NASA TECHNICAL MEMORANDUM

NASA TM-75942

EFFECT OF GRAVITATION STRESS AND HYPOKINESIA ON BLOOD VESSELS OF THE TESTICLE

E. F. Palazhchenko

Translation of "Vliyaniye gravitatsionnykh peregruzok i gipokinezii na krovenoshnyye sosudy yaichka", Arkhiv Anatomii, Gistologii, i Embriologii, Vol. 64, No. 5, 1973, pp 57-63

(NASA-TM-75942) EFFECT OF GRAVITATION STRESS AND HYPOKINESIA ON BLOOD VESSELS OF THE TESTICLE (National Aeronautics and Space Administration) 14 p HC A02/MF A01 CSCL 06S

N80-16726

Unclas

G3/52 46917

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546 November, 1979

UDC 611.146.6-02:612.014.47]-092.9

EFFECT OF GRAVITATION STRESS AND HYPOKINESIA ON BLOOD VESSELS OF THE TESTICLE

E.F. Palazhchenko
Department of Normal Anatomy of I. P. Pavlov
First Leningrad Medical Institute

In three series of experiments rabbits were exposed to single maximum endurable stresses of cranio-caudal direction, hypokinesia for periods of one-eight weeks, and hypokinesia followed by gravitation stresses. The stresses caused dilatation of the vessels, greater sinuosity, uneven contours and occasional ruptures of the walls and extravasation. The greatest part of the capillaries were dilated; the least part constricted. In hypokinesia there was an increasing atrophy of the testis. At early terms the arteries constricted and from the fourth week they began gradual dilatation; the veins were dilated in all periods. Sinuosity, unevenness of the contours, bulb-shaped protrusions and constrictions increased along the course of the vessels. The number of injected vessels diminished. Later there was atrophy of the spermatogenic epithelium and of the muscular coat of the vessels. Hypokinesia followed by stress resulted in pronounced lesions in all the links of vessel bed of the testicle such as deformation of the vessels and of the wall structure.

In the available literature there are no studies covering /57*
the effect of hypokinesia and the combined effect of hypokinesia

*Numbers in margin indicate pagination in original foreign text.

and stress on the structure of vessels in the male sex gland. At the same time the endocrine glands, including the sex glands, take the most active part in the processes of the body's adaptation to extreme factors (K. F. Lev[illegible]kaya, 1948).

Three series of experiments were made on 110 sexually mature male rabbits weighing 2400-2800 g. A preliminary study was made on 20 rabbits of the normal structure of the blood channel of the testicle.

In the first series of experiments on 30 rabbits a study was made of the effect of one-time maximum endurable stresses of a cranio-caudal direction on the vessels of the male sex gland. For this purpose the rabbits were revolved on a centrifuge with platform radius 1 m, the magnitude of the overload equalled 9 units and lasted 12.5 minutes.

In the second series of experiments on 40 animals the effect was revealed of the successive action of hypokinesia and stress. Here at first the animals were placed in specially made close cages. The effect of hypokinesia was observed in dynamics in 1, 2, 4, 6 and 8 weeks.

In the third series of experiments on 40 animals the effect of the successive action of hypokinesia and stress was revealed. Here at first the animals were placed in close cages for the same periods as in the second series.

After the passage of the indicated periods the rabbits were exposed to a one-time maximum endurable stress of cranio-caudal direction of the same magnitude and duration as in the first series. After the end of the experiments the animals were killed. Fifteen of the animals in the third series died during rotation on the centrifuge.

The study technique consisted of injecting an x-ray contrast mass or Gerota mass into the testicular vessels with subsequent x-ray diffractometry or clarification according to Malygin. Part of the preparations were histologically processed with hematoxylin-eosin staining of the sections and van Giesen staining. The extra-organ and intra-organ arteries of first-fifth orders were studied on the x-ray photographs.

On the clarified preparations studies were made of the intra-organ arteries and veins, as well as the vessels of the microcirculatory channel. The width of the vessels was measured with an ocular micrometer.

Fundamental data. First series of experiments. After single longitudinal stresses the dimensions and weight of the testicle increased. On the x-ray photographs a considerable dilatation of the extra-organ arteries was observed: a. testicularis--800-850μ (normally 600-650 μ), a. epididymica cranialis --350 μ (normally 200-250 μ) and others. The number of injected intra-organ arteries was increased as compared to the norm (fig. 1, b). Along the course of the intra-organ arteries the dilatations alternated with stenoses, which was especially well visible on the clarified preparations (fig. 2). Both the extra- and intra-organ arteries became very coiled with uneven contours and numerous loops. Often extravasations and the emergence of the stain beyond the limits of the vascular wall were encountered (see fig. 1, b). On the clarified preparations the veins were also significantly dilated, their diameter reached 250-280 μ (normally 100-140 μ), many of them became coiled with numerous diverticuli along the course of the vessel. Sometimes ruptures were observed in the venous wall with the emergence of the stain into the surrounding tissues. A large /59
number of the capillaries were dilated, only some were constricted.

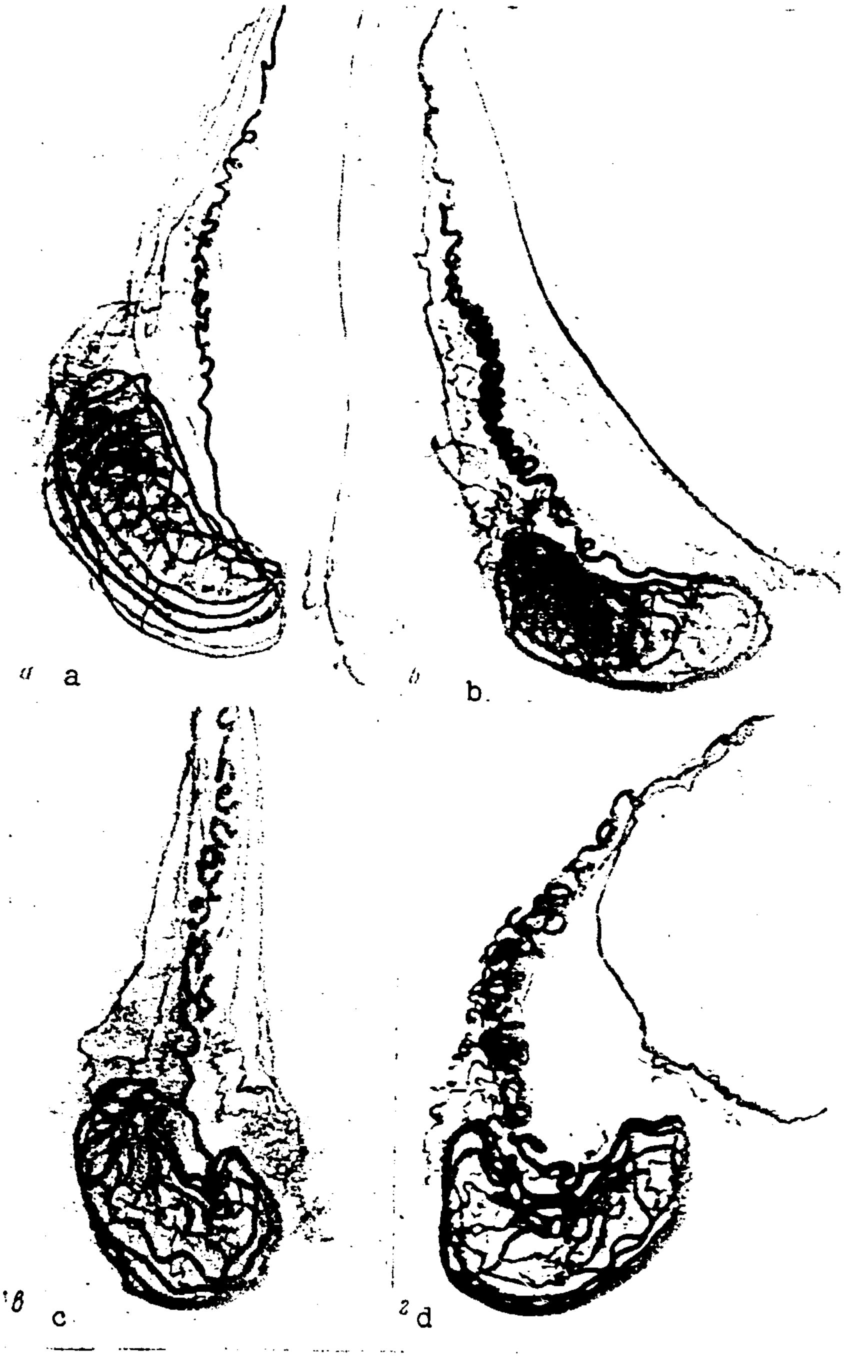

Figure 1. Arteries of Testicle after Stress, Hypokinesia and Combined Effect of Hypokinesia and Stress
a--arterial bed of rabbit testicle in the norm; b--after effect of single maximum endurable stress of cranio-caudal direction;

c--after effect of hypokinesia lasting 8 weeks; d--after effect of hypokinesia for period of 8 weeks and subsequent single stress. Photograph from x-ray photograph.

On the histological preparations the spermatogenic epithelium differed little from the norm. In small vessels sometimes ruptures were observed in the inner membrane or even in the entire vascular wall.

Consequently, the effect of single maximum endurable stresses in the head-pelvis direction produces dilatation of all the links in the vascular system of the male sex gland. A strong increase occurs in the twisting and looping of the arterial cone and other arteries, sometimes ruptures and extravasations of small vessels are observed.

The number of injected intra-organ vessels was considerably increased as compared to the norm, the majority of capillaries are dilated. Such pronounced changes in the angioarchitecture of the testicular vascular channel can be explained by the direction of the stress vector and its location in the caudal section of the animal's body. Stenosis of part of the capillaries once again confirms the conclusion that the action of gravitation stress on the vessels is a result of the set of hemodynamic and neurohumoral factors (M. G. Prives, 1968, 1970).

Second series of experiments. Within a week after hypokinesia the vascular bed differed little from that in the norm. Within 2 weeks one could note a certain reduction in the organ dimensions. As for the vessels, then as compared to the norm the twisting was increased of the a. testicularis and its branches of the second and subsequent orders. The number of injected intra-organ arteries was somewhat reduced as compared to the norm, they were moderately constricted, starting with the branch of the third order. Thus, for example, on the x-ray photographs the diameter of the branches of the fourth order was equal to

Figure 2. Testicular Vessels after Stress
a--vascular channel of testicle in norm; b--vascular channel of testicle after single maximum endurable stress of cranio-caudal direction. Microphoto from clarified preparations. Injection of vessels with Gerota stain. Rev. 8, stain 7.

80-90μ (normally 100-120μ). The veins were expanded (150-180μ; norm, 100-140μ). The number of injected vessels of the microcirculatory bed was insignificantly reduced as compared to the normal (figure 3,b).

Within four weeks a more pronounced atrophy of the organ /60 was observed. The extra-organ arteries and their branches of the second orders were dilated. Thus the diameter of a. testicularis reached 700-720 μ (normally 600-650 μ), a. ductus deferentis--350 μ (normally 200-250 μ). The branches of the third and subsequent orders were constricted. The number of injected intra-organ arteries was considerably reduced as compared to the norm. Both on the x-ray photographs, and on the clarified preparations one could note a greater twisting, looping and irregularity in the contours of both the extra- and intra-organ arteries. On the clarified preparations the veins were even more dilated, their diameter reached 170-190 μ,many of them acquired twisting and protrusions along the course of the vessel. In the microcirculatory bed the number of injected vessels was considerably reduced as compared to the normal (fig. 3,c).

Within 6 and 8 weeks of hypokinesia the testicle was strongly atrophied and shrivelled. The extra-organ and intra-organ arteries of the second and third orders were dilated to an even greater degree than in the previous periods of hypo-kinesia.

Thus the diameter of the a. testicularis was already 720-760 μ, the a. ductus de[illegible]rntis--330-350 μ. The intraorgan arteries of the fourth [illegible] subsequent orders were partially constricted, partially dilated. All the links in the arterial bed were very twisted, with numerous constrictions. The number of injected intraorgan arteries was sharply reduced as compared to the norm and the early periods of hypokinesia (fig. 1, c). The veins were also very dilated, their diameter reached 220-250 μ and many of them acquired twisting and numerous bulb-shaped protrusions.

In the microcirculatory bed the number of injected vessels was sharply reduced as compared to the norm and the early periods of hypokinesia. A large part of the capillaries were constricted and twisted (fig. 3, d). On the histological sections in these periods atrophy of the spermatogenic epithelium was observed. The vascular wall also underwent changes, the muscular membrane became considerably thinner than normal, while the adventitia, on the contrary, was thickened (fig. 4).

Thus, the limitation in the motor activity of the animal resulted in atrophy of the testicle. The atrophy increased as the periods increased. This was also confirmed by the histological studies, especially in animals in the late periods of hypokinesia. In the arterial section of the vascular bed, starting with the fourth week, the extra-organ arteries were dilated, and their twisting and looping increased. The number of injected intra-organ arteries was reduced with the periods, from the first-fourth weeks they were constricted, and then they gradually began to dilate. In the venous section of the vascular bed an increasing dilatation of the vessels was observed, an increase in their twisting,and the appearance of bulb-shaped protrusions and constrictions. In the microcirculatory bed the number of injected vessels decreased with time.

Consequently, under the influence of hypokinesia morphological changes began in the blood channel of the male sex gland which coincided with the changes occurring in the testicle itself. Apparently, limited movement in the animal, results, on the one hand, in a decrease in the flow of blood to the testicle, and on the other hand, in impairment of outflow. As a consequence of this a reduction occurs in the number of injected intra-organ arteries, as well as the vessels of the microcirculatory bed.

Disruption in nourishment of the organ produces changes in the angioarchitecture of the blood channel which lead to atrophy of the spermatogenic epithelium and of the entire testicle. The male sex gland, as is known, belongs to the organs that possess high sensitivity to oxygen deficiency (B. V. Gritsulyak, 1968; Ye. P. Mel'man and B. V. Gritsulyak, 1972; Ye. P. Mel'man, 1972).

Third series of experiments. Within 2 weeks after hypo- /61
kinesia and the subsequent effect of one-time maximum stresses a considerable dilatation was observed of the extra-organ arteries, both as compared to the normal, and as compared to the corresponding periods of hypokinesia. The number of injection intra-organ arteries was greater as compared to the norm and with the two-week hypokinesia. If within 2 weeks

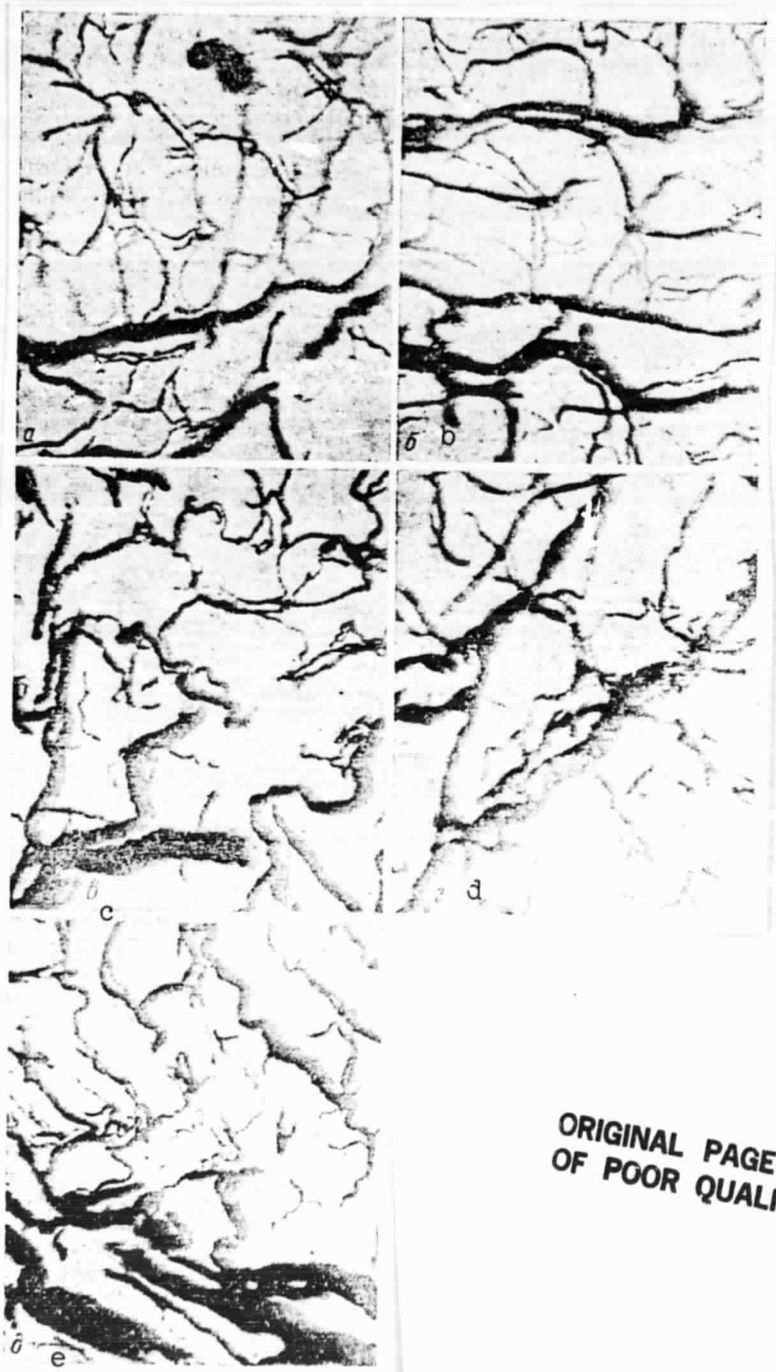

Figure 2. Testicular Vessels after Effect of Hypokinesia in Dynamics and Combined Effect of Hypokinesia and Stress
a--vascular bed of testicle in norm; b--vascular testicular bed after hypokinesia lasting 2 weeks; c--vascular testicular

bed after hypokinesia lasting 4 weeks; d--vascular testicular bed after hypokinesia lasting 8 weeks; e--vascular testicular bed after hypokinesia lasting 8 weeks with subsequent single stress. Microphoto from clarified preparations. Injection of vessels with Gerota stain. Rev. 8.,stain 7.

after hypokinesia their constriction is observed, then in the combined effect the intraorgan arteries are dilated. Thus, the width of the arteries of the fourth order equalled 125-130 μ /62 (normally100-120 μ). Besides the very pronounced twisting, the extra- and intra-organ arteries were considerably deformed with alternating stenoses and dilatations. Often ruptures were observed in the vascular wall and extravasations. On the clarified preparations the veins were dilated more strongly than in hypokinesia, their diameter now reached 230-250 μ (normally 100-140 μ, whle after hypokinesia lasting 2 weeks it equalled 150-180 μ). In the microcirculatory bed the number of injected vessels was greater than in hypokinesia without stress, they were twisted and dilated, while part of the capillaries were constricted.

In the periods within 6 and 8 weeks after hypokinesia and the subsequent effect of one-time maximum stresses many rabbits (60%) died on the centrifuge. Their extra-organ arteries were very dilated as compared to the normal. But in comparison with the corresponding periods of hypokinesia their width was increased insignificantly. Thus the diameter of the a. testicularis reached 730-780 μ (during hypokinesia of the same period 720-760 μ), and a. ductus deferentis-350-380 μ(during hypokinesia 330-350 μ). As for the intraorgan arteries, then they were clearly dilated as compared to the normal, and as compared to the corresponding periods of hypokinesia.

The number of injected intra-organ arteries was considerably lower than normally, however, greater than in hypokinesia after 6-8 weeks. In addition, one should stress the more pronounced

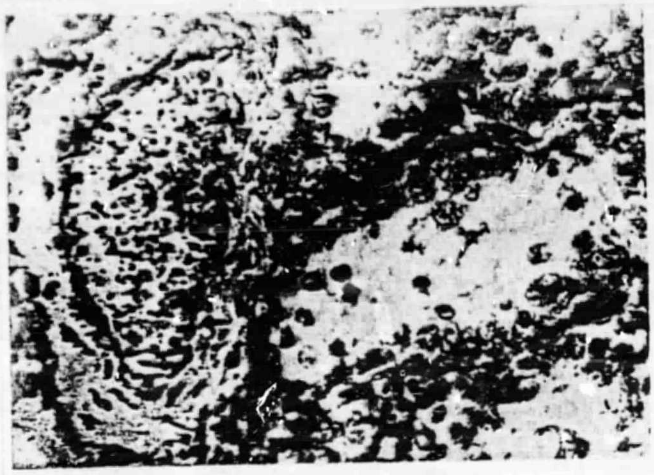

Figure 4. Spermatogenic Epithelium and Vascular Wall after Hypokinesia Lasting 8 Weeks
Hematoxylin-eosin. Rev. 40, stain 10.

(as compared to hypokinesia) twisting, looping, deformation and nonuniformity in the diameters of the arteries (fig. 1,d). On the clarified preparations the veins were very dilated as compared to the normal, but insignificantly as compared to hypokinesia, their width reached 220-280 μ (normally 100-140 μ, in hypokinesia 220-250 μ). Both in the veins and in the arteries often the contrast mass emerged from the vascular wall, and numerous ruptures and extravasations of the small vessels were observed. In the microcirculatory bed the number of injected vessels was considerably greater than in hypokinesia, they were partially dilated, and partially constricted(fig. 3, e).

On the histological sections atr phy was noted of the spermatogenic epithelium, the latter was detached and clustered into a structureless homogeneous mass. The vascular lumen was clogged with erythrocytes, the intima was stretched, often ruptured, the muscular membrane was also stretched and considerably thinner than normal, the adventitia was thickened. /63

In summarizing the results of the last series of experiments one can conclude that in the early periods the changes in the testicular vessels produced by the effect of hypokinesia and subsequent stress are similar to the changes produced only by stresses. However their degree in the combined effect is expressed considerably more strongly. In the late periods of hypokinesia the additional effect of the stress factor produces changes in the blood channel of the organ that differ a lot from those in the early periods. The changes occur to a great degree in the intra-organ testicular vessels, here a sharper deformation of the vessels is noted, a change in the structure of their wall, and their more frequent ruptures both as compared to one stress,and as compared to the combined effect of hypokinesia in the early periods and stress.

References

Gritsulyak, B. V. Kompensatornaya perestroyka krovenosnogo rusla semennikov i nekotoryye morfofunktsional'nyye sdvigi v nikh v usloviyakh narushennoy vaskulyarizatsii ["Compensatory Reconstruction of the Blood Channel of the Testes and Certain Morphofunctional Shifts in Them under Conditions of Disrupted Vascularization"], Author's abstract of dissertation, Ivano-Frankovsk, 1968.

Levitskaya, K. F. , Byull. eksper. biol., XXV, 4 (1948), 285-289.

Mel'man, Ye. P. Arkh. anat., 3 (1972), 120-128.

Mel'man, Ye. P and Gritsylyak, B. V. Arkh. anat., 1 (1972), 88-94.

Prives, M. G. "Certain Laws Governing the Effect of Gravitational Stress on Structure of Vascular System, " Vopr. aviats. i kosmich. anatomii ["Questions of Aviat. and Space Anatomy"], Leningrad, 1968, 7-32.

IX Mezhdunar. kongr. anat. Tez. dokl. ["Ninth International Congress of Anatomy. Summaries of Reports"], Moscow, 1970, 230-231.