Cryotherapy – General Remarks

Cryotherapy is one of the most known physical methods in therapy. There are more and more articles on this subject, and the first book by Prof. Zagrobelny " Local and All-Organism Cryotherapy" was published in Poland. Germany and Poland are the leading countries in the world in this area. However, reading of Polish and foreign publications still induces us to ask questions about basic issues and to get clarified the following subjects:

1. Incoherence in terminology
2. No clearness of definitions of stimulating and non-stimulating methods in cryotherapy
3. Not complete explanations and one-sidedness in the area of refrigerating media and treatment techniques in order to achieve the required cryotherapeutic effects

To unify and make more precise some terms I propose to follow diagram 1.

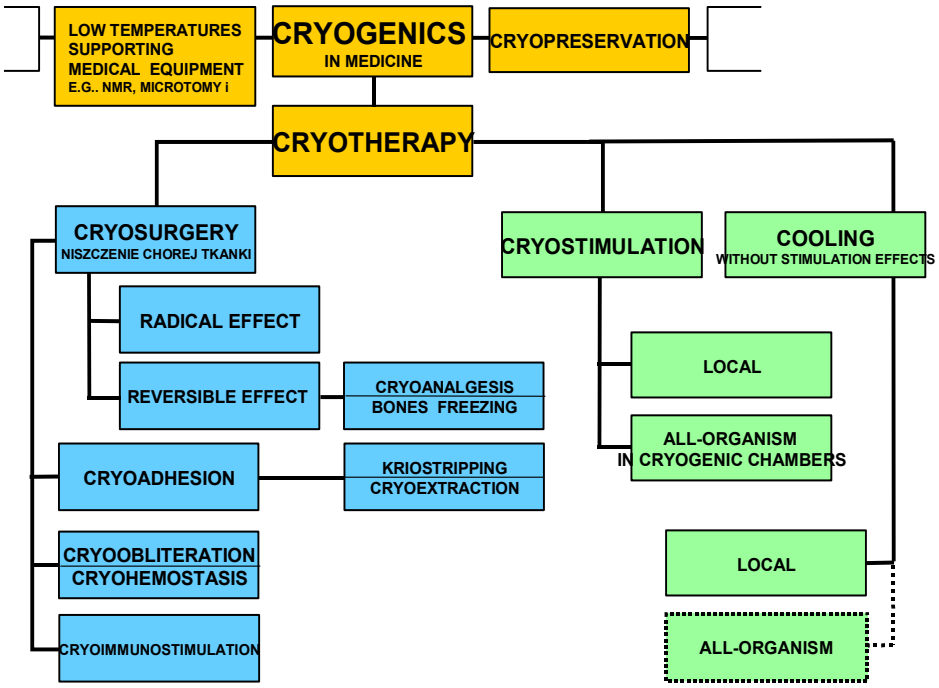

diagram 1

The cryotherapy term placed in it has a very wide meaning and covers all treatment methods by means of low temperatures. Due to great generalisation this term is misused very often both by doctors and therapists. Each of them means something completely different when answering our question about a device for cryotherapy or describing effects on tissues. A gynaecologist or dermatologist thinks of destroying tissues through freezing, and physiotherapist bears in mind stimulating or cooling effects which do not destroy tissues. They use the correct word but not precise enough for the purposes they mean.
It is also worth-mentioning that in physics cryogenics was called the science dealing with phenomena in temperatures below -100°C despite a wider meaning of the Greek word krios – ice, cold. Extreme low temperatures are in turn a term denoting the area of temperatures near absolute zero, i.e. -273°C.
The division I proposed, which is informed of in some theses, into cryosurgery, cryostimulation and cooling defines the terminology more precisely in the therapy area where low temperatures are used. Each of the three concepts requires different application techniques. In particular it is essential to distinguish cryostimulation from cooling, because I cannot find any clear and concrete explanation in any thesis.

Various cryogenic measures are used in rehabilitation such as: pouring cold water on the body, ice or snow packs, wrapping with wet sheets, thermogel application, blowing with cooled air, condensed gases vapours and others. Different cryogenic measures and methods of their application condition whether to use **non-stimulation (cooling)** or **stimulation (cryostimulation)** method.

Let's consider a few definitions of cryostimulation despite the fact that other authors use interchangeably cryotherapy term:

1. „Application of physical stimulus to lower the temperature of tissues for medicinal purposes is called cryotherapy"– Prof. K. Spodaryk
2. „Cryotherapy is a non-invasive application of extremely low temperatures of cooled air, condensed gases vapours, locally or throughout all organism to cool body integuments radiationally for a period of time not to exceed 3 minutes' exposure" – Prof. Z. Zagrobelny
3. „Stimulating application of cryogenic temperatures superficially – below -100°C, operating very short (2-3 minutes) in order to bring about and utilize physiological, constitutional reactions to the cold, aid of primary treatment and facilitating treatment by means of motion should be considered as the idea of cryotherapy" – Ph. D. H. Gregorowicz
4. „Cryotherapy is the application of the temperature below -100°C within 2-3 minutes over external surface of the body in order to bring about and utilize physiological reaction to the cold" – Ph. D. K. Księżopolska-Pietrzak
5. „So the idea of cryostimulation is the cool tissues as quick as possible in the shortest possible time in order to bring about reflexive plethoric reaction." – Ph. D. W. Gawroński

Although the second definition includes imprecision from point of view of physics, which will be cleared up later on, almost all authors are unanimous in that "rapid cooling - nearly the sucking of relatively very small quantities of heat out of tissues is the essence of cryostimulation" – Prof. Z Zagrobelny. Etymology of the term of cryotherapy is described in detail in Ph. D. W Gawroński's thesis {Rehabilitation 2003, 7, No. 2}. Most of the authors in their theses which are published relate cryostimulation closely temperatures so-called extreme ones below -100°C being aware of that that the cooling process must take place very quickly. Temperature is an important parameter but not the only one and application of a source of the cold of -100°C temperature does not guarantee the proper effect. A dose of cold is more objective concept, but it does not reflect the complexity of the cryotherapeutic treatment phenomenon.

Now let's trace the process of the taking away of heat:

Method 1:

The quickest way to take away heat is touching a tissue with a cold metal cryoapplicator or directly spraying a condensed cryogen onto it. That is a method applied in cryosurgery to destroy tissues. It is not applied in cryostimulation, because application of a probe or spraying of cryogenic liquid longer than a few seconds would cause damage to skin and it would not bring about the intended stimulation effect.

Dose of heat taken away during a cryosurgical treatment event that lasting for many minutes is not big due to a very limited area exposure from several mm to several cm.

Method 2:

Water with ice is the quickest non-destructive method to cool a tissue. Heat exchange in icy cold bath is several dozen times greater than in a cryogenic chamber where the air temperature is approx. -120°C. The same refers to local cryostimulation.

The quantity of heat to be taken away is controlled by the treatment duration.

Method 3:

Local cooling by condensed gases vapours, i.e. of liquid nitrogen, air (-195°C) or carbon dioxide (-75°C). This is a quick, very convenient and patient-friendly method of the cooling of any part of the body. Cooling velocity can be controlled by the quantity (velocity) of the gaseous stream while applying cold air or CO_2, or by the distance between the nozzle and the tissue while applying LN_2. This way you can assure the taking away of a great amount of heat, at the same no damage to skin comes about (cryodestruction).

It follows from the above considerations that rapid taking away of a heat dose does not to be associated with so-called extreme temperatures. The statement that cryostimulation effect can be brought about only when you use the temperature below -100°C is a misuse which does not have any justification from heat exchange point of view.
So a question arises why we do not apply icy baths instead of cryogenic chambers? An icy bath is unpleasant and a shock which could be applied only in few cases. The taking away of heat in a chamber comes about slower and mainly by means of radiation in a dry atmosphere of the air of the temperature of approx. -120°C, where the cold is felt as something "friendly"
I would like to introduce the concept of the wet cold (water with ice), the damp cold (air of the temperature of -15°C ÷ -35°C) and the dry cold (cryogenic gases below -60 C) – diagram

Description of the diagram: Kind of a refrigerating medium in cryostimulation

- wet cold – water with ice

temperature > or = 0°C

- damp cold – cold air

temperature from - 15°C to 30 °C

- dry cold – condensed gases vapours

temperature : LN2 vapour: - 196°C
LAir vapour: - 190 °C
LCO2 vapours: -75°C)

Each of the a/m factors can bring about cryostimulation effect. The quickest way is to use water with ice, but it is the method too radical in the event of an all-organism cryostimulation ant too troublesome when applying it locally. Additionaly the patient's reaction is different in relation to different kind of refrigerating medium.
The dry cold is felt least as unpleasant. Practically each of us can experience this phenomenon staying outdoors in the wintertime when weather conditions are different.
Damp in a gas of the temperature below -60°C is practically not sensed and such a cold is the most convenient for the patient.

Method 4:
Cooling, that is such a taking away of cool so as not bring about stimulation effect.
We use sacks with ice, gels etc. to cool, i.e. the media considered to traditional or old fashioned by some authors. From the effects point of view they are cheap and the most convenient methods of slow, long-lasting maintenance of tissues under lowered temperatures to avoid further development of traumatic effects after fresh injuries. Application of rapid-acting cooling measures, such as water with ice, liquid nitrogen or CO_2, vapours is in this case improper and can cause bigger extravasations, swelling and further damage to tissues. In the case of fresh injuries, probably the most adequate procedure to follow is recommended in the book by K. Knight, i.e. the PRICE procedure (Procetion, Rest, Ice, Compression, Elevation).
I would like to remind that sacks with ice take away heat many time slower than water with ice.

The amount of heat taken away as well as penetration of the cold inwards is in case of cooling big due to its long duration.

From diagram 3 you can notice that cooling and cryostimulation are completely different methods of operation as far as refrigerating medium, application and usage are concerned.

CRYOTHERAPY

COOLING
WITHOUT STIMULATION EFFECT

REFRIGERATING MEDIA
- sacks with ice
- gels
- cold water of temperature 10 – 15°C

APPLICATION METHOD
- small doses of cold not bringing about stimulation
- long-lasting application of cold, e.g. from 30 minutes to 1 hour, 2-hour pause and another application
- movement – not advisable
- limb lifting is helpful
- limb compression is helpful

WHEN TO APPLY
- fresh injuries
- fresh burnings (blowing with a dry gas)

CRYOSTIMULATION

COOLING MEDIA
- water with ice
- liquid nitrogen vapours (temperature approx. - 195°C)
- CO2 vapours (temperature approx. - 75°C)
- Cold air (temperature approx. - 30°C)

APPLICATION METHODS
- Big intensive doses of cold nearly to the whitening of tissues (0°C)
- Short doses of cold max. 3 minutes
- Movement advisable (kinesitherapy) as early as during the treatment
- Obligatory kinesitherapy after the treatment (in most cases)

WHEN TO APPLY
- Injuries under healing phase
- Rehabilitation
- Rheumatologic, degenerative changes
- Spastic changes)

In the opinion of Prof. K. Spodaryk the fundamental meaning to achieve the assumed biological (therapeutic) effect have the following factors:

- Cooling pace, i.e. time to achieve low temperature in the tissue,
- Temperature achieved in the tissue,
- Duration of low temperature existence in the tissue.

Additionally I would like to introduce other parameters (without precise thermodynamic calculations), illustrating cryotherapy phenomenon, *refer to table 1 1*:

Type of treatment	**Intended effect**	**Dose of energy (of the cold)**	**Energy stream (of the cold) power/ cm^2**	**Cooling pace**	**Temperature reached upon the surface of the skin**	**Depth of temperature penetration down in the tissue**
cryosurgery	Tissue damage	small	Very big	very high	od -2^0C do -190^0C	From several mm to a few of cm
cryostimulation	Increase in blood flow, increase in metabolism	medium	medium	high	max. ok. 0^OC	shallow
Cooling down	Maintenance of lowered temperature of the tissue	big	small	low		deep

table 1

According to the definition of cryostimulation quoted earlier the essence is to take away as much heat as possible from the surface of the organism within approx. 3 minutes. Why just within 3 minutes? It follows from the limited capacity to exchange heat as the skin temperatures cannot be lowered below 0°C. Experiments show that the dose of heat taken away from the organism within approx. 3 minutes is a stimulating dose, and for example in the case of all-organism cryotherapy it amounts to 65,2 kcal (in the opinion of Prof. Zagrobelny).
Shorter time of the treatment will bring about not large stimulation of the organism, a longer one can lead to contrary effects than intended. At this point treatment techniques in local cryostimulation should be discussed individually.
Objectivity of a treatment is not possible in cryosurgery and cryotherapeutic practice. Proper application of the cold is dependent on the surgeon's or therapist's practice and knowledge. In my opinion in the available literature there are not any publications by experienced cryotherapists giving guidelines and procedures. The treatment often consists in "blowing" of a given part of the body from the distance of 30 - 40 cm. In this case application of a cryogenic medium below -100^0C and assuming the treatment duration as 3 minutes or more do not guarantee the therapeutic effect.

I suggest drawing attention to the individual phases of the treatment:

I. Preparation for the treatment:

- Drying up of the surfaces to undergo application by means of spirit wiping or just "blowing" with a cold cryogen,
- Estimation of the treatment duration as in my opinion 3 minutes are the average time. Different duration is foreseen for a muscle-bound or fatty person, and a different one is for a slim person of low weight.

II. Dosing of the cold:

- Application of the cold in an intensive way, mainly to the muscular tissue (indirectly through the skin) and less onto the skin, under which there is a bone (e.g. in the vicinity of trochanters).
- Achievement of the short-term whitening of skin phase. This phase of the treatment requires exceptional attention and at the same time gives you certainty of a rapid and intensive taking away of heat.
- Achievement of the "dull pain" phase caused (according to one of the hypothesis) by narrowing of blood vessels, which gives you certainty of adequate cooling and bringing about the first phase of vascular play. This does not apply, e.g. to persons with vasodilatation disorders and with feeling disorders.

III. Activities after the treatment:

- Observation whether an active plethora surface was formed with clear delimitation from the skin surface not covered with the treatment (the second phase of vascular play).
- Observation whether (if any) there are pale spots upon reddened surfaces. They are pain trigger points which should be (suggestion) cooled separately by means of special cryopuncture nozzles.

Cryotherapy is becoming more and more popular in Poland mainly due to the research and theses conducted by university and clinical centres with involvement of many people.
For my part I would like to inform of the existing vagueness form the point of view of thermodynamics and practice of cryotherapy application through the above comments I have made, and present my own point of view.

Wiesław Brojek
President
CryoFlex Poland Sp. z o.o.