Death in Potassium Deficiency
Report of a Case Including Morphologic Findings

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Autopsy of a patient with the sprue syndrome dying in hypokalemia revealed the myocardial and renal lesions of potassium deficiency. Similar renal changes are described under various names in the recent literature. It is suggested that they result from potassium deficiency since they occurred in patients who died with disorders commonly associated with electrolyte imbalance.

The clinical manifestations of potassium deficiency have been studied extensively,1-4 but only a few observations concerning the morphologic changes in patients with this ion deficiency are recorded. For this reason, it may be of interest to describe the findings encountered at autopsy in a patient who died with potassium deficiency and steatorrhea of undetermined etiology.

Report of Case

First Admission (Feb. 23, 1950 to April 22, 1950).

A 37 year old Negro janitor was admitted for investigation of a change in bowel habits and vague abdominal complaints.

History. In November, 1949, he first experienced excessive flatulence and a frequent urge to defecate. His stools were said to be soft and of the usual color. Postprandial nausea and emesis were noted later. The vomitus consisted of the fluid imbibed with or without a small amount of food. The symptoms continued and he soon noted the onset of lower abdominal aching, cramping pain. This would come "in spells" and was associated with tenesmus. His appetite diminished; he became weak, and lost 10 to 15 pounds during the month of January. By February, 1950, the patient had to stop work and remain in bed most of the time. Later he began to have five or six loose, watery bowel movements each day. When hospitalized he had lost approximately 30 pounds.

The family, social, and past histories and the review of systems were noncontributory.

Physical Examination. The temperature was 98 F., pulse 88, and the respiration 16 per minute. He was an asthenic Negro, appearing chronically ill, with evidence of recent weight loss. No abnormal pigmentation of the skin or mucous membranes was seen. Examination of the eyes, ears, nose, mouth and chest was not contributory. The abdomen was scaphoid; slight abdominal tenderness without rebound tenderness was noted but no palpable organs, masses or free fluid were detected. Peristalsis was quiet except for periodic rushes associated with the cramping pain. Rectal examination was not remarkable and yellow stool was noted on the examining finger. Both testes appeared atrophic. The cremasteric reflexes were absent bilaterally.

Laboratory Studies. Periodic determination revealed the hemoglobin to vary from 12 to 14 Gm., the red blood count from 3.8 to 6.2 million per cu. mm., the hematocrit from 37 to 52 per cent packed red cells, the sedimentation rate from 4 to 10 mm. in one hour (Westergren), and the white cell count from 4,200 to 10,500 cells per cu. mm. with an essentially normal differential count on four occasions. The red cells were normocytic, and their indexes were within normal limits. Bone marrow studies showed a cellular marrow with no abnormal cells or megaloblastic changes. The urine was negative. The fasting blood sugar was 77 mg. per 100 cc., cholesterol 147 mg., and total protein determinations varied from 6.7 to 7.4 mg. The serum potassium determination was 3.58 mEq. per liter, and the calcium 9.5 mg. per 100 cc. Congo red test showed 69.8 per cent of the dye remaining in the patients serum at the end of one hour. Pancreatic function studies on duodenal drainage before and after stimulation with secretin and Mecholly, were within normal range. The serum amylase was 149 units, and the serum lipase 0.55 units. The glucose tolerance test was normal. The serum Kahn test was negative. The icterus index was 4. Using x-ray film the stool test for trypsin was positive. Repeated examinations of the stool for ova and parasites, and cultures for pathogenic bacteria were negative. Fat balance studies revealed 45 per cent of the dry weight of the feces to be fat, with a total nitrogen of 3.3 Gm. per 100 Gm. of feces. Proctoscopy was negative on two occasions.

Roentgenologic Studies. Gastrointestinal roentgenologic study showed a bowel pattern as seen in deficiency syndromes, with a normal esophagus, stomach and duodenum as well as a diverticulum of the sigmoid colon. A chest film, flat plate of the abdomen, and gallbladder series were normal.

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Hospital Course. Throughout the two months hospital stay the cramping, abdominal pain persisted with at least three to six large, bulky, foul-smelling stools per day. An attempt to control his abdominal discomfort by the use of atropine and mild sedatives was unsuccessful. The symptoms increased after meals. He continued to have marked anorexia. The patient was given a high carbohydrate, low fat diet with supplementary vitamins, intramuscular injections of liver, and also capsules of Tween 80, but no significant improvement occurred. The clinical impression was steatorrhea of undetermined origin.

Interval. The patient was followed in the medical clinic. He continued to lose weight, felt weak and had at least three to four bulky bowel movements each day.

Second Admission (June 12, 1950 to June 19, 1950).

The patient was readmitted for further evaluation. The physical examination was unchanged except for a more apparent weight loss.

Laboratory Studies. The hemoglobin was 10.6 Gm. per 100 cc., and the serum cholesterol 112 mg. The white blood count was 6,900 cells per cu. mm. There was 1 plus albuminuria on three occasions, and asymptomatic, microscopic hematuria which varied from 4 to innumerable red blood cells per high powered field.

Roentgenologic Findings. The small bowel was not remarkable aside from a nonspecific “deficiency pattern.”

Hospital Course. Surgical exploration was considered but not attempted. The patient was discharged on the same diet and medications with the addition of pancreatin.

Interval. In the clinic intravenous pyelograms, made to determine the cause of hematuria, were normal.

Third Admission (Nov. 8, 1950, died Nov. 11, 1950).

The patient was again admitted because of extreme weakness and lethargy.

Physical Examination. The temperature was 96 F., the pulse 54, and the respirations 10 per minute. The blood pressure was 94/60. The only change noted was extreme emaciation.

Laboratory Studies. The hemoglobin was 12.1 Gm. per 100 cc., the red cell count 4.61 million cells per cu. mm., the hematocrit 45 per cent packed red cells, normal indexes, sedimentation rate 12 mm. in one hour (Westergren), white cell count 9,950 cells per cu. mm. with 92 segmented forms and 8 lymphocytes. Two eosinophil counts were reported as no cells per cubic millimeter. The urine pH was 5.0 with a specific gravity of 1.000, a trace of albumin, sugar negative. A few granular and hyaline casts were noted on microscopic examination. The total base was 134.7 mEq. per liter, serum sodium was 122.8 mEq., and serum chlorides 102 mEq. The nonprotein nitrogen was 45 mg. and the total proteins 4.67 mg. per 100 cc.

Hospital Course. The patient became progressively weaker and was unable to take nourishment. It was necessary to supplement his intake with parenteral fluids. It was thought that his weakness could not be explained on the basis of low serum sodium alone and potassium deficiency was considered. The patient died before electrocardiograms could be taken. It was noted that he could not breathe unless his head was held extended but potassium replacement therapy was not instituted. The terminal stage developed rather suddenly following an intravenous infusion with five per cent glucose in normal saline and he died with complete flaccid paralysis. The serum potassium run in duplicate, “less than 1.25 mEq. per liter,” was reported after death.

Autopsy

Gross Findings. The body showed marked emaciation. The mucosa of the small and large intestines, with the exception of the appendix and rectum, revealed many irregularly distributed, shallow ulcers up to 7 cm. in diameter. These were most numerous in the terminal ileum. The dilated stomach contained about 500 cc. of yellowish, mucoaid material. Its mucosa appeared normal. The mesenteric lymph nodes were enlarged, soft, pale, and fleshy.

The heart weighed 210 Gm. (normal 323 ± 40 Gm.), and was not dilated. The valves and the red-dish-tan myocardium, as well as the coronary vessels and their ostia, were not remarkable.

The kidneys (combined weights 342 Gm.) showed a smooth outer surface. On cut surface the 7 mm. cortex was pale and the medullary striations were not prominent. The remainder of the urinary tract, as well as the prostate and seminal vesicles were not remarkable.

Additional findings were ascites (150 cc.), bilateral hydrothorax (15 cc. each side), and a left hydrocele. There was no atherosclerosis. The liver (1,080 Gm.) showed no fatty metamorphosis. The lungs (380 Gm. each), esophagus, spleen (98 Gm.), pancreas (90 Gm.), biliary system, adrenals (combined weight 10 Gm.), bone, bone marrow, and musculature were not remarkable. Because of restrictions only a segment of the lumbar spinal cord, and a fragment of the thyroid were removed, and appeared normal.

Histologic Findings. The ventricular myocardium alone revealed a marked, diffuse, interstitial infiltration by neutrophilic polymorphonuclear leukocytes, lymphocytes, and large mononuclear macrophages (fig. 1). Some myocardial fibers near the infiltrates showed necrosis, and occasional naked sarcolemma sheaths were seen (fig. 2). The muscle fibers contained much brown pigment in the paranuclear position, but no demonstrable fat. The pericardium, valves, endocardium, and blood vessels were not remarkable.

The kidneys revealed marked vacuolization of the
Fig. 1. Interstitial myocarditis. The inflammatory cell infiltration involves primarily the septa. Hematoxylin-phloxine; × 210.

Fig. 2. Interstitial myocarditis. The muscle bundle in the center reveals a smudged cytoplasm, indicative of necrosis. Hematoxylin-phloxine; × 840.

Fig. 3. Tubular nephritis. Note the marked vacuolization of the tubular epithelium. Some tubules contain dense hyalin casts. Hematoxylin-phloxine; × 210.

Fig. 4. Fatty metamorphosis of the renal tubular epithelium. The dark granules represent stained lipid. Note that not all vacuoles contain fat. Sudan IV stain; × 420.
tubular epithelium, chiefly in the proximal convoluted, and, to a lesser degree, in the distal convoluted tubules (fig. 3). The vacuoles varied in size and in their location within the cells. Many of the vacuoles found in the subnuclear position in the proximal convoluted tubules contained fat (fig. 4). The majority of the vacuoles in a supranuclear position failed to stain for fat or glycogen. Occasional necrosis and shedding of the tubular epithelium was noted. The tubules contained much granular acidophilic material and some hyaline casts. The glomeruli, blood vessels and interstitial tissue were not remarkable.

The ulcersations in the small and large intestines reached the submucosa and revealed marked subacute and chronic inflammation. Lipid deposits were not demonstrable in the intestinal wall or in the mesenteric lymph nodes.

The liver showed slight congestion and minimal necrosis of liver cells in the central lobular areas. The liver cells throughout revealed a shrunken, granular, acidophilic cytoplasm. They contained much brown pigment which did not stain with iron stain. Sudanophilic material was absent.

Additional findings were pulmonary edema and congestion, as well as lipid depletion of the adrenals.

**Final Anatomic Diagnoses.** Interstitial myocarditis and tubular nephritis consistent with hypopotassemia; ulcerations of small and large intestines consistent with idiopathic sprue; congestion of viscera; ascites, 150 cc.; hydrothorax, bilateral, 15 cc.; pulmonary edema; lipid depletion of adrenals; emaciation; brown atrophy of liver; hydrocele, left.

**COMMENT**

The diagnosis of potassium deficiency in this patient is based upon the appearance of a terminal, faccic paralysis resulting in respiratory death, an extremely low serum potassium level, and the autopsy findings of marked interstitial myocarditis and tubular nephritis. The ion deficiency appeared to result from a chronic steatorrhea of undetermined etiology. The clinical and autopsy findings in this case closely resemble those reported by Perkins, Petersen, and Riley.

Interstitial myocarditis associated with potassium deficiency has been observed in patients as well as in experimental animals. Follis and associates studied the development of these lesions in rats. They found that the myocardium first revealed loss of striations, followed by poor staining of the cytoplasm, and finally karyorrhexis and karyolysis. Fatty metamorphosis of the muscle fibers did not occur. Concurrently there was infiltration of the myocardium by neutrophilic polymorphonuclear leukocytes, and large mononuclear cells, and, later, fibrosis. Analysis of the hearts showed a 35 per cent decrease in potassium. Others observed similar chemical and morphologic changes in animals receiving a potassium deficient diet as well as injections of desoxycorticosterone acetate.

Myocardial lesions similar to those produced in experimental animals have been encountered in patients with potassium deficiency. Goodol and MacBryde were the first to note focal myocardial necrosis with lymphocytic infiltration in a patient with Addison's disease who had been treated with desoxycorticosterone and showed clinical evidence of potassium deficiency. Myocardial lesions were found by Perkins, Petersen, and Riley in a patient with the sprue syndrome and clinical evidence of severe hypokalemia. The occurrence of potassium deficiency in the sprue syndrome was clinically recognized before morphologic lesions were noted. A report published several years ago described a patient with lymphosarcoma and the clinical evidence of potassium deficiency, but the myocardial and renal changes were not mentioned at autopsy.

"Hypokalemic myocarditis" was described by Rodriguez, Wolfe, and Bergstrom in two patients dying in diabetic coma.

The renal lesions in this patient closely resemble those observed in experimental animals with potassium deficiency where fatty metamorphosis occurs followed by necrosis and finally calcification of the epithelium of both proximal and distal convoluted tubules. Fatty metamorphosis of the renal tubular epithelium was distinct in this patient but many of the vacuolated epithelial cells failed to take the fat stain. Perkins and co-workers noted marked vacuolization of the renal tubular epithelium but could not demonstrate the presence of lipid. Darrow and Miller found renal tubular changes, but no myocardial damage, in a few of their animals.

Renal tubular lesions similar to those occurring in patients and animals with potassium deficiency have been described under various names. Williams and MacMahon observed "clear cell nephrosis" in a patient with weak-
ness, weight loss, anorexia, vomiting and hypotension. The electrocardiograms were interpreted as showing left axis deviation and probable myocardial damage. The serum sodium was 125 mEq per liter and two serum potassium determinations were 2.9 and 3.7 mEq per liter. The exact manner of the patient’s death was not recorded. At autopsy a pancreatic carcinoma “in situ,” osteomalacia, coronary artery sclerosis, a small myocardial scar and “clear cell nephrosis” were found. Kulka, Pearson, and Robbins described a “distinctive vacuolar nephropathy” in patients who at autopsy were found to show a variety of intestinal disorders, particularly ulcerative colitis. They mentioned potassium deficiency among the factors possibly related to the renal lesion. Jensen, Baggenstoss, and Bargen observed similar changes in a few patients who died from the complications of chronic ulcerative colitis. It is probable that these renal tubular lesions can be attributed to potassium deficiency, particularly when encountered in patients with long standing, severe, intestinal disorders.

Potassium deficiency should be suspected when weakness and lethargy appear in a patient with electrolyte imbalance. The diagnosis is suggested by the clinical picture, electrocardiograms, and serum potassium determinations. The events which occurred in our patient indicate that potassium deficiency may become a clinical emergency.

**Summary**

Myocardial and renal lesions of potassium deficiency are described in a patient who died with the sprue syndrome and hypokalemia. Similar renal lesions are described under a variety of names in recent literature. It is suggested that they result from potassium deficiency since they were found in patients who died with disorders commonly associated with electrolyte imbalance.

**REFERENCES**

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