When Antibiotics Could do Everything, or Triumphant Expansion of Vacuum Therapy in Medicine Practice

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Abstract. Without applying for absolute completeness of information, in this article an attempt to present the vast popularity of vacuum therapy in various spheres of medicine is made when with the advent of antibiotics, appear, method opportunities in surgery of wounds are exhausted. The basis of this work was made by the analysis, mainly of those publications which can apply for a priority of scientific and practical realization of useful properties of a technique regardless of an impressive variety of versions of its name. The method was widely adopted in the treatment of vascular pathologies and skin diseases. It was effective in obstetric and gynecologic practice, in surgery with respect to ophthalmology, neurology and otolaryngology. Experience testifies that low vacuum is useful as all-strengthening means and a way of prevention of radiation and circulator injuries. Due to local influence by negative pressure, positive results are reached, certainly, at urological problems, including erectile dysfunction, and in sports medicine. Significant popularity of this method is connected with pathophysiological effects which are observable in vacuum therapy. They define the key to success, its popularity and justified expansion of this physical factor as treatment-and-prophylactic means in medical practice.

Keywords — double arterial hyperemia, barotherapy, vacuum therapy, vacuum massage, dosed focal vacuum, abdominal decompression, local negative pressure, LOD-therapy, LNP, LBNP, vacuum gradient therapy, interval vacuum therapy, NPWT.

I. INTRODUCTION

Even fluent acquaintance to classical monographs at the beginning of the XX century, devoted to vacuum therapy, strikes with a versatile range of pathology at which it has medical character. Regarding this, A. Bier stated: "I don't know any means which could be so successfully applied, besides so multilaterally, at the most various diseases". In the big list of diseases in which artificial hyperemia is extremely useful, problems from eyes, the central nervous system, in particular the brain, rigidity of joints of various origin, lymphostasis and other types of liquid stagnation, varicose dilatation of veins of the feet, tuberculosis, neuralgia, fever and other states are still posed. It seemed, for an artificial hyperemia in general there are no contraindications. However, paying tribute to favorite "child", A. Bier noticed: "To other can seem that I went too far. On the contrary, I don't stick to that belief that the means possessing in such degree ability to eliminate any harmful moments deserves still much bigger distribution. It is unfair to demand from one means that it cured everything; such means isn't present and won't be" [1].

All further history of use of low vacuum confirmed validity of admiration of the great German surgeon. The unfading success of vacuum therapy in medical practice promoted large-scale distribution of its influence in many branches of health care. To be fair it is important to notice that this method had the greatest value in purulent surgery and in the treatment of wounds [2-4]. Revolutionary opening all of winning antibiotics and their large-scale introduction observed from the 1940’s in medicine pressed the importance of vacuum therapy in surgery of wounds and wound infection. However, numerous past practices concerning successful use of low vacuum in pathology, received an impulse for profound studying of indisputable proofs of pathogenetic validity and extreme usefulness of this natural factor [3-5].

II. THE ANNALS OF HISTORY

Vacuum therapy for circulatory disorders

For a long time it was evident that vacuum changes blood circulation in tissues, there were attempts to apply it for treatment of various vascular diseases. In this regard, the most popular method was the method combining a two-phase pressure impact by both negative and higher than atmospheric pressure [6]. Apropos, this method is still mentioned in articles and special manuals as an alternative method of treating obliterating thromboangitis and other diseases caused by chronic arterial circulatory disorders.

Some of the most popular modifications of the device for treating circulatory disorders are Pavaex and Traxator, as well as their respective techniques. The alternating action of negative pressure in rhythmically changing doses provided an op-
portunity to improve the haemocirculation in the affected area due to the incorporation of arterial collaterals into the circulation system. Technically improved appliances were used in phlebothrombosis and its consequences (indurative edema and chronic feet ulcers), for obliterating diseases of arteries and lymph circulation disruptions, including post lymphadenectomy ones [7-8].

The Swedish scientist S. Rastgeldi (1972) shared his extensive personal experience in employing alternating pressure in the treatment of peripheral vascular diseases. In his profound treatise "Pressure Treatment of Peripheral Vascular Diseases," he presented the analysis of many publications dedicated to this issue, considered various aspects of application of the method and expressed his appreciation of it [9].

Later, the way of alternate creation of negative and normal atmospheric pressure in the device used for this purpose received the name interval vacuum therapy. Improvement of a local blood-groove at the expense of "capillaryarisation" of tissues in the form of a dilatation of the microcirculatory course and strengthening macro- and microhaemoperfusions in tissues of extremities is thus provided. This positive effect is successfully realized in vascular surgery, dermatology, in the treatment of sports trauma and in other spheres of medical practice [9, 10].

**Evolution of a pressure chamber of Kravchenko**

The lives of the scientists who were engaged in elaborating new methods of use of vacuum in surgical practice and the fate of their ideas varied greatly. The majority of the above-mentioned technological solutions aimed at creating artificial hyperemia received official recognition and were registered as patents. However, this process has not always been smooth [11]. An example of a "thorny path" one of his – **Kravchenko's apparatus** – had to follow on its way to recognition is an instructive story told by M.S. Khromchenko in the book "Doubts and Persistence" [12]. Due to certain circumstances, a civil engineer V.A. Kravchenko became interested in Bier's method and developed an apparatus producing an obvious medicinal effect in treatment of patients with profound ischemia of limbs. The idea and its technical solution were duly registered as invention application on February 23, 1933. Following the established procedure, the invention application was considered by the session of the USSR Ministry of Health (Narkomzdrav) on inventions. The conclusion was more than severe: "To reject the application and pass it to the archives as constituting no original proposal and not well-grounded".

The author did not agree to this decision and continued working on his device. He even gained support from some physicians, including a neurosurgeon academician N.N. Burdenko, who claimed: "The idea is good; the device may be used in treatment of peripheral circulation disorders. The device should allow not only lowering the pressure, but also increasing it." In spite of such a powerful support, the "creation" survived only thanks to the initiative of V.A. Kravchenko and the enthusiasm of the few doctors, who saw its outstanding positive results. They took a certain risk using the device with no official certification in their practice. Experience shows that the most favorable therapeutic effect of vacuum was observed in the treatment of long-time healing wounds.

The essence of V.A. Kravchenko's invention was that the proposed device provided the possibility to create active hyperemia. It was made possible due to two innovations: a supporting site for an arm or a leg, which held the limb in the same position during the session, and also a special pneumatic cuff sealing the system. The fundamental distinction of such a cuff from its prototypes is that while negative pressure in the chamber is created, the limb and, consequently, the superficial venous vessels are not compressed. As a result, free blood outflow is preserved. In addition, following N.N. Burdenko's recommendations, the apparatus was modified so as to allow for oxygen supply in order to increase the local hemic oxygenation of tissues.

At the same time, it was quite natural that the clinical success of the method alone was not sufficient for its recognition by the scientific community. It was necessary to explain the regularity of nascent positive results. Unfortunately, it turned out to be the weakest link in the engineer's achievements. All the attempts to provide a pathophysiological foundation for the positive effect of the suggested device seemed to be mechanistic; and each time the author was recommended to carry out a comprehensive pilot research involving participation of various specialists - pathologists, biochemists, and biophysicists.

Nevertheless, in the early 1960's, the improved samples of V.A. Kravchenko's device were tested at the Research Institute of Clinical and Experimental Medicine of the Russian Federation Ministry of Health (V.A. Miroshnichenko) and at the Ail-Union Research Institute of Physical Education (A.V. Korobkov). This testing put an end to the epopee of official recognition of the inventor's works. In 1969, 36 years after the initial filing, they were finally estimated at their true worth. The author was issued two certificates, confirming the novelty of the pressure chamber in creating active hyperemia for medical and prophylactic treatment of limbs (AS N240941), as well as the novelty of the method of treating various diseases using active hyperemia and barometrical pressure difference (AS N243787) [13, 14].

The study conducted in the Research Institute of Clinical and Experimental Surgery (at present – the All-Russia Surgery Research Center) marked the beginning of a new stage in exploration of artificial hyperemia created by vacuum. V.A. Miroshnichenko has proposed a method of treating obliterating vascular diseases of limbs named "double arterial hyperemia". The principle of its functioning is that initially oxygen is pumped under pressure into V.A. Kravchenko's chamber, which leads to the increase in tissue respiration rate. As the pressure goes back to its initial level, absolute physiological reactive hyperemia is registered. At the final stage, negative pressure is created in the chamber by artificial increase of hyperemia in the affected tissues [12].

A new direction in the use of vacuum owed its emergence to
a complex research organized by the All-Union Research Institute of Physical Education (USSR) and investigating the effect of negative pressure on the restoration of sportsman's body productivity after intensive trainings and competitions, as well as after certain sport traumas involving the musculoskeletal system [15]. For creating the vacuum, Kravchenko's pressure chamber was used. Various physiological effects were noticed under these circumstances, including the analysis of the dynamics of hemic (erythrocytes and hemoglobin content in peripheral circulation) and hemodynamic characteristics [16].

V.A. Kravchenko's idea was further elaborated upon in further studies on treatment of obliterating atherosclerosis of blood vessels of the leg. For example, I.E. Rozovsky (1970, 1972) suggested several modifications of the vacuum pressure chamber, which were granted inventor's certificates [17, 18]. Studies showed that comprehensive therapy, including pressure effect, positively alters the blood circulation in the affected limb and influences the entire body [19]. The method proved to be efficacious not only clinically, but also financially. The preliminary estimate of economic costs of using V.A. Kravchenko's pressure chamber on an outpatient basis has confirmed its considerable profitability [20]. Eventually, over the recent decade "barotherapy" – the method of treatment based on pressure alternation using V.A. Kravchenko's apparatus – has become classical, and manuals on physiotherapy assign enough place for its description.

It is appropriate to mention here another issue related to the application of such devices. They were used for the prevention of thromboembolic complications during surgery and in postoperative periods. The matter is that hypo-dynamic condition typically developing in patients due to surgical intervention, the so-called "muscular pump", stops functioning. As a result, there occurs venous congestion, which is considered to be a risk factor for thromboembolism. A special device applied to a limb was used to rhythmically change the pressure, imitating the function of a "muscular pump", and this way the local blood circulation was maintained on the proper level. In practice, this idea proved to be very successful [21, 22].

### Polyvalent opportunities of vacuum massage

Another interesting field where vacuum has found application is therapeutic massage. Its first records date back to the beginning of the 20th century. At that time a number of special appliances that enabled realization of the idea received official patents [23, 24]. Besides, vacuum apparatus and vibrators that found their application as effective massage tools in dermatological diseases, were designed [25]. Many years later the method became the focus of attention again. Several devices for vacuum massage of the head were proposed [26, 27]. The vibrating effect produced on the skin proved to be curative in treating alopecia, headache, and other disorders.

Elaborating on the massage techniques for different parts of the body using the medical cupping-glass (the so-called "trigger point vacuum therapy"), scientists began to consider this method as a constituent of reflexotherapy [28]. It is assumed that vacuum static and vacuum kinetic massages are no less efficient than acupuncture, classic, trigger point and segmental massage, physiotherapy and pharmacotherapy, and in some cases can substitute all these methods combined. The method of vacuum massage is used to eliminate obesity and "cellulitis" [29, 30]. It has gained recognition in comprehensive treatment of certain respiratory and vocal apparatus, related to the patient's professional activity [31].

Developing the idea of such therapeutic massage, P. Mikhailichenko (2000) worked out the method of "vacuum gradient therapy" wherein the effect is obtained through the exposure of deep tissues to negative pressure. The author provided extensive indications for the use of vacuum in therapeutic and preventive purposes, from internal diseases and up to musculoskeletal pathologies and cosmetic problems [32].

The option of physiotherapeutic influence in which the successful combination of two factors of laser therapy and vacuum massage takes place is very curious. According to the authors, the similar way of treatment is especially useful after surgery, including those concerning sports trauma. As a result, laser and vacuum massage accelerates the processes of tissue regeneration, liquidates development of stagnation in various bodies and tissues, prevents emergence of contractures and atrophy of muscles, and as repeatedly mentioned earlier, normalizes blood and lymphatic evacuation in vascular pathology. A final important component of this method is - normalization of the psychoemotional status of patients with neurosises [33].

An exotic experience is observed in the implementation of low vacuum to various pathological processes in the eye clinic. To this day, the use of indirect (through the ages) and direct (directly through the cornea or conjunctiva of eye) eyeball massage. The first of these options is considered to be more secure, and because the strike found the active supporters in the treatment of many eye diseases. Historical aspects of this problem in presented in detail in the work of V. Aleksakin'a [34]. Without forgetting the opinion of A. Bier on the possibility of use of an artificial hyperemia in this sphere of medicine, it is necessary to pay tribute to scientific and practical researches I.A. Veller (1971) with special attention to the use of the local barotherapy combining local variable influence by negative and positive pressure upon an affected eye [35]. The main positive effect of this technique was shown in the form of the expressed increase of oxygenation of liquid in eye cameras. Such barotherapy is recommended at violation of the accommodation, progressing short-sightedness, asthenic states and violations of visual working capacity, the keratitis, acute impassability of retinal arteries, dystrophies of the retina, atrophy of an optic nerve, open-angle glaucoma and in ambylopia.

### Potential of measured focal vacuum in clinical practice

The steady expansion of the field of vacuum application has promoted a great number of studies examining the use of this physical agent in dentistry. The positive changes in the development of parodontosis as a result of vacuum massage or dosed vacuum treatment have been reported. These changes were
determined not only in clinical studies, but also found in experimental morphological verification. It has been proved beyond doubt that with the application of different modes of vacuum therapy, negative pressure produces different effect on protein and mineral metabolism in parodontium tissues [36, 37].

In order to enhance the therapeutic effect in treatment of a number of dental inflammatory diseases and inflammatory dystrophic musculoskeletal pathology, the "electro-vacuum method", or "medicinal electrophoresis under vacuum" as well as "vacuum d'arsonvalization" method were developed. It is believed that the combined action of vacuum and directed electron stream facilitate penetration of medications into the soft tissues [38-40].

The majority of scientists have studied specific issues in various aspects of vacuum therapy. It was proved that the dosed focal vacuum alone as well as in combination with medications is successful in treating rheumatoid arthritis, a number of dermatological and neurological diseases, including acne vulgaris, neurodermatitis, psoriasis, dermatosis, lichen ruber planus, peripheral nervous system diseases, and spinal osteochondrosis [41-44].

Here is another example of longevity of vacuum in medicine. Already at the beginning of the 19th century, artificial hyperemia was very popular as a therapeutic agent in otology. Muck (1905), Spiess (1905), Prym (1905) and Sondermarm (1905) used original devices of their own design for curing the diseases of tonsils, nose, and paranasal sinuses [1]. Years passed, and otorinolaring specialists recalled the method of vacuum therapy and started applying it in treatment of chronic tonsillitis again [45]. In turn, the ability of vacuum to mechanically remove purulent exudate from the inflammatory focus was taken into consideration in the design of "YAMIK" - sinus catheter used for treating Highmoritis [46]. This property of vacuum effect has also been successfully realized in practical otology in the treatment of sensoroval deafness, otosclerosis, vasomotor and allergic rhinitis by other researchers [47].

Vacuum therapy in surgical practice

Experts in traumatology and orthopedics have shown recurrent interest in vacuum as a physical factor. There have been rather interesting publications devoted to the use of a vacuum apparatus for prevention and treatment of the syndrome of long-lasting compression of soft tissues of the limb – "the crash syndrome" [48]. However, the experience of using vacuum in the comprehensive treatment of fractures turned to be more prominent. For example, in primary surgical debridement of open bone injuries, the damaged tissues were successfully treated by vacuum, which considerably reduced the microbial population density in the area [49].

It is remarkable that explaining the effectiveness of hyperemia, A. Bier (1908) brought in his monograph numerous opinions on "the increased nourishment" of tissues in the area this therapeutic factor was applied to. He assumed that active hyperemia can stimulate regenerative processes in a damaged bone and illustrated his idea with clinical observations. Further development of this idea has found solid support in a number of studies, which provided scientific validation to the fact that vacuum therapy applied to a fractured area enhances reparative reactions in the bone tissue [50, 51]. H. Willenegger has obtained similar favorable conditions for ossification by using antibacterial irrigation drainage, which was efficacious even in infected fractures of tubular bones [52].

Vacuum therapy has also been successful in comprehensive treatment of chronic recurrent fistulous osteomyelitis. V.S. Kononov has introduced an authentic technique of closed treatment of hematogenous osteomyelitis in children. He advocated vacuum irrigation drainage of the intramedullary canal using two tubes inserted into the canal through cutters [53].

Vacuum therapy has found its application in abdominal surgery as an effective remedy for duodenal stump fistulas after gastric resection [54]. In addition, low dosed negative pressure is known to be an integral attribute of the aspiration-irrigation method applied in treatment of intestinal fistulas [55, 56]. In the light of the above, listing osteomyelitis and intestinal fistulas among counter-indications for vacuum therapy application seems to be somewhat odd [57]. As can be seen from the publications, practical experience contradicts such assertions.

A landmark in the history of thoracic surgery has the idea G. Bülau (1891) to use extraction draining of pleural empyema [58]. He received strong praise patriarch of purulent surgery V.F. Voino-Yasenetsky: "Bülau's permanent syphongage is an excellent idea and it can be an indispensable treatment method in many cases" [59].

A considerable contribution to the solution of the existing problem of treating purulent pleurisy was made by G. Perthes. In 1898 he invented a water-jet suction whereby pus was removed from the pleural cavity, and the constant negative pressure maintained in the cavity made for expanding the lung [60]. The aspiration treatment of pleural empyema has earned high appreciation in V.V. Lavrov's dissertation (1912) [61]. Later, the medicinal effect of negative pressure was realized through the "high vacuum" method that was successfully employed in treatment of chronic pleural empyema [62]. We should mention that the aspiration method of treating suppulsive pleurisy enjoys extensive endorsement in many modern manuals on thoracic surgery.

Vacuum therapy in obstetric-gynecologic practice

The history of vacuum application in obstetric-gynecologic practice is rather interesting. The vacuum extraction method in medical abortions is widely-known. However, the potential of the method in this field of medicine has been realized much more extensively. As early as at the time of universal fascination with venous hyperemia, Eversmann (1905) and Rudolph (1905) used it as a therapeutic agent in vaginal inflammatory pathology [1]. As can be seen from the publications, half a century later, vacuum therapy of dry-air cupping glasses regained their popularity in gynecology, and the incredible...
healing power of vacuum was successfully applied in treatment of cervical erosion [63].

At the same period, another method of treating inflammations of female internal genitals that also used negative pressure – "abdominal decompression" – received experimental support. Its pathogenetic efficiency was firmly substantiated in clinical practice [64, 65]. A little later, the method of "vacuum and electrovacuum therapy" was elaborated, successfully tested, and approved for implementation in patients suffering from chronic recurrent uterine appendage appendicitis [66].

In search for solution to the infertility problem, certain researchers used dry-air cupping glasses to eliminate ovarian dyscrinia as one of the major pathogenetic obstructions to conception. In treatment of infertility caused by inflammatory diseases of female genitals, the above mentioned method of abdominal decompression was successfully applied [67, 68].

The results of the study performed by V.A. Kulavsky, who developed an original system of obstetrics methods making use of local vacuum [69], proved that dosed negative pressure applied in certain operating modes relieves pain during the delivery, are worthy of notice. The method proved to be particularly useful in obese women [70]. The same opinion is expressed by professor O. Heyns, who used the effect of abdominal decompression in obstetric practice. Not only did it facilitate the delivery, but also promoted faster physical and intellectual development of the newborns, they began to walk and talk earlier [71].

The presented data were firmly validated during the experiments carried out under the supervision of A.V. Korobkov at the P. Lumumba Peoples Friendship University (Moscow). It consisted in placing a hermetic chamber on the abdomens of pregnant mice and rats and creating "abdominal decompression". The research showed considerable acceleration in the development of the fetus exposed to the local negative pressure as compared to the control animals. At the same time, their cerebral structures contained much more RNA molecules responsible for protein synthesis and, consequently, for reparative reactions [12].

It is established that the created difference of barometric pressure promotes activation of transmembrane metabolism [72]. Positive change of a blood-groove in a uterus is proved to reorient the blood circulation, and reached thus "the effect of inflow" remains within at least 24 hours after single influence. This circumstance allowed to visualize indications to use of a method of an abdominal decompression for prevention and treatment of fetoplacental insufficiency, including owing of late gestosis. It is clinically proved efficiency of a method in prevention of not incubation of the pregnancy, a fraught delay of prenatal development of a fetus, and also at treatment of already developed its hyptrophy and a hypoxia [73].

**Clinical effects of local negative pressure**

For a long time curative properties of vacuum therapy were used in urological practice. It is useful to remember, that the creation of local depression round the penis placed in a cup, for the first time was approved by J. King for treatment of violations of an erection in 1874. In Russia I.V. Zabudovsky (1909) from which easy hand there was a specific name of a method – LOD-therapy and its synonyms – a fallodecompression and pneumomassage became the popular writer of this technique [74]. Hereafter, working on technical improvement of the apparatus, J.F. Webb (1921) offered a whole series of devices, which bore only partial resemblance to "Junod's boot" and the likes. The method of treatment received a specific name "Vacuo-Thermic-Body-Treatment". The author recommended it for treating the consequences of congestive conditions of male genitals, including varicocele and orchitis, as well as varicose veins of legs and "chirospasm" [75]. Apparently, from that time it is possible to conduct chronology not lost the relevance and now scientifically reasonable way of disposal of impotence by means of vacuum therapy.

In the early 1960's, new terms denoting the effect of negative pressure on the leg – "leg negative pressure (LNP)" and on the lower body – "lower body negative pressure (LBPN)" first appeared in the special literature. Such studies were extremely topical and met the requirements of that period. By studying the peculiar condition of the main vital organ systems in unusual circumstances, scientists came closer to the understanding the changes occurring in a biological organism during the space flight. This allowed for the opportunity to use the idea of local negative pressure in astronauts' training, thus helping to get prepared for the negative consequences of long-lasting stay in a state of weightlessness [76-78].

Later on, by studying the effects of vacuum on human body, A.V. Korobkov created a theory of "the effect of local negative pressure" (LNP). Following this theory, he came to a conclusion that this physical factor triggers strong physiological reactions. It is aimed at maintaining the integrity of the body and increases the natural level of protective mechanisms in tissues [79, 80].

The results of numerous studies were presented at least at two scientific conferences, devoted to physiological and clinical effects of vacuum on the human body (Moscow, 1972, 1976). Two collective volumes on the subject edited by professor A.V. Korobkov were published in 1972 and 1974 [79, 81]. They presented the obtained clinical and experimental findings and attempted to provide a scientific foundation to the effectiveness of this method in clinical practice.

Further interest in vacuum therapy as an effective method of treatment and prevention of various pathologies didn't weaken. On the contrary, on a number of positions, remaining classical, this method increased its expansion to different spheres of medical activity [4, 5]. There were, apparently, exotic scopes among which it is possible to specify its uses as means of complex prevention beam diseases. It was established that local decompression promotes intensity of a capillary blood-groove, improves the functional condition of the microcirculatory course that creates necessary conditions for adaptation of blood supply to the requirements of tissues for delivery of oxygen, nutrients and their unloading from the final products of me-
III. CONCLUSIONS

In conclusion, we would like to note that vacuum as a physical factor has stirred great popularity in many fields of medicine. Its main purpose was either the direct or indirect reduction of the inflammatory response, as well as improvement of the circulation regarding various vascular pathologies. The only exception was the studies of the effect of vacuum on the human body in space and that acquired a somewhat different, practical significance. The centuries-old experience of using low dosed negative pressure shows that "the tool used extensively by nature" can be, and actually is an effective therapeutic method when in the hands of a wise physician.

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