Dependency Between the Porosity and Polymeric Structure of Biomaterials Used in Hernia Surgery and Chronic Mesh - infection

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Hernia prostheses have become, naturally, the standard in the surgical treatment of parietal defects. The development of this surgery led, besides the general complications relating to the surgery, to the occurrence of complications due to the prosthetic material used. Septic complications due to prosthetic material are difficult to treat, with long-term evolution and decrease in the patient's quality of life. The objective of this study is to demonstrate that the incidence of septic complications can be reduced if morphological properties and clinical implications of the implants are known. Prosthesis susceptibility to infection is directly related to its structure, porosity and type of filament, these being the main criteria to be taken into account, especially when intra-operative septic times are expected. In conclusion, the incidence of chronic sepsis can be reduced by choosing, when clinical conditions allow, monofilament macroporous materials less susceptible to chronic infection.

Key words: mesh infection, hernia, mesh porosity, polypropylene, ePTFE, polyester

Restoring abdominal wall defects using textile materials has become, in recent years, the standard in hernia surgery. The evolution of this surgery was and is directly related to the emergence of new polymer structures with high biocompatibility. Their use has resulted in solving the main postoperative complication, recurrence, but there are, however, other complications that can occur; they are related to the presence of the textile material in the tissues, the reaction of the tissue to this material being dependent to the prosthesis structure and, last but not least, to the septic risk associated to parietal prostheses.

The first plastic material widely used in the treatment of hernias was nylon. However, it was losing its resistance in time due to hydrolysis, resulting in a high incidence of recurrence and a high risk of prosthetic infection which required its removal. It was therefore necessary to identify another synthetic material, non absorbable and resistant to infection; several materials were tested, including polypropylene, polytetrafluoroethylene and polyethylene [1].

Experimental part

Material and methods

The aim of this study is to evaluates the clinical implications that occur secondary to the relationship between polymer porosity and filamentary type and risk of infection, generating chronic suppurations.

Foreign body reaction generated by the presence of the prosthesis in tissues is passing through three essential steps: protein absorption, cell recruitment and ultimately, fibroid encapsulation. It has been shown that the geometric structure and porosity of the prosthetic material is more important in the host tissue reaction than the type of polymer used. The tissues' foreign body reaction to various polymeric structures can be influenced by modifying the pores of that structure; increasing pore size increases biocompatibility while decreasing pore size compromises material integration [2]. Therefore, if macroporous prostheses are integrated into the adjacent structures, microporous prostheses cause poor cell activation, are not integrated into the adjacent tissues, resulting in the formation of a fibrous granuloma that surrounds the structure forming a scar as a breastplate, and favouring the bacterial development and the prosthesis retraction.

Because of these characteristics, postoperative evolution is directly dependent on the nature and architecture of the polymer used. The porosity of the implant must be at least 75μm to allow infiltration of macrophages and fibrocytes. The flexibility of the materials with high porosity is because it reaction that form fibrous granuloma, develops only at the level of the polymer wires, pores allowing tissue ingrowth, compared to microporous structures that cause the formation of fibrous bridges leading to stiffness scar. Multifilament type does not affect the porosity structure, but increase the surface contact at the implant. This encourages developments of the bacterial population in the implant. (fig. 5)

Prostheses with a porosity of more than 1mm have a low contact area and therefore induced inflammatory reaction will be less intense and complications such as chronic pain and implant infection will diminish.

In 1997 Amid highlights, for the first time, the importance of a correlation between alloplastic material porosity, biocompatibility and side effects and classifies these polymers in four main groups, according to the tissues' reaction to their structures and according to postoperative complications[3]. (table 1) In current practice are used four basic materials: polypropylene, polytetrafluoretylene, polyester, polyvinylidene - fluoriode (PVDF).

Polypropylene is, perhaps, the most popular material used in hernia surgery; it is a hydrophobic polymer having the following benefits: flexible structure, resistance, quickly integration into the adjacent tissue structures, resistance to infection due to its monofilament structure (fig.1) with large pores allowing penetration of fibroblasts, macrophages and development of fibrovascular structures

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I	Macroporous >75 microns (ex. prolene)
II	Macro with microporous (ex. dual mesh, polypropylene with ePTFE)
III	Microporous (ePTFE)
IV	submicronic pore/sheets

Table 1
CLASSIFICATION OF PROSTHETIC MATERIALS ACCORDING TO POROSITY (ACCORDING TO AMID)

in the depth of the prosthesis (fig. 2 and 3), resulting in a very good tensile strength.

The disadvantages of macroporous prostheses relate also to the severe inflammatory reaction responsible for the occurrence of adhesions between the viscera and the prosthesis, and intestinal fistulas, even years after the initial surgery [1,2,4-6].

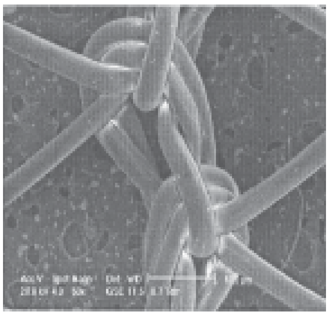

Fig. 1. Monofilament macroporous structure - (polypropylene)

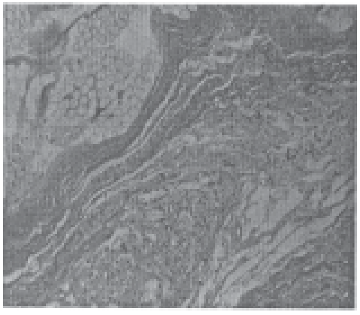

Fig 2. Fibrillar and hyalinized fine connective tissue, of intense pink colour, entangled with adipose tissue (right central region) and chronic inflammatory elements (nuclei are purple), arranged diffusely and foreign body consisting of non-absorbable sutures (upper central region) Van Gieson's stain; Magnification x 100

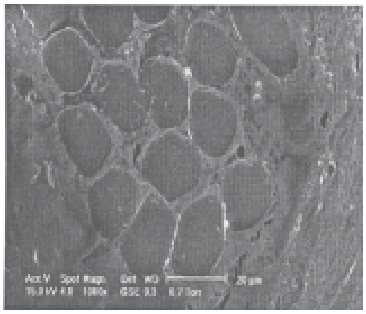

Fig.3 Monofilament macroporous (polypropylene) structure, fully integrated into the adjacent tissue

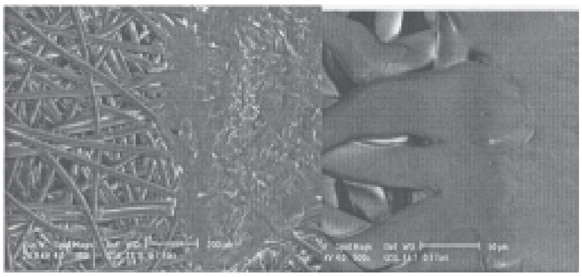

Fig. 4. Multifilament microporous polymeric structure (ePTFE)

Expanded polytetrafluorethylen (ePTFE) is a hydrophobic synthetic fluoropolymer due to the negative load with microporous structure that causes a low inflammatory reaction (fig 4). Due to its microporosity, it does not integrate into the adjacent tissues but it becomes encapsulated and the passage of bacteria in the synthetic structure is enabled while macrophage migration is prevented. Due to this structural feature, the infection occurring in these prostheses cannot be cleaned by the body. In favour of these prostheses stands the low cellular reaction which allows their fitting in the intraperitoneal area, the risk of visceral-prosthesis adhesions being low, the disadvantages being represented by the risk of infection requiring removal of the prosthesis and the absence of tissue integration with granuloma formation that increases the risk of relapse. Their association with a macroporous prosthesis improves the adhesion to the abdominal wall (dual mesh) [4, 5,7, 8].

Polyester – it is a multifilament microporous structure which induces, the same as ePTFE, local granulomatous reaction corresponding to each fibre that subsequently confluences, forming a granuloma that surrounds the prosthesis, resulting in a low elasticity scar, increasing the risk of seroma formation and septic complications (fig. 5) [4, 6, 8, 9].

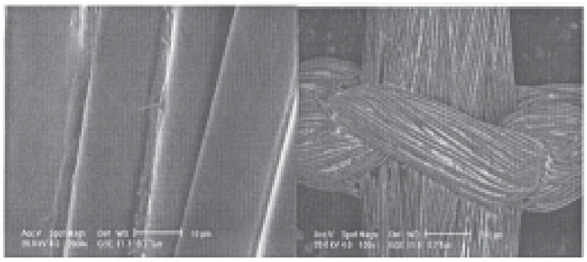

Fig. 5. Multifilament structure (polyester)

Polyvinyliden fluoride - is a polymer with better resistance to hydrolysis and degradation over time and that keeps the elasticity compared to polypropylene and polyester. Foreign body reaction is greatly diminished compared to that induced by polypropylene and strictly runs around polymeric fibers. Low inflammatory response allows the use of these implants in laparoscopic surgery, without having to apply a protective coating to separate the viscera.

Results and discussions

Prosthesis infection in hernia surgery has an incidence ranging between 2 and 5%, depending on the size of the study group [1,7]. Most studies on the septic risk in the surgery of abdominal wall defects assess risk factors such as: dissection extension, prosthesis size, surgery length, associated diseases etc. that are undoubtedly directly involved in the septic risk of these surgical operations without, however, taking into account, comparatively, the prosthetic materials used.

Modern surgery for abdominal hernias involves the "tension free" fitting of a polymer prosthesis, but until choosing a prosthesis appropriate for each individual case, the surgeon must take into account the patient's

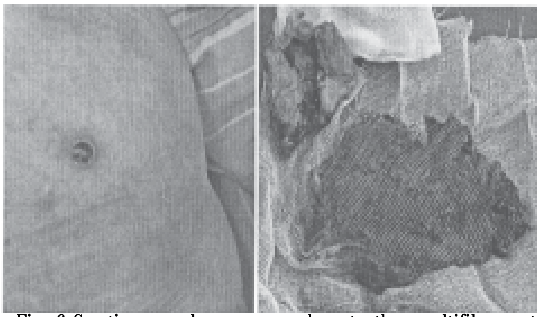

Fig. 6 Septic granuloma secondary to the multifilament implant - excision of the prosthesis and fistulous tract

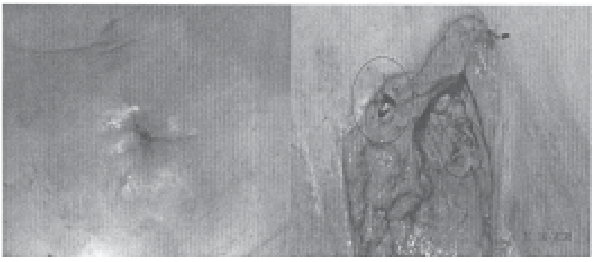

Fig. 7. Chronic sepsis caused by using multifilament materials (polyester) to fit the prosthesis (marked in a black circle). In the depth of the wound the polypropylene prosthesis integrated in the tissue can be seen

particularities and the prosthesis' characteristics. The compatibility between the abdominal wall structures, which vary according to the surgical procedure to be used, and the characteristics of the prostheses' polymer structures play a major role in the postoperative evolution and complications secondary to prosthesis fitting. The surgeon's understanding of the mechanical and structural characteristics of prostheses and the choice of the appropriate material for the surgical procedure to be performed can prevent further complications in the short and long run in relation to the time when the surgery took place.

While hernia recurrence greatly decreased due to prosthetics and a possible relapse can be corrected, a particular problem is represented by chronic infection with long and slow evolution, affecting the quality of life of these patients who, sometimes, because of a minor asymptomatic parietal defect, get to pay with years of suffering because of the use of unsuitable materials or incorrect combination of these materials. Not rare were the cases where a properly performed surgery, using macroporous materials, was compromised, in terms of septicity, by using multifilament microporous threads that generated chronic suppurations with evolution over many years (fig.7).

The surgeon's choice often relies on tradition and not on studies and clinical evidence. In high septic risk cases or septicity-related operations it is recommended to choose monofilament macroporous prostheses and to avoid using multifilament microporous materials [10-12].

Conclusions

It should always be borne in mind that the prosthetic material choice is as important as the surgical prosthetic fixing procedure. By knowing the structural properties of polymeric materials and by choosing them according to their porosity and filamentary structure, considering the general conditions of the surgery, the incidence of septic complications secondary to the use of synthetic materials can be reduced.

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