.322
Removal of the prosthesis	1 (1.6%)	2 (3.3%)	0.619
Clavien-Dindo Classification			
no complications	44 (73.3%)	34 (57.6%)	0.071
Clavien 1-2	11 (18.3%)	11 (18.6%)	0.965
Clavien 3-4	4 (6.6%)	14 (23.7%)	**0.009**
Clavien 5	0 (0%)	0 (0%)	_
Hospital stay			
Total hospital stay (days) median [range]	5 [1-29]	7 [1-28]	**0.001**
ICU stay (days), mean ± SD	0.17 (±0.67)	0.44 (±2.30)	0.744
Non-ICU stay (days), mean ± SD	1.25 (±3.18)	1.49 (±2.69)	0.226
Unscheduled rehospitalization	2 (3.33%)	10 (16.95%)	**0.013**

Table 4: Univariable and multivariable analysis of risk factors for surgical site infection (SSI)

Variables	No SSI (n=103) n(%)	SSI (N=16) n(%)	Odds Ratio (OR) (95% CI)	*p*	OR adjusted for ASA, type of prosthesis (95% CI)	*p*
Age (Mean ±SD)	59.22 (±11.87)	57.56 (±14.97)	0.989 (0.949 – 1.032)	0.85	0.997 (0.952 - 1.045)	0.91
See			0.778 (0.251 – 2.408)	0.66	0.854 (0.259 - 2.814)	0.80
Female (N, %)	38 (36.89)	5 (31.25)				
Male (N, %)	65 (63.11)	11 (68.75)				
BMI (Mean ± SD)	27.75 (±5.74)	27.75 (±6.33)	0.951 (0.369 – 2.451)	0.88	1.075 (0.411-2.811)	0.88
ASA Score			1.532 (0.530 – 4.426)	0.43	.	.
1-2 (N, %)	56 (54.37)	7 (43.75)				
3-4 (N, %)	47 (45.63)	9 (56.25)				
Past Medical History						
Alcohol abuse	22 (21.36)	3 (18.75)	0.850 (0.222 – 3.248)	1.00	0.712 (0.178 - 2.855)	0.63
Active smoking	49 (47.57)	6 (37.50)	0.661 (0.224 – 1.954)	0.45	0.650 (0.206 - 2.055)	0.46
Diabetes	14 (13.59)	5 (31.25)	2.890 (0.872 – 9.575)	0.13	4.127 (1.009 - 16.875)	**0.04**85
Immunosuppression	45 (43.69)	8 (50.00)	1.289 (0.449 – 3.700)	0.64	1.226 (0.397 - 3.782)	0.72
Inflammatory bowel disease	9 (8.74)	4 (25.00)	3.482 (0.928 – 13.062)	0.07	3.237 (0.692 - 15.148)	0.14
Cirrhosis	8 (7.77)	1 (6.25)	0.792 (0.092 – 6.790)	1.00	0.542 (0.059 - 4.936)	0.59
Chronic renal insufficiency	10 (9.71)	2 (12.50)	1.329 (0.263 – 6.706)	0.66	1.431 (0.264 - 7.768)	0.68
Obesity	29 (28.16)	7 (43.75)	1.985 (0.676 – 5.827)	0.25	1.656 (0.519 - 5.282)	0.39
Chronic obstructive pulmonary disease	27 (26.21)	3 (20.00)	0.704 (0.184 – 2.686)	0.76	0.794 (0.198 - 3.186)	0.75
Cardiovascular risk factors	54 (52.43)	8 (50.00)	0.907 (0.316 – 2.602)	0.86	0.899 (0.282 - 2.865)	0.86
Malnutrition	1 (0.97)	0 (0.00)	.	.	.	.
History of liver transplant	33 (32.04)	4 (25.00)	0.707 (0.212 – 2.359)	0.77	0.759 (0.214 - 2.686)	0.67
History of renal transplant	8 (7.77)	1 (6.25)	0.792 (0.092 – 6.790)	1.00	1.053 (0.108 - 10.273)	0.96
Type of prosthesis						
Synthetic	57 (54.81)	3 (20.00)	4.851 (1.292 – 18.210)	**0.01**	4.585 (1.167 – 18.017)	**0.02**9
Biologic	47 (45.19)	12 (80.00)				

Ventral hernia location	32 (31.07)	5 (31.25)	1.009 (0.324 – 3.142)	1.00	1.339 (0.402 - 4.461)	0.63
Midline						
Subcostal	27 (26.21)	4 (25.00)	0.938 (0.279 – 3.158)	1.00	0.885 (0.251 - 3.124)	0.85
Peristomal	40 (38.83)	8 (50.00)	1.575 (0.547 – 4.533)	0.40	1.352 (0.441 - 4.144)	0.60
Transverse	10 (9.71)	0 (0.00)	.	.	.	.
VHWG 2/3			0.612 (0.207 – 1.807)	0.37	1.270 (0.570 - 2.831)	0.55
2 (N, %)	51 (49.51)	6 (37.50)				
3 (N, %)	52 (50.49)	10 (62.50)				
Ventral hernia repair with stomal transposition	3 (2.91)	0 (0.00)	.	.	.	.
Associated colectomy	1 (0.97)	2 (12.50)	14.560 (1.239 – 171.159)	**0.05**	38.381 (2.186 - 673.843)	**0.01**
Hernia neck diameter (cm): Median (range)	5.00 (3.00 ; 10.00)	8.00 (5.00 ; 20.00)	1.069 (0.991– 1.154)	0.07	1.060 (0.980 - 1.147)	0.14
Onlay	1 (1.01)	0 (0.00)	.	.	.	.
Inlay	0 (0.00)	1 (6.25)	.	.	.	.
Sublay	68 (68.69)	6 (37.50)	0.274 (0.091 – 0.820)	**0.02**	0.287 (0.089 - 0.925)	**0.03**
Underlay	29 (29.29)	8 (50.00)	2.414 (0.827 – 7.046)	0.10	2.306 (0.723 - 7.359)	0.16

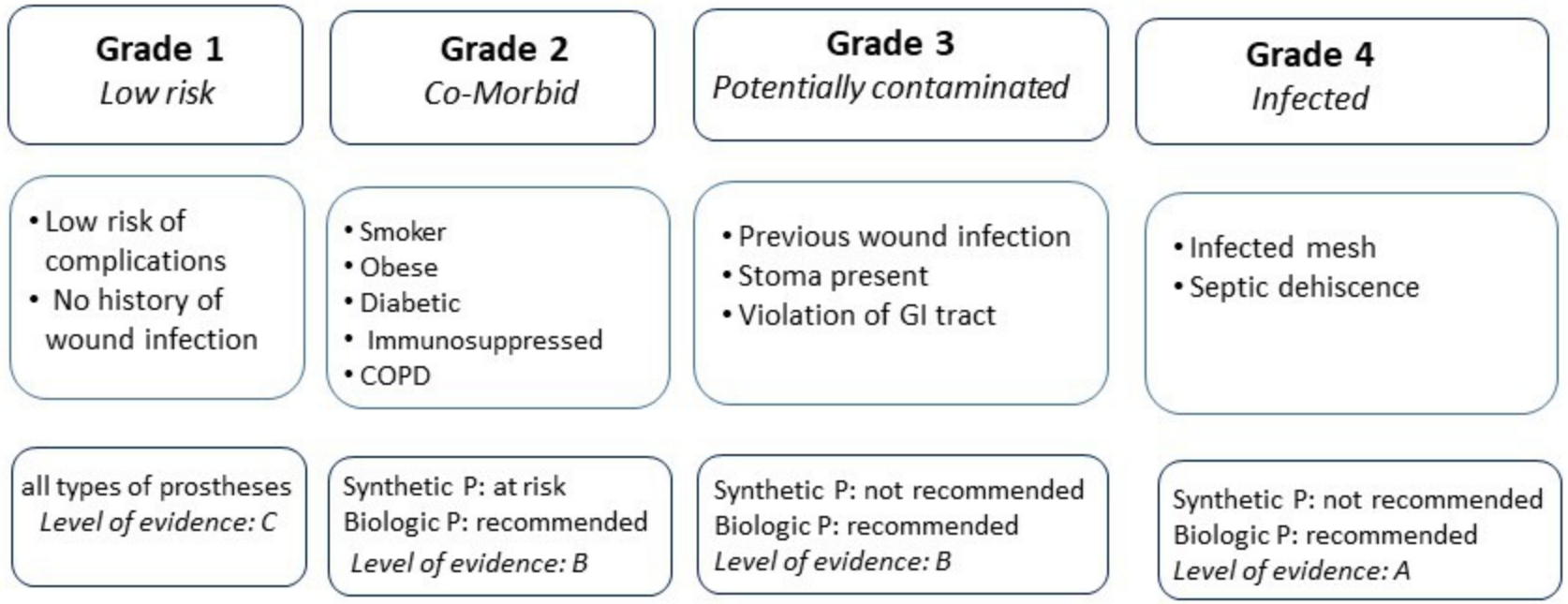
SSI: Surgical Site Infection; SD: Standard deviation; 95% CI; 95% Confidence Interval; ASA: American Society of Anesthesiologists; BMI: Body Mass Index; VHWG: Ventral Hernia Working Group

Figures

Figure 1: Recommendation of the type of prosthesis to use depending on the VHWG ventral hernia classification (3) * P = prosthesis; GI: gastrointestinal

Figure 2: Flow diagram of the study population

Figure 3: Recurrence-free survival curves for ventral hernia as a function of the type of prosthesis used (Kaplan-Meier)


Grade 1
Low risk
Grade 2
Co-Morbid
Grade 3
Potentially contaminated
Grade 4
Infected
• Low risk of complications
• No history of wound infection
• Smoker
• Obese
• Diabetic
• Immunosuppressed
• COPD
• Previous wound infection
• Stoma present
• Violation of GI tract
• Infected mesh
• Septic dehiscence
all types of prostheses
Level of evidence: C
Synthetic P: at risk
Biologic P: recommended
Level of evidence: B
Synthetic P: not recommended
Biologic P: recommended
Level of evidence: B
Synthetic P: not recommended
Biologic P: recommended
Level of evidence: A

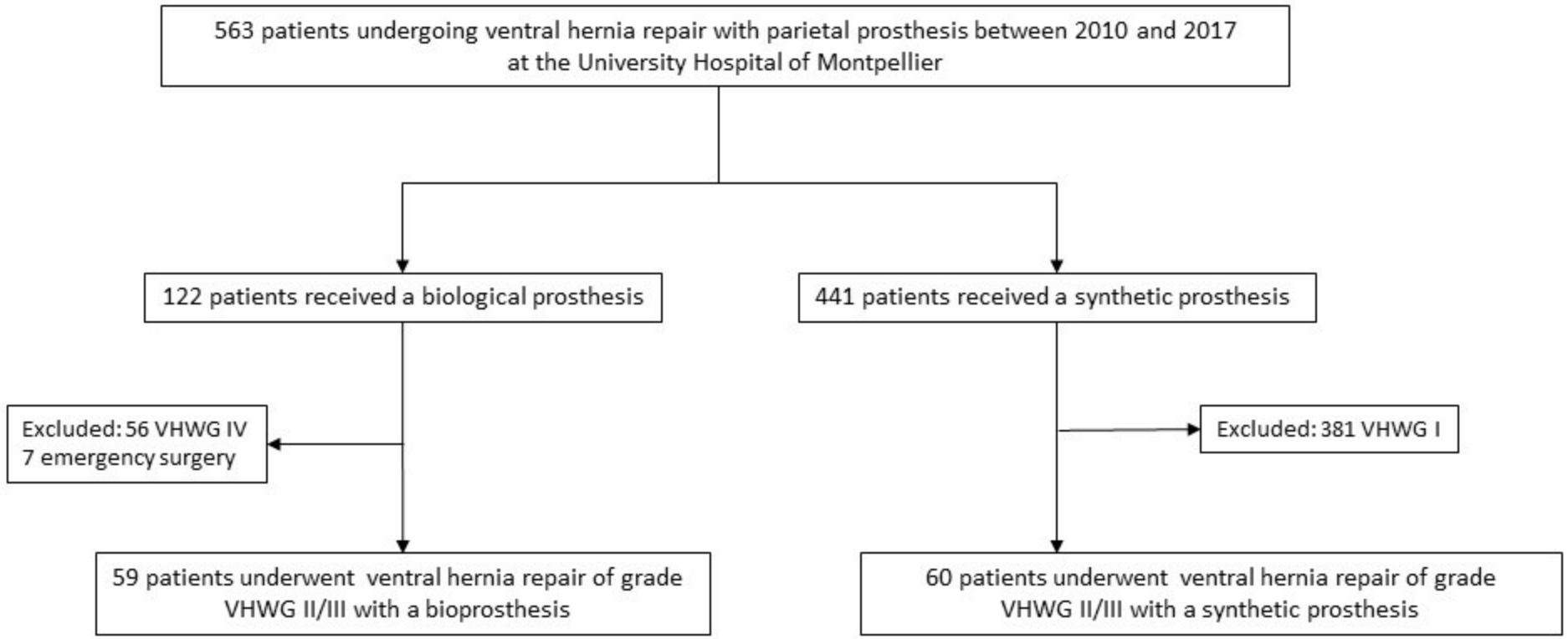

563 patients undergoing ventral hernia repair with parietal prosthesis between 2010 and 2017 at the University Hospital of Montpellier
122 patients received a biological prosthesis
441 patients received a synthetic prosthesis
Excluded: 56 VHWG IV
7 emergency surgery
Excluded: 381 VHWG I
59 patients underwent ventral hernia repair of grade VHWG II/III with a bioprosthesis
60 patients underwent ventral hernia repair of grade VHWG II/III with a synthetic prosthesis

Figure 3: Recurrence-free survival curves for ventral hernia as a function of the type of prosthesis used (Kaplan-Meier)