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PATHOLOGY OF SELENIUM POISONING
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In 1933 Robinson (1) demonstrated that the toxicity of cereals and grasses grown in South Dakota was due to the presence of selenium, which was absorbed from the soil in toxic quantities. Selenium is the only mineral element absorbed by plants in sufficient quantities to cause the death of the animal. Beath et al. (2) demonstrated that certain plants were able to absorb and accumulate large quantities of selenium when they were grown on certain types of soils. The poisoning caused in the animals by the ingestion of seleniferous grains and plants was described under the term “alkali disease” and “blind staggers”. Both terms are misnomers and were given before the cause of the disease was recognized. Since the symptomatology and pathology of the disease are different, the old terms are retained to describe the different phases of the disease.

The “alkali disease” in domestic ungulates is characterized chiefly by hoof deformities, some loss of hair, loss in weight and occasionally by swelling of the joints (3). In “blind staggers”, symptoms are lack of coordination and object differentiation, greatly impaired vision and paralysis. The animals assume a characteristic stance, wander aimlessly, often in circles and blindness may or may not be present. The symptoms may develop in from a few hours to several days (4). Occasionally some animals recover before paralysis develops. However, these animals remain in poor condition, and younger animals are stunted in growth and appear dull. Both conditions are produced by the long continued intake of subtoxic levels of selenium in the foods; therefore, both are considered chronic selenium poisoning. The different manifestations of the disease are believed to be due to the different forms of selenium which are present in the plants and grains. Moxon (5) postulated that the selenium which was bound to the proteins and was relatively insoluble in water caused “alkali
disease” while “blind staggers” was caused by the organic selenium compounds which were soluble in water. Unpublished data by Beath indicates that feeding small daily portions of seleniferous native range plants to cattle for over a year’s time did not induce the “alkali disease” type of injury. The pathology developed was clearly of the “blind staggers” trend. The authors believe that the form or forms of organic selenium are the critical factor in determining which type of injury will result from cattle ingesting seleniferous foods.

The possibility of the absorption of selenium in man in endemic areas was investigated by Smith et al. (6). They found that in the rural population in the seleniferous areas, the selenium concentration in the urine was from 10 to 200 micrograms per hundred cubic centimeters. The normal human urine in non-seleniferous areas contains no selenium.

The use of selenium compounds in industry increased the distribution and possibility of selenium poisoning in man. Investigations dealing with this phase of the work were carried out by Dudley (7). He reported that absorption of selenium occurred in workers employed in the extractions and purification of the element.

It is evident from this brief review that selenium poisoning is important both from the human and animal point of view. Experimental studies dealing with selenium poisoning were carried out by many investigators. Stenn (8) and Moxon et al. (9) wrote excellent general reviews on the many phases of selenium poisoning.

The pathological studies dealing with selenium poisoning are limited, and many times descriptions given under chronic selenium poisoning present acute and subacute pathologic changes. Draize and Beath (10) reported the gross and microscopic pathologic changes observed in 100 range cattle and sheep suffering from “blind staggers” and “alkali disease.” Lillie and Smith (11) reported the histogenesis of hepatic cirrhoses in chronic selenium poisoning.

Our investigations indicated that selenium produced acute, sub-acute, and chronic “alkali disease” and “blind staggers” type
poisoning. Each one of these toxic phases presented definite pathologic changes. The understanding of the pathologic changes will greatly clarify the whole syndrome of selenium poisoning. We would like to present the pathologic changes of the different types of selenium poisoning.

EXPERIMENTAL PROCEDURE

The material for this report was obtained from 10 range animals showing acute selenium poisoning, 5 range animals showing "alkali disease," and 10 showing "blind staggers" type of chronic selenosis. Also included is a study of the gross and microscopic pathologic changes of subacute and "blind staggers" type of chronic selenium poisoning produced experimentally.

Yearling ewes were used as experimental animals, and the selenium was administered by drenching. We have used these larger animals because we studied, in addition to the pathologic changes, the influence of protein diets, the chemical changes in the tissues, and the elimination and the distribution of selenium in the tissues. The latter studies were reported elsewhere (12, 13, 14). The animals were fed with high, medium, and low protein diets. These diets influenced the toxic and lethal dose of selenium, but did not alter the pathologic changes. In the low protein group the toxic and lethal dose was much lower than in the high and medium protein group (12). The division of the present paper will be based on the pathologic changes observed and not on the diets fed to the animals.

For the pathologic studies we divided the animals in three groups: Group I, the animals received selenium until signs of intoxication appeared and then the feeding of selenium was discontinued for 61 days, at which time the animals were killed. The total selenium given in 44 days to 4 sheep was 860 mg. and to 2 sheep, 360 mg. of selenium each. Group II, the animals received selenium until death. In 116 days 6 sheep received 1922 mg. and 3 sheep in 64 days, 632 mg. of selenium each. Group III, the control group, received no selenium, but was maintained on the same diets as the experimental animals. Group I, in which the selenium feeding was discontinued after the toxic effects of
selenium developed, was considered as presenting subacute selenium poisoning; Group II shows the chronic "blind staggers" type of selenium poisoning.

The material for acute selenium poisoning presented here was obtained from animals which died of selenium poisoning due to the ingestion of large amounts of seleniferous plants. They showed the characteristic symptoms of acute poisoning (15).

The material for "alkali disease" presented was obtained from range animals showing the symptoms of the disease (3).

All the tissues were fixed in 10 per cent formalin and stained with hematoxylin and eosin.

**PATHOLOGIC ANATOMY**

The gross and microscopic pathology was the same whether selenosis was produced experimentally or whether the animals showing the symptoms of selenium poisoning were obtained from seleniferous ranges.

**Acute Selenium Poisoning**

On the parietal peritoneum there were large numbers of petechial hemorrhages; in some cases the hemorrhages became confluent involving the subserous tissue. The mesenteric vessels showed acute congestion and dilatation. The smaller vessels in this area presented a beaded appearance.

The heart was enlarged, and on the epicardium and the endocardium there were numerous petechial hemorrhages. The lungs showed acute hemorrhages and edema. The stomach presented congestion, hemorrhages, and extensive necrosis involving the mucosa and occasionally the submucosa. In the intestines, colitis and hemorrhagic mucoenteritis were present; occasionally necrosis was observed. The mesenteric lymph nodes were enlarged and soft, and the cut surface was reddish and moist. The liver was enlarged and soft, and there were many hemorrhagic areas present. In addition there were areas of necrosis which were either focal or diffuse in their distribution. Acute yellow atrophy of the liver was frequently observed. The gall bladder was enlarged and distended. The mucosa was pale red.
kidney was enlarged and soft. The capsule stripped with ease, leaving a smooth grayish surface. The cortex was swollen and bulging. There were focal hemorrhages present which were more prominent in the medulla. The urinary bladder was usually distended, and the mucosa was red and swollen. The spleen was soft and enlarged. The pulp scraped with ease and was reddish in color. The pancreas and adrenals showed acute congestion. The general picture in acute selenium poisoning was hemorrhages and smooth muscle atony.

Subacute Selenium Poisoning

The main pathologic change in subacute poisoning was increased fibrosis in all the organs. The extent of fibrosis depended upon the duration and the amount of selenium given to the animals. The heart appeared normal in size and firm in consistency, with areas of myocardial fibrosis. The lung showed areas of fibrosis. There were a few blebs at the apex and the base of the lung. Usually the gastro-intestinal tract was normal, but occasional fibrosis was observed in the stomach. The liver was slightly smaller and firm with a fine granular surface. The normal architecture was not very greatly disturbed. The kidney was somewhat smaller and firm. The cortex was narrower; the medulla showed areas of fibrosis. Occasionally the calyces showed some calcification. The spleen and adrenals were small and firm. The anterior pituitary, in three animals, was smaller in size than normal and showed focal fibrosis. All other organs appeared normal.

Chronic Selenium Poisoning, "Blind Staggers"

The pathologic changes observed in this type of poisoning were acute exacerbations superimposed upon a chronic degenerative process. All the organs showed chronic degenerative changes in combination with acute toxic reactions.

The peritoneum showed congestion and hemorrhages. The heart was atrophied and showed fibrosis. All the layers of the heart showed hemorrhages. The pericardium contained an increased amount of fluid. The lungs were voluminous, heavy, and doughy. Acute congestion, hemorrhages, and increased fibrosis were present. Congestion of the blood vessels was observed
throughout the gastro-intestinal tract. There was stasis of food material in the stomach; in some cases, hemorrhages and ulceration were present in the stomach. The large intestines were rarely involved. The liver was smaller in size and doughy in consistency, and extensive fatty changes, necrosis, and fibrosis destroyed the normal architecture of the organ. The kidney was firmer than usual and normal in size. Sometimes it was enlarged and pale in color. The boundary between the cortex and medullary portion was indistinct, and there were petechial hemorrhages. Occasional calcification of the tubules and hydropnephrosis were observed. The spleen was enlarged and firm. The cut surface showed pale areas interspersed with red and grayish-red. The gall bladder was always enlarged. The wall was thin and transparent. The mucosa showed hemorrhages. In two animals enlarged gall bladders and cholecystitis were present. In those cases, acute hemorrhagic pancreatitis developed, and the animals died suddenly. In acute hemorrhagic pancreatitis the pancreas was swollen, soft, and dark in color. The pancreas in all other cases showed acute congestion. In the brain edema and congestion were present. The anterior pituitary appeared edematous, and in two animals there were areas of necrosis. In our experimental animals no degenerative changes in the reproductive organs were observed. However, animals which were obtained from seleniferous ranges and which survived one attack of “blind staggers” showed atrophy of the reproductive organs. The long bones showed erosion on the articulating surfaces. The gross pathology of the other organs was congestion, hemorrhages, and increased fibrosis.

Chronic Selenium Poisoning, “Alkali Disease”

Compared with the pathologic changes in “blind staggers,” the lesions of “alkali disease” presented a more chronic, progressive degenerative change. The severest injury was in the heart and liver. The heart was soft, flabby, and atrophied (so-called dish-rag heart), and showed areas of myocardial fibrosis. Hemorrhages were not so common as observed in “blind staggers.” The lungs showed focal fibrosis, early congestion, and some edema. The stomach showed atrophy of the mucosa, thickening and fibrosis of the submucosa, and occasional ulcers. The mesenteric
lymph nodes were firm and fibrosed. The liver was small and firm, owing to the large amount of fibrous tissue. The normal architecture was completely destroyed. The color of the liver varied depending upon the extent of injury. Islands of normal liver tissue intertwined with yellowish-green and brownish colorations due to the deposition of fat, staining of the bile, and deposition of pigment. The gall bladder was rarely enlarged. The usual bluish color of the thin-walled normal gall bladder was lost. The surface appeared opaque, the wall was thickened and fibrosed, and the cavity was contracted. The kidney showed focal fibrosis; in some cases it was contracted and scarred. Renal calculi in many cases lodged in the pelvis of the kidney, causing obstruction of the urine and producing hydronephrosis. The spleen was atrophied and firm. The trabeculae were thickened, and there was an increase of connective tissue and fibrosis. The pituitary was smaller in size and firm in consistency. The reproductive organs showed atrophy. Erosion of the long bones on the articulating surfaces was present, and in advanced cases the bone marrow appeared gelatinous.

Effusion: In all types of selenium poisoning, ascites was common in occurrence. Gelatinous degeneration of the fat was observed, commonly in “blind staggers” and “alkali disease.” Effusion in the joints was present frequently in “alkali disease.”

At necroscopy the controls did not show pathologic changes similar to those observed in the experimental animals.
Fig. 1. Acute Selenosis: Lung showing hemorrhage in the alveoli. x 64.

Fig. 2. Acute Selenosis: Coagulation necrosis of the epithelium of the duodenum. x 64.
Fig. 3. Acute Selenosis: In the liver necrosis, fatty infiltration and dilation of the sinusoids are present. x 64.

Fig. 4. Acute Selenosis: Kidney. Hemorrhages in the collecting tubules of the medulla. x 64.
Fig. 5. Acute Selenosis: Spleen. Necrosis of the Malpighian corpuscle. x 64.

Fig. 6. Subacute Selenosis: Liver showing early fibrosis and fibroblastic and bile-duct proliferation. x 64.
HISTOPATHOLOGY

**Acute Selenium Poisoning**

In acute selenium poisoning, the outstanding pathologic changes observed were necrosis, hemorrhage, edema, and congestion.

The heart showed myocardial necrosis, hemorrhages, and cloudy swelling. The necrosis was focal in distribution, while the hemorrhages were present in the epicardium and endocardium. In the lung, alveolar hemorrhages (Fig. 1) and occasionally hemorrhages in the interstitial tissue were present. In the gastro-intestinal tract, the mucosa and submucosa showed the most marked changes. Edema, hemorrhages, and coagulation necrosis of the epithelium were observed (Fig. 2). The microscopic picture of the liver was a combination of necrosis, hemorrhages, dilatation of the sinusoids, and congestion. In many areas the greater part of the liver cells were necrotic, and the cells were swollen or disintegrated and replaced by granular debris (Fig. 3). If the animal survived the toxic dose for several days in addition to necrosis and hemorrhages, fatty degeneration was present. In the kidney the epithelium of the convoluted and collecting tubules showed considerable degenerative changes. The cells lost their normal appearance and were granular. There were extensive hemorrhages in the collecting tubules in the medulla (Fig. 4). The glomeruli usually were not affected. In the spleen the pulp and the sinusoids were crowded with red blood corpuscles and showed extensive necrosis (Fig. 5). Sometimes the sinusoids were compressed by the congested pulp. All other organs showed acute congestion and hemorrhages.

**Subacute Selenium Poisoning**

The myocardium showed areas of replacement fibrosis. The lungs showed thickening of the alveoli due to the increased proliferation of fibroblasts. Around the bronchioles large numbers of lymphocytes accumulated, forming enlarged lymph follicles. In the gastro-intestinal tract there were accumulations of lymphocytes around the blood vessels and focal fibrosis. In the liver, early fibrosis and fibroblastic and bile-duct proliferation were present.
In some cases, there were delicate tissue strands outlining the liver lobules by communication between central and portal areas. The kidney showed some injury to the convoluted and collecting tubules. There were red blood cells present in a few tubules and cloudy swelling of the epithelial cells. There were a few fibrosed glomeruli and increased interstitial tissue and atrophy of many of the tubules. In the sex organs, the ovaries and testicles of animals with pituitary injury showed some atrophy. The sex organs in the other animals appeared normal. The reticulum of the spleen was greatly increased, and there was some thickening of the walls of the blood vessels and trabeculae. The reticulo-endothelial system showed marked hyperplasia. The organs showed varying degrees of fibrosis.

**Chronic Selenium Poisoning “Blind Staggers”**

The heart showed fibrosis, congestion, and necrosis in the myocardium (Fig. 7). There was a sero-fibrinous exudate around the coronary vessels. In many cases fatty degeneration was present. The lungs with the thickened walls of the alveoli showed edema and hemorrhages. In many cases the alveoli were compressed or completely obliterated. The thickening of the alveolar walls was due to the increased fibroblastic proliferation, lymphocytic infiltration, hemorrhages, and edema (Fig. 8). The albuminuous fluid present in the alveoli stained intensely with eosin. The gastro-intestinal tract showed desquamation of epithelium, congestion and hemorrhages, and frequently ulcerations were present in the stomach. In the liver varying degrees of fatty changes, necrosis, and early fibrosis were the outstanding pathologic changes. In some areas all the liver cells contained large amounts of fat, and the normal structure of the liver cells was obliterated (Fig. 9). In other areas there was an increased bile-duct proliferation, necrosis around the central veins and delicate strands of fibrous tissue separated and compressed the liver cells (Fig. 10). The pancreas showed either acute hemorrhagic pancreatitis or congestion. In the kidney various stages of glomerulonephritis and tubular changes were present. In many cases the avascular glomeruli showed an increased cellularity due to the increased endothelial proliferation. The convoluted tubules showed coagula-
Fig. 7. Chronic Selenosis, "Blind Staggers": Myocardial fibrosis, necrosis and congestion. x 264.

Fig. 8. Chronic Selenosis, "Blind Staggers": The alveolar walls of the lung are thickened due to increased fibroblastic proliferation, infiltration of lymphocytes, hemorrhages, and edema. x 64.
**Fig. 9.** Chronic Selenosis "Blind Staggers" : The normal liver cell structure is obliterated and replaced by fat. x 64.

**Fig. 10.** Chronic Selenosis, "Blind Staggers" : Delicate strands of fibrous tissue separate the compressed liver cells. Necrosis around the central vein is present. x 64.
Fig. 11. Chronic Selenosis "Blind Staggers": Avascular glomeruli with increased endothelial proliferation and coagulation necrosis of the convoluted tubules. x 264.

Fig. 12. Chronic Selenosis, "Blind Staggers": Glomeruli space filled with albuminous fluid. Necrosis of the convoluted tubules. x 264.
Fig. 13. Chronic Selenosis "Blind Staggers": Fatty infiltration of the glomeruli, increased endothelial proliferation and crescent. Necrosis of all the tubules. x 264.

Fig. 14. Chronic Selenosis "Blind Staggers": Extensive reticular fibrosis, fibroblastic proliferation, and increased fibrosis in the lymph follicles and atrophy of the follicles. x 64.
tion necrosis (Fig. 11). In other areas the glomerular space was filled with albuminuous fluid, and the proximal convoluted tubules showed necrosis (Fig. 12). Some of the glomeruli showed endothelial proliferation, fatty infiltration, epithelial crescents, and coagulation necrosis of all the tubules (Fig. 13). These various changes were observed in all kidneys. However, one phase was more prominent in one animal than in the others. In addition to these changes, occasional calcification of the calyxes, increased interstitial tissue, and diffuse tubular hemorrhages were present. In hydronephrosis, atrophy of the tubules and compensatory hyperplasia were present.

In the spleen the sinusoids were dilated, and the pulp appeared to be stuffed with red blood cells. Many of the Malpighian corpuscles appeared hyperplastic. There was an increased reticular fibrosis and thickening of the trabeculae and of the walls of the blood vessels. The lymph nodes showed congestion, hemorrhages, fatty infiltration, and various degrees of fibrosis (Fig. 14).

Fig. 15. Chronic Selenosis, "Alkali Disease": Increased myocardial fibrosis and atrophy of the muscle fibers. x 64.
FIG. 16. Chronic Selenosis "Alkali Disease": Lung showing thickening of the walls of the alveoli due to increased fibroblastic proliferation and interstitial tissue. x 64.

FIG. 17. Chronic Selenosis "Alkali Disease": Liver showing the loss of normal lobulation and beginning of early cirrhosis. x 64.
The anterior pituitary showed necrosis and edema, and in some cases there were extensive hemorrhages. The necrosis involved all the cells of the anterior pituitary. The sex organs, ovaries, and testicles showed congestion, but were otherwise normal. Atrophy of the reproductive organs was observed in animals which recovered from attacks of “blind staggers”.

**Chronic Selenium Poisoning “Alkali Disease”**

Histologically this type of poisoning presented a more advanced degenerative change when compared with “blind staggers.” In all the organs the severe irritation which was observed in “blind staggers” was absent, and the degenerative processes were increased.

In the heart there were an increased myocardial fibrosis, atrophy of the muscle fibers, and some pigmentation (Fig. 15). There were small localized areas of lymphocytic infiltration and of edema separating the muscle bundles. In the lungs the walls of
the alveoli were thickened due to the increased interstitial tissue and fibroblastic proliferation. The thickening of the walls of the alveoli completely obliterated the normal histologic structure of the organ (Fig. 16). The liver presented a variable picture. There were fibroblastic, fibrocytic, and bile-duct proliferation, fibrosis, and the loss of normal lobulation (Fig. 17). In some areas the hepatic tissue was surrounded by fine fibrous bands. There were lymphocytic infiltration and pigmentation present. Some of the liver cells were atrophic, and others showed hyperplasia. In more advanced cases the liver showed portal cirrhosis (Fig. 18). In the kidney, atrophy, hyaline degeneration, and calcification of the tubules were present. There was an increase of interstitial tissue, fibrosis, and thickening of the walls of the blood vessels. In hydronephrosis, atrophy of all the structures and compensatory hyperplasia were present. In the spleen some Malpighian corpuscles were hyperplastic and others showed fibrosis. The reticulum and trabeculae were thickened throughout (Fig. 19). In all cases the sex organs showed atrophy, and there was

Fig. 19. Chronic Selenosis "Alkali Disease": Spleen with increased fibrosis of the reticulum and of the Malpighian corpuscle. x 264.
an increased fibrosis. The pituitary showed replacement fibrosis, but necrosis was not observed. All other organs showed changes similar to those observed in "blind staggers," but the fibrous tissue was more abundant.

DISCUSSION

It is evident that each different type of selenium poisoning presented a well-defined pathologic entity. Diagnosis can be made on the basis of the pathologic findings in the liver, lung, kidney, gastro-intestinal tract, and spleen. It is erroneous to base the diagnosis on the changes observed in a single organ since selenium enters in the blood very rapidly and produces injury in all the organs. The action of selenium appears to be similar to that of arsenic. The primary injury appeared to be cellular due to the capillary damage. Wright (16) reported that the selenium inhibited the oxygen consumption of rat liver, brain, and kidney, but had no effect on muscle tissue. The action of selenium on the respiratory enzyme suggests that the cellular anoxemia and subsequent cellular necrosis were due to the inhibition of oxygen consumption of the cells by selenium. The pathologic findings indicate that organs in which the oxygen consumption was interfered with showed the most severe damage. The liver, kidney, lung, and spleen showed the most severe damage, and they stored the highest concentration of selenium. The kidney, lung, and gastrointestinal tract serve as means of elimination of the toxic substances. Smith, Westfall, and Stohman (17) have shown that in cats 50 to 80 per cent of selenium was excreted in the urine and from traces to 18 per cent in the feces. McConnell (18) reported that in rats 10 per cent of the selenium was eliminated by the respiratory system. In sheep we found that only 30 per cent of selenium was eliminated in the urine; therefore, much larger quantities were stored in the different organs (14). The organs which serve to detoxify or eliminate the selenium stored the largest amount and showed the most severe injury. We observed the most severe functional disturbances in the kidney. The animals developed oliguria and anuria. The non-protein nitrogen showed an increase from the average normal value, 32 mg. per cent, to an average value of 102.0 mg. per cent. Our
observations indicate that in larger animals the most important functional disorders were associated with hepatic, renal, respiratory, circulatory, and gastric dysfunctions. This was contrary to that reported by Smith et al. (19). They found that in rats the symptomatology in milder forms of chronic selenium poisoning point to gastric and hepatic dysfunctions and to the possibility of injury of the hematopoietic organs.

The presence of hemorrhages in acute selenium poisoning was due to the direct injury of the capillaries by selenium. In acute poisoning the selenium in the blood may vary from 10 to 15 parts per million. This high concentration of selenium was no doubt responsible for the severe capillary damage and subsequent hemorrhages. In chronic selenium poisoning the selenium ranged from 1 to 5 parts per million; therefore, the hemorrhages observed in this type of poisoning must be due to some other factor or factors. Our studies indicated that in chronic selenosis the ascorbic acid level of the blood and liver was greatly reduced (13). These results suggested that the hemorrhages and the erosions of the bones were the signs of ascorbic acid deficiency. Svirbely (20), studying the effect of selenium on ascorbic acid, found that in vitro the selenium oxidized ascorbic acid, and in vivo, rats with symptoms of selenium poisoning showed a marked decrease in the ascorbic acid content of the liver and adrenals. Whether in selenium poisoning a simple oxidation of the ascorbic acid occurred or whether selenium interfered with the synthesis of ascorbic acid could not be stated definitely. However, it is possible that both processes may take place simultaneously in selenium poisoning.

Severe liver injury in chronic selenium poisoning was accompanied by a decrease of vitamin A in the blood and in the liver (13). The decreased vitamin A offered an explanation for the blindness which was frequently, but not always, observed in "blind staggers." The blindness was not produced by selenium as it was assumed previously, but developed as a result of the injury to liver and the subsequent reduction of vitamin A.

Although injury to the pituitary was observed in only a few of the animals in chronic selenosis, this injury offered an explana-
tion for the lack of fertility and stunted growth which was observed in chronic selenium poisoning by Beath et al. (4) and Franke et al. (3). In experimental chronic selenium poisoning, the germ cells were found normal on microscopic examination in those animals in which the pituitary was not injured. Atrophy of the genital organs was observed in those cases where actual pituitary damage was present. The atrophy of the genital organs, therefore, must be associated with the decreased gonadotropic hormones and with subsequent sterility. The stunted growth and sterility in the young animals must be the result of a polyglandular dysfunction. Studies dealing with the effect of selenium on the endocrine glands will be investigated in the near future.

CONCLUSIONS

1. The gross and microscopic pathologic findings of acute, subacute, and chronic selenium poisoning were presented.

2. In acute selenium poisoning, the outstanding pathologic changes were necrosis and hemorrhages due to capillary damage. In subacute poisoning, various degrees of repair and early fibrosis was observed in all the organs. Chronic selenosis was subdivided into two groups: “blind stagger” and “alkali disease.” In “blind stagger” on a low grade, chronic injury, an acute exacerbation was superimposed. The tissues showed chronic degenerative changes with acute toxic reaction. In “alkali disease,” chronic, toxic degenerative changes were observed in all organs, and acute irritation was absent.

3. The relations of the pathologic changes to the functional disorders were discussed.
REFERENCES


