The mechanical structure anterolateral abdominal wall; methods to repair parietal defects

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Abstract

The term of structural mechanics – borrowed by anatomy from building/construction techniques – is a physical term of statics, which along with dynamics represents the fundamental chapter of the physics of all buildings. Natura constituted such a perfect geometric solution to ensure mechanical structure in all directions. However anatomy knows a number of weaknesses located in the umbilicus, white line, inguinal canal, semicircular line Spiegel. Abdominal muscles form a contractile, the belt principally oriented in the direction of the transverse muscle fibers, which pressing abdominal contents through his tone, reduces visceral cavity by compressing the spinal plan and modeling intra-abdominal pressure.

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Selection and/or peer-review under responsibility of the University of Pitesti, Romania

Keywords: fibrous tissue, collagen, mechanical structure, lambos, micro-architectonic images.

1. Purpose of the paper

The term 'mechanical structure' – borrowed by anatomy from construction techniques – is a static physical term which, along with dynamics, represents the fundamental chapter of the physics of all constructions. Assessing the mechanical structure merely by establishing momentary and local clichés like, for instance, the architecture of the white line, of Cooper's ligament, does not contribute in any way to research, even if we were to replace the complete file of these micro-architectonic images. As we shall see, the defects and the alterations of these micro-structures lay at the basis of cronic vices regarding the contention of the anterolateral abdominal wall (eviscerations and hernias).

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The anatomic mechanical structure of the anterolateral abdominal wall is:

- basic, expressly structured to contain and to resist the forces of the segment's functionality - the fibrous tissue;
- auxiliary (derivative), structured for other functions (contractility and motor activity) – the muscles;

Thus:

- classic hernias form in the fibrous tissue by the delaceration of the microscopic mechanical structure (main deficiency);
- evantrations happen as a result of the breach or of the displacement of the muscular wall (derivative deficiency).

The mechanical structure is not only made up of the main component – the fibrous tissue – but also of the muscular component which, although assigned to the contractile function, comes under the general function of contention. The muscles, as structural elements, do not come under the physical definition of the mechanical structure, although they are part of it. Consequently, we will have to study the fibrous structures as primary holders of the walls' mechanical solicitations. The fibrous tissues suffer regular defects with a pathogenic profile that is valid for several cases, constituting hernias, while the muscles, when they are affected by interruption or are paralysed, determine atrophic defects, always constituting evantrations. We have to mention that muscles are followed up by aponeuroses that are themselves the fundamental components of the mechanical structure, especially upon the intersection between the various kinds of resistance to abdominal pressure and those derived from the motor activity of every muscle and muscular ensemble.

The abdominal pressure is a fundamental function of the wall and not only a pathogenic factor for hernias, as it is erroneously believed in various surgery circles. It is the one that generates and bears the abdominal press, and, only when its compulsory pressure/resistance proportion rises over 1 do hernias (chronic disorder of this proportion) and evantrations (acute disorder of this proportion) appear. The abdominal press is the fundamental factor in the current conception for the stability of the abdominal organs' position. The notion of fibrous tissue is, of course, suggestive of the mesenchyme (mesenchymal connective tissue) whose components are the cells and the fundamental substance. The cells cannot be disregarded or ignored from the constitution of the mechanical structure, especially since they are the ones that secrete and synthetise the fundamental substance monomers; this substance is the one that forms and carries the mechanical structure of the abdominal wall, at least as far as its mesenchymal-fibrous component is concerned. As to the fundamental substance, we need to remind that it is formed mainly of two constitutive elements: the fibres and the matrix proteoglycans (mucopolysaccharides). We need, however, to anticipate over the role of the intracellular contractile network in its continuity with the cell membrane and the collagen in the contention forces distribution. Many of the current experimental surgery schools that are devoted to the cicatrisation process manipulate regularly nowadays the notions that are linked to these two essential components of the mechanical structure.

Our world is one of systems and even the structural unity of the cosmos is a system, and the mechanical structure is part of it. Ever since the 5th decade of the 19th century, Birtalanfi has established the mathematical theory of systems, opening the new era of conceptions; and, with the 7th decade, Wiener and Rosenblueth have set the basis for cybernetics, whose current materialization and refinement into mathematics and technology represent the modern working tool in present knowledge.

It is a well known fact that the system represents the multitude of phenomena and interdependent and interactional elements, which presupposes two elements that manifest and develop themselves according to the laws of cybernetics:

a. **Organization.** As far as organization is concerned, the natural tendency of the cybernetics’ laws’ actions is that of evolution of matter towards complex and hypercomplex.

b. **Relationships.** The existence and functioning of systems spontaneously and mandatorily generate feedback.

Collagen represents 6% of the weight in humans, it is the resistance mechanical component of the complex,
with a resistance of the ligament fiber equal to that of a steel fiber, with equivalent diameter. The structural collagen is continuously mechanically solicited in the construction of organ motion.

Polymerization of collagen determines the primary colastromin fibrils, the tropocollagen precocious fiber and the mature fiber, classified into 4 types:
- Type I – the structural collagen of the tissue skeletal system;
- Type II – the molecule of the absorption of elastic compression (cartilages);
- Type III – the undefferentiated molecule of embrionary tissues;
- Type IV – the crystallization molecule in cornea, crystalline, vitreous body of the eye.

In classic conception, the muscular aponeurotic wall’s solidity is regarded as being insured by the muscular and aponeurotic fibers that constitute it. Thus, the fibers of the external oblique muscle are directed up-down and backwards-forward, the fibers of the internal oblique are directed the other way round, the ones belonging to the cross muscle are directed horizontally, and the ones belonging to the abdominal right are directed vertically.

Nature has constituted such a perfect geometrical solution of the mechanical insurance in all directions. Notwithstanding, anatomy is faced with a series of weak spots located at the level of the umbilicus, of the white line, of the inguinal canal, of the Spiegel semicircular line. The abdominal muscles form a contractile belt, which is mainly oriented on the direction of the muscular fibers of the cross muscle that presses down the abdominal content through its tonus, downsizes the cavity by compressing the viscera along the spine and modulates the intra-abdominal pressure.

2. Abdominal wall defects

The following are recognised as causes: tumor resections, post-operative hernias, radiotherapy, massive infections, congenital anomalies.

The priorities with these defects, that are difficult to achieve simultaneously, are: covering the wound, protection of internal organs, insuring fascia support, rebuilding the muscular function, esthetics.

- **Skin grafts** solve only the covering of the wound, representing the only possibility in the case of massive fascia, extensive abdominal wounds, cases in which the grafts must be applied only after debridement. They become quite adherent in internal structures and the ulterior surgical act is very difficult. Although it is a simple method of closing abdominal defects, the problem of the abdominal wall’s lack of support is a major one, so that the patients are forced to wear belts.

- **The lambos** – the abdomen is no longer regarded as a skin area accidentally vascularized, but as an area with specific vascularization sources that has to be researched. The tubular type lambos, of proximity or distance migrated, the local multiple lambos trained to cover defects that require a reconstruction within the entire thickness of the wall are nowadays of historical importance. In all the thickness, the skin lambos have to contain the entire subcutaneous tissue up to the deep fascia, considering the concept of fascia-coutaneous lambos. They can rise on the medial pedicles from the piercers of the abdominal right muscle, on the lateral pedicle from the intercostal piercers, on the superior one from the superficial epigastric artery or on the inferolateral one from the inferior epigastric vessels. Towards the lateral side, these types of lambos have to contain the fascia of the external oblique muscle as well, the inguinal lambo coming under this category. The depidermized skin lambos are used as fascia substitutes, taking into consideration the fact that the pilose follicles of the sebaceous glands disappear, the perspiratory glands being the only ones left. The muscle-fascia lambos have the advantage of being able to be dynamic substitutes for maintaining the posture, they can assist the effort of defecation and do not interfere with the respiratory dynamics. The abdominal right muscles can be rised as muscle-fascia lambos on the superior or inferior pedicle, having the advantage of displaying the largest rotation curve, but having the disadvantage of interfering with the dynamics of the abdominal wall. When the fascia support is compromised, the skin grafts from the fascia lata can be used, or the fascia allografts that can survive up to three months. The synthetic prostheses cover the viscera, externalize the necrotic margins
allowing the drain, downsize the abdominal pressure, do not determine stasis in the inferior vena cava and have distention capacity along with the viscera and the diaphragmatic excursions. They can be covered with skin by using any of the methods because they have reperitonealization capacity simultaneously with the apparition of fibrin, so that within 96 hours it converts into a cellular network covered with mesothelium, which, in histogilical terms, indicates a peritoneal layer.

3. Reconstruction principles of the anterolateral abdominal wall

Surgical techniques appear, disappear and reappear along with the evolution of surgery and of the surgical techniques and materials.

From a historical point of view, several stages have been covered for the recovery of a substance loss at the level of the abdominal wall, stages that have comprised the following types of surgical interventions:

- one plan sutures (Maas - 1884);
- several plans sutures (Maydl - 1886);
- aponeurotic sutures (the end of the 19th cent.);
- otoplasties through the display of the right abdominal wall (the Welti procedure - 1941);
- Mayo-Judd otoplasties, a technique still in use today in lateral and sub-umbilical eventrations;
- relaxing incisions otoplasties;
- fascia lata autografts;
- free total skin grafts;
- prosthesis – have appeared because of the inconvenient techniques that use autografts.

Their history started with the use of metallic prosthesis with silver, tantal or steel thread, until the advent of synthetic prosthesis, which have been made of several types of material: nylon, raylon, silicone, expanded polytetrafluoroethylene, mersilene, marlex, of which only the last two correspond best to the necessary qualities of a parietal prosthesis, and these are: nontoxicity, durability, flexibility, resistance. All these characteristics allow the development of a force appropriate to the function of the anterolateral abdominal wall, with minimal tissular reaction.

In spite of the suture materials, of the surgical techniques and of the prosthesis materials, post-operative dehiscence wounds still appear, like for instance: hernias, eventrations, unwanted scars. Any incision and repair of the abdominal wall has to be done so as to least perturb the anatomy of this region. This is the reason why parallel or „T” incisions that compromise the circulation and denerve the muscles are contraindicated, the incisions over arterial and innervation sources, the incisions against tension lines, as well as sutures that are too tight, so as not to determine focal areas of necrosis by interrupting the circulation.

The standard abdominal incisions are based on easy access to intra-abdominal organs and are frequently in contradiction with the anatomic and physiologic conditions specific to the abdominal wall. To these, we add the inappropriate sutures, as well as the possibility of infections, these being the most frequent causes of post-operative hernias. The transversal incisions section the right abdominal muscles, determining diastasis, vertical incisions, even the minimal ones, produce physiological invalidity by sectioning the innervation which determines the muscles' paralysis, which, even if it is cured, will still have unification and even diastasis defects. Any incision that sections the irrigating vessels will determine a belated healing, if not even absent, with necrosis and retraction, followed by lack of substance. The fascia must always be meticulously repaired, as it is a strong tissue with great value in the stability of the suture.

The superior section of the abdominal wall has a firm, smooth aspect, strongly attached to the costal extensions of the muscles and of the fascia. The lateral traction of the muscles is the result of the way fascia fibers are distributed and it is one of the reasons why a paramedian incision in the superior abdomen is difficult to suture. They frequently come undone and we discover that the defect at the level of the muscular system is oriented transversely or horizontally because of the fascia's tension lines on this level.
On the inferior abdomen, the tension lines are favoured obliquely; the transversal line is vaguely represented, and the white line is vague, so the right muscle has the support of the cross fibers that intersect in such a way as the tendency is to protect themselves after the surgical act. On the lowest region of the inferior abdomen, the right muscles are sustained by the pyramidal ones and by their fibrous fusion with the white line, as well as by the reflected inguinal ligament.

Generally, the abdominal median incisions remain the most wide-spread ones because they do not affect the function of the muscular system, the blood infusion or the innervation, and they have the advantage that they can be resutured several times.

Conclusions

- the abdominal mechanical structure is the expression of a logic activity from a semantic-mathematical point of view;
- the element to be studied in the mechanical structure of the anterolateral abdominal wall is, primarily, the fibrous tissue, without us being able to afford to disregard the muscular mechanical structure.

References