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The Ideal Prosthesis for Hernia Surgery

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Abstract

The need to reinforce a failing wall with allogeneic material seems to have been known for a long time since the Egyptians of Antiquity used sheets of papyrus which are perhaps the ancestors of our modern "nets". Since then, several materials have been used with uncertain success and formidable reactions. We had to wait until the 1950s and the progress of the chemical industry to see the appearance of synthetic prostheses which were gradually gaining ground until we knew the current development favored by the craze for laparoscopic surgery. New materials appear regularly on the market, thus putting the surgeon before a choice as vast as difficult, the qualities and the disadvantages of each prosthesis not being always proven. We will try to focus on the synthetic prostheses currently used taking into account their composition, their mechanical characteristics, their behavior in situ with the reactions they induce and their respective complications.

Keywords: Prosthesis, Hernia, Laparoscopy

Introduction

The need to reinforce a failing wall with allogeneic material seems to have been known for a long time since the ancient Egyptians used papyrus sheets which are perhaps the ancestors of our modern "nets" [1]. Since then, several materials have been used with uncertain success and formidable reactions. It was not until the 1950s and the progress of the chemical industry that synthetic prostheses appeared, which were gradually to impose themselves until experiencing the current boom favored by the craze for laparoscopic surgery [1]. New materials regularly appear on the market, thus presenting the surgeon with a choice as vast as it is difficult, the qualities and disadvantages of each prosthesis not always being proven. We will try to focus on the synthetic prostheses currently used taking into account their composition, their mechanical characteristics, their behavior in situ with the reactions they induce and their respective complications. In recent years, prosthetic reinforcement has taken an extraordinary development. In the meantime, the experience of the oldest materials should serve as a reference for new materials and guide our choice modulated by the type of surgery performed: groin hernia, median eventration, laparoscopic or open route [2].

Characteristics of Implants

The characteristics of a good prosthesis were defined a long time ago by Cumberland and Scales:3 chemically inert, not causing allergic or inflammatory reactions, able to withstand mechanical stress, sterilizable, non-carcinogenic, without altering its structure physical by the biological medium, easy to manufacture.

The first synthetic prostheses were nylon mesh (Crinoplaque®). Unfortunately, the gradual alteration of this material in situ has caused it to be abandoned in favor of other materials. Currently, there are still four types of prostheses available which differ in their chemical composition and the type of braiding. Polypropylene, polyester and polytetrafluoroethylene which are non-absorbable and polyglactin and polyglycolic acid which are resorbable [3,4].

Polyester Mersilene® and Dacron® are the two best known forms. Mersilène® was discovered in 1954 and is made up of several braided filaments making up a strand which itself will be knitted, while Dacron® is a braided then knitted monofilament. It is a very fine, flexible, light and permeable net.

Polypropylene

Polypropylene, in the form of Marlex®, appeared in 1959. Three forms are mainly known: Marlex®, Prolen® and Surgipro®. It is a macroporous net, more rigid than polyester. Marlex® is a woven monofilament while Prolen® is woven from two strands and Surgipro® from three. The more strands there are, the softer and more flexible the net.

Polytetrafluoroethylene (PTFE)

First used as a multifilament mesh (Teflon®), it was quickly abandoned because of its multiple complications. It reappeared in a modified, "expanded" form in the 1970s (Goretex®). It is widely used in vascular surgery. The net is very flexible and so microporous that it looks more like a patch than a net.

Polyglactin and polyglycolic acid

Vicryl® (polyglactin) and Dexon® (polyglycolic acid), which appeared in the early 1980s, are the only resorbable prostheses. The resorption of a Vicryl® prosthesis is done gradually from

the third week with almost complete disappearance of the net in thirty days. The process is slower with Dexon® which disappears after 90 days [5]. These prostheses are flexible but much less extensible than a polyester.

Unfortunately, these promising prostheses have disappointed. Indeed, if their mechanical resistance initially allows them to support a failing wall, it is not the same in the longer term. The scar tissue that develops in place of the digested prosthesis is not of good enough quality to guarantee parietal solidity [6,7]. Currently, these nets are only used in a septic environment or to prevent evisceration.

Tolerance and resistance

The role of a non-absorbable prosthesis is not to replace the wall but rather to help rebuild it. Indeed, the mechanical behavior of a net in the laboratory, if we consider various tests of resistance to elongation or bursting, do not show significant differences between the materials usually used and are all clearly more resistant than 'a wall [8]. In situ, the areas of weakness are those around the attachment points of the prosthesis, which tear as the scar tissue on which the mesh is located resists.

The behavior of foreign material in contact with living tissue has been well studied by several authors, including Arnaud at the end of the 1970s. This is a foreign body reaction with the appearance of polymorphonuclear and macrophages. From the tenth postoperative day, these cells are gradually replaced by fibroblasts whose activity will intensify with the production of collagen until they completely colonize the prosthesis and integrate it in about four to six weeks. There is therefore a critical period between the seventh and fifteenth day before the fibroblastic reaction is intense. It is especially during this period that the stability of the prosthesis must be ensured by fixing points.

The weakness of the inflammatory reaction is the reflection of the biological tolerance whereas the intensity of the fibroblastic activity is the witness of a good resistance by the creation of a scar tissue of good quality. In addition, the risk of infection is proportional to the local inflammatory reaction. The ideal prosthesis would be one that would cause a weak inflammatory reaction and an intense fibroblastic activity.

The duration of the inflammatory reaction differs according to the authors: for some, it disappears in a few weeks, for others, it persists for several months [9-11]. This reaction depends not only on the material used but also on its texture or porosity.

The quality of mesh incorporation depends on its porosity, texture, and location in vivo. To allow rehabitation of the prosthesis by fibrocytes and collagen, the pores must have a size of 75 to 100 µm. The typical example of a microporous prosthesis that will never be fully incorporated is PTFE [12]. Thus, a polypropylene net will be integrated while a PTFE net will be encapsulated.1 The somewhat rough texture of the Marlex® fibers would increase the fibroblastic reaction and would make its incorporation better.

The most favorable location and which allows the best integration is either between two muscle layers or in the pre-peritoneal space. The pre-aponeurotic space is where the fibroblastic infiltration will be the weakest, thus compromising the long-term resistance of the mesh.

Resistance to infection

The risk of an infection occurring on a non-absorbable prosthesis is linked to the inflammatory reaction that it induces, to the immune defenses of the host and to the behavior of bacteria [10]. Any foreign body induces tissue lysis by the inflammation that it provokes, favoring the action of bacteria. In addition, leukocytes lose their bactericidal power on contact with the prosthesis [12]. Finally, bacteria generally measure 1 µm while polymorphonuclear cells measure 100 to 150 µm. The microporous nets thus allow the passage of bacteria which nest in the hollow of the net, but not that of leukocytes [13]. The Mersilène® net is macroporous but each strand is made up of braided filaments providing micropores between them! In reality, no prosthesis currently on the market is resistant to active infection, so they cannot be used in a septic environment.

In all cases, the onset of an infection occurs early, because a mesh colonized by scar tissue is no longer accessible to bacteria [14].

Adhesions and their complications

As described above, the mesh provokes an intense inflammatory reaction which seems to be the price to pay to obtain a good quality fibrosis ensuring the solidity of the parietal repair. This will be accompanied by the formation of adhesions with the surrounding tissues which could be the source of future intestinal fistulas [15].

This problem has been well studied in animals, in particular when the prosthesis is placed against viscera. Tissues react identically to materials of the same texture [15,16]. Thus PTFE causes little inflammatory reaction and few adhesions, whereas woven prostheses generate many adhesions [13].

Some authors have tried meshes made of non-resorbable material covered with a resorbable material in order to present a resorbable surface in contact with the intestine: these are composite meshes, for example Dacron®-polyglalactin or polyester-collagen or even polypropylene-polyglactin . This combination is supposed to prevent tight adhesions and the consequent risk of intestinal fistula [16]. What seems to change in reality is not the quantity of adhesions but rather their looser quality, but the studies are quite contradictory and hindsight too weak to be able to conclude [16].

Choice And Indications Of The Prosthesis

Choosing a prosthesis can be difficult. First of all, you have to wonder about the goal you want to achieve: fill a defect or restore its function to an abdominal wall? Is it a trivial inguinal hernia or a large median eventration?

What is the most resistant and best tolerated mesh, presenting the least risk of complications such as infection, adhesions, fistulas? Currently, there is no response.

In order to form an opinion, it would be necessary to study the behavior of these different materials in vitro, in vivo in animals and finally in humans. Unfortunately, studies on the subject are often contradictory and above all difficult to compare: the parameters studied are poorly defined or not defined and often different. Terms such as porosity, pore size, net mesh, filament, strand, weight per m2 or m3 or km (!) make things pretty much incomprehensible [16].

There are a number of points on which most authors roughly agree. PTFE elicits few inflammatory reactions resulting in poor integration. The risks of displacement and migration, even

in the long term, are great. It is a prosthesis to be avoided for parietal surgery. Some authors, all the same, prefer it when used in contact with the viscera for the low adhesions it causes.

Polypropylene generally causes more intense inflammation than polyester, making it less tolerable but stronger in the long run. It is more aggressive on the intestine for example and could be responsible for digestive fistulas. However, this problem also exists with polyester. In an attempt to reduce the inflammatory reaction, while keeping a non-absorbable prosthesis serving as a matrix for parietal reconstruction, polypropylene is woven with polyglactin (Vypro®). For some authors, this solution is excellent and induces significantly fewer reactions, for others, there are no significant changes [16].

To limit the risk of adhesions and digestive fistulas which seem to be very rare but which everyone fears, new prostheses have appeared: composites, but the follow-up is still too short to be able to draw any conclusions.

Polyester is significantly softer and more manageable than polypropylene. Its handling in large eventrations is therefore easier, it adapts better to structures and is better tolerated. But its flexibility makes it difficult to use in laparoscopy!

Recently, other nets have appeared on the market: macroporous multi-filament polypropylene (Surgipro®) and two-dimensional knitted polyester (Parietex®) to name but two. But then, the risk of infection becomes greater. Indeed, to avoid infection as much as possible, a macroporous net in which bacteria would have difficulty hiding would be needed. However, the less there are filaments, the more the net is rigid. The only true macroporous net is the Marlex® which is made of a large-mesh woven monofilament. At the opposite extreme we find PTFE (Gore-Tex®) which has no pores. Between two we find all the variants with large-mesh nets but whose strands are made up of several filaments creating micropores between the filaments!

Another controversy concerns the “shrinking” of the net. In reality, the net does not shrink, it is a reduction in the size of the prosthesis linked to cell rehabitation and resulting, by scar retraction, in a loss of surface. This loss is of the order of 25-30% for the nets known to date. Amid even claims that this retraction would reach 70% when it comes to “plug” type nets (mesh plug) [17,18].

Conclusion

Finally, the different prostheses offered are equivalent in quality and defects [7]. There are, however, a few facts. Firstly, the loss of surface of the prosthesis which implies the use of large meshes in order to ensure a good long-term result. Then the constant inflammatory reaction (with the exception of the PTFE) which should lead us to caution as to the site of implantation of the prosthetic material. Thus, as a precaution, it is preferable to insert a prosthesis in a site where it will not be in contact with the viscera while being correctly incorporated. The ideal place remains for the moment the pro-peritoneal or retro-muscular space in major eventrations.

And in the treatment of inguinal hernia? A question still remains unanswered: what happens to neighboring organs such as a spermatic cord in humans when they come into contact with a net?

In recent years, prosthetic reinforcement has taken an extraordinary development. The industry is not mistaken and it provides the surgeon with an impressive variety of different models of prostheses, but the advantages and disadvantages of which are not as obvious as one might imagine. In fact, it is urgent to develop criteria which correspond to clinical reality and which make comparisons possible. The type of surgery performed: groin hernia, median eventration, laparoscopic or open route [19-21].

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