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TRANSLATION

EFFECT OF IONIZING RADIATION ON THE HEART
REACTION OF THE HEART IN NORMAL CONDITIONS TO RADIATION

By

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FOREIGN TECHNOLOGY DIVISION

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EFFECT OF IONIZING RADIATION ON THE HEART

REACTION OF THE HEART IN NORMAL CONDITIONS TO RADIATION

S. G. Antonyan

Together with previous investigation, pointing toward the radio resistence of the cardiomuscle [84], a great number of report appeared, causing considerable morphological, biochemical [85, 86], a functional displacements in myocarditis in response to the action of ionizing radiations.

A trophy of muscular tissues (fibers), granular degeneration of muscular cells of myocarditis at therapeutic irradiation was noticed by Schweitzer Ye. [85]. A. S. Vartin and Ye. A. Pokhl[99] detected necrosis, fatty degenerative infiltration in the heart after local radiation of the thoracic area. Numerous investigations showed, that various branches of the heart react unevenly to radiation [62, 75]. As is pointed out by J. Ross [83], the zone of necrotized heart muscle stretches with a radius of 3.8cm around the source of radiation. But general dystrophic changes are considerably expressed in these sections, where greater vascular harms were observed. Deep degenerative changes in the heart all the way to the disappearence of muscular fibers were detected by A. A. Tibaudyu and V. L. Mattik [97]; A. Verteman [100] (Werthemann). Opinions about the degree of radiosensitivity of the myocarditis to various dosages of radiation are contradicting. A. Desjardings [66] assumes, that the heart muscle can be harmed only when high radiation dosages are used.. Microscopic investigation of Yu. I. Arkusskiy and K. G. Volkova [3] detected a complete absence of any expressed changes in the cardio muscle and in its stroma, and also in artioventricular system of the ganglions. In the heart muscle of mice, rats and guinea pigs afted X-ray radiation with a dosage of 4NED no special changes were discovered [20]. Analogous data were obtained by L. M. Shabad [53]; I. M. Zhdanov [18].

Inconsiderate changes were notices during the radiation with a dosage of 3000-6000 r. Recently Smith, Parker, Calvin and Henry [91] confirmed similar results during the action of small dosages of gamma-radiation (30-100r) on dogs. Others (77) detected no disruptions in the heart muscle and coronary vessels within 2-14 months after exposure (7500r). J. E. Leach [78] established, that only at 10,000 r appear microscopic displacements in the myocarditiz. The observed disruptions are bound by the author with the direct action of X-rays on the cardio muscles.

After total irradiation Ye. Stefanov 91 (92) also detected no changes in the heart muscle. D. S. Sarkisov [45] detected hemodynamic and dystropjic disruptions in the myocarditis and also in the intra-heart nervous apparatus of the heart and in intramural gangions of the vegetative nervous system. Greater importance in this case is attributed by the author to the disruption of nervous-reflector system. Greater importance in this case is attributed by the author to the disruption of nervous-reflector mechanisms, controlling the activity of the heart. But other investigators [102] have not detected any histological changes in the heart. N. A. Krayevski [23] discovers numerous hemorrhages, whereby the development of hemorrhages is more evident, the more the radiation symptoms are expressed and the longer it lasts. The most frequent zone of formation of hemorrhages appears to be rear wall of the auricle and the area of the left ventricle. A similar picture of pathological changes is given by V. B. Zayratyants [19]. Dystrophy of muscular fibers all the way to necrosis fo the heart muscles of rabbits were discovered by S. I. Teplov; V. S. Sverdlov; B. F. Korovin [50] at a general (500-1200 r) and local action on the area of the heart (200 r) of x-rays.

Data of investigations by A. Jones and J. Wedgwood [74] in clinic and in experiment show that radiosensitivity of the heart appears to be low and that structural changes in myocarditis are noticed only at sufficiently higher ionizing radiation dosages. The discovered degenerative changes in heart muscle is explained by the authors by the degree of vascular harm to the heart. K. K. Berdjis [61] showed, that heart hypertrophy is detected in a majority of animals, which obtained 3 x 350 r of total radiation, in all animals, which obtained 900 r of local radiation per area of one or both kidneys. Coronary vessels were relatively resistant to the action of x-rays. In the heart muscle of rabbits, subjected to a volume of radiation in dosages of 200-1000 r, s. Kosmider: Z. Szezurek; Petelenz [76] detected degenerative and proliferative disturbances, and also a reduction in content, which in the opinion of the authors, depends upon the injury of the testicles of myocarditis fibers.

In this way on the basis of data with respect to morphology of radiation injury of the myocarditis, can be noticed the considerable contradiction of facts. Some investigators detected considerable disturbances in the heart muscle [85, 91, 62, 19, 50], other under the very same physical conditions of radiation detected no disturbances in myocarditis [18, 20, 92, 66]. If the thesis of radioresistance of the heart muscle originated on the basis of morphological investigations then functional disturbances, on the contrary, discovered a considerable injury to the heart during the action of relatively low dosages of ionizing radiation. Tsiwidis [94] after internal radiation detected deformation of teeth P.R.S.T. of the electrocariogram and a reduction in heart frequency of systole. Others [73] after local irradiation of the cardio area with x-ray detected no electrocardiographic changes. Clinical data [68] at roenntgenotherapy of thoracic organ were perfectly negative. But F. V. Hartman and others [75] after x-ray radiation in a dosage of 1ND of the forward thoracic wall of animals detected an inversion of the tooth T, a reduction in voltage QRS. A change in EKG and in the rhythm of the heart were noticed by R. Levy and R. Golden [80], Gabriel G. [69], who exposed to x-rays in dosages of 620 r the n.vagus and n. symathicus, which deformation of EKG and an increase in tone of n. vagi. However at direct radiation of the heart with greater dosages the changes in EKG bore a considerable but short nature. J.E. Gendraw [70], at radio-and roentgen therapy (165-185kv; 25 ma, 2mm, 50 cm) of the thorax of people noticed an equilibrium of the tooth P, ventricular fibrillation, reduction of QRS voltage, inversion of tooth T. P. Eggers [67] described a ventricular fibrillation, depression of tooth T, and also paroxysmal tachocardia and extrasystole among the patients. E. Stefanov [92] noticed the most expressed change in EKG at the 2-3 diurnal period after radiation. The author concludes, that the EkG method is of little use for the analysis of thin changes in an injured organism.

DEformation in EKG were also noticed by others [82] at direct irradiation of the heart, furthermore, the patients displayed flickering of auricles, left ventricle extrasystolia, considerable reduction in voltage of tooth T [4]. According to others [3], changes in EKG remain for 10-12 days, after which the EKG returns to normal. Yu. I. Arkusskiy, M. M. Mints; and K. N. Chochiya [4] emphasize, that direct illumination of the heart area during roentgeno-therapy and radiotherapy more often and more frequently causes sideways deviations of EKG, than radiation of the peripheral sections of the body. They have also notice during the irradiation of the neck area sharp displacements in vegetative nervous system, change in its regulating role with respect to the cardio-vascular system. The changes in EKG are considered by the authors as an expression of disruption of heart metabolism during irriation of the vegetative nervous system and its elements, accompanied with the separation of adrenal like and choline like substances.

During the highest point of radiation illness A. Mozkhuzin and I.P. Peymer [34] observed on rabbits and dogs an elongation of the interval, Q-T, increase in systolic index and other disruptions in EKG are explained by them by the difficulty in the restoration processes taking place in the heart. According to S. I. Teplov; V. S. Sverdlov; and B. F. Korovina [50] electrocardiographic displacements in the irradiated organism depend upon the destruction of oxi-reduction processes. Recently E. Senderoff and others [88] after radiation of a dog's heart with x-rays in dosages of 1300-3500 r discovered no electrocardiographic displacements; but A. Jones and J. Wedgwood [74] consider, that in contrast to structural disturbenaces in the myocarditis EKG changes at more moderate radiation dosages, than it is observed in experiments of certain investigators.

The important role of the nervous system in disruptions of heart activities during irradiation of the brain is mentioned by V, A. Fanardszhan and K. A. Kyandaryan and others [51, 52] at multiaxial roentgenokymographic investigation of patients.

A very important fact of detecting by the method of electrocardiography of deep dystrophic processes in myocarditis in the absence of morphological changes. This speaks about injuriness of molecular changes. But the latter may also not take place at reverse nature of changes in the myocarditis. In this respect become understandable these various data, which appear during the investigation of the morphology of radiation affection. L. Gempel'man, L. Liske; D. Gofman [11] at nuclear reactions at Loas Alamos labs noticed among hospitalized patients an anemic noise and deformation of EKG (reduction of tooth T and segment S-T). S. P. Grozdow (16.17); I. A. Pigalev; B.B. Moroz; S. P. Grozdow [40] bind the change in EKG and previous disturbances in the activity of the cardio-vascular system with the ejection of adrenaline, to changes taking place immediately after the radiation, characteristic for myocarditis, which is in state of hypoxia. This point of vision is confirmed also by V. I. Ryabov [43]. It is known that adrenaline, boosting the oxidation processes, causes anoxia in the muscle of the heart [71, 72, 44]. Slight changes in EKG were noticed among patients at roentgenotherapy of the heart area [97, 64] due to malignant formations.

During local determination of O_2 stress in myocarditis of rabbits (polarographic method) irradiated with gamma-rays Co^{60} in dosages of 800 r is noticed an increase in 02 stress in myocardis within 3 hours after radiation. After expiration of the first diurnal periods the value of the O_2 stresses become normalized. Within three diurnal periods in a part of the animals O_2 stress is maintained within normal limits, they continue to increase in a majority of animals [1,2]. The detected increase in O_2 stress when comparing with data of blood pressure and coronary bleeding affirmation is given about the deterioration in O_2 need by the myocarditis (depression of tissue oxidizing processes) in vivo experiments. The oppression of oxidation-reduction processes in the irradiated organs (experiments in vitro) is indicated by Baron [59] data, Van Bekkum and other [96], L. V. Mytarevaya [36] and also by experimental results (on brain tissues in situ) A. D. Snezhko [48].

On the change of metabolism in the myocarditis, as well as the synthesis of individual sarcoplasmic albumina of oxidizing oxidation phosphorylation ferments is pointed by S. S. Oganesyan and T. S.

Zaminyan [38] who discovered a disruption in quantitative synthesis of water soluble myocarditis albumina among irradiated rats.

In this way, literature data do underline the complex mechanism of functional changes in cardio-vascular system among irradiated animals, which includes displacements in the nervous and endocrinal regulation,as well as in the very myocarditis.

A brief increase in the tonus of this or any other branch of vegetative nervous system with subsequent stable reduction of same after illumination was observed by M. I. Nemehov [37]. Further was remarked a reduction in tonus of the sympathetic and stray nerves as well. This is indicated, for example, by A. Zuppinger [10] investigations, who showed, that the reaction to radiation can be changed under the effect of vegetative nervous system, and R.M. Lyubimova [28] noticed phase changes in cortical neurodynamics. The author assumes, that hardest disrupted is the symphatic branch of vegetative nervous system. Greater resistance possess centers of parasympathetic innervation [29]. In the first days after introducing the radioactive substance I.A. Pigalev[39] noticed in the organism an excitation of the vascular motorial center and development of retardations in much later periods. Simultaneously was noticed the excitation of the stray nerve, appearance in the blood of acetylcholino like substances, which as result gave a depressing effect. This is also attested by data of K. Onkelinn [81]. A. V. Lebedinskiy [24] assumes, that in conditions of an irradiated organism occurs a change not only of the functional state of higher branches of TSNS and in first place of subcortex formations, but also a change in receptorial systems, responsible for the origination of changes in reflectorial regulation of blood circulation. Participation of vegetative innervation in organismal reactions on the action of ionizing radiation is realized by ordinary reflection mechanisms [25]. Under the effect of radiation was discovered [22, 26] a reduction in irritation threshold of the Gering nerve, increase in intensity of depressor reaction. The observed changes carried a phase character, which is also indicated by electrophysiological investigations of M. N. Livanov [30]. A phase state in the condition of cerebral cortex is parallel to the state of peripheral organs [31].

Considerable disruptions in hypophysial-adrenal system at radiation illness, affecting the activities of the heart, were noticed by L. F. Semonov [46]. According to the author during the radiation illness the hypophysial adrenaline system experiences subsequently an activation phase, phase of depression and second phase of active function. A considerable amplification of brain layer secretion of adrenal glands was noticed already in the first hours after irradiation [38]. During this period was noticed an increase in the content of adrenalin in the blood of rabbits [57, 32, 33]. As is assumed by A. V. Lebedinskiy [27] the ejection of adrenaline in the early period of radiation illness may appear to be the cause of the connection of neuro-endocrinal mechanisms into the reaction of the mechanism to the radiation effect.

Reaction of functional changed heart to radiation. A greater role in the degree of heart illness is played by the state of the nervous system of the animal at the moment of radiation, as well as the state of the myocarditis.

In this respect are of considerable interest these investigations, which study the disruptions of the cardio-vascular system in response to the action of ionizing radiation depending upon the state of functional load of the heart muscle [9, 10, 42, 54, 57 and others]. S. S. Vayl; G. A. Zenginidze and D. S. Sarkisov [9] noticed considerable changes in the heart muscle, due to the effect of x-rays, in conditions of different state of nervous system. In the experiments by the authors, when combining the increase in heart load (orthostatic position of the animal) with radiation much more serious injuries of the heart muscle were detected, than at individual radiation or increase in heart load. In another series of operations the authors in conditions of destroyed heart innervation noticed during radiation dystrophic changes (all the up to micromyomalation) in such dosages which ordinarily caused no myocarditis injury [10]. In this case was shown the protective action of narcotics, used prior to radiation.

Considerable dystrophic changes in the heart during radiation in combination with the physical function was detected by V. D. Armstrong and V. O. Kester [57] (Caster), V. M. Pinchuk, E. I. Shcherban' [42].

In mice, irradiated in the period of swimming, lethalness dropped [54]. The protective nature of training is explained by S. N. Sergeyev [47] by the amplification of oxidation-restoration processes.

About the prophilactic action of chromical hypoxia with respect to radiation illness speak data of also other authors [90, 6]. In near closeness to these investigations are operations carried out on cold sleeping animals [41]. M. D. Pomeramtseva, as well as others, assume that the protective effect of narcotic dream depends upon hypoxia as result of depression of the respiratory center. Retardation in the appearance of radiation illness until the cold sleeping animals do wake up was observed by K. Brace [63], F. D. Vasilenko [8] succeeded in revealing, that irritation of the symphatetic nerves after radon gives a much stronger effect, then to the radon I.L. Kislovskaya [22] assumes, that an increased excitability of nerve centers on the day of radiation (and for 3-7 diurnal periods) is at a specific level and further excitation of same during the rewinding of coronary arteria and subsequent irritation of the Gering nerve leads to an amplified reactions, and its weakening - to the development of prohibitory retardation, according to N. B. Ginzburg [12, 13] myocarditis infarct at radiation illness is much heavier, than among non-irradiated. Electrocardiographic and morphological investigations by the author point toward a greater dispersibility of necrobiotic processes when the myocarditis infarct is combined with radiation illness all the way to the development in individual cases of cardio aneurisms. Senderoff and others [89] discovered that irradiated dogs withstand better sharp cardio coronary deficiency at ligiration of coronary arteria, then control animals. Experiments have shown, that toward expiration of the first diurnal periods is observed a more considerable deterioration in O_2 requirements in comparison with irradiated animals without disruption of coronary hemorrhage. A similar card is observed also in the region, provided with a ligated vessel, as well as in differently distant sections from it[2].

Considerable changes in the heart muscle, reactivity of cardiovascular system were detected at the action of certain pharmacological substances among irradiated animals. V. I. Korchemkin [55, 56] under the effect of Strontium -90 observed a much higher in comparison with control dogs sensitivity to adrenaline and acetylcholine . Electrocardiographic injuries in irradiated dogs after introduction of mediators were more considerable. During the effect of adrenaline and acetylcholine the teeth R and T experience much longer changes. Reaction of blood pressure in individual times of injury among iradiated animals during the introduction of adrenaline is considerably smaller, than in control animals. Analogous changes among rabbits, infected by polonium during the introduction of adrenalin, have noticed also other investigators [35, 16, 65]. Among irradiated rabbits S. P. Grozdov [17] after experimental myocarditis observed a much heavier course of radiation illness, then only in irradiated. P. D. Gorizontov and B. B. Moroz [15] assume, that radiosensitivity of the heart increases, if the radiation is carried out on the background of changed myocardium.

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Literature

1. Antonyan, S. G. Tes. Doklady no Konfer. Patogenesis Eksper. Prof. i. Terap Luchevykh Porazheniy 15, MZ. SSSR. 1962.

2. Antonyan, S. G. Tez. Doklady na Konfer. Molodykh Uchenykh MZ SSR, Moscow 9, 1963.

3. Arkussakiy, Yu. I. Volokova, K. G. Vestnik Rentogenografii i Radiologii 17, 273, 1936.

4. Arkusskiy, Yu. I, Mints, M. J., and Chociua, K. N. Vest Roentg. 18, ed. 5-6, 334, 1957.

5. Arkusskiy, Yu. I., Mints, M. M. Vest. Roentg. i Radiolog. 20, 38-39, 1938.

6. Barbasheva, Z. I. Doklady Academii Nauk SSSR. 107, 5, 761-764, 1956.

7. Bychkovskaya, I. B. Vest. Roentg. i Radiolog 6,10-15, 1955.

8. Vasilenko, F. D. Problem of Balneology, Moscow, 70-76, 1952.

9. Vayl, S. S. Zedginidze, G. A. Sarkisov and D. S. Reudy. VMMS, vol. 54, 1956.

10. Vayl, S.S., Functional morphology of disturbance in heart activities, Medgiz 1-29, 1960.

11. Gempel'man, L., Lisko, G. and Gofman, D. Acute Radiation Syndrome Moscow, 1954.

12. Ginzburg, N. B. Medical art 12, 1263, 1950.

13. Ginzburg, N. B. Medical art 3, 50, 1961.

14. Gloriozov, B. N. Clinical Medicine 22, 12, 60, 1949.

15. Gorizontov, P. D, and Moroz, B. B. Cardiology 4, 3-8, 1962.

16. Grozdov, S. P. Bulletin of Rad. Med. I. P. 38, 1960.

17. Grozdov, S. P. Dissertation Moscow, 1961.

18. Zhdanov, I. M. Trudy Tsentral. Nauch. Issled. Inst. Roengen i Radiolog. 159, 1941.

19. Zayrat'yants, V. B, Trudy Vsesoyuz. Konfer. po Med. Radiolog. Eksper. Med. Radiolog. 85-88, 1957.

20. Zedginidze, G. A., and Kotik, M. Z. and Larionov, L. F., and Pavolova, A. L. Popova, Ye. A., Sobolev a N. G. Shabad, L. M. Shor G. V. Vestn. Roentgen. i Radiologii, 17, 356-361, 1936.

21. Kislovskaya, I. L. Collec. of rep. on radiation med for 1958, Moscow 1959.

22. Kislovskaya, I. L. Bulletin of radiation medicine 1, 49-54, 1960.

23. Krayevskiy, N. A. Outlines of pathol. anatomy of radiation illness, Moscow, Medgiz, 1957.

24. Lebedinskiy, A. V., Medical radiology I, 2, 1956.

25. Lebedinskiy, A. V. Nakhilnitskaya, Z. N. Smimova, N. P.. Tz. Doklady Nauchn. Konferen. posviashch 40 latiyu so dya oshovaniya TSNIRRI MZ SSSR, Lenin grad 6, 1958.

26. Lebedinskiy, A. V. and Nakhil'nitskaya, Z. N. Effect of ionizing radiations on nerves system, Atomizdat, 1960.

27. Lebedinskiy, A. V. Medical radiology, vol. 2, 1, 1957.

28. Lyubimova, R. M. Tez. Doklay po voprosam of specif, reaktsii or-ma na vozdush, ioniziruyushchiye izlucheniya;,Leningrd, 1955.

29. Lyubimova, R. M. Bull. Radats. Meid. 2, 1956.

30. Livanov, M. N. Vsesouz. Konfer. Po Med. radiologii eksper. Med. Rad. lu, 1957.

31. Livanov, M. N. Certain problem of the action of ionizing radiation on the nervous system Moscow, 1962.

32. Maslova, A. F. Bullet. of experimental, biolog. and medical 9, 81, 1958.

33. Maslova, A. F. Medical radiology 4, 12, 36, 1959.

34. Mozzhukhin, A.S. and Peymer, I. A. Bull. of radiat, medic. 2, 1956.

35. Moroz, B. B. , Grozdov, S. P. and Petrovina, Ye. N. Radiobiologiya vol. 2, ed. 1962.

36. Mytaryeva, L. V. Medical radiology I, 1. 34, 1956.

37. Nemenov, M. I. Vestnik Roent. i radiolog. 24, ed, 1962.

38. Oganesyan, S. S. and Zaminyan, T. S. Doklady Akademii Nauk ARm SSR, vol. 34. 5, 207, 1962.

39. Pigalev, I. A. Bull of the effect of radiation and clinic of radiation illnesses, 1954.

40. Pigalev, I. A,B. B. Moroz and Grozdoy, S. P. Medical Radiology 6, 12, 29-36, 1961.

41. Pomerantsevz, M. D., Author refer. Canad. dissert. Moscow 1956.

42. Pinchuk, V. M. and Shcherban', E. I. Radiation illness and combined effects on the organism, Leningrad, 318-325, 1958.

43. Ryabov, V. I. Collec. of materials of scient. confer. on pathology physiolog. s/kh of animals 1962, Moscow, 83-84, 1962.

44. Rayskina, M. Ye. Biochemistry of nervous regulation of the heart, Moscow, 1962.

45. Sarkisov, D. S. Trudy Voyenno-Morskogo med. Akad. 65, 5-23 1956.

46. Semenov. L. Conferen. on studying react. of the endocr. system to the effect of ioniz. radiat (thesis of rep) Leningrad, 4-5, 1956.

47. Sergeyev, S. N. Arkhivy Patologii 4, 29-33, 1960.

48. Snezhko, A. D. Biofizika, 2 ed. i, 67, 1957.

49. Tarkhanov, I. R. and Izvestiya, S. Petersburgskoy biologicheskoy laborat. I. ed. 3, 47-52, 1896.

50. Teplov, S. I., Sverdlov, V. S. and Korovskin, B. F. Medicinal radiology 4, 3, 27, 1959.

51. Fanardzhyan, V. A., Kandaryan, K. A., Papoyan, S. A. and Adovyan, M. I. Vestnik Rentgenlog. i radiolog 4, 55-57, 1954.

52. Fanardzhyan, V. A., Kyandarysn, K. A. , Belgaryan, A. G. and Papoyan, S. A. Effect of ioniz, radiation the animal organism, Kiew, 1960.

53. Shabad, L. M. Vestnik roent, 17, 364, 1936.

54. Scherban, E. I. Problems of radiobiology, vol,3, 412-420, 1960.

55. Korchemkin, V. I. In book Referaty rabot, posvyashch. radioakt, strontsiyu, Moscow, 40-41, 1959.

56. Korchemkin, V. I. Medical radiology, 5.9, 22, 1960.

57. Armstrong, W. D., and W. O. Caster. Feder. Proc. 15, 1, 5, 1956.

58. Bacq Z. M., Alexander P. Fundamentals of radiobiology, 267, 1955.

59. Barron, E. S. G. Radiation Biology, 1, 283-314, 1954.

60. Barron, E. S. G. Biological effects of external X and gamma radiation, 1954.

61. Berdjis, C. C. Strahlentheraple 112, 4, 595-603, 1960.

62. Borman, M. Am. J. Roentg, 18, 2, 111, 1927.

63. Brace, K. C. Science 116, 3021, 507, 1952.

64. Catterall, M. Brit. J. Radiol. 33, 387, 159--164, 1960.

65. Danysz. A. Acta physiol. plon. 12, 6, 833-848, 1961.

66. Desjardings A. U. Am. J. Roentg. 27, 3, 479, 1932.

67. Eggers, P. Munch. med. Wschr. 88, 9, 242, 1941.

68. Emery, E. S., Gordon B. Am. J. med. scien. 170, 884-887, 1925.

69. Gabriel, G. Strahlentherapie 34, 4, 813-822, 1929.

70. Gendreau, J. E. Ann. Surg. 93, 476-480, 1931.

71. Gollwitzer-Meter Kl., Kramer, K., E., Kruger. Pflugers Arch. ges. Physiol. 237, 639, 1936.

72. Gollwitzer-Meier Kl., Kroetz Ch. Klin. Wschr. 580, 616, 1940.

73. Gordon B., Strong, G. F., Emery, E. S. Am. J, Radiol. 11, 4, 1924.

74. Jones, A., Wedgewood, J., Brit. J. Radiol. 33, 387, 138-158, 1960.

75. Hartman, F. W., Bolliger, A., Doub, H. P., Smith, F. J. Bull. Johns Hopkins, Hosp. 41, 1, 36-60, 1927.

76. Kosmider, S., Szezurek, Z., Petelenz, T. Arch. immunol. et therap. exptl 10, 2, 459, 1962.

77. Leach, J. E., Sugiura K. Am. J. Roentg. 48, 1. 81, 1942.

78. Leach, J. E. Arch. inter. med. 72. 6, 715-745, 1943.

79. Leach, J. E. Am. J. Roentg. 50, 5, 616-628, 1943.

80. Levy, R. L., Golden, R. Am. U. Roentg. 18, 2, 103, 1927.

81. Onkelinn, Cl., Nature 195, No. 4838, 302, 1962.

82. Prosser, C. L., Painter, E. E., Liscon, U., Brues, A. and Jacobcon, L. O. a. Swift M. M. Radiology 49, 3. 299, 1947.

83. Ross, J. M. J. pathoi. bacteriol. 35, 5, 899, 1932.

84. Sabrazes, J. and Riviere P. Compt. rend. Acad. d. sci. 124. 979-982' 1897.

85. Schweizer, E. Strahlentheraple 18, 4, 812, 1924.

86. Seguy, G. and Quenisset, F. Compt. rend. Acad. d. sci. 124. 14, 790, 1897.

87. Senderoff, E., Kavee, D. J., Johnson, R., Baronofsky, I. D. Proc. Soc. Exp. biol. a. med. 100, 1, 1, 1959.

88. Senderoff, E., Kahn. H. Pecka. I. D. Baronofsky. Am. J. Reenig. 83. 6, 1078-1082, 1960.

89. Senderoff, E. M. Kaneko, A. R. Beck, I. D. and Baronofsky. Akm. J. Roentg. 86, 4, 740-751, 1961.

90. Smith, F. and Grenan, M. M. Science 113, 2946, 686, 1951.

91. Smith, D. J., Parker, R. C., Calvin H., and Henry C. E. Am. J. Physiol. 197, 4, 725-729, 1959.

92..Stefanov, E. Strahlentherapie 77, 1. 1947.

93. Thibaudeau, A. A., Mattick, W. L. J. canser, research 13, 3, 251-259, 1929.

94. Tsiwidis, A. Pflugers Arch. ges. physiol. 148, 264-272, 1912.

95. Tsusuki, M. Am. J. Roentg. 5, 2, 1926.

96. Van Bekkum, D. W., Jongepier, H. J., Nieuwerkerk, H. T. M. a. Conen J. A. Brit. J. Radiol. 27, 314, 127, 1954.

97. Vaeth, J. M. , Feigenbaum, L. Z., Merrill, M. D. Radiology 76, 5, 755-762, 1961.

98. Warthin, A. S., Pohle, E. A. Arch. inter, med. 43. 1, 15-34 1929.

99. Warthin, A. S. and Pohle, E. A. J. Am. med. Assoc. 89, 22, 1927.

100. Werthemann, A. Strahlentherapie 38, 4, 702-709, 1930.

101. Zuppinger, A. Strahlentheraple 92, 3, 364, 1953.

102. Caster, W. O., Armstrong, W. D., Simonson, E. , Ami. J. Physiol.188, 1, 169,1957.