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REVIEW ARTICLE

Postoperative Mesh Infection—Still a Concern in Laparoscopic Era

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Abstract Introduction of synthetic mesh was a landmark breakthrough in the management of hernia repair and has significantly reduced recurrence rates. But in addition to the benefits, some more problems have come in picture major being 'mesh infection'. Prolene mesh has shown promise when used in abdominal and inguinal hernia repair, especially when used in planned surgeries. This material, derived from monofilament polypropelene, is found to be biologically inert in almost every person. Being a foreign material, a slightest breach in asepsis can lead to favourable environment for bacterial proliferation and form a 'biofilm'. This phenomenon especially after laparoscopic surgeries gives rise to chronic discharging sinus at the port site, abscess formation around mesh and even sepsis. It appears that laparoscopic hernia repair is a promising method but having chances of mesh infection owing to difficult approach and lack of uniformity in sterilization of laparoscopic instruments. Slightest breach in sterility or protocols might lead to such a large ventral wall sinus, increasing morbidity and cost of treatment. Treatment of infected mesh is possible by local debridement, irrigation, mesh removal and systemic antibiotics culminating in increased morbidity over duration of disease, but still it would be worth emphasizing—'Prevention is better than cure'.

Keywords Mesh infection · Mesh rejection · TEP · Ventral wall sinus · Atypical mycobacteria · Complication of meshplasty

Method Review is prepared by searching the following terms in Google scholar, PubMed and Pubmed Central and exploring the related articles popped on the side of page. The terms were 'Mesh infection', 'Mesh rejection', 'Post operative sinus formation in meshplasty' and 'complications of meshplasty'.

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Introduction

The use of synthetic mesh for the repair of hernias has reduced recurrence rates significantly. Unfortunately, the use of synthetic mesh can be complicated by infection despite aseptic technique and perioperative prophylactic antibiotics. When these complications occur, the surgeon and the patient are faced with a complex situation, often necessitating multiple surgical interventions. The exact incidence of this problem is understood poorly because of the lack of standardized definitions and reporting. Literature reported as high as 10 % infection rate following hernia repair with polytetrafluoroethylene (PTFE) mesh [1]. Although this cannot be generalized to other types of meshes, still it is worth identifying the causes for it and ways to prevent it. It is difficult to say where the infection came from and whether it was endogenous or exogenous [2]. Colonization of bacteria, properties of mesh, methods of sterilization and disinfection of laparoscopic instruments and mycobacterial infection constitute important aspects regarding mesh infection.

Factors Influencing Mesh Infection

Patient factors such as chronic obstructive pulmonary diseases, high body mass index [3], smoking, advanced age and American society of Anaesthesiologists (ASA) score ≥3 are associated with higher chances of mesh infection [4]. Also

other factors such as prior surgical site infection, other procedure from same incision at the time of repair, associated enterotomy or enterocutaneous fistula and use of micro porous mesh or Vicryl prolene composite mesh [5]; lack of tissue coverage of the mesh also predispose for mesh infection [3], so as longer operating time and with early part of surgical learning curve [4].

Type of Mesh Prone for Infection

Interestingly, the nature of the braiding of the mesh seems to correlate with the location of bacterial attachment. Fluorescence microscopy shows that the majority of bacteria adhered in areas where mesh intertwined [6]. However, it appears that the antiadhesive coating on the polypropylene affects *Staphylococcus aureus* attachment significantly. The highest overall count is found on the multifilament polypropylene as compared with monofilament polypropylene [6] as the former is having more surface area [7]. Also, multifilament such as polyester [8] and hydrophobic meshes significantly increase bacterial persistence or spreading in the infected area in contrast to monofilament polypropylene and lightweight meshes [9] as with vicryl prolene composite mesh which have high bacterial adhesion rate [5]. PTFE mesh is associated with more mesh infection and intestinal fistula formation [10].

Further micro-porosity promoted bacterial growth as compared with large pore mesh [6]; this is attributed to bacterial penetration of pores that are too small to enable leukocyte migration and bacterial clearance [7].

Properties of Mesh—Water Contact Angle

The wettability or water contact angle of meshes influences bacterial attachment [11]. A material with a high contact angle is considered hydrophobic and potentially less attractive for attachment by certain bacterial strains. A material with a low contact angle is considered hydrophilic and perhaps more attractive for attachment by bacterial strains. But contradictory results of various studies have failed to show advantages of hydrophilic polyester-based mesh (Parietex Composite; Covidien) over hydrophobic cPTFE (MotifMesh; Proxy Biomedical), polypropylene (PP) (Visilex; Bard) and PP/PTFE (Composix; Bard) mesh [6].

Bacteriology—Colonization of Bacteria

Colonization or adherence of bacteria on the surfaces of a mesh is a prerequisite for mesh-related infection [12]. Recent studies have shown infection rates ranging from 0.7 to 2 % in laparoscopic ventral hernia repair [13] and as high as 9–18 % in open inguinal and incisional hernia repair [14]. The presence of foreign material decreases the number of bacteria needed to cause infection by a factor of 10^4 [15]. Some risk factors leading to synthetic mesh-related infections include a history of infection, as well as obesity, smoking, diabetes, immune-compromised state or bowel injury [13]. The usual causative organism associated with cases of mesh infection are *Staphylococcus* spp., especially *S. aureus*, *Streptococcus* spp. (including group B streptococci), gram-negative bacteria (mainly enterobacteriaceae) and anaerobic bacteria (including *Peptostreptococcus* spp.) [16].

Bacterial attachment, proliferation and biofilm formation on the surface of synthetic materials are essential steps in the sequence leading to mesh infections [17]. In particular, *S. aureus*, which often is present on the skin and form biofilms, is the organism most commonly associated with mesh infection [18]. Biofilm is formed following the attachment of a community of bacteria to a surface and subsequent release of an exopolysaccharide matrix. This 'biofilm skeleton' protects the bacteria from antibiotics and the host defence system, thus facilitating persistent infections and challenging attempts to eradicate these infections [19, 20].

Mycobacteria—an Underestimated Threat

Initially isolated as 'undulated bacillus' from syphilitic lesions, *Mycobacterium smegmatis* was reported by Wallace and associates [12] to be a pathogen in a number of human skin and soft tissue infection [20]. Other rapidly growing nontuberculous mycobacteria associated with human disease include *Mycobacterium goodie*, *Mycobacterium fortuitum*, *Mycobacterium chelonae* and *Mycobacterium abscessus* [21] among which *MNN goodie* has been found to be infecting mesh in similar context [22]. Contamination of the surgical field by mycobacteria is high while using minimal invasive methods comprising various scopes, in which surgeons are relatively reluctant for high-grade sterilization, instead they would rather go for high-grade disinfection only [23]. When using potable water for rinsing, the user should be aware of the increased risk of recontaminating the medical device with waterborne organisms, e.g. pseudomonas, atypical mycobacteria, etc. [24]. A medical device that is not completely dried provides an ideal environment for rapid colonization of bacteria. Additionally, mycobacteria are highly resistant to drying; therefore, rapid drying will avoid possible colonization but may not result in freedom from atypical mycobacteria [24]. Hence, we discourage the repeated use to unsterilized tacker instrument for laparoscopic meshplasty or advocate high degree of disinfection or sterilization to prevent atypical mycobacterial infection.

Contamination of Disinfectants

Members of the genus *Pseudomonas* (e.g. *Pseudomonas aeruginosa*) are the most frequent isolates from contaminated disinfectants—recovered from 80 % of contaminated products

[23]. Growth of common skin microorganisms (e.g. *Staphylococcus epidermidis*, diphtheroids) has been documented from the umbilical area even after skin preparation with povidone-iodine and ethyl alcohol. Similar organisms were recovered in some instances from the pelvic serosal surfaces or from the laparoscopic telescopes, suggesting that the microorganisms probably were carried from the skin into the peritoneal cavity [25].

Method of Sterilization of Scopes

Laparoscopes, arthroscopes and other scopes that enter normally sterile tissue should be sterilized before each use; if this is not feasible, they should receive at least high-level disinfection [23].

Optimal sterilization precludes some of the basic steps, having their own importance viz. dismantling of laparoscopic instruments; decontamination with disinfectant solutions containing chlorine 0.5 %; precleaning preferably by wiping blood with enzymatic methods such as protease, lipases, amylase, etc.; cleaning with enzymatic and detergent-based preparations and rinsing under running water to reduce the bioburdon, although ultrasonic cleaning is 16 times better; drying with air guns and, sterilization with steam at 135 °C at 30 PSI pressure for 60 min or with cold ethylene oxide (EO) gas at 80 °C for 4 h and 30 min or warm EO gas at 145 °C for 2 h and 30 min, and storage should be done in proper sequence to ensure optimal sterilization [20, 26].

If such sterilization could not be achieved due to lack of resources, at least high-level disinfection should be used [20, 23, 26]. Intermediate-level or low-level disinfection which retains fungi, viruses, spores and in addition atypical mycobacteria respectively is not recommended; 2 % glutaraldehyde and 6 % stabilized hydrogen peroxide and per acetic acid (acetic acid/hydrogen peroxide) are the usual disinfectants used. Recommended usage is 2 % glutaraldehyde for 10 min for endoscopes, fibre optic cords and telescopes and 1 h for other metallic trocars mainly to prevent infection with atypical mycobacteria [20, 26]. Newer methods such as STER RAD which uses hydrogen peroxide vapours, low temperature gas plasma and RF energy are also useful for sterilization of laparoscopic instruments [20, 26].

Re-sterilization of Mesh?

Single use of mesh is always recommended [27] but resterilized mesh with ethylene oxide preferably [27] or autoclave can be used without considerable changes in recurrence and infection. Decreased human fibroblast growth associated with resterilised meshes [24] and unfavourably influenced characteristics of mesh due to sterilization could influence the biocompatibility of meshes [26] making such use debatable.

Diagnosis of Mesh Infection

Clinical findings such as fever, pain, local swelling and discharge from wound and haematological readings of leucocytosis, elevated ESR and C reactive protein are consistent with mesh infection. Investigations such as ultrasonography, computed tomography and peritoneal fluid sampling can help in confirming diagnosis [28, 29]. Scintigraphy with Tc^{99} antigranulocyte antibodies has been found to help in diagnosis of silent intraabdominal mesh infection [30].

Prevention of Mesh Infection

Although difficult to treat, postoperative mesh infection is preventable. Early steps, such as sticking to the principles of surgery such as strict asepsis, meticulous haemostasis and delicate tissue handling, are the key stones in its prevention [28]. Use of antibiotic impregnated drapes [31], preoperative [32] and perioperative systemic antibiotics [33], topical application of antimicrobials [33] and application of antibiotic releasing substances such as gentamycin-releasing collagen tampons [19, 33] over the mesh have been used with variable success.

ePTFE impregnated with antibiotics such as silver or chlorhexidine [34] has been shown in laboratory studies to minimize bacterial adherence [34, 35] in contrast to vicryl prolene composite mesh which have high bacterial adhesion rate [5].

Management of Infected Mesh

Intravenous antibiotics and excision of mesh form key stones in the management of mesh infection [28]. Treatment of mesh infection depends first and foremost on the patient's clinical status. Patients who are unstable as a result of severe sepsis secondary to presumed mesh infection should be operated on urgently for drainage of the infection, possibly deferring explantation which can require protracted, tedious dissection until the patient has stabilized [7].

The management of infected mesh might differ according to the type of mesh used. Specifically, it is suggested that infection of polyester or polypropylene mesh might be managed with drainage and antimicrobial agents only, whereas the infected mesh should be surgically removed in cases of infection involving expanded polytetrafluoroethylene mesh [36]. This could be attributed to the fact that a PP mesh becomes incorporated into the anterior abdominal wall with neovascularisation within 2 weeks of implantation, allowing leukocytes and macrophages to gain access to the local microenvironment [7]. Local management includes removal of skin sutures, opening of wound and drainage of pus, irrigation with saline/povidone-iodine and gentle debridement of the wound [37].

Conservative management includes the following: we can put percutaneous drain within the fluid collection with

gentamicin 80 mg in 20 ml of saline infused through drain three times a day [38] or can use negative pressure wound therapy (NPWT) using reticulated open cell foam (ROCF) [39] or judicious use of vaccume assisted closure [40] or can put vancomycin paste on the infected mesh to seal the infection [35].

Surgical management includes mesh explantation which consists of opening the prior incision and extirpating the mesh, sutures and tacks, with closure of the fascia, if possible. More recently, there has been a trend toward mesh salvage, as explantation is plagued by hernia recurrence, loss of domain and risk of enterotomy or enterocutaneous fistula formation [7] to solve this problem. Rectus abdominis myofascial flap closure, known as 'separation of parts' hernia repair, can be done to reduce the hernia recurrence rates [41]. We can do mesh excision and repair with biological mesh [1] such as porcine-derived dermal matrix (Strattice) [7] as they do not inhibit the body's ability to fight infection and do not require removal when exposed or infected [7] but it may just be a temporary solution until we can permanently repair hernia [35]. Mesh removal with primary skin closure has been practised, particularly for patients who are critically ill or who have little or no tissue coverage of their abdominal organs. Some author advocates waiting 6–9 months before implanting another mesh and performing a preoperative biopsy of subcutaneous tissue for culture to ensure that no residual bacteria are present [7].

Conclusion

Although in routine practice mesh infection is still a concern in laparoscopic and open repairs, it is preventable by means of selection of mesh material, maintaining sterility of prosthesis and operating set up, proper disinfection and sterilization of scopes and adequate antibiotic coverage as an when required. Re-sterilization of mesh though proven effective is not indicated in view of morbidity associated with mesh infection. Treatment of infected mesh is possible by local debridement, irrigation, mesh removal and systemic antibiotics, but still it would be worth emphasizing—'Prevention is better than cure'.

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

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