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Abdominal wall mesh infection: a diagnostic and therapeutic flowchart proposal

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Summary
Background Since there is still no univocal codified treatment for mesh infection or fistulization following abdominal wall repair, the aim of this study is to propose a diagnostic and therapeutic flowchart based on personal experience and literature review.
Methods We retrospectively evaluated 12 patients who developed mesh infection or enterocutaneous fistulas after mesh implantation for abdominal wall hernias. Patients had had different types of mesh implanted: 6 polypropylene meshes, 3 expanded polytetrafluoroethylene (ePTFE) meshes, 2 dual mesh, and 1 polyester mesh. Based on our experience and literature review, we extrapolated a diagnostic and therapeutic flowchart.
Results The clinical course and results of treatment were heterogeneous in this group of patients. Four patients (33%) underwent fistulectomy with excision of the fistulous canal in association with removal of the infected mesh. One patient (9%) underwent fistulectomy with partial removal of the polypropylene mesh and resection of the affected tract of the ileum. Five patients (42%) underwent excision of the infected mesh. Conservative treatment was resolutive in two cases (16%). Of the 10 cases with a surgical procedure, in two cases a conservative approach with total parenteral nutrition (TPN) was initially adopted; this approach may have reduced the invasiveness of the surgical procedure. Three patients (25%) experienced a chronic fistula, nine patients (75%) healed and showed no recurrence after a mean follow-up of 18 months.
Conclusion The approach to mesh fistulization should be tailored to every single patient. In the majority of cases, a multistep approach seems to be necessary.

Keywords Abdominal wall fistula · Abdominal wall surgery · Hernia repair complications · Mesh removal · Mesh fistulization

Main novel aspects

- No consensus on a codified treatment is to date available for abdominal wall fistulas.
- Early and late-onset abdominal wall mesh infections show different features and therapeutic results.
- Our diagnostic and therapeutic flowchart is an attempt to codify a shared approach based on available literature.

Introduction

The use of prosthetic materials has reduced the risk of hernia recurrence and become the gold standard in abdominal wall surgery. However, mesh use has developed new complications such as infections of the prothesis or of the surgical scar, or fistulas with or without a direct communication between the bowel and the skin [1].

Fistulas after abdominal wall repair and mesh infections are still a challenging clinical situation, leading to a chronic condition in a minority of patients, as reported in the literature [2–4].

The reported incidence of surgical site infection in hernia surgery ranges between 1 and 4% in some se-

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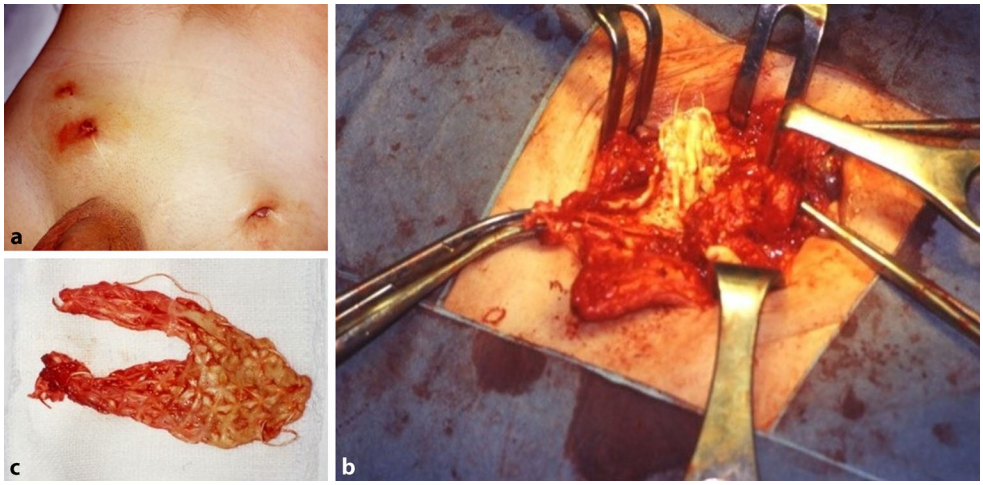

Fig. 1 Case 2. **a** Fistulous canals after inguinal hernioplasty. **b** Surgical removal of the expanded polytetrafluoroethylene (ePTFE) mesh. **c** ePTFE mesh removed

ries [4, 5] and from 0 up to 16% in others, depending on the type of material used [6, 7]. In complex and contaminated hernia repair, the reported incidence reaches 38.9% [1].

This percentage is not to be underestimated and it can be influenced by comorbidities such as diabetes, obesity, and immunosuppression, as well as by specific mesh materials [1, 6]. Given that prosthetic hernioplasty is the most common procedure in general surgery today, and that approximatively 20 million prosthetic hernioplasties are performed every year worldwide [8], prosthetic infections seem to be an important issue for health systems. There is no univocal codified treatment or shared therapeutic work-up to successfully treat these patients.

The aim of this work was to propose a diagnostic and therapeutic flowchart for the treatment of enterocutaneous fistulas or mesh infection following abdominal wall repair based on our experience and literature review.

Materials and methods

Between 1994 and 2019, 4713 patients were surgically treated for abdominal wall hernias in the Abdominal and Emergency Surgery Unit of our General Surgery Department.

Among those operations, 12 patients (5 males, 7 females) with a mean age of 65 years (range 48–78) developed mesh infections or enterocutaneous fistulas after mesh implantation for abdominal wall hernias; 9 (75%) of these patients had been previously operated in our department and 3 (25%) were admitted to our department after development of this complication. Every patient in this study presented an acute mesh infection.

Four (33%) patients developed mesh infection and fistulization after groin hernia repair, three (25%) after umbilical hernia repair, four (33%) after incisional hernia repair, and one (9%) after epigastric hernia repair. Patients had different types of mesh implanted: six (50%) polypropylene (PP) meshes, three (25%) expanded polytetrafluoroethylene (ePTFE) meshes (Fig. 1), two (16%) dual mesh, and one (9%) polyester (POL) mesh. Mesh position is summarized in Table 1. All patients with a mesh infection were included in this study, not considering comorbidities as excluding factors. Data were retrospectively extracted from our database, which is progressively and prospectively recorded. As shown in Table 2, the onset of a mesh infection occurred in two different periods: the first from 1 to 6 months and the second from 2 to 18 years. Seven patients out of the 12 (59%) developed a mesh infection in the first 4 months after hernia repair, four patients (34%) developed a late mesh infection from 2 to 18 years after abdominal wall surgery, and one patient (9%) developed a mesh infection after 6 months. Ten patients out of the 12 presented one or more comorbidities: most common were obesity (six patients, 50%) and diabetes (three patients, 25%), other frequent comorbidities were hypertension and cardiopathy (six patients, 50%). All patients complained about the appearance of a fistulous tract near or within the previous surgical scar, with output of purulent (11 patients) or enteric material (one patient). For three patients the fistula was preceded by a tumefaction within the surgical scar (seroma): the superimposed infection of the seroma led to fistulization between the mesh and the skin above.

Every patient underwent a culture swab of the purulent material followed by antibiogram in order to choose the right antibiotic therapy.

Three patients (25%) needed no diagnostic methods because of the clinically evident infection; two patients (~17%) began their diagnostic work-up with echography, eight patients (~67%) also needed a CT scan, and six patients underwent fistulography. Patients' features are summarized in Tables 1 and 2.

Additionally, we reviewed the literature of the last 25 years, selecting the biggest series published till now.

Table 1 26-year monoinstitutional experience of our Abdominal and Emergency Surgery Unit: diagnostic and therapeutic workup

Case	Symptoms	Diagnostic workup	Type of mesh	Treatment	Follow-up	Result
1	Output of purulent material	Echography Fistulography CT	Polypropylene/ extraperitoneal	Fistulectomy and removal of the infected piece of prosthesis	9 months—no recurrence. Second intention closure	Healed
2	Output of purulent material	Fistulography CT	ePTFE/extraperitoneal	Fistulectomy + prosthesis removal	1) Second intention closure after 30 days	Healed
3	Output of purulent material	No diagnosis	Polypropylene/ extraperitoneal	Removal of subcutaneous polypropylene stitches and second intention closure	2 years—no recurrence	Healed
4	Output of enteric material and fever	CT	Polypropylene/ extraperitoneal	1) Total parenteral regimen 2) Partial removal of the mesh and apposition of biological prosthesis	Closure of enterocutaneous fistula after parenteral regimen, persistence of prosthesis infection. Resolution of clinical situation after 1 year	Healed
5	Output of purulent material	Fistulography CT	ePTFE/extraperitoneal	Fistulectomy and removal of prosthesis	1 year—no recurrence	Healed
6	Output of purulent material and fever	CT	Dual mesh/ intraperitoneal	Removal of ePTFE stratus	Appearance of incisional hernia and leakage of purulent material still after 3 years	Chronic condition
7	Output of purulent material	Echography Fistulography CT	Polypropylene/ extraperitoneal	1) Total parenteral regimen. 2) Fistulectomy with resection and ileal recanalization and apposition of polyglactin 910 mesh. 3) Two closure attempts with platelet-rich plasma (PRP) and one with fibrin glue	1) Output decrease of the fistula. 2) Enterocutaneous fistula recurrence	Chronic condition
8	Output of purulent material	No diagnosis	Dual mesh/ intraperitoneal	Infected prosthesis removal	After 3–4 months second intention closure	Healed
9	Output of purulent material	No diagnosis	ePTFE/extraperitoneal	Infected prosthesis removal	1 month—no recurrence	Healed
10	Output of purulent material	CT	Polypropylene/ extraperitoneal	No fistulous canal. Antibiotic therapy (ciproxin + dalacin c)	After 4–5 months second intention closure	Healed
11	Output of purulent material	Fistulography	Polyester/ extraperitoneal	Prosthesis removal and cavity cleansing	Second intention closure after 4 weeks	Healed
12	Output of purulent material	CT Fistulography	Polypropylene/ extraperitoneal	1) Drainage of the seroma 2) Apposition of antibiotics directly on the mesh 3) Removal of the synthetic mesh and apposition of biologic mesh	1) Healing after Biological mesh apposition. 2) After 1 month: fistula recurrence	Chronic condition

CT Computed Tomography, *ePTFE* expanded polytetrafluoroethylene

Results

The clinical course and results of treatment were heterogeneous in this group of patients in terms of their morbidities and performance status as well as the type of mesh implanted and the extension of the fistulous canal.

Four patients underwent a fistulectomy with excision of the fistulous canal in association with the removal of the infected mesh. This kind of intervention was possible with ePTFE meshes (two cases) and partially with polypropylene mesh (two cases). One patient, who had a fistulous canal in communication with the ileum, needed a fistulectomy in association with partial removal of polypropylene mesh and a resection of the affected tract of the ileum. Five patients, one with ePTFE mesh, two with dual meshes, one with polyester, and one with polypropylene mesh, underwent excision of the infected mesh: for the ePTFE and POL meshes the removal was total (Fig. 2), for the PP mesh the removal was partial, while for the dual mesh it was only possible to remove the ePTFE stratus (Fig. 3).

In two cases surgery was unnecessary: in one case we obtained complete resolution of the infection with antibiotic therapy, while in the other case the removal of subcutaneous polypropylene stitches and a second-intention closure were enough to heal the patient.

Antibiotic therapy was targeted for every patient based on the results of antibiogram and culture swabs, which demonstrated a variable bacterial flora composed of either Gram + or Gram − species. The most represented bacteria were *S. aureus, E. Coli,* and *Pseudomonas aeruginosa.* Among the 12 patients, in two cases (17%) we initially tried a conservative approach with total parenteral nutrition (TPN) before performing surgery. In four cases (30%), during the surgical approach, it was necessary to repair the abdom-

Table 2 26-year monoinstitutional experience of our Abdominal and Emergency Surgery Unit: patients' features

Case	Year	Sex	Age (years)	Comorbidities	Primary operation	Time interval
1	2005	M	57	Mitral valve stenosis with atrial fibrillation (mechanic valve)	Inguinal hernioplasty	6 years
2	2000	M	48	No comorbidities	Bilateral inguinal hernioplasty	2 years
3	2008	M	58	Obesity, polycythemia, diabetes, cardiac failure, arrhythmias, smoke, alcoholism	Umbilical hernioplasty	1 month
4	2015	M	62	Obesity, diabetes	Laparoplasty and cholecystectomy	3 months
5	2018	M	78	Hypertension, peripheral neuropathy, GERD, gastric polyposis, psoriasis, COPD	Inguinal hernioplasty	18 years
6	2017	F	73	Obesity and cardiopathy	Laparoplasty	3 months
7	2018	F	71	Obesity, bilateral sensorineural hearing loss, hypertensive cardiopathy, osteoporosis, chronic venous insufficiency, anxious depressive mood	Laparoplasty	3 months
8	2012	F	60	Obesity, adrenal adenoma, epilepsy	Epigastric hernioplasty (strangulated)	4 months
9	2010	F	76	Hiatal hernia	Inguinal hernioplasty (strangulated)	6 months
10	2014	F	66	Obesity, hypertension, cerebral ischemia	Umbilical hernioplasty (relapse)	3 months
11	2006	F	63	No comorbidities	Umbilical laparoplasty	15 years
12	2019	F	73	Diabetes, immunosuppression, neoplastic patient	Parastomal laparoplasty with recanalization	1 month

GERD gastroesophageal reflux disease, *COPD* chronic obstructive pulmonary disease

inal wall. Among those four patients the defect of the abdominal wall was repaired in one case by direct stitches and in the other three cases by the apposition of a mesh: two biological meshes and one absorbable polyglactin 910 mesh.

The mean hospitalization was 30 days for eight patients in the study (67%), while four patients were hospitalized for only 5 days thanks to a rapid improvement of their clinical situation (among those, in two cases the removed mesh was polypropylene, partially removed).

During hospitalization the main complications were the appearance of a sterile seroma (in 5 cases, 42%) which sometimes needed drainage and in one case (8.3%) the development of an incisional hernia.

One patient required a second hospitalization due to infection recurrence.

Three patients (25%) experienced a chronic fistula, i.e., persistence of the fistula for longer than 6 months, which was impossible to resolve because of the clinical condition of the patients or due to the numerous failed attempts that led those patients to refuse further reoperations.

Nine patients (75%) healed and showed no recurrence after a mean follow-up of 18 months.

Results are summarized in Table 1. Literature review results displaying main series data are summarized in Table 3.

Discussion

Before the advent of prosthetic hernioplasty, the incidence of hernia recurrence after hernia repair exceeded 20% after 15 to 25 years [13].

Prosthetic surgery is well known to have incremented the risk of surgical site infections [14]. Although the real incidence of infection is difficult to determine, it is estimated to be about 5% higher than in non-prosthetic surgery [10]. Certainly, the extent of body reactions to the mesh depends on the type of prosthesis, the amount of material used, and the structure of the mesh, as well as the characteristics of patients that define individual risk [15]. Nowadays there are many types of mesh available, initially classified into three types by Amid in 1997 [16] based on the composition of filaments (mono or multifilament), density, weight, and porosity ([17]; Table 4). Many attempts have been made by several surgeons to describe a theoretically ideal mesh, considering biocompatibility, infection risk, handling, socioeconomics, and longevity as the main characteristics [17]. Moreover, there are many different mesh placement techniques (intra- or extraperitoneal), based on the type of mesh and their possibility to maintain contact with the bowels. Identifying the right mesh for each patient is not an easy task: since there is no ideal mesh as yet, there is no consensus about which material is the best for any patient and no consensus even about the best mesh positioning or the best technique (open, laparoscopic, robotic [18]).

The most used mesh material is PP, followed by, ePFTE then POL [17, 19].

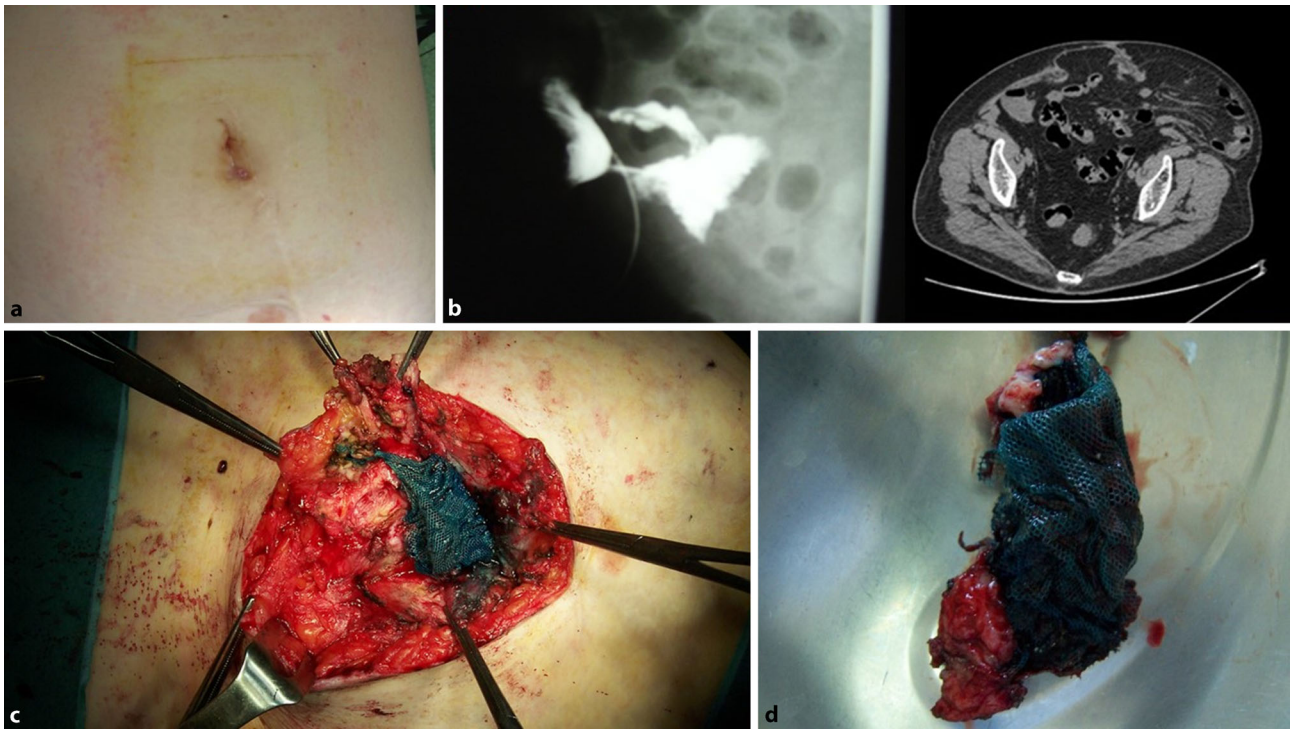

Fig. 2 Case 11. **a** Umbilical fistulous canal. **b** Diagnostic work-up: fistulography and CT (computed tomography) scan. **c** Surgical removal of the Polyester mesh. **d** Polyester mesh removed together with the fistulous canal

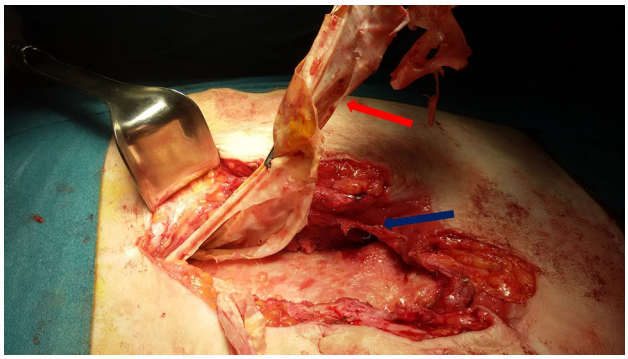

Fig. 3 Case 6. Surgical removal of the dual mesh: *blue arrow* indicates the incarcerated polypropylene sheet, impossible to remove; *red arrow* indicates the expanded polytetrafluoroethylene sheet that was totally removed

Next to these synthetic materials there are other types of mesh that are less commonly used: absorbable and composite mesh and the newest biological mesh, introduced in the late 1990s [20].

Features, advantages, and disadvantages of the most common types of mesh are summarized in Table 4; [17, 19–24]. Results of prosthetic hernia repair also depend on surgical techniques.

Given the abovementioned mesh infection rates (1 up to 16%) for open surgery, the mini-invasive techniques seem to show different infection rates: for laparoscopic incisional hernia repair the reported incidence in the literature is estimated to be lower (3.6%) [5], while for robotic hernia repair, the reported incidence of skin and soft tissue infections is higher compared to laparoscopic and open techniques, because of longer operative time [25].

Clearly, the incidence does not only depend on the type of intervention but also on the amount of mesh material used, on the type of filament (mono- or multifilament), and on the weight of the mesh: according to some authors, lightweight mesh seems to be less prone to infections [5], although no significative differences to heavyweight mesh have been found in other studies [26].

The most common symptoms referred by patients in our series were pain, redness, tumefaction, or output of malodorous purulent fluid from the site of the surgical scar.

Diagnostic workup began for nearly every patient with abdominal wall echography in order to study the degree of inflammation of the abdominal wall and the extension of the abscess. Moreover, the majority of patients needed to complete the study with a CT scan with injection of diatrizoic acid and fistulography, in order to establish the communication with the bowel.

Three patients needed no diagnostic methods because the infection and fistulization of the skin were clinically evident. For one of these patients the infection of the scar and the fistulization of the skin with the mesh was evidently due to subcutaneous polypropylene stitches that had a pointed tip that emerged from the subcutis and infected the wound. The patient, together with the foreign body granuloma, showed a fistula with purulent output for many

Table 3 Comparison between our study and the largest case series reported in the literature

Authors	Years	Cases	Treatment	Results
Bueno-Lledò J. et al. [3]	2004/2014	66	Surgery (72.7%) Conservative treatment (27.3%)	PMR required in up to five operations for healing. One persistent mesh infection after CMR
Birolini C. et al. [9]	1996/2012	41	Surgery (100%)	65.9% uneventful postoperative course. Four major complications. No follow-up data obtained for 11 patients
Levy S. et al. [5]	2007/2016	34	Surgery (100%)	3.4 interventions per patient, high recurrence rate. Healing after CMR
Tolino M. J. et al. [10]	2001/2005	32	Surgery (100%)	51 interventions for 32 patients
Stremitzer S. et al. [11]	2000/2005	31	Surgery (45%) Conservative treatment (55%)	Conservative treatment was applied for absorbable meshes. Surgery was performed for synthetic non-absorbable meshes. All treatments were resolutive
Sabbagh C. et al. [12]	2000/2010	25	Surgery (96%) Conservative treatment (4%)	PMR was performed in 92% of cases; up to five interventions were necessary for healing after PMR
Current study	1994/2019	12	Surgery (84%) Conservative treatment (16%)	Three chronic fistulas out of 12. Two re-interventions. Two conservative attempts after surgical failure (1 healing and 1 persistence)

PMR partial mesh removal, *CMR* complete mesh removal

Table 4 Features of different types of mesh

Type of mesh	Main features	Advantages	Disadvantages
Polypropylene (PP)	Synthetic hydrophobic monofilament mesh	Flexible, easily handling, resistant to infection	Hardly removable due to strong fibrotic reaction
Expanded polytetrafluoroethylene (ePTFE)	Synthetic microporous structure (<75 µm)	Little inflammatory effect, placeable in contact with the bowels	More prone to infections due to poor macrophages infiltration
Polyester (POL)	Synthetic hydrophilic material	Rapid fibroblastic infiltration and adhesion to tissue	More subject to infections, loss of strength over time
Polyglycolic acid (DEXON®)	Synthetic absorbable material	Absorption within 90 to 180 days with collagen ingrowth, easy to cut	Loss of strength by 50% within 2 to 10 weeks
Polyglactin 910 (VICRYL®)	Synthetic absorbable material	Placeable intraperitoneally	Poor collagen ingrowth, high incidence of relapse within 4 weeks
Composite mesh	Combination of two or more materials:	Intraperitoneal placement with a specific orientation (microporous side in contact with the bowels, microporous side in contact with parietal tissue)	High risk of infection of old generation composite mesh, limited tissue integration (low strength), higher costs if compared to PP mesh
PP composite	PP + poliglecaprone-25 PP + polyglaction 910 PP + poliglecaprone-25 + polydiaxone PP + collagen-oxidized film PP + ePTFE PP + hydrogel PP + oxidized regenerated cellulose + polydiaxone PP + PVDF PP + carboxymethylcellulose + hyaluronic acid	Improved physiological function – Improved physiological function and reduced adhesions Reduced adhesions – – – –	–
Polyester composite	Polyester + collagen-oxidized film Polyester + Dimethylsiloxane	Reduced adhesions	–
Others	Polyglycolic acid + trimethylene carbonate Glycolide, lactide + trimethylene carbonate	Reduced risk of infection Long-term absorbability	–
Biological mesh (porcine small intestine submucosa, human acellular dermis, xenogenic acellular dermis)	Acellular xenogenic or allogenic sources with collagen-rich scaffolding	Highest biocompatibility—mainly used in complex abdominal wall surgery (infected hernia repair or patients with high postoperative risk of infection)	Longer operating time, higher risk of complications: seroma, degradation, laxity, lack of integration, and recurrence. Highest costs
Coated mesh	PP mesh coated by SRT (squid ring teeth) protein PP mesh coated by polyglactic acid (PLA)	Biocompatible, high tissue integration, high collagen deposition (stronger scar tissue), low signs of inflammation, low costs of production	Long-term studies are still necessary

weeks; removal of the Prolene stitches was enough to close the fistula.

While acute mesh infections are usually treated with antibiotics and irrigations, the management of chronic mesh infections is not yet univocal [4].

Conservative treatment should be considered as a first approach to chronic mesh infections to avoid the risk of a second surgical intervention. However, the use of antibiotics in chronic conditions is not recommended because of the high risk of bacterial resistance and the high percentage of failure [27, 28].

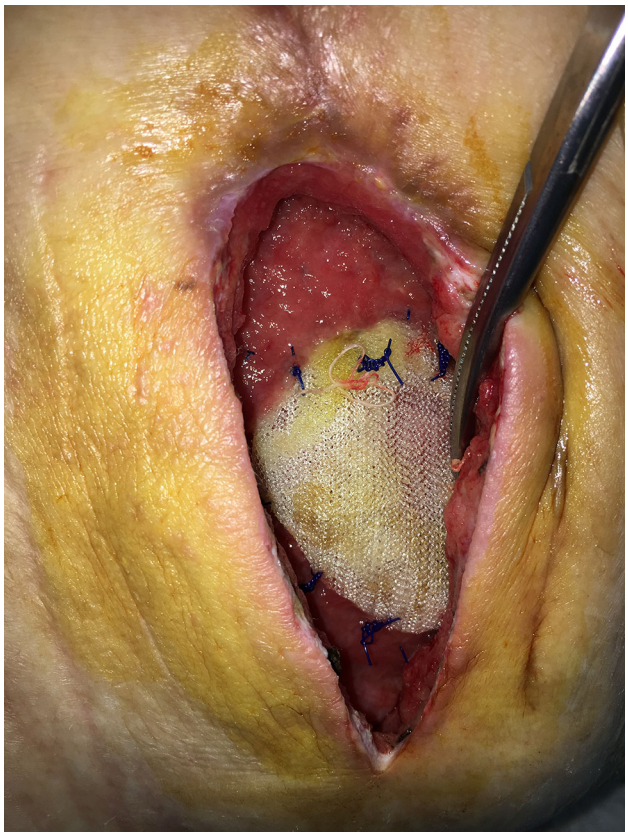

Fig. 4 Case 12. Exposed polypropylene mesh: conservative attempt of infection healing by instillation of antibiotics directly onto the mesh

When the presence of a cutaneous fistula exposes the mesh, it is possible to instill the antibiotics directly onto the infected mesh (Fig. 4). In this case, it is recommended not to close the wound but to use vacuum-assisted closure (VAC) in order to reduce bacterial load and promote tissue regeneration by taking advantage of negative pressure [27].

According to some authors the best way to overcome a mesh infection is surgical treatment: it should be considered only after failure of conservative treatment. The surgical approach is based on removal of the entire mesh when possible, or of just the infected part of the mesh if it is not possible to remove the whole mesh [3, 27, 29]. Although complete mesh removal gives the best results in terms of fistula closure and healing, partial mesh removal becomes necessary when a PP mesh is implanted, due to the high fibrotic reaction caused by this kind of mesh. Indeed, by some authors this is not considered a problem for mesh infection healing; in fact, according to Birolini [30], PP mesh can also be implanted to repair abdominal wall defects in contaminated fields. Besides, the high immunogenic property of PP is well known and could explain why it is less prone to infections than POL or ePTFE [31].

The defect of the abdominal wall should then be repaired at the same operating time using a late-absorbable or a biological mesh (despite the higher cost), in order to reduce the risk of re-infection compared to a synthetic nonabsorbable mesh and to reduce the risk of hernia recurrence, which is consistent if no mesh is placed after the removal of the previous one [27–29].

When mesh infection results in an enterocutaneous fistula the treatment should be focused on the closure of the fistulous tract.

Enterocutaneous fistulas are the most common of all intestinal fistulas and in 75–85% of cases they are due to surgical complications (iatrogenic fistulas) [32].

In a variable percentage (15–71%) [33], enterocutaneous fistulas exhibit spontaneous healing; moreover, when a fistula leads to a chronic condition, it is necessary to establish a therapeutic workup in order to avoid complications such as intestinal failure or sepsis that could be fatal for the patient.

Following our observations, we could classify two periods for fistula presentation: an early-onset (1 to 6 months) and a late-onset (2 to 18 years) fistula.

In the literature, deep prosthesis infection is generally observed as an early-onset postoperative complication, only a few cases of late-onset mesh infection have been described [34–37].

Early-onset fistulas may be favored by comorbidities of the patient such as obesity and diabetes, which increase the risk of surgical site infection [38]. Every patient who developed an early-onset mesh infection in our study presented obesity or diabetes as a comorbidity, except for one.

Defining the etiology of late-onset mesh infections is more difficult. According to Delikokous et al. [34], late-onset mesh infections do not depend on the type of mesh implanted, while Bliziotis et al. [35] assert that using multifilament polyester mesh leads to a higher incidence of infections and fistula formation and that microporous mesh is related to a higher incidence of infections and seroma formation.

In our study, we observed four late-onset mesh infections: two patients had an ePTFE mesh implanted, one a PP mesh, and one a POL mesh. Out of these, one patient developed a mesh infection 6 years after hernioplasty due to a sexual trauma. The patient developed a traumatic hematoma due to anticoagulant therapy and the hematoma went through a superimposed infection that determined the late-onset of a cutaneous fistula.

A hypothesis that we have developed while observing late-onset mesh infection in the current study is that it may depend on bacterial anachoresis. Robinson and Boling defined anachoresis as the process by which blood-borne bacteria and other foreign materials are attracted to focal areas of inflammation [39, 40]. The anachoretic process is commonly believed to cause pulpal and periapical inflammations, considered as foci for systemic diseases. Bacteria from these areas of inflammation do not remain in the blood but take refuge in another area of inflammation [40]. Our

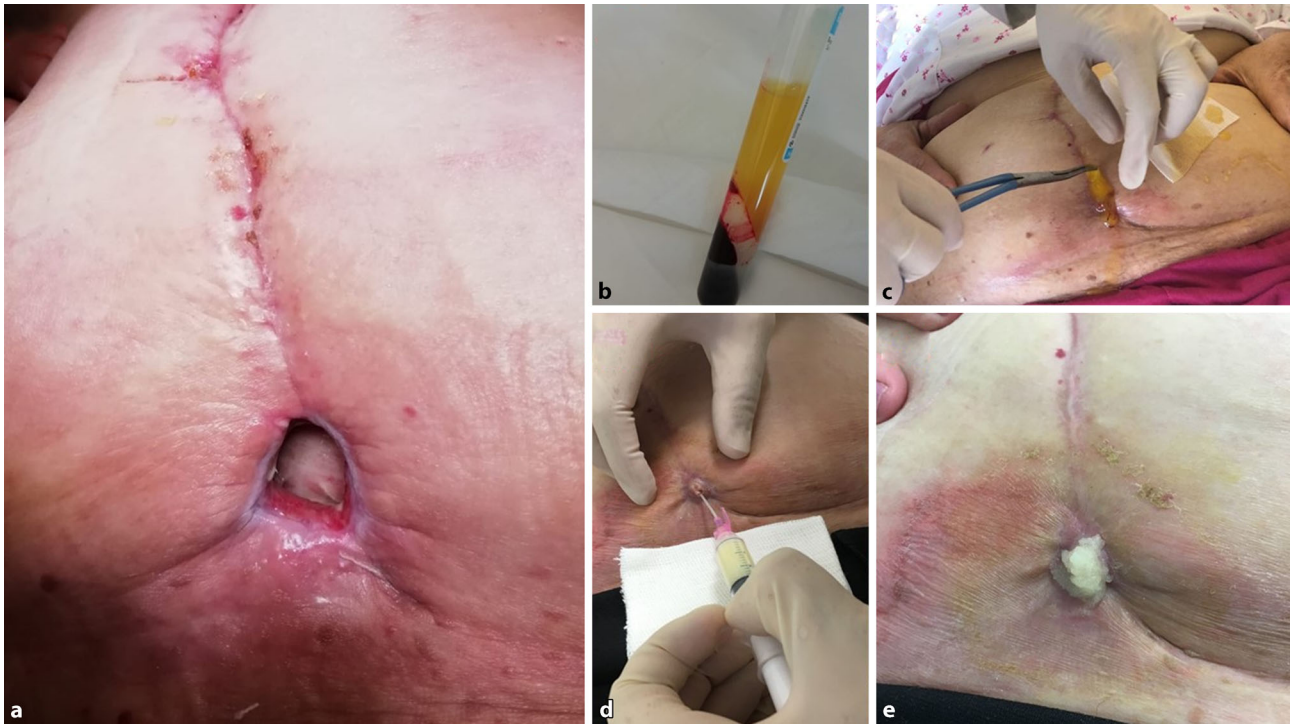

Fig. 5 Case 7. **a** Exposed mesh from an over-pubic fistulous canal. **b** Platelet-rich plasma (PRP) prepared from the patient's own blood and centrifugation. **c** Apposition of PRP directly onto the fistulated skin. **d** Second attempt with sealant apposition of fibrin glue directly onto the fistulated skin

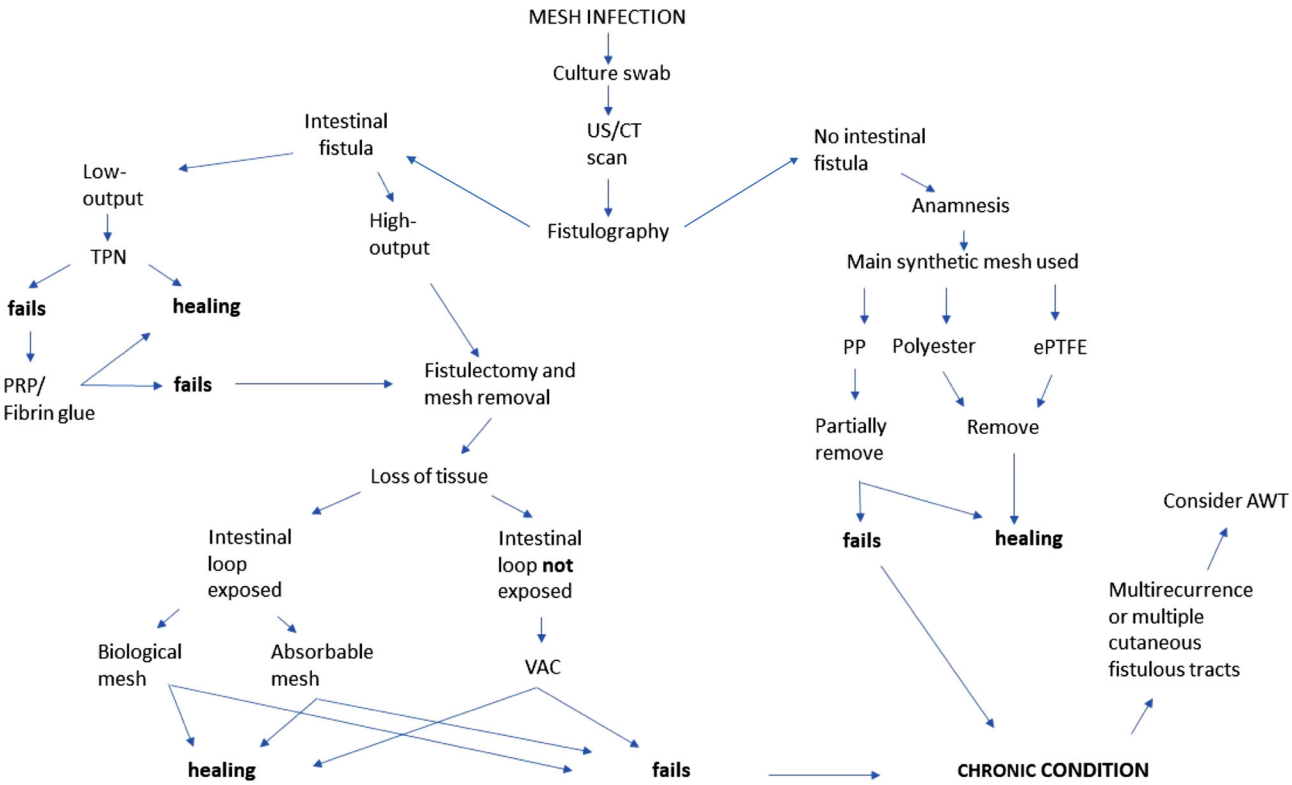

Fig. 6 Diagnostic and therapeutic flowchart of abdominal wall mesh infections. *US* ultrasound, *CT* computed tomography, *TPN* total parenteral nutrition, *PRP* platelet-rich plasma, *PP* polypropylene, *ePTFE* expanded polytetrafluoroethylene, *VAC* vacuum-assisted closure, *AWT* abdominal wall transplant

hypothesis is that this anachoretic process may explain late-onset mesh infection, probably caused by an nonspecific inflammation of the organism, probably during a period of immunosuppression.

The management of enterocutaneous fistula includes, as a first approach, nutritional support, preferring the enteral route to parenteral nutrition [32, 41] to decrease the output of high-output enteric fistulas and to close the low-output enteric fistulas with a mean percentage of success of about 77% [42–45].

In this study we had opted for TPN in two cases: in the first case, TPN successfully closed the enterocutaneous fistula but surgery was then necessary in order to remove the recurrently infected mesh. In the second case, TPN decreased the fistula output and the patient underwent surgery; removal of the mesh and a consequent ileal resection were necessary. When nutritional support fails to close or reduce the fistula, other conservative treatments can be considered before a surgical approach.

The use of sealants such as PRP (platelet-rich plasma) and fibrin glue are good alternatives to surgery, especially for the closure of low-output fistulas [33].

Platelet-rich plasma is an autologous sealant obtained by centrifugation of the patient's blood. It contains growth factors that allow healing and closure of the fistulous tract [46].

Fibrin glue is usually derived from porcine/bovine blood products; therefore, it has a higher risk of infection transmission compared to autologous materials such as PRP. On the other hand, PRP has the disadvantage of needing to draw blood ([33, 46]; Fig. 5).

When conservative treatments do not succeed in closing the fistulous tract within 4 to 8 weeks, surgery becomes necessary, although some authors propose waiting 6 months before surgery in order to avoid further complications [32].

Surgical treatment also depends on the clinical condition of the patient. When possible, fistulectomy and removal (also partial) of the infected tract of the mesh is recommended, followed by reconstruction, if necessary.

Although there are many surgical techniques proposed for treatment of mesh infection and fistulization, they all have a high failure rate; thus, despite numerous attempts, some patients remain in a chronic condition.

Beyond the complexity of surgical treatment, chronic fistula can sometimes become an unsolvable problem, not because of technically impossible operation (despite being challenging), but rather due to the patient's psychological refusal of a further operation, given the unsuccessful results of previous ones.

Restricted number of patients, heterogeneity of data, variable follow-up time (~1 year to 20 years), and the absence of a univocal approach are limits of the present study, like many previously published ones. Thus, no guidelines for treatment of these rare complications are available to date (Table 3). Following our experience and reviewing the largest case series in literature, we propose a diagnostic and therapeutic flowchart (Fig. 6).

To the best of our knowledge, this is the first attempt to create a codified diagnostic and therapeutic flowchart based on the literature, trying to put order into the "Tower of Babel" of technical proposals.

This report aims to be a step forward in the therapeutic workup of mesh fistulization.

According to our experience and literature review, we think that the approach to mesh fistulization should be tailored to every single patient, based on their clinical condition, the type of fistulous tract (low-output or high-output fistula), and the type of mesh implanted in the previous surgery, given the large heterogeneity of patient characteristics in all published series.

In the majority of cases, a multistep approach seems to be necessary. Starting from the most conservative treatment, the fistulous tract must be reduced and closed, until reaching the surgical solution when all conservative treatments fail. Unfortunately, not even surgery is always a definitive solution.

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