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Igor V. Venin Founder of Biphasic Waveform Defibrillators

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Abstract

Igor V. Venin since 1966 and up till now has been an outstanding engineer of the Soviet Union and Ukraine, who has dedicated all his life to defibrillators development. Under his guidance 16 models of DC defibrillators with different waveforms, including the world's first defibrillator with biphasic waveform (1971) have been developed and put into commercial production.

Keywords

History of Defibrillation, World's First Biphasic Defibrillator, Gurvich-Venin Biphasic Defibrillation Pulse

1. Introduction

The second half of the XX century was the epoch of tremendous growth of electric heart defibrillation. In the USSR electrophysiologist Naum L. Gurvich [1] and electric engineer Igor V. Venin [2] contributed considerably to the solution of this problem. Venin was born in 1938 in Primorski Krai (Russia). In 1964 he graduated Lviv Polytechnic Institute (Ukraine) and started working as an engineer and since 1970 as a senior research fellow and then Head of Laboratory of Lviv All-Union Research and Design Institute of Electronic Medical Apparatus (NPO REMA). Since 1998 up to the present moment Venin has been in charge of a research group of engineers in Lviv (Ukraine). The main direction of this group is to work out defibrillators with biphasic pulse of different

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kinds. All his career of a scientist can be divided into 3 main stages.

2. The First Stage of Career (1966-1967)—The Construction of Monophasic Waveform Defibrillator

The first defibrillator which was developed in 1967 under the guidance of Venin (ID-66) differed from the first in the world monophasic waveform defibrillator of "the system of N.L. Gurvich" (ID-1-VEI, 1952). It was of a much smaller size and weight (30 and 22 kg correspondingly).

3. The Second Stage of Career (1968-1990)—The Construction of the First in the World Biphasic Waveform Defibrillators

In 1967 Gurvich and Makarychev on the analysis of experimental data hypothesized that two phase pulse with equal amplitude of both phases (symmetric biphasic pulse) can reduce the effective current force two times in comparison with monophasic pulse [3] [4]. In connection with it Venin and co-authors worked out a circuitry of forming biphasic quasi-sinusoidal pulse with any prescribed stable relationship of amplitudes of the first and of the second phases [5]. Together with Gurvich and his colleagues (Tabak and Bogushevich) Venin participates in experimental studies on animals to optimize the main parameters of biphasic pulse in the Laboratory of General Reanimatology of the USSR Academy of Medical Sciences, Moscow. In 1969 the upper limit of the second phase amplitude was established (about 65% of the amplitude of the first phase), which secured the obvious advantage of biphasic asymmetric quasi-sinusoidal pulse in comparison with monophasic pulse (Edmark pulse), and also biphasic pulse with equal amplitudes of both phases [6] (in 1995 in the experiment on dogs the optimal amplitude of the second phase of biphasic quasi-sinusoidal pulse was established, which is about 55% of the first phase [7]). Simultaneously Gurvich and Venin determined the optimal length of the first phase of biphasic pulse, which is about 5 ms. In 1971 Lviv Plant of Medical Electronics (REMA) launched serial production of the first in the world defibrillators (DI-03 and DKI-01) with biphasic asymmetric quasi-sinusoidal pulses (**Figure 1**). Both apparatus with stable biphasic pulse duration were developed under the direction of Venin and they depending on the transthoracic impedance (TTI) discharged not more than ~140 - 200 J on the patient. Later the pulse was named after its authors—the Gurvich-Venin pulse. In 1974 biphasic pulse was registered in the USSR as a standard pulse for cardioversion and defibrillation [8]. The results of the experimental study of comparative efficacy and safety of biphasic and monophasic pulses were published in Resuscitation journal in 1980 [9]. The article aroused a great interest of European and American specialists who dealt with developing defibrillators. So in 1983 O'Dowd wrote in his review the following: "If such results can be verified, this would be the most significant development in defibrillators since the advent of the Lown waveform" [10]. In 1988 Schuder *et al.* [11] confirmed in their experiments on calves the evident advantage of biphasic quasi-sinusoidal pulse over monophasic pulse. In 1990 Venin and employees of Institute of General Reanimatology, Russian Academy

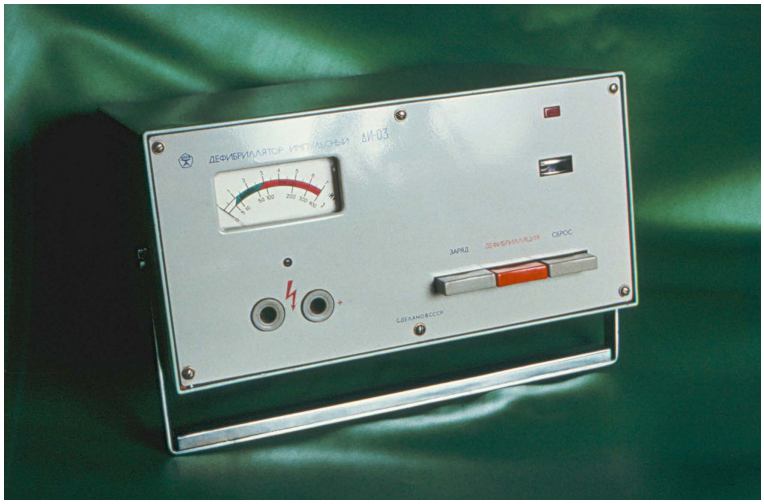

Figure 1. The world's first biphasic waveform defibrillator DI-03 (USSR, 1971).

of Medical Sciences were invited to Physio-Control Corporation, USA (**Figure 2**). The first clinical research studies of efficacy of Gurvich-Venin pulse, during sudden cardiac arrest, caused by ventricular fibrillation (VF) were published in 1994 and then 1997-2003 with the analysis of dose dependant success of low-energy discharges in eliminating primary and secondary VF [12]-[14]. The first clinical research studies of the efficacy of experimental defibrillator with Gurvich-Venin pulse, developed in the USA, were published in 1995 [15]. The first serial defibrillator with biphasic truncated exponential pulse (ForeRunner AED) was produced in the USA in 1996 (25 years later than in the USSR) [16].

4. The Third Stage of Career (1990 - Present)—The Construction of Current-Based Biphasic Waveform Defibrillators

The third stage (1990 - present)—the construction of current-based biphasic waveform defibrillators, providing stable value of the current, set by the operator. It is generally thought that current of enough power should go through the heart, capable of depolarizing the critical mass of myocardium for successful defibrillation. As TTI of patients is in a broad range, the use of the established method of discharge doze gradation according to the power of energy is not physiological descriptor of defibrillation. At the same time defibrillation based on stable current levels is the best physiological criterion of its dose [17] [18]. The first transitional model of incomplete "current" biphasic defibrillator DKI-A-01 was developed by Venin and his colleagues in 1991. Due to technical difficulties the authors were not able to provide steady power of current of maximal discharge electricity in treating patients with high TTI. Therefore the value of maximal discharge was calibrated not by the amplitude of the current but by the power of energy (190 J). In the next three models of "current" defibrillators this technical problem was successfully solved. In 2010 Venin and his colleagues (Redko and Serikov) suggested using stepwise biphasic quasi-sinusoidal pulse (**Figure 3**) instead of "smooth" for defibrillation. The replacement of the classical Gurvich-Venin pulse by the stepwise one allowed increasing efficacy of low energy discharges and reduces defibrillator weight from 8 to 5.5 kg. According to the computer simulation of the exposure of the first phase of biphasic pulses on cardiomyocyte membrane the stepwise quasi-sinusoidal pulse has a lower current intensity threshold values, causing excitation of cardiomyocyte membrane than the classical quasi-sinusoidal Gurvich-Venin pulse [19].

Figure 2. The working meeting in the USA, March 1990 (Redmond, WA, Physio-Control Corporation). From L to R Dr. G.G. Ivanov, Dr. V.N. Semenov, director of Institute of General Reanimatology of the USSR Academy of Medical Sciences, Dr. V.A. Vostrikov, I.V. Venin (NPO REMA), Gilbert W. Anderson, Physio-Control Corporation president.

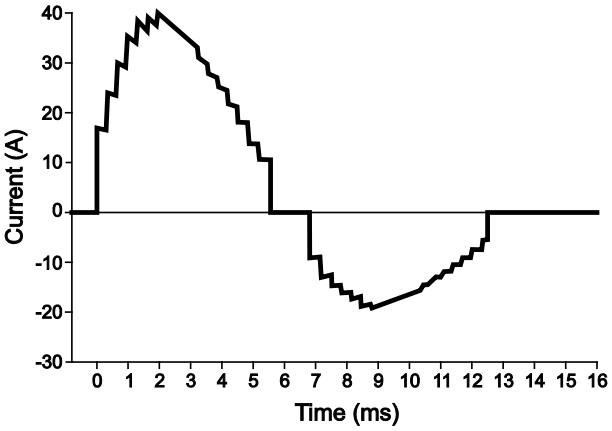

Figure 3. Biphasic stepwise asymmetric quasi-sinusoidal pulse waveform ("DKI-N-02 St" current-based defibrillator, current amplitude 40 A, TTI 50 Ω, energy 200 J).

5. Conclusions

On the whole from 1966 till 2014 under the direction of Venin 16 models of defibrillators were developed and went into commercial production: one with monophasic and 15 with biphasic waveforms, 6 out of them "current-based" with biphasic waveform of 3 kinds: quasi-sinusoidal, truncated exponential and new stepwise quasi-sinusoidal. It all makes about half of all developed and puts into production defibrillators from 1952 to 2014 in the USSR, Russia and Ukraine. Besides it, Venin worked out apparatus for short-term electrical anesthesia during conducting electrical cardioversion of tachyarrhythmias (ELITAN-01). The results of years-long researches carried out by Venin and coauthors are represented in 3 standards, 6 patents of the USSR, 7 patents of the USA, France, England, Finland, in 22 articles and 6 abstracts.

In conclusion we would like to say that at present time Venin is probably one of the few highly qualified professionals, who have fully devoted more than 48 years of his life to developing of innovative defibrillators.

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