Mesh-related infections after hernia repair surgery
M. E. Falagas\textsuperscript{1,2} and S. K. Kasiakou\textsuperscript{1}

\textsuperscript{1}Alfa HealthCare, Athens, Greece and \textsuperscript{2}Tufts University School of Medicine, Boston, MA, USA

ABSTRACT
Clinicians have been challenged in the past few years by an increasing variety of novel non-infectious and infectious complications following the widespread use of meshes after open or laparoscopic repair of hernias. The possibility of a mesh-related infection occurring weeks or even years after hernia repair, should be considered in any patient with fever of unknown origin, or symptoms and/or signs of inflammation of the abdominal wall following hernia repair. The reported incidence of mesh-related infection following hernia repair has been 1\%–8\% in different series, and this incidence is influenced by underlying co-morbidities, the type of mesh, the surgical technique and the strategy used to prevent infections. An approach that combines medical and surgical management is necessary for cases of mesh infection. The antimicrobial treatment regimen chosen initially should include coverage of \textit{Staphylococcus} spp. and, particularly, \textit{Staphylococcus aureus}.

Keywords Hernia repair, infectious complications, mesh-related infection, \textit{Staphylococcus aureus}, \textit{Staphylococcus} spp.

Accepted: 25 August 2004

\textit{Clin Microbiol Infect} 2005; 11: 3–8

INTRODUCTION
Within the last few years, the use of meshes has become standard procedure in hernia repair surgery throughout the world. Implantation of a mesh during the surgical management of this common problem has been found to reduce the rate of recurrence of a hernia. For example, use of a mesh for the repair of incisional hernias has been found in different studies to decrease the recurrence rates by an average of 30\% [1–3], while in a randomised clinical trial involving 289 patients in which non-mesh vs. mesh repair of primary inguinal hernia was compared, it was found that recurrence rates were 7\% for the non-mesh technique vs. 1\% for mesh repair [4]. However, mesh-related complications have become increasingly important. Such complications include seromas, adhesions, chronic severe pain, migration and rejection of the mesh, and mesh-related infections.

The present review focuses on mesh-related infections. Data for the review were obtained from searches of Medline, Current Contents and references from relevant articles. In addition, several articles were identified through searches of the extensive files of the authors. The search terms were ‘mesh’, ‘infection’, ‘open hernia surgery’, ‘laparoscopic hernia repair’, ‘inguinal hernia repair’, ‘infectious complications’, ‘biomaterials’, ‘antibiotic prophylaxis’ and ‘prevention’. All English language papers were carefully reviewed.

MESH-RELATED NON-INFECTIONOUS COMPLICATIONS
Important advances in research and development by the biomedical materials industry have led to the production of relatively inert and biocompatible surgical meshes. However, it has been noted in clinical practice that surgical meshes can trigger various responses when implanted in the human body, including inflammation (known as foreign body reaction), fibrosis, calcification, thrombosis and infection.

Foreign body reaction refers to a process in which proteins such as albumin and fibrinogen are absorbed initially by the surface of the polymer. Subsequently, the physiochemical properties

Corresponding author and reprint requests: M. E. Falagas, 9 Neapoleos Str., 151 23 Marousi, Greece E-mail: matthew.falagas@tufts.edu

© 2004 Copyright by the European Society of Clinical Microbiology and Infectious Diseases
of each polymer result in the degradation of the absorbed proteins. This process results in the attraction and stimulation of macrophages, which respond by releasing inflammatory substances and growth factors. Other inflammatory cells (T-lymphocytes, polymorphonuclear cells, eosinophils, plasma cells and fibroblasts) are then attracted to the surface of the polymer, leading to the formation of a granuloma. Such granulomas are characterised by locally increased cell turnover, which may continue for periods of several years after the implantation of the mesh. Foreign body reaction also depends on the surface area of the mesh that is in contact with the host tissue [5]. Clinical manifestations of foreign body reaction are seroma, rejection, migration of mesh, adhesions and pain.

Meshes made of non-absorbable polymers have been used most frequently in clinical practice. The main non-absorbable polymers are polyester, polypropylene and expanded polytetrafluoroethylene. However, given the fact that absorbable polymers are associated less frequently with foreign body reactions and adhesion, newer meshes are made of a combination of absorbable and non-absorbable polymers [6,7]. The mechanical and biological properties of meshes are associated with the type of tissue structure (woven or knitted) and the type of fibre used (mono- or multifilament) [8]. The pore size of the mesh also plays a role in the safety and tolerability of surgical meshes [9].

**MESH-RELATED INFECTIOUS COMPLICATIONS**

**Incidence**

Mesh-related infections following surgery occur relatively infrequently compared with other device-related infections. However, they are of considerable clinical importance, not only for the patients and surgeons, but also for other medical specialists. The question of whether the incidence of infectious complications is higher after hernia repair involving the use of a mesh, in comparison with older techniques not involving use of a mesh, remains controversial. The results of a recent trial in which a comparison was made between umbilical hernia repair with or without a mesh in 200 adults showed that the rate of post-operative complications, including infection, was similar following both procedures [10]. A similar result was obtained in a meta-analysis of 20 trials (5016 participants) of open mesh vs. non-mesh repair of groin hernias [11]. In contrast, the results of a randomised trial of 160 patients with simple or complex hernias who underwent suture repair, skin graft or mesh repair showed that the rate of infectious complications was lower following suture repair than following the other two techniques. In addition, mesh implantation led to an increased rate of infections following repair of both simple and complex hernias [12]. A further study showed that the use of mesh during the repair of a ventral hernia or a hernia defect >10 cm in size was associated significantly with an increased number of wound complications [13].

Incidences of mesh-related infection after hernia repair of up to 8% have been reported (Table 1) [14–18]. The rate of infection is influenced considerably by underlying co-morbidity, and seems to be increased in patients with diabetes, immunosuppression or obesity. Of great interest is whether the type of prosthetic material or the precise technique used for hernia repair can influence the incidence of mesh infection. In most recent published trials, the differences in complication rates following different surgical approaches and the use of different meshes have been compared. However, none of these studies focused specifically on the mesh-related infection rates. Leber et al. [19] conducted a retrospective cohort analysis of 200 patients who underwent open repair of abdominal incisional hernias with prosthetic material, with the aim of determining whether the incidence of long-term complications was influenced by the surgical technique. The authors concluded that the precise surgical approach did not influence the incidence of long-term complications significantly, including

<table>
<thead>
<tr>
<th>Reference</th>
<th>Study population (n)</th>
<th>Technique of hernia repair</th>
<th>Incidence of mesh infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heniford et al. [14]</td>
<td>407</td>
<td>Laparoscopic ventral and incisional hernia repair</td>
<td>0.98%</td>
</tr>
<tr>
<td>Heniford et al. [15]</td>
<td>822</td>
<td>Laparoscopic ventral hernia repair</td>
<td>0.7%</td>
</tr>
<tr>
<td>Kirschtein et al. [16]</td>
<td>103</td>
<td>Laparoscopic incisional hernia repair</td>
<td>2%</td>
</tr>
<tr>
<td>Petersen et al. [17]</td>
<td>121</td>
<td>Open incisional hernia repair</td>
<td>7%</td>
</tr>
<tr>
<td>Cobb et al. [18]</td>
<td>95</td>
<td>Open incisional hernia repair</td>
<td>8%</td>
</tr>
</tbody>
</table>

© 2004 Copyright by the European Society of Clinical Microbiology and Infectious Diseases, *CMI, 11*, 3–8
mesh infection. Although several authors have suggested that the laparoscopic approach to hernia repair has fewer post-operative complications compared to open repair, there are no clear, specific data regarding mesh-related infection rates [20–22].

There is no consensus in the literature as to whether the use of non-absorbable mesh for incisional hernia repair is contraindicated in potentially contaminated surgical settings. Recently published data have indicated that the rate of mesh-related infections is comparable for ‘clean’ surgical procedures and for cases where potentially contaminated surgical procedures, such as appendectomy, cholecystectomy or enterectomy, are performed at the same time as incisional hernia repair [23,24].

The influence of mesh type on the incidence of infection was investigated in a recent study; the results showed that the use of multifilament polyester mesh resulted in a higher incidence of infection, small bowel obstruction and enterocutaneous fistula formation than the use of other types of mesh (knitted monofilament polypropylene, polytetrafluoroethylene or woven polypropylene) [19]. In addition, studies in experimental animals have shown that microporous mesh is associated with higher rates of infection and/or development of seromas, whereas macroporous mesh is associated with a higher incidence of adhesive and erosive events. Microporous mesh has a pore diameter of 10 μm, with the result that bacteria can penetrate the mesh, but polymorphonuclear leukocytes (with a diameter of 75 μm) cannot. This means that the bacteria in the mesh are protected from immunological defence mechanisms [25–27].

Clinical symptoms and signs

The reported interval between hernia repair and the manifestation of a mesh infection ranges from 2 weeks to 39 months [28]. Patients usually present with symptoms and signs of local acute inflammation (a combination of pain, erythema, tenderness, swelling and increased temperature in the abdominal wall in the area of the mesh). In addition, patients may have systemic manifestations such as fever, malaise, chills or rigors. A mesh-related infection can sometimes manifest with a discharging fistula, or with an intra-abdominal abscess. Rare cases of patients who presented with osteomyelitis following inguinal hernia surgery with implantation of a polypropylene mesh have been reported [29].

Microbiology

The usual causative organisms associated with cases of mesh infection are Staphylococcus spp., especially Staphylococcus aureus, Streptococcus spp. (including group B streptococci), Gram-negative bacteria (mainly Enterobacteriaceae), and anaerobic bacteria (including Peptostreptococcus spp.) [28]. In a study of mesh-related infections following incisional herniorrhaphy, 63% of the microorganisms isolated were methicillin-resistant S. aureus (MRSA) [18]. Rarely, mesh infections are caused by Candida spp. or Mycobacterium spp. [30,31]. Mesh infections can manifest with chronic, persistent or recurrent symptoms and signs. The infecting agents in some of these reported cases were small-colony variants, usually of S. aureus. The main characteristic of these infections is that they respond poorly to antimicrobial treatment regimens [32].

Prevention

The most important point regarding the prevention of mesh-related infections is that foreign body reactions depend on the amount of the prosthesis (mesh) used. For this reason, surgeons should try to minimise the area of mesh that is introduced during the hernia operation, since the inserted foreign material is an ideal medium for bacterial colonisation [33].

In addition, four main approaches to the prevention of mesh infection have been used. First, the wound can be rinsed with an antibiotic-containing solution, starting immediately after the dissection of the hernia sac, and then intermittently until the skin is sutured. It has been shown in an animal model that this approach inhibits the adhesion of bacteria to the surface of the mesh, as well as their growth [34]. Moreover, in a randomised trial of 162 patients who underwent inguinal hernia repair, there were no wound infections following the application of a single dose of cefamandole directly to the wound [35]. However, the effectiveness of lavage with solutions containing antimicrobial agents is controversial, since antibiotics require a defined
duration of contact with pathogens, while lavage is usually a more rapid process.

A second approach involves the use of material placed in front of the mesh to slowly deliver an antimicrobial agent locally. In a randomised trial, the use of gentamicin-laced collagen tampons was tested in 301 patients undergoing prosthetic groin hernia repair. The collagen tampons were placed in front of the mesh before the aponeurosis of the external oblique muscle was sutured. This new technique resulted in fewer post-operative infections in comparison with 294 patients undergoing surgical repair for the same hernia without the use of gentamicin-containing collagen tampons [36].

Third, a mesh containing embedded antimicrobial agents can be used. Such a mesh is thought to help prevent bacterial adhesion and colonisation when implanted in wounds, with a subsequent reduced likelihood of post-operative infections.

Finally, traditional intravenous perioperative administration of antimicrobial agents can be used. Although hernia repair operations are classified as clean surgery, the administration of intravenous antibiotics perioperatively has been shown to be beneficial if a prosthetic material (mesh) is involved [37,38].

All of the above-mentioned strategies seem to be beneficial in reducing the incidence of mesh-related infection after hernia repair. However, no definitive recommendation can be made in favour of any particular approach in the absence of comparative outcome data. The current standard preventive strategy for other types of surgery, i.e., the perioperative administration of appropriate intravenous antibiotics perioperatively has been shown to be beneficial if a prosthetic material (mesh) is involved [37,38].

Diagnosis and treatment

A clinician should strongly consider the possibility of a mesh-related infection in any patient who presents with fever of unknown aetiology, symptoms and/or signs of inflammation of the abdominal wall in the area of the mesh, or other less common clinical manifestations of mesh infection, such as an enterocutaneous fistula or abdominal abscess in the area of the mesh.

Imaging techniques, including ultrasound and/or computerised tomography, can be useful for the diagnosis of mesh infection. Such techniques usually reveal an area of inflammation in the subcutaneous fat around the mesh, which has different echogenic or density characteristics, respectively, from that in other conditions, such as seroma. Additionally, the results of these imaging tests can indicate the presence of a fistula or an abscess.

It is important that no attempt should be made to perform a diagnostic paracentesis of mesh-related seromas when there are no symptoms and/or signs of inflammation of the abdominal wall. This is because of the real possibility of introduction of bacteria into the area of seroma during paracentesis, leading to the transformation of an aseptic reaction into an infectious process.

When a mesh-related infection occurs, a combined medical and surgical approach involving intravenous antimicrobial agents and complete surgical removal of the mesh is the preferred management strategy. For a variety of reasons, monotherapy with intravenous antibiotics generally has a poor outcome. The most important of these reasons relates to the fibroblastic response of the organism to the polymer of the implanted mesh, which results in the development of a thick fibrous capsule surrounding the mesh. Consequently, when an infection is established, this capsule restricts the penetration of antimicrobial agents into the infected mesh. In addition, it is well known that Staphylococcus spp., which are the most common causative organisms in mesh infections, produce a biofilm on the prosthesis, with the result that the microorganisms are protected simultaneously from antibiotics and the immune responses of the host organism [39].

Incomplete removal of the mesh should be suspected in any case with persistent or recurrent symptoms and/or signs of mesh infection. However, the results of a recent study suggested that the management of infected mesh might differ according to the type of mesh used. Specifically, it was 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 [17].
CONCLUSIONS

Clinicians should promptly consider the possibility of mesh infection in any patient who has undergone hernia repair surgery involving a mesh, and who has fever of unknown aetiology or signs of infection of the abdominal wall. There is no adequate evidence in the literature concerning the specific risk factors for such infections. Whether the surgical technique used for the repair of a hernia or the precise type of implanted mesh influences the rate of development of a mesh-related infection remains to be clarified.

As yet, there are no published reports of comparative trials of different antimicrobial regimens for the management of mesh-related infections. Consequently, no definitive recommendations can be made concerning the preferred medical management strategy. However, given the known facts regarding the microbial aetiology of mesh-related infections, and the pathogenesis and characteristics of infections involving other types of prosthetic material, antimicrobial agents used for the treatment of mesh-related infection should at least include coverage for *Staphylococcus* spp.

REFERENCES


