PATRIZIA ANNA D'ALESSIO

TENSEGRITY AND BEYOND

ABSTRACT: TENSEGRITY AND BEYOND
The tensegrity concept describes the organization of matter into compressive and tensional moments, aimed at providing stability to a structure. Its legacy by engineers and architects is well established. In the past decades, thanks to the work of the American biologist Donald Ingber, the notion of tensegrity has been brightly developed in cell biology. In this paper, the new fields that the tensegrity concept could invest are described, with the aim to provide a holistic vision on the tensegrional strategies the body is performing to conserve its stability, integrity, shape and youth. On the base of James Oschman's work on connective tissue, the fundamental hypothesis that aging is a mere matter of body shortening, as a consequence of stress to the musculo-skeletal apparatus, is discussed. A few considerations are spent on the reversibility of a negligible tensegrional support, through the implication of the para-sympathetic system. The latter is the most potent anti-inflammatory device of the body, set in motion by physical stimulation, beyond immune and biochemical regulations.

Vivre est une invention arrachée à la terreur … les êtres sont inégaux devant l'angoisse.
Anne Defourmantelle, *Éloge du risque*

1. *Introduction*

The term "tensegrity" is the contraction of "tension by integrity", a concept that has been exported from Richard Buckminster Fuller's visionary architectural vocabulary to be introduced into biology by Donald Ingber. But knowledge of its physical principles was familiar to Romans already, as they used it in the construction of aqueducts. At the edge of the 20th century, Eugène Freyssinet utilized the concept to give birth to "reinforced concrete". Here, we will try to implicate its importance along quite different routes, transcending architecture, and after a first halt in cell biology, observe its more ample implication in human aging hypotheses. We think indeed that tensegrity addresses a line of evidence that Western biology is still ignoring, between visible and invisible phenomena and at the root of human behavior, operating at the early stages of the development of intentionality.

In order to illustrate the importance of tensegrity in the human body – as a constitutive principle, as well as a functional mechanism – two conditions will be analyzed: 1. the passive transformation of human morphology over time through a negligible exploitation of tensegrity structures in the body, that will induce its shortening, on the way to the ineluctability of aging; 2. the dynamic integration of the relationship between elastic and compressive behaviors into body's dynamic structures (muscles, tendons) in order to create tensegrional devices, oriented towards morphology conservation.

The architectural ambition of sustaining buildings was indeed the initial motivation for the development of tensegrity, in order to build structures that would not collapse when challenged by time, aiming at some extension in stability, if possible. For that reason, tensile rebar was inserted in concrete, generating "reinforced concrete".

Tensegrity systems naturally belong to the class of initial deformation systems, completing a family of constructions generally qualified as "pre-stressed" the initiator of which was Eugène Freyssinet (1879-1962) inventor of the "reinforced concrete" during the first quarter of the 20th century.

The concept of tensegrity, after its enunciation by the American architect Richard Buckminster Fuller[1] (1892-1983), was used to build several structures, in order to exemplify the concept. Tensegrity is at the heart of systems working as «islands of compression in an ocean of traction». Fuller uses the term to describe the notion of integrity obtained by a complex system maintained by elastic tractional elements.

As the XXth century proceeded, new definitions arose such as that of René Motro a French physicist, Professor at the "Laboratoire de Mécanique et Génie Civil" of the University Montpellier 2, who proposed

> a system of tensegrity as a stable status of auto-equilibrium, containing a discontinuous ensemble of compressed components within a continuum of tensed components[2].

The American cell biologist, Donald E. Ingber, Founding Director of the Wyss Institute for Biologically Inspired Engineering at Harvard University, and professor of Vascular Biology became interested in tensegrity because of

> the age-old question of how life emerged through self-organization of inorganic components[3].

How groups of molecules

> self-assemble to create living cells with emergent properties, including the ability to change shape, move, and grow.

He was in fact interested in the

> fundamental design principles that guide self-assembly in natural systems[4]

[1] R. Buckminster Fuller, *Tensegrity*, in «Portfolio Art news Annual», 4, 1961.
[2] S. Djouadi, R. Motro, J.C. Pons, B. Crosnier, *Active Control of Tensegrity Systems*, in «Journal of Aerospace», 11, 2, 1998.
[3] D. Ingber, *The Architecture of Life*, in P. d'Alessio – J. Dhombres, *The Architecture of Life: from Plato to tensegrity*, Brepols, Turnhout 2005.
[4] *Ibid*.

and identified in the tensegrity concept and constructions the possibility of a theoretical assessment. He further linked the basic concept to the geodesic architecture first described by Buckminster Fuller,

> which self-organizes and mechanically stabilizes hierarchical collections of interacting components in three dimensions[5].

This type of organization allows shape and pattern stability to emerge «through establishment of a mechanical balance between global attractive (tensile) forces and local repulsive (compressive) forces», in simpler terms, «through continuous tension and local compression». As Ingber began to understand the model, he played with the hypothesis that it could be useful to shed a new light on cell structures.

> I began to explore the possibility that cells may use tensegrity architecture to structure themselves: I constructed one of the simplest types of tensegrity models by connecting six wood dowels (compressions struts) with a continuous series of elastic tension cables. The resulting structure was stable and exhibited a spherical form when unanchored even though none of the rigid struts physically contacted any other; these struts were effectively pulled up against the force of gravity and stabilized in space through interconnection with a continuous series of tensed cables (continuous tension)[6].

What really changed in the last decades is the fact that the area it addressed by the tensegrity concept has considerably expanded its horizon. The notion of elasticity has become central for biology and medicine, far beyond mechanics. Moreover, numerous discoveries regarding the tensile nature of the fibers contained in the connective tissue and their organization were able to shed new light on their capacity to play a strategic role in the architecture of the living. Flexible water-containing structures, that Jean-Claude Guimberteau[7] calls "microvacuoles", are in fact multifibrillar flexible bodies enclosing microvolumes ensuring shape and mobility, but adaptability and resistance to gravitational forces as well. Moreover, knowledge about ion

[5] *Ibid.*
[6] *Ibid.*
[7] J.-C. Guimberteau, Videofilms *Strolling under the skin*, ADF Video productions, 2005; *The Skin excursion*, EndoVivo Productions, 2009.

exchanges within a given tissue and their importance in signaling, has fundamentally changed our vision of the "body inside".
The tensegrity concept can also be applied to social sciences, because it has to do with life in general. Thus the gliding of fibers or the dispersion of tension, minimizing compressive forces, might play a dynamic role in social life, or at least in its communication forms. For that reason we will primarily concentrate on the concept of pre-stress, eventually created by Freyssinet, but abundantly considered by Fuller and Ingber.

2. *Pre-stress state and trauma's compensation*

Pre-stress is by definition the condition that allows matter to be a perfect receptacle for what has to come, because this can only be stress. Pre-stress is a sort of permissive condition, an alert system, well relaxed, but tonic, able to stretch itself immediately if needed. Thus, pre-stress is already contained in the primordial model of Ingber.

> The pre-existing tension in the cables served to minimize movement of the struts and hence, to stabilize the architectural form of the model. However, when the same model was physically anchored at multiple points to a rigid foundation, the entire spherical model spontaneously spread and flattened to minimize stresses and strains within its elements. This structural transformation precisely mimicked the flattening observed when spherical cells attach to a culture substrate. Furthermore, if the anchors of the spread adherent model were cut, the model cell spontaneously retracted, rounded, and bounced off the substrate, just as living cells do when their molecular anchors are clipped[8].

Once the tensed condition acquired, it has to be reversed as soon as possible, tension being extremely expansive for a building as well as for a cell, and a balanced distribution is always the option to which the whole system aspires. As Ingber puts it,

> it is impossible to see the pre-stress within adherent cells in culture on rigid dishes because they exist in a state of isometric tension and thus, this feature of cell structure is commonly invisible to viewers. However, when the same cells are cultured on flexible rubber substrates, this internal tension can be easily visualized as the cells pull on their adhesions and cause the substrate to … fold up

[8] D. Ingber, *op. cit.*

> in wrinkles[9].

From wrinkles to the whole body, there is only one step:

> Tensegrity also is essentially the way all animal bodies are built.
>
> Indeed, our bodies are composed of 206 compression-resistant bones that are pulled up against the force of gravity and stabilized by interconnection with a continuous series of tensile muscles, tendons and ligaments.

Because the aim remains to resist gravity as long as possible:

> it is the tone or pre-stress in our muscles that gives us stability[10].

Not only stability, one would add, but also the key of aging or alternately, not aging. We are stuck to the idea of an apparent inevitability, with its notion of wear (*usura*), corresponding to very old concepts that we have obediently integrated, calling upon irreversible corruptions of the elastic mechanics that maintain the body in its youthful shape. In fact, it is the opposite. We are built by powerful mechanisms aiming at a permanent cellular renewal. It is only when this possibility fails that the body resigns itself to accompany the shape modification called aging. But this change of form is not inevitable. If trauma and gravity reduce the body, it is also true that understanding this mechanism of decay can make us appreciate, develop, practices to preserve or reconquer this elastic quality of the body, ultimate strategy for the maintenance of its neoteny, a question of morphology.

Because, what is observed is not aging (the ultimate outcome of chronic inflammation with its corollary loss of function) but a progressive alteration of morphology. In fact, the change of shape that takes place over time does not in any way stand for aging, understood as malfunction of parts as in a car, but rather for compensation strategies in front of trauma.

What happens while this morphological transformation is accomplished? Everything starts with the stress of the individual, more or less intense, contrariety or deep shock, but also physical

[9] *Ibid.*
[10] *Ibid.*

trauma, the body does not make the difference. In any case, the pre-stressed body implements a compensatory scheme, based on tensegrity. The first of these changes, is endured by the preferred dialogue partner of the brain, the muscle. In his chapter "Gravity and Physical and Emotional Structure"[11], James Oschman, American biologist and considered the initiator of connective tissue research, depicts how any trauma is recorded as a change in the internal structure of the body. In his youth, working at the Woods Hole Research Center, Massachusetts, Oschman had the chance to have as next door colleague Albert Szent-Györgyi[12], whose seminal work on the semi-conductivity of proteins and about identification of myosin have so much contributed to the development of the current integrated vision in biology.

In the case of a mild trauma, the structures involved are organized to retrieve their original position, once the healing phase is completed. However, repetitive "displacements" can have cumulative effects. This is particularly the case if there is a change in the way of carrying loads, because then a change with respect to gravity is installed. Indeed, there is an ideal "pattern", and it is possible – according to Oschman – that

> *all* traumas to the body alter the relation to gravity by causing deviations from the original pattern, the form we have inherited to enable us to cope with gravity[13].

These small post-traumatic adjustments function exactly like reward behaviors in the face of psychological suffering, that we call compensatory changes. Oschman insists on this point:

> Even a small change in alignment and movement will result in compensatory changes throughout the body[14].

By themselves innocent, these alterations seem at first glance to provide adaptability and thus stability. But in fact,

[11] J. Oschman, *Energy Medicine: The Scientific Basis*, Churchill Livingstone - Elsevier Limited editors, London 2000, pp. 160-161.
[12] A. Szent-Györgyi, Nobel Prize in Physiology or Medicine in 1937, credited with discovering vitamin C and the components and reactions of the citric acid cycle.
[13] J. Oschman, *Energy Medicine: The Scientific Basis*, cit.
[14] *Ibid.*

> the patterns of neural activity, blood and lymph flow, and muscular contraction will be altered[15].

In addition, these so far minimal adaptive changes will pursue their neo-architectural assessment during the recovery process with even more damage.

> If recovery is prolonged, some muscles will atrophy from disuse, others will become hypertoned from being overworked.

Indeed, "muscles act as pumps" because they have kept this *modus operandi* from the time when the essential activity of an organism consisted in swallowing and expelling (notably the primal soup contained in the sea, from which it drew its nutrients).
By their pumping movement, the muscles mobilize blood and lymph, but when they become immobilized and "flaccid", nutrition and oxygenation of cells and tissues will be reduced. Finally,

> when a muscle is chronically shortened, it gradually loses the ability to relax. Tension will always be present[16].

One could add that tension will become ubiquitous, communicating its condition to far regions, as a consequence of the local change. This tensegrional interpretation of the decay of the youthful morphology of the human body contributes in our view to the possibility of a non-intrinsic aging mechanism, rather a "in response to" mechanisms of aging.
This same hypothesis is highlighted by this passage from Plato's Timaeus:

> Instead of considering the organization of the bodies only from the point of view of a mechanical assembly (a juxtaposition of elementary triangles), we could define them as a tension, internal to their geometric assembly, which confers them their cohesion. It is by this way that fatigue and the wear of time can contribute to the relaxation of this "structural tension" and thus favor illness and death[17].

In essence, trauma, in general, generates immobilized muscle groups, that become hypertonic, unable to relax. It is the emergence of a specific attitude associated to a substantial loss of elasticity. Postural imbalances resulting from physical or

[15] *Ibid.*
[16] *Ibid.*
[17] Plato, *Timaeus*, 81b, translation L. Brisson, GF Flammarion, Paris 1999.

psychological trauma can equally lead to chronic disease. When pre-stress and tensegrity do not account any more for the dynamics of a body, eventually broken by its soul, the flexor muscles, vital for our posture (shoulders, gait), especially the psoas, supporting the strategic relationship between the spine, pelvis and the musculoskeletal system, are compromised.

However, the body does not passively contemplate its increasing vulnerability. It tries to thwart the already existing compensation, in order to restart a balance. Thus, Oschman explains,

> connective tissue fibers will be laid down to thicken and strengthen these structures that are called upon to provide extra support[18].

Except that the underlying tension is no longer there, the reactivity, which makes the living, is lost. Functional vacuum envelopes have been created instead. Worse, traces of an altered structure (and function) can be retained indefinitely after the lesion is healed.

> A widely held misconception» – Oschman tells us – «in our culture is that these accumulated imbalances cannot be reversed. This is not the case[19].

One of the consequences of this progressive muscular degeneration mainly deprives the brain of its permanent conversation with its privileged partners, the muscles. *In fine*, a deterioration of morphology results in an alteration of the inbuilt communication.

3. *Between physical and psychological stress*

From Plato's Timaeus triangular/tensional anatomy and physiology to the emergence of the concept of tensegrity in architecture and contemporary biology, there has been a long history[20] around the basic forms and geometric properties of matter and bodies[21], in

[18] J. Oschman, *Energy Medicine: The Scientific Basis*, cit.
[19] *Ibid*.
[20] P. d'Alessio and J. Dhombres, *Architecture of Life, from Plato to tensegrity*, cit.
[21] D.W. Thompson, *From Growth and Form*, Canto edition, Cambridge University Press 1992.

and around the notions of tension, tensor, elasticity. When the concept of tensegrity finally appeared at the beginning of the 20th century, the ancient vision that a body is maintained in its *equilibrium* structure because of the elastic properties of its geometric components reappeared.

Going back to pre-stress, is it possible to develop the analogy between physical and psychological stress? If a (profound) distress is able to shorten the muscles, would conversely, an (intense) pleasure have the capacity to lengthen them?

> An emotional response – says Oschman – immediately precipitates the contraction of the flexor muscles and movement away from structural balance[22].

This point is important because gravity

> pulls the structure downward, making the body shorter.

In fact, according to Oschman, trauma is substantially an architectural lesion, accounting more than other phenomena to the aging phenomenon, in becoming shorter and drowned in a sea of tension. Would aging thus be the aerodynamic consequence of the choice to stay vulnerable, defining a certain availability of man to be exposed to risks, conditions rich in evolutionary perspectives? This again seems coherent with the "in response to" mechanism.

Ineluctably, reversibility becomes an issue. If we stick to the idea that tensegrity is not only a structural element of matter and body, but contributes as well to such vital functions as movement, migration, regeneration and communication, thus pathological processes leading to chronic diseases and accelerating aging and death, will be characterized by a lack of available tensegrity devices (that we identify with a negligible tensegrional status), we could aim at re-introducing. One of the most important contributions to aging (*via* the describe tensegrional/gravitational mechanism) is the installation of chronic inflammation. This undeniably enhances the tensional

[22] J. Oschman, *Energy Medicine: The Scientific Basis*, cit.

status through activation of the ortho-sympathetic system[23]. Conversely,

> recovery from an emotional shock requires flexibility and resiliency of the musculoskeletal system, an ability to return the body toward the ideal pattern of relationship with gravity[24].

A great ally of tensegrity is thus represented by the activation of the vagal tonus, principal tool of the para-sympathetic system[25], based essentially on relaxation of the contractures, governing healing, secretions and the alternation from tension to relaxation, allowing the body to return to a state of pre-stress. Essentially, pre-stress consists in alertness, which in turn allows a sensitive body to comply to an alteration of the environment without freezing in the posture of compensation. Indeed, verticality can be trained and seems to be the most powerful antidote to the change of form over time. Relaxation, a synonym of anti-inflammation, is brought by such simple activities as tasting a taste we like (which in turn immediately activates the *vagus* nerve) or listening to a sound or a melody we like (here physical waves are being transduced into electromagnetic modifications in the body, contributing to the relaxation of excessive tension).

In his informative book *Scrupulous Souls, Anguished Lives, Sad Obsessed*, Pierre Henri Castel[26] challenges Plutarch and Evagrius

[23] The autonomic nervous system functions to regulate the body's unconscious actions. The ortho-sympathetic system (SNS) helps us to cope with acute challenging conditions, to which we have immediately to adapt, risking survival. Its deployment is stopping all other activities in order to establish a "flight or fight response", within seconds.

[24] J. Oschman, *Energy Medicine: The Scientific Basis*, cit.

[25] The para-sympathetic nervous system (PSNS) is one of the two divisions of the autonomic nervous system (a division of the peripheral nervous system (PNS)). The autonomic nervous system is responsible for regulating the body's unconscious actions. The para-sympathetic system is responsible for stimulation of "rest-and-digest" or "feed and breed" activities that occur when the body is at rest, especially after eating, including sexual arousal, salivation, lacrimation (tears), urination, digestion and defecation, maintenance of body temperature. Its action is described as being complementary to that of the sympathetic nervous system, which is responsible for stimulating activities associated with the "fight-or-flight" response.

[26] P.H. Castel, *Scrupulous Souls, Anguished Lives, Sad Obsessed*, Ithaque, Paris 2011.

to give an account of the question of psychic constraint. The ancients, did they know about it? Initially, the debate around Aristotelian and Neo-Platonic instructions focuses on the opposition between virtue and reason: is

> virtue defined by reason

or is

> virtue defined by a determination of reason[27].

But

> to act in accordance with what is held for the *"juste milieu"* sort of equidistance of emotional investments, virtue by definition, is still subject to an inevitable form of social negotiation.

Considering for a moment the basic equipment of an individual allowing him to face the phases of the transformation of the relation to himself ... it seems clear that it will be

> by bodily feeling that everything starts[28].

Thus, "feeling better" is an act of resetting. In fact we feel "better" when we feel "ourselves".

Thus, for an individual in perfect health, even sporty, too restrictive a work organization (or social organization) can make him/her loose this precious balance. Faltered between the exhaustion attributed to "overwork" (but in fact due to a motivational deviation) and inexplicable physical pains (cynically labeled as "algodystrophy" by doctors, this individual tries to treat the famous "back pain", the most common *noxa* in the world, whether in a developed country or not. There everything stops, or rather a query begins, in which the person will be as alone as if living at the dawn of humanity.

In order not to get lost in this quest for the sensation of ourselves, let us turn to Spinoza read by Deleuze[29]. Reformulating the question of Plutarch and Evagre, as well as of Saint Augustine, he proposes that the essential is to

---

[27] *Ibid.*, p. 59.
[28] *Ibid.*, pp. 271-272.
[29] G. Deleuze, *Leçon sur Spinoza*, February 24th 1978, http://www.yrub.com/philo/spinozadeleuze1.htm

> take a starting point on a joy and, on that, try to win locally, to extend this joy.

On the other hand, he also suggests some sort of training to get used to negative emotions. Here again, what is interesting is neither the joy (for once) nor the suffering, but the application of a force at a given moment, the "starting point". Also the result intrinsically promised lays in this sibylline formulation, "to win locally" as if the fact of becoming oneself by the surge of a sensation had to be torn from an enemy as on a battlefield. In fact, the starting point is almost a dramatic decision. We each write a play, ours, a dreamlike comedy, summarizing our expectations, our secret hopes, our ambitions while conceding all the linguistic freedoms since the book will remain inside our own archives, sarcophagus of "reason". Our subjective inclination to ourselves counts more. This is perhaps the first of the rules of an ethics of verticality.

However, the relationship between the external and internal events of the body, from its receptivity or its impressionability, is an intrinsic part of the mixture of bodies (or spirits) in the course of history, since it includes those who are no longer physically among us. Thus,

> each body is defined by a certain power to be affected[30].

Is there a need for the subject endowed with receptivity to alert the body of what is upcoming in its close environment of elements capable of affecting it? Would warning messages, from external or internal elements whatever they are (physical, nutritional, climatic, infectious, emotional, mnemonic ...), all use the same micro-fibrillar pathways of the connective tissue? Use of the tensegrity concept may facilitate the task of better understanding the physical paths of cell signaling, traveling from the outside through the inside of the body, establishing the kind of virtuous equidistance mentioned earlier.

[30] B. Spinoza, *Ethique* III, prop. 29, Seuil, Paris 1988.

4. *Physical stimulation and its consequences*

Indeed, those who like Rudolph Virchow (1821-1902), have brought the first tracks to establish the value of a biological and medical answer to these questions, had not asked them to themselves. Thus Georges Canguilhem[31] (1904-1995) notes that Virchow's "cell theory"[32] is not the affirmation that a living being is composed of cells, but first that the cell is the only component of all beings alive, and then, that every cell comes from a preexisting cell.

On the other side of the world of psychoanalysts, sociologists, psychologists, and philosophers, biologists are also trying to expand their categorical horizon. Thus, from the notion of the cytoskeleton whose changes of state between distended and tense, hyper-tense and pre-stressed to be relaxed or even relapsed, Donald Ingber calls for the "extended cytoskeleton".

Models based on the study of acupuncture[33] have made it possible to better understand the signaling between cells, conveyed by the fibrillar system of the connective tissue. Favored by this strategic location, the response induced by mechanical stimulation could then interest the whole body. Just think of the evocative power of a light touch. How does it work? We think of a "propagation" related to a "distension". Stimulation would therefore propagate, probably exploiting at the same time the electrical conductance of the connective tissue, thanks to a "distension" mode. Physical touch, such as the one given by a massage, is transduced to a potent stimulation of the para-sympathetic system, thus inducing anti-inflammatory and relaxing

[31] G. Canguilhem, *La théorie cellulaire*, in *La connaissance de la vie*, Hachette, Paris 1952, pp. 47-98.

[32] R. Virchow, *Die Zellularpathologie in ihrer Begründung auf physiologische und pathologische Gewebelehre*, Verlag, Berlin 1858, Hildesheim Olms (1966), pp. 256-267.

[33] H.M. Langevin, D.L. Churchill, M.J. Cipolla, *Mechanical signaling through connective tissue: a mechanism for the therapeutic effect of acupuncture*, in «The FASEB Journal», 12, 2001, pp. 2275-2282.

issues, allowing the body to rest from the tensional grip and reset.

In any case, it is obvious that there is a constant household there, a kind of *perpetuum mobile* made of dynamic re-hierarchisation of the living, bringing together "order" and "struggle", "a putting in order" "hierarchical" at the base of local exchanges and processes, within the "Zellenrepubliken".

Nietzsche, probably under the influence of his reading of Virchow and Roux, was sensitive to this idea of permanent re-hierarchisation of the living, finalized to his own "*Selbstgestaltung*" ("self-realization"[34]).

Here we find back Ingber's concern, declined at the very beginning. Alternating between the extensible and retractable state, the importance of a "distension" activity opens up to "spacing".

Hydrated molecular blanks, these micro-fibrillary networks are thus able to a "distensinoal" mode, to contribute to the smooth functioning of the "sliding" of our personal archives. But nothing is guaranteed: what slips lulled by the silence of the organs, can hang on or ask to be restrained.

The fiber thus "stressed", by its connection to the proteins of the extracellular matrix, communicates with the membrane of the cells by means of a movable hinge, integral with them, which obeys only the laws of ambient ionicity, re-situating us at the beginning of time. May be life really

> emerged through self-organization of inorganic components

contained in the primordial soup, allowing all the facets of the imaginable and unimaginable possibilities of the universe to intermingle. How then groups of molecules

> self-assembled to create living cells with emergent properties, including the ability to change shape, move, and grow…

[34] B. Stiegler *Le corps vivant selon Nietzsche ou la mémoire en alerte*, in P. d'Alessio, *L'alerte du Corps*, UNESCO, Philosophy editions, 2003, pp. 30-32.

be came organized remains a mystery. But the important thing is the legacy, consisting in a "fundamental design principle that guides self-assembly in natural systems" identifying in the tensegrity concept and constructions, the possibility of a theoretical assessment.

PATRIZIA ANNA D'ALESSIO MD Haematologist, PhD in Haemorheology is academic lecturer and research Associate Professor at Universities Paris René Descartes and Paris Sud

patriz.dalessio@gmail.com