Sunshine and fresh air vs. the Finsen ultra-violet rays and the Roentgen rays in tuberculosis of the joints and bones : read at the Fifty-fourth Annual Session of the American Medical Association, in the Section on Surgery and Anatomy, and approved for publication by the Executive Committee / De Forest Willard, M.D.

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SUNSHINE AND FRESH AIR VS. THE FINSEN ULTRA-VIOLET RAYS AND THE ROENTGEN RAYS IN TUBERCULOSIS OF THE JOINTS AND BONES.

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The increasing use of the Finsen light and of the *x*-rays in the treatment of cancerous lesions of the skin and deeper tissues, and especially their use in lupus and other tubercular skin affections, naturally arouses the question of the utility of these rays in the cure of tuberculosis of the joints and bones. The results thus far obtained are certainly sufficient as regards tubercular lupus to warrant the continuance of our efforts in this direction, but the opportunities for noting the effect on deeper tissues in tubercular joints have not yet been sufficient to warrant definite conclusions. A large number of cases will be required to decide the question of benefit, since from the nature of the disease speedy conclusions will be unjustifiable. The course pursued by the tubercular process in joints is always slow, and there are such great differences in the rapidity of progress that the surgeon is very likely to draw wrong conclusions from the results of any method of treatment instituted.

The inhibitory action of the actinic light ray and of the *x*-ray on the growth of tubercular bacilli in the laboratory is undoubtedly positive, and such experimentation is an essential part of our progress in accurate knowledge. Combined with these experiments, however,

must be careful clinical observation and an accurate recording of facts as they present themselves. I am free to confess at present writing that no definite conclusions can be formulated; only that progress, though slow, is hopeful. At the present time we are erecting at the University Hospital a complete plant for the thorough testing of the therapeutic effect of these light rays, and also of the *x*-rays, and I trust that at the end of five years certain positive data will be secured.

Any method or form of treatment that will tend to retard or inhibit the growth of these bacilli is helpful in the long fight with tuberculosis, and the part of the surgeon must be twofold: First (and I purposely put this proposition first), the fortification of the individual for the conflict; second, the destruction of the enemy.

The secret of success in the battle with tuberculosis of the bones and joints rests overwhelmingly on the resistive power of the individual. While, therefore, the Finsen light and the *x*-ray may have their effect in retarding or inhibiting the growth of the bacilli in a local area, it should be remembered that even the total destruction of this small company means but the temporary crippling of the invading army, and that real safety lies entirely in the permanent upbuilding and strengthening of the resistive powers.

The tubercle bacilli are vegetable parasites subject to the fundamental laws of organic life. Their growth is favored by a lack of resistance of tissues and by a fertile soil. This lack of resistance may be due to traumatism of moderate, rather than of severe, degree, or to temporary constitutional causes, or it may be the result of an inherent and hereditary cell weakness. When special soil and special environment are provided, these bacilli will run a speedy and definite course. That their course can be retarded or totally inhibited is definitely proven both in laboratory and clinical experience. Their growth is facilitated by darkness, dampness, moderate hyperemia and all depressing physical and mental influences. They

are resisted by light and air and food, and thorough oxygenation of the tissues, by environment, soil and phagocytic defense. The absence of any of these favorable conditions means growth; their presence, destruction of the foe.

The most powerful agents in our possession for the inhibition and destruction of these micro-organisms are sunlight and fresh air and abundant nourishment. The sun's rays are undoubtedly more helpful than any artificial rays, just as natural waters compounded by the chemistry of the Ruler of the universe differ very decidedly from the waters artificially compounded by the chemistry of man.

While experimentally the strongest sunlight in summer takes more than an hour to kill bacteria, yet the ultimate influence is undoubtedly more beneficial than artificial contrivances. The large proportion of hours of sunshine in Colorado undoubtedly has much to do with the reputation of that region for the cure of tuberculosis. The beneficial effect of the sun bath was well known to the ancient Greeks and Romans, and we have been too tardy in again bringing into service measures which they learned from practical experience, and which we in our blindness have overlooked. As surgeons, we can with benefit learn a lesson to-day from the washerwoman and the farmer.

In my own hospital wards I have always considered the sun porch as the most important of all the means of cure. Every tubercular joint case confined to bed, either with horizontal extension or with fixation or traction of joint, spends the entire day at all seasons lying directly in the sunshine, his eyes and head being protected by a green shade attached to the head of the bed. The effect on health, appetite and cell resistance is simply marvelous. When able to walk about, patients are encouraged to play in the sunshine, not in the shade. I have not infrequently sent out into the sunlight and fresh air apparently hopeless cases of joint disease with lardaceous

organs, and have had them return with sinuses healed, waxy changes arrested and health restored. Of course, it is necessary that surrounding conditions, even in the country, shall be healthful, since many farm houses are unsanitary in the extreme.

In the treatment of tuberculosis of the joints not only are mechanical and operative measures necessary, but all the accessory conditions of health are essential: a superabundance of easily digested and nutritious food, and clothing adapted to the surrounding conditions, in addition to the sunshine and air. There are few individuals who have not observed the influence of darkness and poverty and vice on the general health, and yet few physicians realize the importance of securing the brighter and better conditions. The time is near at hand when sanatoria for the treatment of tuberculosis of the hard parts, as well as those of the soft tissues, will be established. Outdoor life in tents, either in the pine forests or in the hospital grounds, promises a simple practical application of the principles enumerated. Cheeks will grow more rosy, flesh will increase, energy will improve, and resistive power will speedily be such as to control and overcome the tubercle bacilli.

McKenzie and Galloway[1] have also adopted this most excellent principle of treating cases of tuberculosis of joints in the open air by having them live in tents, thus giving patients all the advantages of sunshine and fresh air that are now in vogue in the lung tuberculosis sanatoria. The appetite is greatly improved under such conditions; more food is taken, and it is better digested.

Dr. Flick's regulations at the White Haven sanatorium for consumptives are just as applicable to joint tuberculosis as to phthisis cases: patients to live in tents and to spend their life absolutely out of doors, air to circulate freely through the sleeping apartments, ample bed covering to be supplied. Each patient to take at least three quarts of milk and six eggs a day; more if possible. In addition, a good dinner in the middle of

the day, and a light breakfast and supper. Dinner of roast beef, vegetables and dessert. The gain or loss in weight are the best indications for adaptation of treatment and food.

Poncet, of Lyons, and Perdu and Blanc[2] have also applied the method practically by exposing joints covered with iodoform gauze to the direct action of the sun for hours in the day. As the case recorded by them, however, had had a previous excision of the knee, the report only shows that the sun's rays acted helpfully in the cure.

Eve[3] applied the light and heat of ordinary electric light bulbs (96 candle power) to a number of cases of arthritis with benefit. Mobility increased and pain was almost entirely relieved. The limb was placed under a canopy made of blankets thrown over a cradle, and the heat raised to 250 F. The beneficial effects of the heat seem to have been increased by the bright light.

Kime[4] uses direct sunlight, concentrating it through an adjustable photographic ray filter, a plano-convex lens of 18 inches focal length and 6 inches in diameter. Behind it, ¾ of an inch distant, is placed a plain plate glass. Between the lens and the plate glass is a space for the blue copper alcoholic solution, which cools the sun's rays and absorbs all but the blue or actinic rays, which are rich in their chemical and germicidal powers. Although such a light focussed to a small point is hot, yet it can be regulated so as only to produce hyperemia, new vigor, new cell action and repair.

Heliotherapy or actino-therapy would probably be the best designation for this method of application of the concentrated sun's rays to the cure of disease; electro-phototherapy for the condensation and application of electrical rays to the same purpose.

Within my recollection, Butler in the 60's, successfully employed sunlight for the treatment of epithelioma of the skin, using for the purpose an ordinary biconvex lens.

Finsen at Copenhagen, Rikli, Koch, Strauss, Arloing

and others, deserve great credit for their experimental and practical application of the bactericidal action of the sun's rays.

Finsen has shown by his experiments that the blue, actinic or chemical rays, which include the violet and ultra-violet rays, are the only ones that have an especial influence upon animal life and are bactericidal. The red, green and yellow heat rays have no effect upon the micro-organisms. It is the actinic rays which produce sunburn, not by burning the skin, but by slight irritation which produces the pigment deposit. Finsen also experimented with the effect of rays of the sun in smallpox cases, and found that if the patient was kept under red glass and red curtains, etc., that there was no scarring. The concentrated sun's rays have been proven by experiment to be capable of destroying bacilli in a few seconds, instead of hours, and it is also claimed that a concentrated electric light in which the ultra-violet rays are in abundance has a greater bactericidal power than even the sun's rays. These ultra-violet rays in the electric light are in shorter wave lengths, while in sunlight they are of longer wave lengths; the shorter ones have already been absorbed in the atmosphere.

The actinic rays penetrate much deeper into the tissues when the latter are rendered bloodless by pressure or by ice. The passing of the ultra-violet rays through ice renders them more destructive to the tubercle bacilli from the fact that the chilling of the skin by the ice renders it more anemic, and thus gives the rays a better opportunity to act upon the bacilli. Ice is transparent to the violet and ultra-violet, but is opaque to the red and ultra-red rays. Pigmented skins and cicatricial tissue interfere with the penetration of light rays, as does also great vascularity. The skin and intermediate parts should be protected when the *x*-rays are used, but do not need protection, save from the heat, from the Finsen light. In order to retain all the ultra-violet rays (which are the most efficacious) blue sulphate of copper was

first used, as blue excludes the red rays, but now only ordinary cold running water is employed between the lenses to arrest the red rays and cool them. Finsen also used a lens of rock crystal in place of glass, in order to allow the ultra-violet rays to pass through more easily. The lamps used were from 25 to 75 amperes, since above that strength it was found difficult to cool the rays sufficiently by the use of water. Finsen's large lamps have 35,000 candle power.

In the lamps made in London by Marshall and Woods and Leslie Miller, an interrupted current is used of about 12 volts, and the sitting is prolonged from five to twenty minutes. With some of the new lamps an area of the size of a dollar can be treated at one exposure. In the sunlight baths, Finsen has his patients walk about naked. Finsen's electric bath consists of gigantic arc lights, 100 amperes, suspended six feet from the floor. Patients lie naked on couches. He uses the voltaic, instead of the incandescent, as the former contains more chemical rays. His theory is that the chemical light bath differs materially from the incandescent light baths.

If the *x*-ray can modify local tuberculosis (Muhsam, Fiorantine and others) the Finsen rays are much more likely to produce a beneficial effect.

The lamp now used in the Broca Hospital, Paris, is smaller than Finsen's and more easily handled. The carbon is made with a core of cast-iron, thereby emitting, it is claimed, three times greater amount of ultra-violet rays. The exposures only last twenty minutes, instead of seventy-five, and 30 amperes are used instead of 75 or 80. Anemia of the tissues by pressure is also not considered essential, and the application is made once in two days.

Kjeldsen's lamp is less expensive than Finsen's, and does not require specially trained nurses for its application. Lamps of 5 amperes are employed, and instead of carbon, iron electrodes are used, which are very rich in chemical, and very poor in heat, rays. It is claimed

that a lamp of 5 amperes gives the same result in three minutes that is given in an hour by the use of 80 amperes with the old apparatus, the cost being about one-tenth, and the assistants required being few. It is also claimed that tubercular bacilli, gonococci and streptococci, and bacteria coli communis were inhibited by the light in five seconds, and that anthrax was killed in thirty seconds.[5]

Widmark, of Stockholm, used but a 1,200 candle power electric light, passing the rays through water to absorb the heat rays, then by carrying the rays through a plate of glass, he excluded the ultra-violet rays and reported that under the influence of all the rays except the ultra-violet, the skin was unaffected; under the influence of all except the heat rays, the characteristic inflammatory symptoms developed. It seems probable, therefore, that the ultra-violet rays produce the known effects of light upon the skin.[6]

Erythema solare may be avoided by care and by the not too rapid use of the rays.

If the current is too strong the skin swells and redness and blisters may appear, but sloughing does not occur. Pyrogallic ointment has been used in lupus to make the skin more penetrable to the rays, and may be also useful in joint disease.

The disadvantages of the Finsen method, which will undoubtedly be lessened when the practical mind of the American applies itself thoroughly to this subject are: first, the limited area of the body which can be exposed to the ray of a single lens; second, the length of time required, and third, the large staff of special nurses that must be engaged. An area of only one and a half centimeters can be treated in an hour.

The cost of the running of the Finsen light is a serious one. A recent estimate makes the expense of a four-light lamp for a year to be $3,000.

As regards the risks, the reaction caused by the ultra-violet rays is much less severe than that following the

use of the *x*-rays; the heat rays being interrupted by a stream of cold water, there is, of course, less danger of burning of the tissues, and the tanning or sun-burning of the skin renders increasing strength possible.

King has advanced the theory that the parasite of malaria scarcely ever develops except in darkness, and that it may be the red color of the blood that favors its life, while the violet rays interfere with its evolution. His theory of the action of quinin in the cure of malaria is based upon the fluorescent properties of the drug, which act as a destroyer of the malarial parasite, and that esculin and fracsin give the blue rays. Iodin, which is not fluorescent, unites with the starchy substances in the system, forming an intense violet blue. Methyl blue, which has been introduced for chronic malaria, may also act in the blood by producing rays which are injurious to the growth of the malarial parasite. The painting of the skin with methyl blue is said to enhance the efficacy of the rays.

General Pleasanton's[7] "blue glass theory," which was lauded thirty years ago, undoubtedly had some merit. He built his sun rooms with every eighth pane of blue.

The theory advanced by Bean[8] seems reasonable that a restorative change may be effected in a pathologic cell by which instead of being destroyed, its character may be so altered that it becomes again a normal cell. Such a change may be occasioned by exposure to light, by alteration of temperature, or by some vito-chemical alteration or molecular vibration at present unknown to us. Each individual difference in rapidity of vibration of the light waves evidently has its special effect on cells. If such be the case it is not necessary that the rays should have positive bactericidal influence, but only that they possess an alterative effect.

The photo-chemical properties of sunlight and of the electric Finsen light require much further investigation, both as to their physical and their therapeutic properties.

The observation was made long ago that the course of

tuberculosis differs in brunette and blonde children. Recent observations made upon calves used in the manufacture of animal vaccine, show that the pustules do not develop as well in animals with a dark hide, but that the light-skinned ones are preferable.

Light rays cause contraction in living protoplasm,[9] but Hammer does not believe in the direct action of light on the blood corpuscles. He supposes that certain nervous elements of the skin, in connection with the pigment cells, are put in motion by the ultra-violet rays, and that this motion leads secondarily to hyperemia, inflammation and pigmentation. His experiments on tadpoles, salamander eggs, earthworms, etc., endeavoring to explain the phenomena and to study the relationship between motility of cells and monochromatic light are interesting in showing that light provokes movements in the fetus, and that this faculty must be attributed to the violet rays. White light causes sensibly less action. It is the chemical ray undoubtedly which is the special agent in influencing cell action. Electric light baths and incandescent lamps contain very few chemical rays, not, in fact, as many as ordinary daylight. They can not, therefore, possess the influence of sunlight. These electric light baths probably affect the cells through their heat rays, while a chemical light bath acts differently.

The Roentgen or *x*-rays have been used by myself, by Murphy and a number of other surgeons in the hope of influencing the tubercular process in joints and bones. As remarked in the earlier portion of this paper, it is too soon to determine results, for the reasons there set forth.

The *x*-rays have been proven to have an inhibitory influence not only on the tubercle bacilli, but also on the cholera spirillum, the prodigiosus and the colon bacillus. In the laboratory, after twenty to thirty minutes' continued exposure to the rays, many of the bacteria are killed, and multiplication ceases in nearly all. Some of the micro-organisms, however, survive. Experiments on animals do not seem to warrant the conclusions

that the same action can be expected when these pathologic cells are surrounded by living tissues. Animals inoculated and exposed to the *x*-ray have died sooner than similarly inoculated animals not thus exposed.[10]

Various theories have been advanced as to the method by which the *x*-ray energy is exerted on the cells; each theory has been succeeded by another as equally plausible, but all lack positive demonstration.[11]

The bactericidal power is apparently not due either to the heat, the fluorescent light, electricity or ozone.

In our present state of experimentation various therapeutic methods will be employed. One of these has been the alternation of the Finsen with the *x*-ray; Finsen one hour; *x*-ray, five to eight minutes. The Finsen light has less penetrating power than the *x*-ray, but the combination of the *x*-ray to destroy the germs and the Finsen to act as a curative agent seems to be most advisable. The hard *x*-ray tubes have apparently greater penetrating power than the soft. Tanning of the skin is best done by the slow process. The skin and intermediate parts should be protected when the *x*-rays are used, but do not need protection from the Finsen light, save by cooling.

The amount of irritation produced by the *x*-ray on a part depends on various conditions; the distance from the tube, the time of exposure, the hardness or softness of the tube, the cutaneous idiosyncrasy of the patient, the length of exposure and the personal equation of the experience of the operator. Undoubtedly, however, the nearer the tube and the longer the exposure, the greater will be the danger of burning.

The experiments with *x*-ray on cancerous growths, especially of the skin, and even of the deeper tissues, leads to hope that the life process of tubercular cells may be altered, and that destructive changes may be retarded, if not altogether inhibited.

The superficial effect of either the Finsen or the *x*-ray

on lupus can not be taken as a guide to their effect on deeper tissues in the joints and bones, yet we may reasonably hope that if the former can be influenced, human ingenuity will in time discover a method for the alteration of deeper tissues. In this connection it is interesting to note the recent achievements of Goodspeed that the wave or ray emanations from the human body are sufficient to impress a photographic plate. Very remarkable also are the continuous forces emitted from that new metal, radium. With the advancement of science and of medical knowledge, tuberculosis must and will be conquered.

The application both of the *x*-ray and of the Finsen light is rapidly becoming wider in its scope, but they should be used not as a substitute for mechanical and operative measures, but to supplement them, and to improve or cure the inoperable cases.

CONCLUSIONS.

1. Sunlight, fresh air and good food, together with fixation and protection of the affected joint, are the most important agents in the contest with tubercular infection.

2. Direct exposure to the rays of the sun is essential, and all hospitals should be provided with solaria or sun porches and roof gardens.

3. Patients lying in bed should have the diseased joints exposed to the direct rays of the sun, their heads and eyes being protected by green glasses or shades. The joints may be covered with blue, so as to secure easiest passage of the ultra-violet actinic rays, and local medications rich in iodin may be also employed as desired.

4. Tent life on the hospital grounds, or better, in the open pine forest, can be successfully employed through both summer and winter.

5. Sanatoria should be established for tuberculosis of the hard tissues, as well as of the soft.

6. The concentration of the sun's rays by lenses, as

suggested by Butler, Finsen and others, is of positive benefit in bactericidal influence. As final curative agents, however, the direct sun's rays are most effective. Electrical rays can be used when sunlight is lacking.

7. The Roentgen rays in the laboratory have an inhibitory power on the tubercle bacilli, and may prove useful in restraining the growth of these micro-organisms in living tissues.

8. The actinic rays and the *x*-rays are both apparently helpful in the fight with tuberculosis, but several years will be required to determine accurately their effect. They should be employed not to supercede, but to antedate and to supplement operative procedures, to assist the mechanical protection of the joint, and to increase the general therapeutic measures employed.

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