State of the Body Evaluation on the Basis of Principle of Critical Energy

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An analysis is made of the body internal and external factors that might affect its general condition. This is the starting point that can make it possible to further decide on the risk of surgery. The stresses that a body is likely to undergo may be divided into two categories: - stresses that are externally applied to the body (traumatic injuries, surgery ...); - stresses resulting in an internal effect upon body resistance (damage caused by external and / or internal factors, medical treatments ...), plus the effect of the body adaptive self-adjustment. One resorts to the concepts introduced by the principle of critical energy, namely, the specific energy participation of external stresses and the critical participation, non-dimensional variables, dependent on the behavior of the organism under different stresses. By comparing the values of these concepts, calculated for a patient, one can decide on the risk of one or more successive surgeries over a short period of time. The theoretical results obtained applied to several cases demonstrate the actual implementation of the proposed calculation method and its great practical advantage.

Keywords: body deterioration; surgery; intervention; traumatic risk; principle of critical energy

In the present paper we have intended to put forth a method of calculation based on the body behaviour, its condition, so as to allow for a well informed decision regarding the possible surgical interventions.

The human body may undergo simultaneous, successive or simultaneous and successive actions by various factors such as those likely to cause traumatic injuries, surgery, noise, toxins, chemical and/or radioactive pollutants, various radiations (thermal, ultraviolet, X-rays, magnetic flow, electric flow etc ...), viruses, bacteria, mental stress etc.

a. Currently, when evaluating the cumulative effect of successive surgical interventions at short intervals, the following procedures [1-3] are used:

-a characteristic number, N_i, is assigned to each type of surgery performed or to a certain traumatic injury of an organ. This is the traumatic index and it is calculated with the relationship,

Ni = (risk factor) x (degree of organ lesion);

- the characteristic numbers are summed up and one obtains the total value of the traumatic index;

$$N_t = \sum_i N_i ,$$

that represents the result of the superposition and/or cumulation of various traumatic lesions incurred by the human body;

-N_t is compared to the critical value of the traumatic index, N_{cr}. If:

$N_t < N_{cr}$ - the succession of surgical repairs of lethal organs is considered to be risk-free or with minimal risk of postoperative complications;

$N_t \geq N_{cr}$- there is an increased risk of complications (2.5-3 times higher).

Number N_t, in this case, is indicative of the risk of surgery.

This way of assessing the risk of surgery does not take into account:-the native resistance of the body; - the body deterioration prior to surgery; - the instantaneous damage that may evolve or diminish over time; -the effect of medical treatments, etc.

At present we cannot objectively assess the effects of such influences; subjectively, yes, but with great approximation and without solid scientific foundation.

b. Another example [4;5]:

-a monkey that has been injected with a (critical) amount of polio virus, $m_{p,cr}$ has become infected with poliomyelitis. When injected with an amount of polio virus $m_p < m_{p,cr}$ - it did not get infected!;

-when subjected to a (critically) intense stress S_{cr}, the monkey died, while when the stress intensity was $S < S_{cr}$, the monkey did not die.

The amount of virus and stress intensity have different units of measurement; they cannot be summed up algebraically.

If the monkey is to be challenged simultaneously with a stress of intensity $S < S_{cr}$ and an amount of polio virus $m_p < m_{p,cr}$, the question will be how we can determine whether the critical state has been reached, in other words whether it will die or not!

c. On the other hand, how can we determine - in the case of a specific disease- which is the total effect of simultaneous or successive application of treatments, such as: energy treatment, chemotherapy treatment, acupuncture or presopuncture therapy, etc. ?!

Simultaneous stresses cause the *superposition of their actions*, or their effects.

Successive stresses determine the *cumulation of their actions*, or their effects. Often, the effects of successive stresses diminish over time. The body stresses that precede surgery decisions may result in body *damage*, which reduces the body resistance to surgery.

On the other hand, simultaneous, or successive interventions at relatively short intervals of time on several organs may be extremely dangerous, sometimes even fatal.

It is also necessary to add the particularity of each organism, which is embedded in its *native resistance* to the actions of the destabilizing factors and the behavior (response) to each type of stress load.

Consequently, when *assessing the state of the body* before making a surgery decision, it is necessary to know the:

-*native resistance*, correlated with body immunity, that is implemented at birth, characterized by initial critical participation, $P_{cr}(0)$;

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-body *damages* incurred until making the decision to intervene ($D_j(t)$);

- *body behavior* in relation to each type of stress load (S_i), such as the correlation between cause (S_i) and effect (e_i), as generally shown in [6, 7];

-*the effect of medical treatment before* (or during) surgery, through the correlation between the action of the drug / treatment administered and the momentary increase in body resistance (P_{tr}).

The load and resistance of a body

All of the above-mentioned dimensions should be correlated in a general relationship that contains two terms, one relating to surgical actions and traumatic stresses prior to surgery, and another which pertains to elements of body resistance. Since these actions are measured with different units of measurement, one should resort to the inter-dependence between body load and body resistance, by using non-dimensional variables.

To this end, we can resort to the *principle of critical energy* [5;8], which evaluates interactions of any kind based on the concept of energy. One defines *the specific energy participation* of a certain action S_i through the relation [5,8],

$$P_i(S_i) = \frac{E_i(S_i)}{E_{i,cr}(S_i)} \cdot \delta_i, \qquad (1)$$

where $E_i(S_i)$ is the specific energy (J/kg; J/m^3; J/m^2) introduced into the body by the action of S_i, and $E_{i,cr}(S_i)$ is the critical value of $E_i(S_i)$, that is, that value of the specific energy that determines the achievement of the critical state (for example, death); δ_i=1, if S_i acts in the sense of the evolution of the process affecting the organism; δ_i=0, if S_i has no influence on the body; δ_i=-1 , if the action of S_i is contrary to the process involving the body (opposes body deterioration / destruction).

a. The total participation of specific energies in the action of several loads is defined as the amount [5],

$$P_T = \sum_i P_i(S_i). \qquad (2)$$

Participations are dimensionless variables (reported variables), which allows for their summation regardless of the type of S_i loads and their units of measurement.

b. Critical participation

Critical participation is, as shown, a non-dimensional, time-dependent variable.

In the case of living organisms, critical participation has the expression [9],

$$P_{cr}(t) = P_{cr}(0) - D_T(t) + P_{\arg}(t) + P_{tr}(t), \qquad (3)$$

where

-$P_{cr,\min}(0) \le P_{cr}(0) \le P_{cr,\max}(0)$ shows that the native critical participation (at t=0) which may take values between $P_{cr,min}(0)$ and $P_{cr,max}(0)$, where

$$0 < P_{cr,\min}(0) < 1 \text{ and } P_{cr,\max}(0) \le 1.$$

$P_{cr,min}(0)$ correspunds to a body with low (minimum) genetic resistance while $P_{cr,max}(0)$ correspunds to a body that was genetically endowned with very high (maximum) resistance to *aggressions.*

The total deterioration (non-dimension variable) depends on time and is expressed as,

$$D_T(t) = \sum_j D_j(t), \qquad (4)$$

where $D_j(t)$ is the deterioration produced by action *j* (psychic stress, noise, radiation, viruses, bacteria etc.)

Relation (4) may be written as [9],

$$D_T(t) = D_T^{(ex)} + D_T^{(in)} + D(t), \qquad (5)$$

where

$D_T^{(ex)}$ is the damage caused to the body by some *external actions* (chemical pollution, radioactive pollution, electromagnetic radiation, ultrasounds, viruses, bacteria, toxins etc. ...); $D_T^{(in)}$ is the damage caused to the body by *internal imbalances*, the lack or insufficiency of important intimate components of the body (nutrients, vitamins, trace elements etc.); D(t) is the deterioration caused by aging.

The term $P_{arg}(t)$ in relation (3) is the participation of the specific energy corresponding to the body *adaptive self-adjustment* through homeostasis (*reluctance* to the tendency of modifying the values of the body physiological constants [4;10]).

$P_{tr}(t)$ is the *participation caused by medication*, etc., a non-dimensional variable, which can be positive - when it helps to increase the resistance of the body, null if it has no influence and negative when it decreases the resistance of the body in the given case of load.

c. One compares the two participations

If,

$$\left.\begin{array}{l} P_T < P_{cr}(t) \text{ - the condition of the body is non-dangerous} \\ P_T \ge P_{cr}(t) \text{ - the condition of the body is dangerous} \end{array}\right\} \qquad (6)$$

In the case of a monkey under stress S_k, who was injected with a certain amount of virus, the stress is included in the calculation of $P_i(S_k)$, and the amount of virus that reduces the resistance of the body intervenes in the calculation of the critical participation through the damage it produces.

In order to implement previously existing theoretical developments, it is necessary to use mathematical relations that express the *behavior of the body* when under a certain *load*, written as S_i. Based on this relationship, it is then possible to calculate the specific energy $E_i(S_i)$.

The total participation of specific energy and critical participation by considering the behavior of matter

a. The total participation of specific energy

One considers the non-linear behavior of the body, expressed by the *power* law,

$$S_i = C_i \cdot e_i^{k_i}, \qquad (7)$$

where e_i is the action (cause) effect S_i, and C_i and k_i are material constants dependent on the particularities of the organism corresponding to a certain disease (fig. 1, *a*).

The S_i stress load may have different meanings, namely: surgery, magnetic radiation flow or, electric current density etc.

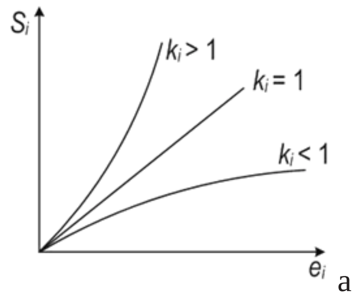

Fig. 1a

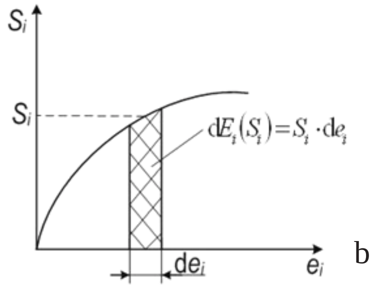

Fig. 1b

The specific energy introduced in the matter by load S_i is calculated with the general relation (fig.1, *b*),

$$E_i(S_i)=\int S_i\cdot de_i=\frac{C_i\cdot e_i^{k_i+1}}{k_i+1},$$

or, taking into account the law of behaviour, from which there results $e_i=(S_i/C_i)^{1/k_i}$, one obtains,

$$E_i(S_i)=\frac{S_i^{\frac{1}{k_i}+1}}{(k_i+1)\cdot C_i^{1/k_i}}.$$

For $S_i=S_{i,cr}$ one obtains *the specific critical energy,*

$$E_{i,cr}(S_i)=\frac{S_{i,cr}^{\frac{1}{k_i}+1}}{(k_i+1)\cdot C_i^{1/k_i}}.$$

The critical value $S_{i,cr}$ is that single load that determines the achievement of the critical state of the body (for example, death).

From the last two relations and from the expression of the specific energy participation (1) results,

$$P_i(S_i)=\left(\frac{S_i}{S_{i,cr}}\right)^{\alpha_i+1}\cdot\delta_i, \qquad (8)$$

where one wrote $\alpha_i=1/k_i$. The value of the exponent α_i depends on the body stressing load rate:

$$\alpha_i=\begin{cases}\frac{1}{k_i}, \text{ if loading } S_i \text{ is slow (quasistatic);}\\ \frac{1}{2k_i}, \text{ if loading is rapid;}\\ 0, \text{ if loading is shock-like.}\end{cases} \qquad (9)$$

The superposition of actions refers to cases where each load applied is below its critical value, $S_i<S_{i,cr}$. As a result, the ratio $\frac{S_i}{S_{i,cr}}<1$. The higher the value of the exponent (α_i+1), the lower the participation $P_i(S_i)$ (one raises to a positive power a subunitary number).

Considering that, in general, matter behavior is logarithmic ($k_i<1$)it results that under slow and fast loading, $\alpha_i>1$ so that $\alpha_i+1>2$ while under shock loading $\alpha_i+1=1$. Consequently, *the highest effect of loading with the same load value S_i is obtained in the case of shock loading.*

The total participation of the specific energies introduced in the matter by several loads S_i, for the behavior given by the power function law (7) is

$$P_T(t)=\sum_i\left(\frac{S_i}{S_{i,cr}}\right)^{\alpha_i+1}\cdot\delta_i. \qquad (10)$$

b. *The critical participation* is calculated with relation (3), where, for organisms with exceptional physical and psychological resistance, one may consider $P_{cr}(0)=1$.

The damage caused to the body by some external actions, for example due to some cause Z_j, is calculated with a relationship similar to the relationship (8)

$$D_j^{(ex)}(t)=\left(\frac{Z_j}{Z_{j,cr}(t)}\right)^{\alpha_j+1}, \qquad (11)$$

where the critical value of action Z_j may be time dependent, $Z_{j,cr}(t)$. The exponent $\alpha_j=1/k_j$, where k_j means the same as k_i from relations (8) and (9). In this case $\delta_i=1$, because Z_j acts in the sense of deterioration. The total damage caused by several external actions has the expression,

$$D_T^{(ex)}(t)=\sum_j\left(\frac{Z_j}{Z_{j,cr}}\right)^{\alpha_j+1}. \qquad (12)$$

For example, the body damage under the action of:

- electric current density J_k (A/m^2) at frequencies up to 10 Mz can be calculated with relation [11]

$$D_k^{(ex)}(J_k)=\left(\frac{J_k}{J_{k,cr}}\right), \qquad (13)$$

where $J_{k,cr}$ is the critical value of J_k, that is, the one value that determines the death of the body. One considered $\alpha_j=0$ because the load caused by an electric current has the character of a shock;

- a chemical pollutant concentration c_j, can be calculated with relation [12],

$$D_j^{(ex)}(c)=\left(\frac{c_j}{c_{j,cr}}\right), \qquad (14)$$

where $c_{j,cr}$ is the critical value of c_j.

Here, too, one considered that the action of the pollutant to be shock-like ($\alpha_j=0$), resulting in a substantially higher deterioration value than in the case of slow or rapid loading, when $\alpha_j>0$.

Damage caused to the body by internal imbalances. For example, damage due to the lack or insufficiency of important intimate components of the body (vitamins, trace elements, etc.) can be calculated with the relationship,

$$D_n^{(in)}=\left(\frac{K_n}{K_{n,cr}}\right)^{\alpha_n+1}, \qquad (15)$$

where K_n is the amount at a certain moment (of vitamins or trace elements etc.), and $K_{n,cr}$, is the value of K_n that alone can avoid the disease, or heal it!

Participation due to medication, medical treatments etc. can also be calculated with a relationship like (8). When action T_k is part of a certain treatment,

$$P_{tr,k}(t)=\left(\frac{T_k}{T_{k,cr}}\right)^{\alpha_k+1}\cdot\delta_k. \qquad (16)$$

where $T_{k,cr}$ is the critical value of T_k, that is, that value alone that stops or prevents the manifestation of the disease. T_k may represent the amount (mass) of drug administered, the applied radiation flow, the intensity of ultrasounds, etc.

δ_k=-1, if treatment helps to overcome the disease, δ_k=0, if the treatment has no effect and δ_k=-1 if treatment stimulates illness or opposes healing.

The total participation caused by several treatments applied is,

$$P_{tr}(t)=\sum_k\left(\frac{T_k}{T_{k,cr}}\right)^{\alpha_k+1}\cdot\delta_k\ . \qquad (17)$$

c. State of the body

If, in a given case, the total participation corresponding to *multiple surgeries* is equal to or greater than the critical participation,

$$P_T(t)\geq P_{cr}(t), \qquad (18)$$

then the intervention is risky.

To increase the safety of multiple surgery, we must ensure that,

$$P_T<P_{cr}(t), \qquad (19)$$

in such a way that the difference ($P_{cr}(t)$-$P_T(t)$) should be as high as possible. That can be achieved by:

- reducing the total damage $D_T(t)$, in general;
- diminishing the damage caused by the action of external factors (shortening the term $D_T^{(ex)}$);

-increasing the body resistance by reducing the deficiency of vitamins, trace elements etc. (shortening the term $D_T^{(in)}$;

- appropriate medical treatments (likely to extend term $P_{tr}(t)$).

It should be noted that the result of the previous assessment differs from individual to individual, each of which is characterized by a certain value of $P_{cr}(0)$ from rel. (3) corresponding to native genetic endowment.

For example, for a fully and indigenously endowed individual, for whom Pcr(0)=1 inequality (19) becomes,

$$P_T'(t)<1-D_T(t)+P_{arg}(t)+P_{tr}(t) \qquad (20)$$

For an individual who was indigenously endowed at a minimal level, for whom $P_{cr}(0)=P_{cr,min}(0)<1$ inequality (19) becomes

$$P_T''(t)<P_{cr,min}(0)-D_T(t)+P_{arg}(t)+P_{tr}(t). \qquad (21)$$

As $P_{cr,min}(0)<1$, it is obvious that $P_T''(t)<P_T'(t)$. If for the case given by relationship (20) one can safely resort to a certain multiple surgery, it is possible that this procedure might not be applied to the second individual for whom the relationship (21) is valid.

In order to use the general results overviewed it is necessary to determine the practical, experimental determination of the values of the critical quantities intervening in the established relations.

The development of some applied research in the sense of the present argument, makes it possible to quantitatively assess the total action upon the body and individualize medical treatments, thus avoiding subjective assessments, mistakes in approaching and use of inappropriate medication or sometimes unnecessary treatments.

Examples

We shall further exemplify the use of established relationships in a few concrete cases. Since there are currently no data for the human body, the values of the variables involved in the expressions of critical participation will be arbitrarily chosen to exemplify the procedure to follow in applying the relationships proposed in the present work.

In all the examples: - one calculates the total participation of the specific energies corresponding to the body's loading $P_T(t)$ according to the general relation (10); – one calculates the critical participation of the body at a given moment, according to the general relationship (3); – one compares the two participations according to relationships (18) and (19) and one decides on the opportunity of surgery or other kind of intervention.

Example 1.

A patient is characterized by the value of her/his native critical participation $P_{cr}(0)=1$, being genetically endowed with a high resistance to external loads. When seeing a physician, the patient's body is characterized by the following deteriorations (5):

-deterioration caused to the body by some recent external actions (radioactive pollutuion, toxins and bacteria) $D_T^{(ex)}=0.15$;

-deterioration caused to the body by internal imbalances (vitamin deficit, trace element deficit), $D_T^{(in)}=0.08$;

-deterioration through ageing, $D_T(t)=0.1$.

The pre-surgical medical treatments (meant to annihilate the effects of toxins and bacteria) result in participation $P_{tr}(t)=0.09$, which – being favourable to the reduction of the influence of toxins and bacteria - is positive.

The participation of the specific energy corresponding to the adaptive self-adjustment of the body is assessed (in the absence of real data) as featuring the value $P_{arg}(t)=0.05$.

The patient is to be subjected to a surgery intervention characterised by a traumatic index surgery $N_1=10$.

Determine whether the intervention is risky or not!

a. One calculates the total participation of the specific energy corresponding to the body's loading through surgery intervention. This is calculated by the general relation (8) where S_i is replaced by the traumatic index N_i. One obtains,

$$P_1(N_1)=\left(\frac{N_1}{N_{cr}}\right)^{\alpha_N+1}\cdot\delta_1, \qquad (22)$$

where $\delta_i=1$, as N_1 corresponds to the evolution of the process (surgery) under consideration. As surgery can be equated with a body shock loading, in the relationship (9), $\alpha_N\approx 0$.

Traumatic Critical Index $N_{cr}=25$.

After replacements in relation (22) results,

$$P_1(N_1)=\frac{N_1}{N_{cr}}=\frac{10}{25}=0.4\ .$$

b. The critical participation is calculated with the general relationship (3) out of which, after replacements, there results:

$$P_{cr}(t)=P_{cr}(0)-D_T(t)+P_{arg}(t)+P_{tr}(t)=$$
$$=1-0.33+0.05+0.09=0.81,$$

where one replaced, according to relation (5),

$$D_T(t)=D_T^{(ex)}+D_T^{(in)}+D(t)=$$
$$=0.15+0.08+0.1=0.33\ .$$

One finds that the first condition (6) or condition (19) is fulfilled, which means that the surgery is not dangerous for the patient.

Example 2

Let us take the previous case with a patient featuring the same data but whose genetic endowment regarding body resistance to traumas is substantially lower, namely characterized by the value of native critical participation Pcr(0)=0.5. According to relationship (3),

$$P_{cr}(t) = 0.5 - 0.33 + 0.5 + 0.09 = 0.31 .$$

In this case $P_1(N_1)=0.4>Pc_{cr}(t)=0.31$ and there is fulfilled the second condition (6) or condition (18), which means that the surgery may be dangerous.

The remedy is to increase $P_{cr}(t)$, for example, by applying medical treatments resulting in an increased term $P_{tr}(t)$.

Example 3

Suppose that in the case of Example 1, during surgery on organ *1* (characterized by the traumatic index N_1), it is found that surgery is required for a second organ characterized by the traumatic index $N_2=7.5$. Assess the condition of the body.

a. The total energy specific participation corresponding to the successive application of two surgeries onto the body is

$$P_T(t) = P_1(N_1) + P_2(N_2),$$

where $P_2(N_2)$ is calculated with a relation similar to relation (22),

$$P_2(N_2) = \left(\frac{N_2}{N_{cr}}\right)^{\alpha_N+1} \cdot \delta_2, \qquad (23)$$

where, similar to the case in relation (22), $\alpha_N \approx 0$ and $\delta_2=1$. Consequently, after replacements

$$P_2(N_2) = \frac{N_2}{N_{cr}} = \frac{7.5}{25} = 0.3,$$

so that

$$P_T(t) = 0.4 + 0.3 = 0.7 .$$

-For the patient in example 1, critical participation is $P_{cr}(t)=0.81$, which means the pattern follows relationship (19), namely $P_T(t)=0.7<P_{cr}(t)=0.81$. Surgery *is not dangerous* to the patient.

-For the patient in example 2, the situation may be dramatic, as the body's stress load in the case of two successive operations leads to a total participation ($P_T(t)=0.7$) which is much greater than the critical participation ($P_{cr}(t)=0.31$) specific to this patient.

Observation. The data used in the calculation examples are fictitious. They do not correspond to a concrete case and they have been approximated in order to illustrate the calculation method proposed by this paper

For a calculation based on actual patient data, research is needed to first determine the following:

-the constants (C_i and k_i) in relationship (7) that express the behavior of the organism to the different external stress loads;

-the procedure for calculating the terms of the critical participation relationship: - the damages caused by some external factors, according to relationships (11) - (14); - damages caused by some internal factors (15); - the influence of medical treatments (16), etc.

Conclusions

A calculation method is proposed for estimating a body's resistance to surgical stress or a succession of surgeries.

In this case, the principle of critical energy, whose mathematical expression is based on non-dimensional variables, can be summed up, regardless of the units of measurement of the stress loads. The loads to which the human body is subjected have been divided into two categories:

-external loads that cause trauma to the body (surgery, traumatic injuries etc.);

- loads with an internal effect on the body's resistance with respect to external loads (external and/or internal damage, medical treatments) plus the adaptive self-adjustment effect of the body.

The action of external stress loads is calculated on the basis of the concept of *specific energy participation corresponding to the load*, which is a dimensionless variable.

The resistance of the body to external stress loads is also calculated on the basis of the *critical participation* concept, and it is dimensionless, too.

By comparing the two dimensionless variables, one can decide whether the trauma sequence the body has undergone or is about to undergo is dangerous or not. The calculation examples, based on fictitious values of the variables involved, show how the relationships proposed by the paper can be actually used. One can foresee the opening of broad ranging research directions, which will lay the ground for the practical use of the proposed relationships thus providing a mathematical basis for surgical decision making.

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