# EDITORIAL

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# CRYOGENICS AND DERMATOLOGY

It was in 1899 that A. Campbell White published the first paper on liquid air in medicine and surgery, and dermatology became the first medical speciality to employ liquified air for therapy. This was twenty years after air had been liquified in the laboratory. The use of carbon dioxide snow for the same purpose was advocated by Pusey in 1907. Other investigators continued work on this imaginative therapeutic method using carbon dioxide snow and liquid nitrogen as refrigerants.

Today cryogenics represents a developing multi-disciplinary science being employed in space and earth with equal importance. Physicists and technologists have reached the age of super-conductivity and cryo-electronics; cryogenics has vast potentials as regards therapy in dermatology.

It is but appropriate to trace our path to the early works of those outstanding chemists and physicists of the 19th and early 20th centuries who through pioneering and dedicated investigations employing their imaginations and mind since the technology then available was unsophisticated helped to build the base on which cryogenics stands today. Again it is only proper to mention the works conducted during the thirty years period 1877-1908 when the so called 'permanent' gases were liquified without which the employment of cryogenics in dermatology, medicine, biological sciences, surgery or engineering would have been impossible.

*The liquefaction of gases*

The familiar fact that a liquid such as water is converted by heat into a vapour (steam) and that the latter reverts to the liquid state on cooling makes it seem likely that many substances which ordinarily exist in the form of gases or vapours such as ammonia or chlorine, would become liquid if cooled sufficiently. The difficulty of applying sufficient cooling, however, prevented an early verification of this surmise. But the experiments of Van Marum and of Northmore (1806), who succeeded in liquifying ammonia and chlorine respectively by the application of pressure, opened up a fruitful field of investigation. In 1823 Faraday succeeded in obtaining liquid chlorine, and in greater bulk than Northmore had done and he was by a suitable choice of materials able to liquify a number of other gases, but he failed to liquify nitrogen, oxygen or hydrogen. These gases for many years resisted all efforts to reduce them to the liquid state. These attempts relied largely on the application of very high pressure and Natterer used pressures upto 2790 atmospheres without success. In consequence of these failures, such gases as hydrogen, oxygen, nitrogen, methane and carbon-monoxide were called the 'permanent' gases.

Between 1852 — 1862 Joule and Thomson reported an outstanding discovery which is now popularly known as 'Joule-Thomson Expansion' which to define is 'the change of temperature which occurs when a gas is driven through a small orifice'. In the year 1869 Andrews described his classical experiment on the condensation of Carbon dioxide. A number of 'permanent' gases were liquified in small quantities by Pictet who used liquid carbon dioxide boiling under reduced pressure as a cooling medium and by Cailletet who allowed the highly compressed gas to expand suddenly, so that in having to do certain amount of work against the pressure, heat corresponding to this work was taken from the gas itself, whose temperature fell in consequence. Cailletet also observed a thick mist when compressing oxygen at -30°C, and in 1877 Pictet liquified oxygen in bulk quantity by the process which bears his name.

These events were followed by an era of major breakthroughs in the liquefication of gases. Dr. Karlvon Linde; a German was the first to realise the industrial application of liquefaction of air and its separation during the same period. The Joule-Thomson effect was applied in 1894-5 to the liquefaction of air on a large scale by Linde in Germany and by Hampson in England. The production of liquid air is now a process of commercial importance and is by the Linde Hampson method with the use of heavy compression to about 200 atmospheres. By this method all gases except Helium had been liquified, many such as hydrogen and fluorine by Dewar, by the end of the nineteenth century and many gases had also been solidified.

In 1906 Dr. George Claude of France introduced an improved technique involving two new principles as compared with Linde-Thomson method. He made use of an expansion engine for assisting in the rapid cooling of the air; he also liquified the air in two stages, thus obtaining two liquids, one rich in oxygen and the other in nitrogen. Helium the last of known inert gases was finally liquified by H. Kamerlingh Onnes of Holland in 1970 and it was found to have a critical temperature as low as -267.9°C. The gas was solidified by Keesom in 1926 when a temperature of only 0.89° absolute was reached i.e. -272.11°C. By the rapid evaporation of liquid helium under reduced pressure, a temperature of only 0.82° above the absolute zero i.e. —272.18°C was reached.

The golden period of scientific discoveries gave birth to the kinetic theory to explain the true meaning of cold. It is but appropriate that we mention here the Charles's law named so by J. L. Gay-Lussac, in honour of J.A.C. Charles who according to Gay-Lussac, made some crude experiments on the subject fifteen years before Gay-Lussac's publication. The implications of the Charles' Law which states that the same rise of temperature produces in equal volumes of all gases the same increase in volume, provided the pressure be kept constant, has led to a conception of an absolute scale of temperature the absolute zero which is taken to be -273°C. Theoretically if the temperature be less than -273°C the gas would have a negative volume, that is a volume less than nothing! If the temperature be -273°C, the gas would occupy no volume! It is impossible to imagine a substance occupying no space, but this seems to be a logical conclusion from Charles' Law. According to the kinetic theory of gases, matter is discrete, not continuous, and is made up of minute particles called molecules. This hypothesis is called the molecular theory of matter. According to the phenomenon of diffusion molecules are in rapid motion. The kinetic theory gives a further meaning to the absolute zero, since in terms of that theory, it is that temperature $-273°C$ at which all molecular motion ceases.

*Containers for storage of the liquid medium*

The temperature of liquid air is about $-190°C$, that of liquid nitrogen being $-196°C$ and of liquid oxygen $-183°C$ and so there is far greater difference between its temperature and that of ordinary atmospheric air, than there is between the temperature of ice and boiling water. The preservation of liquid air is therefore a more difficult problem than would be involved in preventing cold water boiling away while surrounded by a steam jacket at 200°C.

Dr. James Dewar, who was the first to liquify hydrogen in 1898 also conceived the idea of using a vacuum insulated vessel for storage and transportation of cryogenic fluids. The past 80 years has seen a tremendous advance in the technological efficiency of the containers which in right tradition still bear the name of its discoverer Dewar and the best containers of today made out of stainless steel or highly polished aluminium in spite of their large capacities upto 150 litres have a static holding time of over 6 months and a normal working duration of about 3 months.

*Cryogenic media in dermatology*

The commonly employed cryogenic media in dermatological therapy are:

(1) Nitrous oxide where a temperature of $-89.5°C$ can be achieved employing the Joule-Thomson effect. A number of commercial equipments employ this principle where the tip of the probe reaches a temperature of about $-89°C$.

(2) Carbon dioxide snow or dry ice, now obtainable on a commercial scale has a temperature of $-78.5°C$. By dissolving it in ether and allowing the evaporation of the ether a temperature as low as $-110°C$ is obtained.

(3) Liquid nitrogen which has a temperature of $-196°C$ and a high heat of vapourization of 85.7 BTU per hour is the most commonly used medium.

*Factors postulated as to why freezing should damage and destroy living cells*

The phenomenon is still not clearly understood, however, the following factors are postulated:

(a) A mechanical destruction of the cells and the cell walls by intra and extra cellular ice crystal formation.

(b) An osmotic damage due to dehydration of the frozen part.

(c) Thermal shock due to sudden freezing.

(d) Cutting off of the blood flow.

(e) Denaturation of lipoprotein complexes due to the extreme variation in temperature.

However blood vessel damage is the most vital aspect in freezing techniques employed to destroy living tissues, the quantum of injury depending on the intensity of freezing, which in turn will depend on the temperature of the refrigerant and the duration of application. The idea being **quick freezing and slow thawing**. Liquid nitrogen with a temperature of $-196°C$ is the ideal medium.

*Equipments and techniques*

These vary from the method of application of liquid nitrogen with the cotton tipped applicator to the most sophisticated equipments of today where the liquid nitrogen is kept in continuous flow and the tip of the probe is kept at a temperature of $-196°C$ for the requisite period of time needed for therapy.

Since cotton has a low specific heat and during repeat applications layers of icicles form from the atmospheric moisture between each application, and further as the liquid evaporates rapidly on contact with the skin which is higher in temperature a layer of gas is produced between the lesion being treated thereby reducing the heat transfer from the skin lesion. This is not an efficient technique compared to the various standardised cryosurgical units available.

*The cutaneous disorders amenable to cryotherapy*

1. Benign disorders :
   - (a) Angioma
   - (b) Chondrodermatitis nodularis helicis
   - (c) Cutaneous tags
   - (d) Dermatofibroma
   - (e) Discoid lupus erythematosis
   - (f) Granuloma annulare
   - (g) Granuloma pyogenicum
   - (h) Hypertrophic acne scars
   - (i) Keloids
   - (j) Keratoacanthoma
   - (k) Larvae migrans
   - (l) Molluscum contagiosum
   - (m) Porokeratosis of Mibelli
   - (n) Synovial cyst
   - (o) Trichoepithelioma
   - (p) Verrucae (warts)
   - (q) Verrucous nevus
   - (r) Xanthoma palpebrarum
2. Pre Cancerous disorders :
   - (a) Bowen's disease
   - (b) Cutaneous horn
   - (c) Erythroplasia of Queyrat
   - (d) Leukoplakia
   - (e) Arsenical keratoses
   - (f) Seborrheic keratoses
   - (g) Solar keratoses
   - (h) Xeroderma pigmentosa

In the present author's opinion this is only a very partial list and for employment of cryotherapy in dermatology and for using it as an adjunct to other time-honoured therapeutic regimens the initiative and scientific imagination of the dermatocryotherapist is the only limit.

*Advantages of cryotherapy in dermatology*

1. Normally for small lesions no local infiltration is required.
2. Treatment time factor i.e. the time taken for treatment of an individual lesion being low, more number of lesions can be treated at one sitting especially since local injection of an anesthetic is normally avoided.
3. The number of post therapy check-ups is minimal as compared with electro - surgery or scalpel surgery.
4. Post - therapy surgical dressings are unnecessary.
5. The final scarring is minimal with a high degree patient acceptability. In the author's experience therapy by cold has always given less scarring as compared to dessication of tissues by heat.

*Conclusions*

Though cryotherapy has been recognised as highly useful and effective in the treatment of various skin disorders all over the world, it is not practised extensively by dermatologists. The continuing reluctance to try this mode of therapy on the part of the dermatologists is therefore probably due to their unfamiliarity with modern cryogenic techniques.

Cryobiology is a new horizon. Man is exploring space and has great ambitious plans for the future, immediate and distant, to go beyond our solar system, possibly to destinations unknown and unimaginable at present. Such adventures to succeed may exceed his present life span while on travel. The cryobiologist of the future may have to blast the homosapiens off in their youth – in a frozen state of suspended animation – to be thawed at the end of the travel through space, decades later, still in their youth, vigour and ambition to explore their destination and start a fresh civilization.

To quote the Syrian poet Kahlil Gibran (1833 – 1931)

'Yesterday is today's memory and tomorrow is but today's dream'.

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P.S.: The author is the official delegate for the Territory of India for the International Society of Cryosurgery

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**Obituary**

We regretfully announce the Home Call of Dr. Donald M. Pillsbury, Honorary member of our association on October 9, 1980.

*Managing Editor*