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Mesh Graft Infection Following Abdominal Hernia Repair: Risk Factor Evaluation and Strategies of Mesh Graft Preservation. A Retrospective Analysis of 476 Operations

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Abstract

Background Mesh graft infection after prosthetic hernia repair is a challenging complication usually treated by mesh removal. The aim of this study was to identify risk factors associated with mesh infection and to assess the efficacy of conservative wound therapy in preserving an infected mesh.

Methods We performed a retrospective analysis of 476 consecutive patients with incisional hernia who received mesh graft repair between February 1, 2000 and February 28, 2005 at our institution using chart review and clinical investigation.

Results Thirty-one of 476 (6.5%) patients developed a deep surgical site infection involving the implanted mesh graft. Upon multivariate analysis, operation time was the only significant risk factor associated with mesh infection ($p = 0.0038$). Seventeen (55%) of 31 infected mesh grafts were preserved by conservative means. There was a significant association between the type of mesh graft used and the probability of mesh preservation in case of infection: While conservative therapy led to preservation of 100% of infected polyglactin/polypropylene meshes, only 20% of infected polypropylene and 23% of infected PTFE/polypropylene meshes could be salvaged using conservative means ($p < 0.0001$). In none of the patients with preserved mesh graft was hernia recurrence at the former site of infection observed.

Conclusions Operation time is the only significant risk factor associated with mesh graft infection following incisional hernia repair. Conservative treatment should be applied in case of infection of absorbable mesh grafts such as polypropylene/polyglactin, while nonabsorbable meshes such as PTFE/polypropylene or pure polypropylene are much less amenable to conservative treatment, usually requiring early surgical removal.

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Introduction

Deep surgical site infection (SSI) following mesh graft repair of incisional hernia is a serious challenge for both patients and surgeons. Most authors recommend removal of the infected mesh if the infection cannot be resolved by conservative means and/or antibiotic therapy [1–3]. However, mesh removal generally results in hernia recurrence, necessitating subsequent surgical procedures such as autologous flap reconstruction or another mesh graft implantation after the infection has resolved [1, 4, 5]. Therefore, salvage of the infected mesh graft without surgical removal would be desirable. To date, large studies on the salvage of infected mesh grafts using conservative treatment measures are lacking, with only a few authors having described mesh graft-preserving treatment by conservative means in small series of patients [6–8]. The aim of the present study was to identify risk factors associated with mesh graft infection following incisional hernia repair and to assess the efficacy of conservative wound therapy in preserving the prosthetic mesh graft following infection.

Methods

We retrospectively reviewed all abdominal wall hernia operations performed between January 1, 2000 and February 28, 2005 at the Department of Surgery of the Medical University of Vienna, Austria. Patients who received prosthetic mesh graft repair for incisional hernia were identified and demographic data, including gender, age, body mass index (BMI), hernia type, and hernia size, and the presence of diabetes mellitus, use of steroids, and smoking habits were collected. Details on the hernia repair operation included the year and duration of the operation, the surgeon's qualifications, the surgical technique, additional intraoperative procedures, the type and size of the mesh graft, the type of sutures used, the intra- and postoperative antimicrobial therapy, and intraoperative wound irrigation using 250–500 ml of saline before wound closure and drainage. Furthermore, serum creatinine and albumin levels were obtained. Data and characteristics of patients with mesh graft infection were compared with patients without mesh graft infection in order to identify potential risk factors for the development of mesh graft infection.

Operation

Prosthetic hernia repair was performed under general anesthesia. Hernia size was assessed by the treating surgeon at the time of the surgical repair. The intraoperative situs at the time of hernia repair was categorized according to the criteria of the National Academy of Sciences/National Research Council [9], with 465 operations (98%) being classified as clean and 11 (2%) as clean/contaminated. The wounds were routinely seen on the second postoperative day during first dressing change. The skin sutures were removed between postoperative day 10 and 14.

Treatment and documentation of mesh graft infection

In all patients, the diagnosis of a SSI was based upon the presence of cardinal symptoms of infection such as redness, swelling, local hyperthermia, and purulent secretion. Further classification into SSI 1 (superficial), SSI 2 (deep surgical site), and SSI 3 (organ/space surgical site) was made according to the current Centers for Disease Control and Prevention (CDC) criteria [10]. In case of infection, the sutures were removed and smear tests from the wound were regularly performed to identify the germs involved and to adjust antimicrobial therapy. The size of the wound was measured at the onset of infection and documented throughout wound treatment. All patients were treated with best practice wound management according to the guidelines of the European Wound Management Association (EWMA) using periodical dressing changes, wound irrigation with disinfecting agents, as well as fluid absorbent and silver-containing dressings [11]. In the case of mesh infection with an open wound diameter larger than 2 cm or an open-lying infected mesh graft, vacuum-assisted closure (VAC, KCI Inc., San Antonio, TX) therapy was also instituted. In general, secondary wound closure was not attempted as we did not want to omit the concept of open wound treatment, thereby risking potential reactivation of the infection. Antibiotic therapy was given routinely and adjusted according to the smear test results. For the present analysis, the following data were collected: onset of the infection, the size of the open wound, visibility of the mesh graft, and the spectrum of germs derived from smear tests taken during dressing changes. Furthermore, we assessed the total time of wound treatment, the type of antimicrobial therapy, and the duration of VAC therapy if instituted.

Statistical analysis

The impact of demographic and operation-associated factors on the occurrence of infection was assessed by a generalized linear model with underlying binomial distribution and a logit-link function. Effects were described with odds ratios and 95% confidence intervals (CI). Repeated mesh grafts within a patient were modeled with a compound symmetry variance–covariance matrix. Logarithmic transformed values were used for continuous variables with a skew distribution (size of hernia, size of mesh graft, and duration of operation). No patient had more than one infected mesh, thus χ^2 tests and logistic regressions were performed for analyzing the preservation rate of infected mesh grafts. For ordinal variables, a trend version of the χ^2 test was used. In case of small groups, Fisher's exact test for 2×2 tables and the exact version of the corresponding tests for more general tables were used. For multivariate analysis, logistic regressions were performed with exact p values. $p \leq 0.05$ was considered significant.

Results

Patient characteristics

During the study period, 1188 patients with an abdominal wall hernia were operated on. In 478 (40.2%) of these patients, hernia repair using implantation of a prosthetic mesh graft was performed, whereas in the remaining patients primary hernia closure was performed. Indications for mesh graft implantation were a hernia larger than 4 cm or the presence of a recurrent incisional hernia. The type of mesh graft used for surgical repair was chosen according to the individual surgeon's preference. Of the 478 patients

who received a mesh graft hernia repair, 369 (77.2%) had a midline incisional hernia. In 107 patients (22.4%), the hernia was located in another area of the abdomen. One-hundred sixty-one (33.7%) patients received mesh graft implantation because of hernia recurrence after a previous hernia repair. Two patients (0.4%) had to be excluded from the analysis because of missing data. Follow-up was 96%, and the median follow-up was 44 months (range = 1–116).

Development of mesh graft infection

A surgical site seroma was observed in 10 (2.1%) of the 476 patients, while 31 (6.5%) of the 476 patients developed a deep SSI (SSI 2) with involvement of the implanted mesh graft. None of the patients had an organ/space surgical site infection (SSI 3). In patients with mesh graft infection, the wound size was ≤2 cm in 47.1%, >2–10 cm in 23.5%, >10–20 cm in 17.6%, and >20 cm in 11.8% of patients. The median time until clinical onset of infection was 12 days (range = 2–42). Upon diagnosis of infection, all patients received broad-spectrum antibiotics for 7–14 days, which were adjusted according to the antibiogram. Smear test results are given in Table 1.

Table 1 Bacterial spectrum

Bacterial species	No. of affected patients
Coagulase-negative *Staphylococcus*	14
Staphylococcus aureus	10
Enterococcus faecalis	7
Corynebacteria	6
Pseudomonas aeruginosa	5
Methicillin-resistant *Staphylococcus aureus* (MRSA), *Peptostreptococci*, *Staphylococcus epidermidis*	4
Other	6

Risk factors for mesh graft infection

Among the demographic data, BMI was the only factor significantly associated with the development of a mesh graft infection upon univariate analysis, while age, sex, serum albumin levels, the presence of diabetes mellitus, steroid use, and smoking were not significant. With respect to operation-related factors, univariate analysis revealed that the size of the implanted mesh graft and the duration of surgery were significantly associated with the development of a mesh graft infection. Upon subsequent multivariate analysis, which included BMI and duration of surgery (the size of the implanted mesh graft was not tested since it correlated strongly with the duration of surgery with a Spearman correlation of 0.6), only duration of surgery remained significant ($p = 0.0038$). The odds ratio for the operation time-dependent increase in infection risk was calculated as 1.13 for every additional 15 min of operation time [95% CI = 1.04–1.23] (Tables 2, 3). Factors such as size of hernia, operation for recurrent hernia, additional surgical procedure at the time of hernia repair, type of suture, drainage, wound irrigation, antibiotics, and qualifications of the surgeon did not differ significantly between patients with and without mesh graft infection. Also, there was no significant difference in infection rates between patients with clean intraoperative situs at the time of surgery (6.5% or 30 of 465 patients) and patients with a clean/contaminated situs (9.1% or 1 of 11 patients). Concerning the operation technique, open techniques were associated with a trend toward higher infection rates compared with laparoscopic operations (7 vs. 0%); however, this difference was not statistically significant (Table 4). Concerning the type of mesh graft used and the infection rates, there was no significant difference between the groups (Table 5).

Effect of conservative approach to preservation of infected mesh grafts

Since the removal of an infected mesh graft is associated with considerable surgical morbidity as well as an

Table 2 Comparison of demographic and operation-related factors between patients with infected and noninfected mesh grafts

Factor	Noninfection group ($n = 445$)	Infection group ($n = 31$)	p Value
Age	59 years (±13)	61 years (±12.1)	0.38
Body mass index	28 (±5.2)	31 (±5.9)	0.006
Serum albumin	37.4 g/l (±5.5)	38.4 g/l (±6)	0.34
Size of hernia	64 cm^2 (1–1600)	147 cm^2 (16–400)	0.07
Size of mesh graft	200 cm^2 (16–1464)	300 cm^2 (150–900)	0.005
Duration of operation	110 (15–350)	152 (45–340)	0.005

Mean (±SD) is shown for normally distributed data and median (minimum–maximum) otherwise. Univariate analysis

Table 3 Infection rate of mesh graft in association with demographic and operation-associated factors ($n = 476$)

Factor	n	Infection rate (%)	p Value
Sex			
Male	255	6.7	0.81
Female	221	6.3	
Diabetes			
Yes	55	7.2	0.75
No	419	6.4	
Steroids/immunosuppression			
Yes	46	13.0	0.10
No	43	5.8	
Smoking			
Yes	146	6.9	0.95
No	313	6.7	
Serum creatinine			
Normal	399	6.8	0.74
Pathological	70	5.7	
Recurrent hernia			
Yes	161	6.2	0.92
No	315	6.7	
Operation performed by			
Consultant	172	4.1	0.10
Resident	304	7.9	
Additional surgery			
Yes	96	8.3	0.41
No	380	6.1	
Absorbable sutures			
Yes	29	10.3	0.43
No	362	6.6	
Wound irrigation			
Yes	166	9.0	0.12
No	310	5.2	
Drainage			
Yes	420	6.9	0.32
No	56	3.6	
Intraoperative antibiosis			
Yes	378	6.4	0.79
No	98	7.1	
Postoperative antibiosis			
Yes	205	8.8	0.08
No	271	4.8	

inevitable risk of hernia recurrence, we investigated whether an infected mesh graft can be preserved by conservative means. Conservative management of infected mesh grafts consisted of best practice wound management in combination with VAC system treatment if the wound was larger than 2 cm or there was an open-lying mesh graft. This approach led to mesh graft preservation in 17 of 31 (55%) patients, while the mesh graft had to be removed in the remaining 14 (45%) patients. The median duration of conservative therapy was 81 days (range = 24–213).

Table 4 Infection rate of mesh graft in association with operation technique

Operation technique	n	Infection rate (%)	
Laparoscopic IPOM	34	0	$p = 0.15$
Open repair	442	7	
Open sublay	210	7.6	$p = 0.81$
Open onlay	102	7.8	
Open inlay	57	7.0	
Open IPOM	61	4.9	
Other	12	0	

Table 5 Infection rate of mesh graft in association with type of mesh graft

Type of mesh graft	n	Infection rate (%)	
PTFE/polypropylene	164	7.9	$p = 0.65$
Polyglactin/polypropylene	158	8.2	
Polypropylene	89	5.6	
Polyglactin	19	0	
PTFE	36	0	
Other	8	0	

Factors related to mesh graft preservation

Clearly, predictive factors are needed to assess which patients are suitable candidates for conservative treatment of mesh graft infection and which patients should have the infected mesh graft removed early. We therefore analyzed the correlation of demographic factors and operation-related factors with mesh graft preservation (Tables 6, 7). Interestingly, the most significant predictive factor in the univariate analysis was the type of mesh used: While all of the 13 infected polyglactin/polypropylene mesh grafts (100%) could be preserved by conservative treatment, only 3 of 13 infected polytetrafluoroethylene (PTFE)/polypropylene mesh grafts (23%) and only 1 of 5 infected pure polypropylene mesh grafts (20%) could be preserved ($p < 0.0001$). Furthermore, univariate analysis revealed that the mesh preservation was significantly different between patients receiving postoperative antibiotic prophylaxis and patients who did not receive postoperative antibiotic prophylaxis: The patients who had postoperative antibiotic prophylaxis had a significantly increased risk of mesh removal upon infection ($p < 0.036$). We also found a difference in the preservation rate of mesh grafts implanted for recurrent hernia versus mesh grafts implanted for primary hernia: While the preservation rate was 71% in the

Table 6 Comparison of demographic and operation-associated factors between patients with preserved and nonpreserved infected mesh ($n = 31$)

Factor	No preservation ($n = 14$)	Preservation ($n = 17$)	p Value
Age	64 years (±6.4)	59 years (±15.1)	0.24
Body mass index	31 (±5.6)	31 (±6.3)	0.96
Size of hernia	144 (25–400) cm^2	150 (16–300) cm^2	0.52
Size of mesh graft	300 (200–900) cm^2	300 (150–900) cm^2	0.81

Mean (±SD) is shown for normally distributed data and median (minimum–maximum) otherwise

Table 7 Preservation rate of infected mesh grafts in relation to demographic and operation-associated factors ($n = 31$)

Factor	n	Preservation rate (%)	p Value
Sex			
Male	17	53	0.81
Female	14	57	
Diabetes			
Yes	4	52	0.60
No	27	75	
Steroids/immunosuppression			
Yes	6	67	0.66
No	25	52	
Additional surgery			
Yes	8	50	0.91
No	23	57	
Use of absorbable sutures			
Yes	24	42	0.09
No	3	100	
Type of mesh graft			
Polyglactin/polypropylene	13	100	0.0001
PTFE/polypropylene	13	23	
Polypropylene	5	20	
Hernia type			
Primary	21	71	0.019
Recurrent	10	20	
Postoperative antibiotic prophylaxis			
Yes	18	39	0.036
No	13	77	

group operated on for a primary hernia, it was only 20% in the group operated on for a recurrent hernia ($p < 0.019$). However, using multivariate analysis (which included type of mesh graft, hernia type, and postoperative antibiotic prophylaxis), only the type of mesh graft remained significantly associated with mesh graft preservation ($p = 0.0006$). Age, sex, BMI, diabetes, serum creatinine, serum albumin, use of steroids, size of the hernia, size of the mesh graft, type of hernia, operation technique, additional surgery, or use of absorbable sutures during the hernia operation did not have an influence on mesh graft preservation. Interestingly, however, the presence of coagulase-negative *Staphylococcus* ($p = 0.00522$) and *Corynebacterium* ($p = 0.0005$) in the wounds was a significant predictor of early mesh removal, indicating a significant influence of the bacterial spectrum on the probability of mesh preservation in case of infection.

Influence of the institutional learning curve for mesh graft preservation

The conservative treatment of infected mesh grafts depends on specialized skills in wound management that were established throughout the study period in our department. To analyze our own experience, we compared preservation rate of infected mesh grafts in a time-dependent manner throughout the study. Of the patients who suffered from mesh graft infection, 4 were operated on in 2000, 3 in 2001, 8 in 2002, 4 in 2003, and 12 in 2004, respectively. The preservation rate of infected meshes was 0% in the two first years and increased to 38, 75, and 92% in the following years ($p < 0.0001$). This indicates that an increased experience correlated with an increased mesh graft preservation rate.

Recurrence of hernias after mesh graft preservation

After a mean follow-up of 30 months, none of the patients with preserved mesh grafts had a recurrent hernia at the former site of infection.

Incidence of fistula or late-onset mesh infection after mesh graft preservation

None of the patients with mesh graft preservation developed a fistula or a late-onset mesh infection during follow-up.

Discussion

The aim of the present study was to assess the efficacy of best practice conservative therapy for infected mesh grafts after abdominal incisional hernia repair. In a retrospective analysis of 476 patients who received mesh graft repair for

incisional hernia, we have found that best practice conservative therapy leads to preservation of 55% (17/31) of infected mesh grafts. Most importantly, our study demonstrates that in all patients with an infected partially absorbable polyglactin/polypropylene mesh, the mesh could be preserved, whereas the vast majority of infected nonabsorbable meshes (PTFE/polypropylene or pure polypropylene meshes) had to be removed because of failure of conservative treatment.

Mesh infection is a serious postoperative complication after prosthetic hernia repair and is usually treated by removal of the mesh. However, mesh removal generally results in hernia recurrence, necessitating subsequent surgical procedures such as autologous flap reconstruction or another mesh graft implantation after the infection has resolved [1, 4, 5]. As a consequence, mesh preservation using conservative means is an intriguing therapeutic option which could spare patients the necessity of complicated and costly follow-up surgery. To date, large studies on the preservation of infected mesh grafts after incisional hernia repair are lacking and, therefore, the generally accepted therapeutic strategy of mesh removal has not been challenged.

Here, we show that conservative treatment of infected mesh grafts after prosthetic repair of incisional abdominal wall hernias is a promising treatment option that can lead to mesh graft preservation in more than 50% of patients. The most important factor associated with mesh graft preservation is the type of mesh used for hernia repair, with partially absorbable polyglactin/polypropylene displaying a significantly better preservation rate in the case of infection than nonabsorbable meshes such as PTFE/polypropylene or pure polypropylene. The better preservation rate of partially absorbable meshes could conceivably be explained by a larger pore size (2–5 mm) of partially absorbable meshes compared with nonabsorbable meshes in which the pore size is generally much smaller (e.g., 1–2 mm for polypropylene meshes). The wider pore size favors tissue in-growth, thereby leading to a better incorporation of the mesh into the surrounding tissue [12]. We assume that this enhanced in-growth of tissue with partially absorbable meshes is associated with a better migration of leukocytes in the mesh in the case of infection and allows clearance of the infection, while PTFE prostheses are encapsulated in fibrotic tissue which makes them less accessible for immune effector cells and therefore harder to preserve in case of infection [13]. The second reason for the high preservation rate in the polyglactin/polypropylene mesh grafts might be the 50% absorbable fraction of polyglactin which is generally absorbed entirely within 60–70 days after surgery. This again might facilitate the migration of leukocytes into the mesh graft in case of infection.

A further observation we have made is that VAC therapy has the potential to cure even large wounds, provided that a partially resorbable mesh has been used. In our institution, VAC therapy is part of the routine therapeutic armamentarium for the treatment of large and/or deep wounds. We consider VAC therapy very valuable as it offers the potential to actively promote wound healing by continuously reducing the interstitial fluid and the bacterial load as well as shrinking the wound and inducing the creation of regenerative tissue [14–19]. This leads to an increase in wound healing which we think is favorable, especially in case of mesh graft involvement. Furthermore, VAC therapy is a particularly valuable tool in an outpatient setting for patients with complicated wounds requiring a long duration of treatment.

Although VAC therapy costs approximately €60–70/day, studies comparing best practice wound management with VAC therapy for chronic wounds showed a higher cost effectiveness in the VAC group [20]. To prevent an unnecessary conservative treatment in case of infection, we suggest early mesh removal in patients with nonabsorbable and open-lying mesh graft. Moreover, we recommend not to prolong conservative treatment in case of mesh infection in patients operated on for recurrent hernia since we found that mesh grafts implanted in recurrent hernia repair display a significantly lower preservation rate in case of infection. We speculate that patients with recurrent hernias have a worse potential of resolving a mesh graft infection without a mesh removal due to an increase in fibrotic tissue at the site of the operation. Also, contaminated remnants from the first hernia repair, e.g., sutures, which were not removed in the operation for the recurrent hernia may be a reason for a lower preservation rate in this group.

Our data indicate that the success of conservative treatment of mesh infection correlates with the treatment experience: Patients with removed mesh grafts were mainly operated on in the first years of the period of investigation. Also, the decision to remove an infected mesh graft was dependent on mainly the attending surgeon and may have been more likely in the first years because there was little or no experience with preservation of infected mesh grafts during this period. This is illustrated by the fact that the preservation rate of infected meshes was 0% in the two first years and increased to 38, 75, and 92% in the following years. Yet, the fraction of polyglactin/polypropylene mesh grafts used for hernia repair increased from 1% in the first year to 4, 12, 51, 61, and 75% in the following years. Thus, apart from the increased experience, the preferential use of partially absorbable polyglactin/polypropylene meshes might also be a reason for a better preservation rate at the end of the study period.

Clearly, the best approach to reduce morbidity associated with mesh graft infection is to prevent it. We therefore investigated factors associated with a higher risk of developing a mesh graft infection. For surgical site

infections in general surgery, factors such as prolonged operation time, American Society of Anesthesiologists (ASA) score, hypoalbuminemia, BMI, chronic obstructive pulmonary disease, steroid use, diabetes, and others have been identified [21–26]. Our analysis indicated that the duration of operation was a significant risk factor for the development of a mesh graft infection. Every effort should therefore be undertaken to keep operation times short, i.e., by scheduling hernia repair early when the hernia is still small.

Interestingly, patients who had drainage, wound irrigation, or antimicrobial prophylaxis after hernia repair showed a tendency to develop mesh infection, though this tendency was not statistically significant. The above measures were taken according to the individual surgeon's preference and possibly reflect more complicated surgery (i.e., longer operation time), which may subsequently have led to a higher tendency of SSI. Furthermore, upon univariate analysis the mesh preservation rate was significantly lower in patients with infected mesh graft when they received postoperative antimicrobial prophylaxis. Conceivably, antimicrobial prophylaxis may cause a shift of the germ spectrum to a more unfavorable balance of germs, thus facilitating infection. Despite the fact that we cannot completely rule out that the antibiotic treatment was given because of undocumented or unevaluated risk factors, we do not recommend the routine use of antibiotic treatment following mesh graft implantation.

In conclusion, we demonstrate that conservative treatment of mesh graft infection is feasible, despite the fact that it is often time-consuming. Partially absorbable mesh grafts seem to be advantageous compared to nonabsorbable mesh grafts since the likelihood of mesh preservation in the case of mesh infection is higher when a partially absorbable mesh graft has been used for hernia repair.

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