Types of Polymeric Meshes Used to Repair Abdominal Wall Defects

TEODOR DAN POTECA[1], DANIELA ELENA MIHAILA[1], SINZIANA OCTAVIA IONESCU[2], ANCA GABRIELA POTECA[3], MIRCEA TAMPA[3]*, CLARA MATEI[3]

[1] Colentina Clinical Hospital, General Surgery Clinic, 19-21 Stefan cel Mare, 020125, Bucharest, Romania

[2] Bucharest Oncology Institute,Clinic of General Surgery and Surgical Oncology, 252 Fundeni Str., 022328, , Bucharest, Romania

[3] "Carol Davila" University of Medicine and Pharmacy, Bucharest, 37 Dionisie Lupu Str., 020022 Bucharest, Romania

The development of new polymeric materials –either synthetic or biologic- for the surgical repair of abdominal wall primary or incisional defects (one of the most frequent surgical procedures performed in a clinic of general surgery) dates back from the 1950s; inspiration for developing new materials came from several sources, such as the evolution of the surgical techniques, the emergence of laparoscopy and the technologic revolution of the past years. The history of the meshes began with Usher's polypropylene mesh; curently used meshes basically contain polypropylene, polyester and ePTFE, used per se or in different combinations (composite meshes) with various additional materials (omega 3, titan, monocryl, PVDF, hyaluronate). The most important features of the meshes used in the surgical process are: the type of material used, its porosity and its resistance, elements which determine its weight and ability to integrate into the recipient body. The use of meshes allows the repair of many types of abdominal wall defects of various dimensions and the substitution of the areas with lack of substance, as the prostheses stimulate the collagen synthesis. The present article envisages the review of the meshes which have been used more often in our clinic during the past year, and also their features and indications.

Keywords: substitution materials, abdominal wall defects, types of prostheses

The most important functions of the abdominal wall are: contention, protection and compression of the abdominal viscera, the rotation and flexion of the trunk and the forced expiration. The main elements which assure these functions are the abdominal pressure and the elasticity of the abdominal wall.

The target of a surgical procedure performed to repair an abdominal wall defect is to restore it to a form as near as possible to the integrity. The methods to accomplish that goal have been modified over time, as science grew to understand the physiologic and physical mechanisms: a) which lead to the appearance of the defect and b) those involved in the process of cure. Although the anatomic procedures had good results in time, nowadays these are used only in few cases of specific indication, the standard today is overrun by alloplasty (the use of prosthesing materials). The abdominal wall meshes have significantly decreased the rates of recurrence and complications, thus proving their superiority [1].

Once accepted, the necessity to use prosthesing materials gave birth to the competition between the two main types of meshes: the light ones with big stitches and the heavy ones with small stitches. The meshes currently used tend to have a low weight (influenced by the material they are made out of), pores>1mm, an elasticity of 20-35% (at 16 N/cm) and the resistance of the fibers of minimally 16 N/cm [2].

The most important processes involved in mesh appliance are that of tissue acceptance and foreign body reaction. The recent research has lead to the discovery of a *mathematical method* which can be used to predict the behavior of the fiber tissue, the formation of collagen being strictly tied to the enzymatic interaction of fibroblasts [3]

Experimental part

Materials and methods

Types of meshes

The history of the meshes began in 1958 with Usher's *polypropylene* mesh. The meshes used nowadays basically contain the same materials: *polypropylene*, *polyester* and *ePTFE*, used per se or in different combinations (composite meshes), with various additional materials (*omega 3, titan, monocryl, PVDF, hyaluronate*).

None of these variations is an ideal option, and the search for a solution lead to the discovery of biomaterials and collagen matrices derived from the human dermal tissue or from pig intestinal submucosa [1]

The main types of meshes:

-Type 1 : meshes with large stitches > 75 microns (e.g. Prolene)

-Type 2 : meshes with small stitches < 10 microns (e. g. Goretex)

-Type 3 : meshes with big stitches and small-stitched components (e.g. Teflon)

-Type 4 : biomaterials [4]

The features of an ideal mesh are: resistance and durability of the material, the ability to be incorporated in the tissues and the ability to recreate the abdominal wall, the resistance to infections and the ability to prevent formation of visceral adhesions [5].

The high weight meshes were conceived to obtain stability and rigidity by creating scar tissue and a high fibroblastic reaction. They have a big surface, thick fibers of polymers and small pores ,<1mm, while the light weight meshes easily imitate the physiologic features of the abdominal wall, have thin fibers out of polymers, increased flexibility made out of pores >1mm, a small surface and generation of a small scar tissue, with little postoperative pain, increased patient motility and a small degree of recurrence [2].

* *email: tampa_mircea@yahoo.com; Tel.: +40758040752*

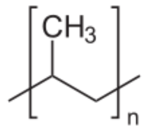
Although they have biocompatibility, the materials used are not biologically inert, as they have physical and chemical properties which lead to the well-known complications of alloplasty: infections, adhesions, seromas, fistulae, fibrosis, calcification, inflammation and thrombosis. The integration of the mesh into the tissue is done with the help of an intense inflammatory process, which involves the use of chemotaxis and the invasion of the area with macrophages and monocytes.

On the other hand, those meshes which are biologically inert sometimes have a strong and violent reaction of foreign body rejection, as they form granulomas, multinuclear cells resulting from the foreign body which becomes surrounded by macrophages and monocytes .

After fixation, the foreign materials absorb part of the proteins of the host in a few seconds, process which precedes even the primary cellular response and has generated the idea of a phagocyte reaction initiated not by the presence of the foreign material, but also by the interaction with products of protein degradation. *Polypropylene*, *polyethylene terephtalate* and *expanded poly-tetra-fluoroethylene* are all non absorbable materials and are components of any mesh [2].

Polypropylene meshes

Polypropylene is a thermoplastic polymer obtained through the polymerization of propylene.

Formula :  $(C_3H_6)_n$

Normally, this material is flexible and tough, mostly co polymerized with ethylene, resistant to high temperatures and low weight; with big resistance to the action of organic solutes, aliphatic and based on chlorine. Polypropylene is colorless and easy to dye. The material is obtained by Ziegler Natta polymerizing reaction.

The melting point for isotactic polypropylene is 171°C, whist the melting point of the commercial one is 160-166 °C, which varies with the crystallization degree. The syndiotactic polypropylene with a crystallization of 30% has a melting point of 130°C[6].

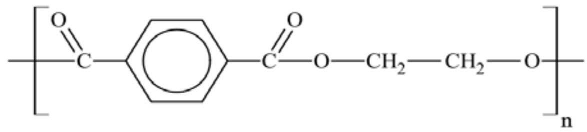
Developed and used for the first time in infected wounds, the polypropylene meshes were used thereafter on a large scale and the association between them and previously mentioned long term complications (adhesions, fistulae, relapse, infections) was consequently discovered. The original meshes made out of polypropylene are those that form the basis of the monofilament meshes with large pores, elasticity and big integration ability (Surgipro, Prolene, Parietene), used in the repairment of the hernias through laparoscopic procedures[7].

ePTFE meshes

Formula of polymerized tetrafluoroethylene :

The material is obtain through the following reaction: $nF_2C{=}CF_2 \rightarrow$ —{ F_2C—CF_2}—. ePTFE is a material developed by Gore, through the polymerization of teflon, being a very tough material, with micropores, having the following properties: resistance, hydrophobia, bio-compatibility, chemical inertness, chemical and thermal resistance, low friction coefficient, low dielectric constant and is difficult to inflame. The structure of the meshes allows gas elimination without allowing the liquids to go through the membrane[8]. Teflon is a white polymer with a density of ~ 2.2 g/cm^3, a melting point of 327°C. These features are due to the carbon-fluoride liaisons [9].

These are smooth resistant and light meshes with small pores which do not allow the formation of adhesions or intestinal lesions. The low-points of this type of mesh appear due to the small pores which favour infections, and most of the time their treatment means the removal of the mesh. They are preferred in substitution alloplasty . The newest and most known variant of these meshes is Dual Mesh, with 2 sides, a tissue slot of 3 microns on a side and a 17-22 on another side, allowing the incorporation of fibroblasts and collagen which on the one hand favour the acceptance into the abdominal wall, but on the other stop the formation of intestinal adhesions [8].



Polyesther meshes

Polyesther is a term used for a larger group of substances, but most frequently for PET (polyethylene terephtalate), whose structure is presented underneath:

Chemical properties: non soluble, melting point > 250°C.

Polyesther resins are rigid, resistant , hardly absorb water, are very stable, unbreakable, resistant to chemical agents, having a semi-crystalline structure and thermal resistance.

These are meshes well integrated in the abdominal wall, are covered on their visceral side by a coat of collagen which dissolves at the same time the polyesther is incorporated. The meshes are elastic, easy to use , pliable, with a granular texture which favours the adhesion to the peritoneum and prevents the sliding of the mesh, inducing a quick fibroblastic answer, but suffering from an accentuated process of contraction.

The currently used meshes from this category are Parietex, with a 3D structure and increased memory, the prostheses being foldable. They can be used both in classic, as in laparoscopic surgery, the special forms of these meshes being used at the “plug-technique repair” of the inguinal hernias.

A special form of those mentioned above is the auto fixated mesh Parietex Pro Grip , used in the cure of inguinal hernias. This presents 3D protrusions (of polylactic resorbant acid) which are adherent, auto fixate immediately after implantation, on the whole surface of the mesh, and assure a more rapid incorporation of the prosthesis and a homogenous distribution of the couple of forces [10]. Although some assumed the idea of improvement of the postoperative pain through the avoidance of the sutures, there is controversy regarding this[11].

Composite meshes

Used mostly in the laparoscopic cure of hernias, they are a special form of meshes with a hydrophilic resorbant collagen barrier on one side and a 3D texture on the other side, which provides wall fixation. This form allows cellular proliferation and rapid integration of the mesh, minimal contraction of the material and increased resistance. One of the most known commercial variants is Parietene Composite.

Other variants of meshes are: with auto-fixation, ring fixation, plug fixation, adhesion leg, memory tapes, cylindrical strata, all of which represent variations of already analyzed meshes. The fixation of the meshes is performed either with monofilament wires, either with stitches, depending on the chosen approach and on the type of mesh.

In the last year, our team used Progrip and Parietene Composite meshes in 55 surgical procedures, some performed classically and some performed laparoscopically, depending on the associated pathology, with a 0 relapse rate until present days and with minimal complications: one post traumatic haematoma in the first day postoperatively and 2 seromas, evacuated without other complications.

Conclusions

After the demonstration on a large scale of the benefits of alloplasty, the treatment standard of abdominal wall defects is the use of prostheses. The co-morbidities, logistics, experience and surgical knowledge are elements which influence the decision of choice in operative technique and the type of mesh used. No mesh (either synthetic or biologic) can be considered to be ideal, the complications being avoided only by attentive selection of the therapeutic options adapted to each patient in particular.

The subject was studied also in [12].

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