* Spinal cords 86

** Brown Pigment (stained) chromes in medullae ollegate (85)

1935

heart - many enlarged (according to me) 80 right ventricular dilation 90

Lungs - all emphysema, [illegible], mucous membrane red 81, 88

Liver - all fatty 81 Color yellowish Brown 89 Greasy

Spleen - some enlarged 81

All but three were embalmed before post mortems

retinas - 88

ACUTE METHYL ALCOHOL POISONING

A REPORT OF TWENTY-TWO INSTANCES WITH POSTMORTEM EXAMINATIONS

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nerves 88

Dec. 7, 1934, the coroner's office of Multnomah County, Ore., was called on to investigate the death of a man who died from so-called denatured or "dehorn" alcohol poisoning. The death of this man was followed in dramatic and rapid succession by the deaths of twenty-one others in the two succeeding days. All of these victims were known to law enforcement officers as having an addiction to alcohol and were commonly referred to as "dehorns"; their family connections were unknown or distant; they lived in cheap rooming houses, worked occasionally and were incarcerated from time to time for drunkenness and vagrancy but otherwise were harmless. Several of the group were wayward members of prominent families. Their ages ranged from 32 to 65, six being in the third, five in the fourth, nine in the fifth and two in the sixth decade of life. Fourteen died after a short time at the Good Samaritan Hospital (attended by Dr. Fred Ziegler), and one, in the Multnomah County Hospital. Five were found dead in hotel rooms and one in a barn. One died in an unknown place in a neighboring city. Their renegade character, their furtive indulgence in their vice and their isolation from interested relatives and friends obscured many of the details of the final episodes that ended the lives of these unfortunate men.

The available clinical data disclosed only some of the terminal signs and symptoms observed during the brief hospitalization of fourteen of the patients and the details of the illness of another who died at home.

Of the fourteen who were hospitalized, five were conscious on arrival, while a similar number were in deep coma; the rest were semicomatose. Most of them were in profound shock, being cold, clammy, pale and perspiring excessively. It was frequently stated that their clothing or the bed clothing was "soaked with perspiration." Three were sufficiently rational to relate some of their subjective symptoms. In the several instances in which it was possible to record the blood pressure, the systolic readings ranged from 110 to 140 and the diastolic readings from 78 to 90, suggesting an increase of pressure

From the Department of Pathology, University of Oregon Medical School.

† nerve tissue (91)

Muscle paralysis, 88

Intense craving and decided preference for denatured alcohol (90-91)

due to terminal asphyxia as death approached. Their initial pallor was overshadowed by marked cyanosis. The eyes were occasionally rolled upward but in general were fixed; the pupils were dilated, with either slight or no reaction to light and accommodation. Several complained

TABLE 1.—*Clinical Data Concerning Patients*

Case	Mental Condition	Blood Pressure		Condition of Skin			Eyes			Respiration	
		Systolic	Diastolic	Temperature	Pallor	Sweating	Pupils	Reaction to Light and Accommodation	Condition	Rate	Lungs
1	Unconscious, irrational	140	90	Cold, clammy	4+	4+	7 mm.	Neg.	Fixed, rolled upward	8	Resonant
2	Semiconscious, irrational, complaining of pain in back	?	?	Cold, clammy	4+	4+	4 mm.	Slight	Rolling	18 decreasing	Resonant
3	Semiconscious, irrational, moribund	120	80	Cold, (shock)	4+	4+	Dilated	Neg.	Fixed	18 decreasing	Resonant
4	Comatose, moribund	?	?	Cold, clammy	3+	4+	7 mm.	Neg.	Fixed	12 to 4	Resonant, rales
5	Comatose, irrational	?	?	Cold, clammy	+	4+	Dilated	Neg.	Fixed	Labored, slow	Rales, mucus
6	Comatose, irrational	?	?	Cold, clammy	+	4+	Dilated	Neg.	Fixed	6	Rales, mucus
7	Comatose, irrational	?	?	Cold, clammy	+	4+	Dilated	Neg.	Fixed	8	?
8	Conscious, rational	126	80	Cold, clammy	4+	4+	5 mm.	Neg.	Fixed	20 to 3	Resonant
9	Comatose, irrational	?	?	Cold, clammy (shock)	4+	4+	Dilated	Neg.	Fixed	12 decreasing	Resonant
10	Conscious, rational, complaining of pain	?	?	Cold, clammy	4+	4+	Dilated	Neg.	Fixed	10 to 3	Resonant
11	Semiconscious, irrational	136	86	Cold, clammy	4+	4+	7 mm.	Neg.	Round, fixed	? regular	Resonant
12	Conscious, irrational	134	90	Cold, clammy	4+	4+	5 mm.	Slight	Fixed	12 decreasing	Resonant
13	Semiconscious, irrational	100	60	Warm, moist (97 F.)	Slight	Slight	Dilated	Slight	Nystagmus	40 decreasing	Resonant rales
14	Conscious, going on to comatose, irrational	?	?	Cold, clammy	4+	4+	Dilated	Neg.	Fixed	12 to 2	Resonant
15 1st admis.	Conscious, rational	110	76	Warm, moist	Slight	Slight	5 mm.	Slight	Dim vision	24	Resonant
2d admis.	Semiconscious, irrational	?	?	Cold, clammy	4+	4+	7 mm.	Neg.	Fixed	26	Resonant

of dimness of vision, while most of them were too moribund to comment on such disturbances.

Marked irregularities of respiration were noted in all. The breathing was irregular, labored and often spasmodic. The rates varied greatly, being at times increased, slowed or normal, but usually diminishing to only 2 or 3 respirations per minute, and terminating in respiratory failure.

The heart rates varied considerably. Many of the patients were pulseless on their arrival at the hospitals. In a number of others the heart was beating rapidly. In most of them, however, there was a slowing comparable to that in their respiration although not always

Dying from Acute Methyl Alcohol Poisoning

Heart		Cyanosis	Reflexes in General	Abdominal Pain	Sensitiveness	Convulsions	Duration in Hospital	Duration After Drinking	Amount of Liquor Consumed, Cc.	Respiratory Failure
Rate	Action									
?	Feeble, distant	4+	Negative	?	3+	0	47 min.	10 hr.	400	+
60 decreasing	Clear	4−	Active (Babinski positive, bilateral)	Rigidity	3+	Clonic, later tonic	70 min.	10 hr. ?	?	+
72	Regular	4−	Normal	0	0	0	50 min.	12 hr. ?	500	+
?	Regular	4−	Absent	?	?	0	40 min.	24 hr. ?	500	+
?	Feeble	4−	Absent	?	?	0	5 min.	24 hr. ?	?	+
Pulseless	?	4−	Absent	?	?	0	5 min.	24 hr. ?	150	+
Pulseless	?	4+	Absent	0	0	0	2 min.	24 hr. ?	400 ?	+
50 to 52	Regular	4+	Slight, slowed	4+	4+	2+	2 hr.	24 hr.	1,000 with friends	+
?	Regular	4+	?	?	0	?	2 hr.	24 hr. ?	200 ?	+
Rapid	Regular, weak	4+	?	4−	4+	0	1 hr., 30 min.	24 hr. ?	?	+
?	Regular	4+	Absent	?	?	+	3 hr., 15 min.	24 to 30 hr. ?	?	Heart +
48	Regular	4+	?	4+	4+	4+	1 hr., 40 min.	24 to 48 hr. ?	?	+
Regular	Strong	4+	Hyperactive	Babinski +	0	Present	9 hr.	27 hr. ?	?	+
108 to 120	Rapid	4+	Absent	4+	4+	0	1 hr., 40 min.	24 to 48 hr. ?	?	+
116	Regular	None	Normal	4−	4+	0	7 hr.	7 hr.	?	None
100	Rapid	4+	Absent	?	?	0	6 hr.	?	?	+

coincident with it. The tones were clear and regular, finally becoming distant and feeble. It is evident from the brief clinical notes that cardiac arrest followed rather closely in the wake of respiratory failure.

The extremely urgent conditions of the patients made examination of the body reflexes inaccurate. In only one was a positive bilateral Babinski sign recorded; in two, the reflexes were normal; in many, absent. In six of the patients there was evidence of marked abdominal

TABLE 2.—*Postmortem Findings in Twenty-Two*

Patient	Number	Age, Yr.	Weight of Patient, Lb.	Weight of Brain, Gm.	Weight of Heart, Gm.	Coronary Disease*	Arterio-sclerosis	Weight of Lungs, Gm.
L. M.	1	52	Obese	Normal	530	None	None	885-700
A. R.	2	48	165	1,270	375	Slight sclerosis	Slight generalized	Light
E. N.	3	39	175	1,590	480	Narrowing 3+	2+	510-460
E. W.	4	52	150	1,220	390	Sclerosis 2+, endocarditis	None	?
C. M.	5	57	160	1,420	380	3+	2+	350-340
B. V.	6	46	150 (fair nutrition)	1,495	not increased	Sclerosis 1+	None	?
R. H.	7	54	135	1,690	370	No sclerosis	None in aorta	580-560
O. O.	8	52	180	1,450	340	None	None	?
C. S.	9	38	180	1,520	500	None	1+	620-510
J. S. (A)	10	45	200 ?	1,590	370	None	1+	?
M. S.	11	41	Well nourished	1,690	460	None	None	?
C. F.	12	65	135	1,790	370	None	1+	630-465
J. H.	13	50	150	1,600	410	None	1+	?
B. P.	14	54	175	1,495	430	Focal narrowing 2+	2+	740
J. J.	15	58	Emaciated	Not examined	330	None	1+	550
J. B.	16	34	Well nourished	Not examined	440	1+	1+	390-390
M. K.	17	60	Emaciated, 105	1,620	410	1+	1+	700-550
A. J.	18	32	165	1,300	540	None	None	760-490
C. T.	19	42	230	Heavy	380	None	None	970-830
L. B.	20	38	180	Not examined	350	None	None	Normal
W. L.	21	58	Moderately well nourished	Heavy	410	None	None	830-770
J. A.	G.S.H. S-1557	32	160 (good nutrition)	Heavy	320	Soft, pliable and patent throughout; heart muscle unchanged	None	200-250

* In this and subsequent columns 1+ means slight; 2+ and 3+, moderate, and 4+, marked.

Men Dying of Acute Methyl Alcohol Poisoning

Condition of Lungs	Weight and Condition of Liver	Condition of Stomach	Condition of Intestines	Weight of Kidneys, Gm.	Weight of Spleen, Gm.
Ant. emphysema, post. hyperemia	Large, fatty	Hyperemia, mucus	Hyperemia in upper portion	434	95
Ant. emphysema, post. hyperemia	Fatty	Blood-streaked mucus, small amount food	Empty	400	60
Emphysema	Fatty 2+ 2,360 Gm.	350 cc. mucoid material and food; edema, hyperemia	Edema 2+, hyperemia, dilatation +	365	110
Emphysema 4+, edema 2+	Cirrhosis 2+	500 cc. food; hyperemia, petechial hemorrhage	Edema 3+, hyperemia 3+, gas 3+	340	185
Emphysema, hypostatic hyperemia	Hyperemia 1,700 Gm.	Hyperemia; thick mucoid material	Hyperemia, edema	280	110
Emphysema 4+, hypostatic edema	Fatty 2+, hyperemia 3+	Mucous material 3+	Hyperemia, edema	Normal	Normal
Ant. emphysema 4+, hypostatic hyperemia 2+	Fatty 3+, hyperemia 3+, 1,500 Gm.	Hyperemia 3+, edema, mucoid material 3+	Hyperemia, edema	390	(250)
Ant. emphysema 4+, hypostatic hyperemia 2+	Fatty 2+, hyperemia 2+	Hyperemia 4+, mucus 4+	Hyperemia, edema	Normal	Normal
Emphysema 2+, hypostatic hyperemia 3+	Fatty 2+, hyperemia 3+ 1,440 Gm.	200 cc. bloody mucoid material	Hyperemia, edema	Normal	Normal
Emphysema 3+, hypostatic edema 2+	Fatty 2+, hyperemia 2+	Hyperemia 3+, edema, bloody mucus 3+	Hyperemia, edema	485	185
Emphysema 4+	Fatty 1+, hyperemia 2+	Hemorrhage 3+, large amount of food material	Hyperemia, edema	460	(220)
Emphysema 2+, hypostatic hyperemia 2+	Fatty 1+, hyperemia 3+	Hyperemia, edema	Hyperemia, edema	440	135
Emphysema 4+	Fatty 2+, hyperemia 3+, edema	Hyperemia 1+, distention 3+	Hyperemia, edema, distention	Normal	Normal
Emphysema 3+, hypostatic hyperemia 2+	Fatty 2+, hyperemia 2+	Hyperemia 2+, edema 2+, mucous material 2+	Hyperemia, edema	450	95
Emphysema 2+, hypostatic hyperemia 2+	Hyperemia 3+, fatty 1+	Hyperemia, 500 cc. bloody mucus	Hyperemia, edema	440	80
Emphysema 2+, hypostatic hyperemia 2+	Fatty 3+, hyperemia 1+	Hyperemia, edema	Hyperemia, edema	440	Normal
Emphysema 1+, hypostatic edema 3+	Fatty 2+, hyperemia 2+	Hyperemia	Hyperemia, edema	?	180
Emphysema 3+, hypostatic edema 2+	Fatty 3+, hyperemia 2+	100 cc. bloody mucus, hyperemia, edema	Hyperemia, edema	440	140
Emphysema	1,840 Gm.	Marked hyperemia, edema	Hyperemia, edema	460	130
Emphysema, hyperemia	Fatty, increased in size	Mucoid matter; walls congested, red	Hyperemia, edema	Normal	Normal
Emphysema, hyperemia	1,340 Gm.	Hyperemia, edema	Hyperemia, edema	380	140
Lungs fluffy, collapsed; bronchial mucous membrane red	Fatty, nonsclerotic 2,300 Gm.	100-150 cc. greenish watery fluid, hyperemia	Marked hyperemia, edema	555	150

pain and tenderness. Terminal convulsions were present in three. These variable sensations may have been altered because of paralyses due to terminal intoxication.

There is no way of knowing exactly how much of the alcohol each one consumed. Scattered notations indicate that much of the drinking was done in groups. In a few instances a single empty pint bottle was found in the bed room containing the dead body. It may be assumed, therefore, that in some cases at least as much as 500 cc. of alcoholic liquor was drunk by one man. It is also difficult to arrive at any conclusion as to the exact time of the consumption of the poisonous liquor with reference to the onset of the symptoms. In one or two cases, however, there were definite statements indicating that symptoms developed in from sixteen to twenty-four hours after the intake. It is doubtless true that in many of the cases the effect was felt much earlier.

The sketchy nature of the clinical observations is mainly due to the brevity of the hospitalization. Six patients died within an hour; three within five minutes, and the remainder within from one to seven hours. The following more detailed citations of events in a few instances will serve to portray better the probable specific clinical manifestations:

CASE HISTORIES

M. S. was admitted to the hospital complaining of diffuse abdominal pain, exhibiting general discomfort and sensing impending death. He stated that with some companions, on the afternoon of Dec. 7, 1934, he drank one or two pint bottles of what was believed to be denatured alcohol. He had no symptoms until the following morning, when he noted a feeling of uneasiness followed by occasional brief but recurrent violently cramping abdominal pains. He was covered with profuse clammy perspiration, which soaked his clothing. He improved slightly after treatment, but later his respiration became slow (3 per minute) and his pulse imperceptible. Terminally, there was convulsive twitching of the face with progressive marked cyanosis and respiratory failure, resulting in death two hours after his admission.

A. J., on admission to the hospital, stated that he had consumed "dehorn" at intervals for two years. Although he was somewhat mentally unstable, he complained of general cramping pains and disturbance in vision. He stated that he partook of portions of two bottles of "dehorn." His pupils were round (5 mm.), equal and reactive only slightly to light and accommodation. The skin was cold and covered with clammy perspiration. Just prior to death a generalized spasm developed. Complete cessation of respiration was noted, then sudden relaxation and death three hours and forty minutes after admission.

B. P., aged 54, a longshoreman divorced, had been known as a periodic drinker and user of denatured alcohol for at least five years. His mother stated that on Saturday, Dec. 8, 1934, he awakened at 8 a. m. She observed that he had been drinking. He asked for his breakfast, which she prepared. She then left for about an hour and on returning found her son sitting quietly at the table with his breakfast untouched. He said he had no pain but "couldn't see very well." About thirty minutes later he went back to bed. He awakened at 2 p. m. and asked

the time, dressed unassisted, spoke normally and with only a slightly wobbly gait left for downtown, complaining that he would be late. In about an hour he was brought back in a delivery truck. He had collapsed on a street corner but was still able to give the necessary directions for being brought home. He was assisted to bed. He removed his jacket carefully, then suddenly pawed and tore his shirt and underclothing from his chest and cried out for air. At the same time he complained of severe, steady, burning pain in the upper part of the abdomen, which caused him to press his abdomen firmly with both hands. The pain and the hunger for air were so intense that he worked himself off the bed and turned over several times on the floor. There was also an unquenchable thirst. He took two glasses of water soon after he was brought home and in the next several hours consumed from seven to ten glasses of water containing sodium bicarbonate. The difficulty in respiration seemed to disappear at times (for five minutes or longer) only to recur again. The blurring of vision persisted until death. At 5 o'clock his speech became incoherent and rambling; he stopped complaining of pain; his breathing became increasingly difficult; cyanosis was marked, and approximately ten hours after the onset of symptoms he died. Many times in previous years the patient had been seen violently ill as a result of his consumption of denatured alcohol; hence no physician was called.

J. A. was admitted to the hospital Dec. 8, 1934, stating that he had been in good health until he took denatured (?) alcohol ("cut with water") on the day before admission. He said that about six hours after drinking the liquor he began to have severe abdominal pain. His pupils reacted sluggishly to light and accommodation, and except for the presence of abdominal pain he appeared in fair condition. His respiratory rate was 24 and his pulse rate 116. Although when he came in he was at first somewhat irrational, he improved and left the hospital after seven hours. About sixteen hours later he was readmitted, having been in the meantime in the emergency hospital of the city jail. It could not be learned whether or not he had had more liquor in the interim. On the second admission his pupils were found dilated, with only sluggish reaction to light. He was almost totally blind. Later in the afternoon (about five hours after admission) his breathing became labored, his pulse weak, and he anxiously gasped for breath. His eyes finally became fixed; his carotid pulse rate was 100; the respiration was 26; cyanosis was marked; he stopped breathing approximately thirty-two hours after drinking the alcohol.

Practically none of the details of these histories were available at the time of the necropsies.

POSTMORTEM EXAMINATIONS

Twenty-one of the bodies were examined by the staff of the department of pathology (coroner's physicians) and one by Dr. C. H. Manlove, of the Good Samaritan Hospital. The excitement of the emergency and the scattering of the bodies in various undertaking parlors so occupied the coroner's staff (Dr. R. Edwin, coroner) that the request for postmortem examinations was not made until the second day of the incident and not until most of the bodies (all but three) were embalmed.

Many of the bodies were found in a good state of nourishment; only two were emaciated (table 1). The weights ranged from 135 to 200 pounds (61 to 91 Kg.). emaciated. The weights ranged from 135 to 200 pounds (61 to 91 Kg.).

Except for the terminal cyanosis, there was commonly seen in these addicts a general pasty pallor of the skin. The hands and feet were dirty, the palms of the hands were slightly workworn, and the hair on the head was unkempt—all attesting to the shiftless indifference of character of these men. In many, the facial expression was agonized. There were some with fresh bruises and lacerations of the face and extremities. Lividity was posterior or lateral, and rigor mortis was in general intensified. One found dead in a barn died lying on his right side. His head was extended; the conjunctivae were suffused; the trunk was distorted and twisted; the hands were clenched with marked extension at the wrists; the lower extremities were flexed at the knees and the hips; the testes were drawn up into the inguinal rings; all this indicated intensive terminal abdominal pain. Such evidences may have been present in all of the bodies and then altered by hospitalization and embalming.

The following pathologic changes were observed in the different organs:

Brains.—All but four of the brains were removed, strenuous objection being offered by relatives in two instances. When the calvariums were taken off, varying degrees of tenseness of the duras were observed. In the several bodies that were not previously embalmed there was marked engorgement of the circulatory system in both the dura and the pia-arachnoid. In many instances the latter was lifted high above the convolutions by clear spinal fluid. In others the subarachnoid spaces were almost obliterated by swelling of the parenchyma. The weights of the brains (after fixation in solution of formaldehyde U. S. P.) were in general increased, ranging from 1,290 to 1,790 Gm.

Most of the brains were pale and wet. Variations in the amount of fluid in the subarachnoid spaces seemed to depend on the degrees of swelling of the brain substances. In practically every one there was some herniation of the cerebellum into the foramen magna. Chronic meningitis was not observed; the membranes were thin. In only one brain was there evidence of a preexisting old cerebral hemorrhage.

In the microscopic examinations the different brains disclosed relative uniformity of appearance. Variations were due to different degrees of edema and hyperemia. There were no old or recent hemorrhages in the dura or in the pia-arachnoid, but in the latter there were small fibrous patches and spreading edema. The optic chiasms disclosed occasional small punctate hemorrhages with, infrequently, other more minute interstitial extravasations of red blood cells. No decisive, disrupting hemorrhages were found here. There was no edematous spreading of optic nerve fibers. If anything, the latter appeared more compact, as though from intrinsic swelling. In the regions of the precentral and postcentral gyri there was moderate to marked subpial edema, with engorgement of small cortical blood vessels and perivascular edema, especially in the subcortical zones, where larger edematous vacuoles were often seen. The edema appeared to extend along the blood vessels, with slight to moderate degrees of perineuronal extension. Nissl granules were often found to be powdery, ragged and frayed, with occasional slight indentation of the cells. In addition, there was some slight satellitosis. Other changes, such as cytoplasmic accumulation of lipochrome (younger brains) and presence of calcospherites in white matter (older brains), were observed. Similar but less marked changes were found in the calcarine convolutions. Sections through the uncus in the different brains revealed in one instance, in addition

to the extension of edema already described in other locations, an old area of hemorrhage (recognized clinically) with amyloid cytoid bodies, powdery granules of hemosiderin and many pyknotic nuclei (glial). In the older brains senile lipochromes were more abundant. In the neurons there were edematous perinuclear clear spaces; there was some incompleteness of nuclear membranes, with a tendency to eccentric position of the nuclei. In some of the brains there was marked satellitosis with perivascular rows of mononuclear cells in the adventitia (one brain). No striking changes were seen in the basal ganglions; small patches of gliosis with slight to moderate edema and a sprinkling of lipochromes in some cells were noted.

Similarly, the medullae oblongatae disclosed varying edema, often marked accumulation of brown pigment in most of the neurons (so that they appeared stuffed) and occasional bloating and desquamation of the ependyma of the medial portion of the ventricular floor. There was no demonstrable alteration in the Nissl granules. In sections of the cerebellum nothing but edema was seen.

The minute alterations observed in the central nervous system (brain and medulla oblongata) consisted, therefore, of marked subpial and moderate cortical and subcortical interstitial edema with spotty perivascular and perineuronal extension. Only occasional minute focal hemorrhages were noted. On the whole, the cellular changes were not marked. The "extensive degeneration of ganglion cells and vascular endothelium with subsequent hemorrhage in the midbrain, pons and medulla oblongata" referred to by Weil [1] was not observed, probably because of the acuteness of the intoxication. In a report concerning six deaths among thirty persons with acute wood alcohol poisoning, Gettler and St. George [2] noted only pronounced cerebral congestion with an increase of spinal fluid and engorgement of blood vessels. Detailed studies of tissues from the human central nervous system in methyl alcohol poisoning are wanting, since many of the patients recovered, and in others microscopic investigations were not made. However, in the brains of rabbits forced to inhale 0.2 per cent wood alcohol for periods of two, four, six, eight and ten months, Eisenberg [3] found degeneration of varying degrees, with an indefinite line of demarcation between the gray and the white matter, diminution of neurocytes with spindling and disappearance of Nissl granules, and a scattering of brownish pigment. In the later stages of the severe intoxications in these rabbits there was marked decrease in the size and number of parenchymal cells. The nuclear changes varied from peripheral wandering to complete karyolysis. Scott and his associates [4] exposed monkeys, rabbits and rats to methyl alcohol by cutaneous absorption,

1. Weil, A.: Textbook of Neuropathology, Philadelphia, Lea & Febiger, 1933, p. 191.
2. Gettler, A. O., and St. George, A. V.: J. A. M. A. 70:144, 1918.
3. Eisenberg, A.: Am. J. Pub. Health 7:765, 1917.
4. Scott, E.; Helz, M. K., and McCord, C. P.: Am. J. Clin. Path. 3:311, 1933.

inhalation and ingestion. They found in their animals capillary congestion, edema and patchy degeneration of the neurons. These changes were more often found in the spinal cords than in the brains. These authors quote Rühle as having found in dogs scattered hemorrhages along the blood vessels of the pons, medulla and cord, as well as large amounts of lipoid in the vascular endothelium and perivascular tissue. The deposition of lipoid often preceded the hemorrhage. Scott and his co-workers concluded that only parenchymal and neuronal tissues were affected. Such experimental evidence is probably of more value in depicting the injurious effect of methyl alcohol on the central nervous

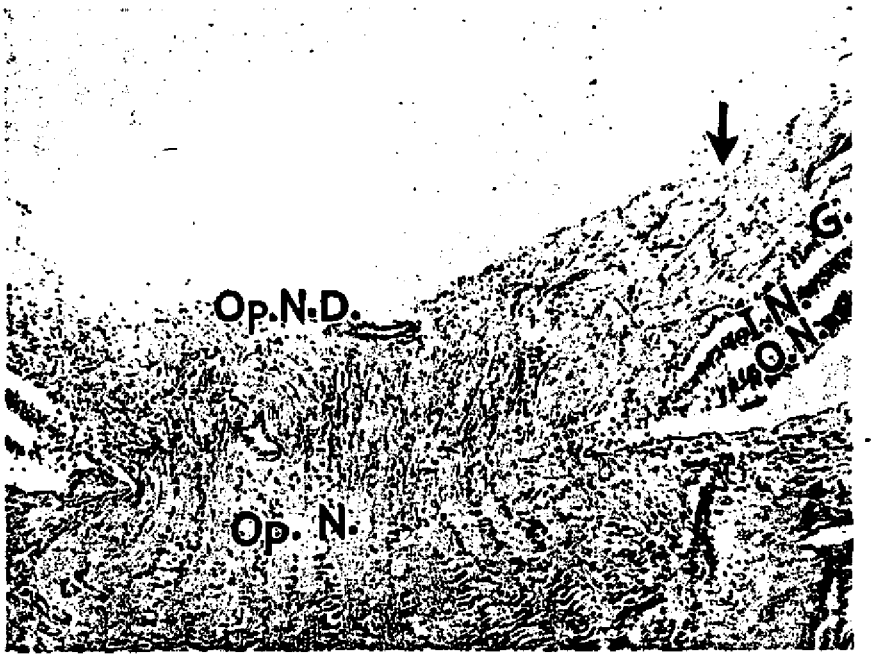

Fig. 1.—Photomicrograph of one of the eyes, showing obliteration of the "optic cup" at *Op. N.D.* *Op.N.* indicates the optic nerve; *G*, the ganglion cell layer of the retina; *I.N.*, the inner nuclear layer, and *O.N.*, the outer nuclear layer. The arrow indicates the region of the magnification shown in figure 2.

system than are the changes observed in such acute conditions as I have described in human beings, material which is not so accurately controlled. However, the susceptibility of the tissues of animals to wood alcohol must be considered in the evaluation, since there is such wide variation in the effects in the different animals studied. The derivatives of formic acid and the alcohol itself may becloud the real changes in the parenchyma of the central nervous system because of their fixative action.

Eyes.—In almost every one of the bodies the eyes were closed by the embalmer, so that their appearance was not noted at autopsy. However, one eye was removed from each body. Except for variations in the amount and in the edema of the retro-orbital fat, no noteworthy changes were observed about these eyes. They were placed in solution of formaldehyde and were later opened to complete the fixation. The retinas were found to be intact, grayish white and slightly

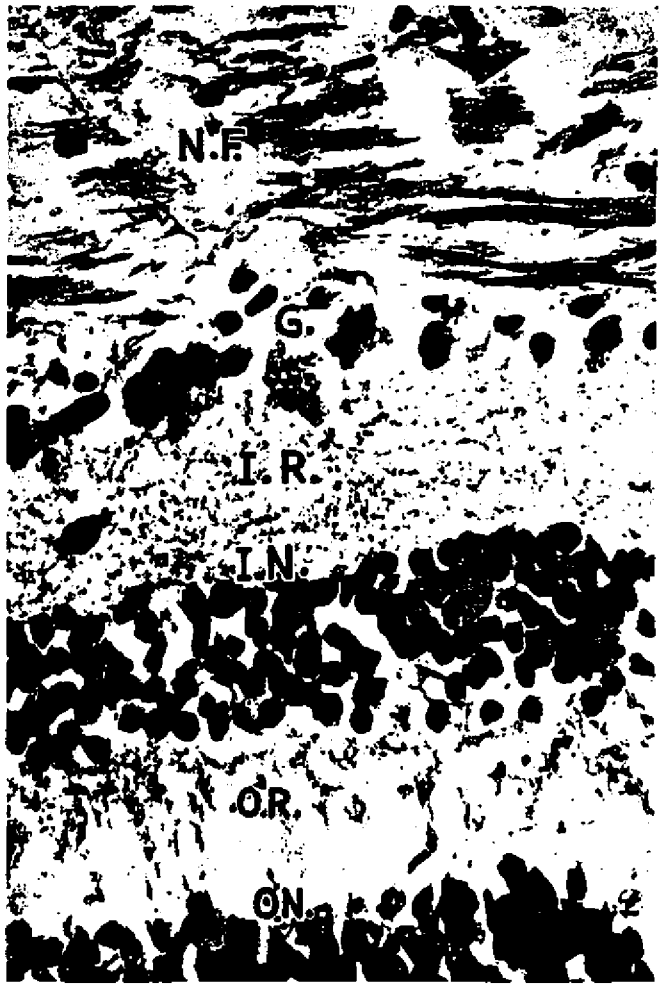

Fig. 2.—Photomicrograph of the retina in acute poisoning from methyl alcohol, showing the general edema, especially in the nerve fiber layer, *N.F.*, and in the ganglion cell layer, *G.* Note the pyknosis and eccentric wandering of the nuclei and the wide separation, as well as the cytoplasmic fraying, of the cells. *I.R.* indicates the inner reticular layer; *I.N.*, the inner nuclear layer; *O.R.*, the outer reticular layer, and *O.N.*, the outer nuclear layer.

wrinkled. The cuppings of the optic disks seemed to be absent and were often difficult to locate except by following the optic nerves (fig. 1). There was evidence of good fixation, increased opacity and toughness of the retinas.

Microscopically, little change was observed in the optic nerves except for edema and hyperemia and some patchy proliferation of glial cells. The most pronounced alterations were observed in the ganglion cells of the retinas: irregular staining, eccentric placement of nuclei, fraying of cytoplasmic outlines, vacuolation and autolysis (fig. 2). In many instances only about one in fifty of these cells approached normal, while in some of the eyes, they were entirely absent in wide areas. These changes in the ganglion cell layer were most marked nearest the disk. There were no noteworthy changes in the glial cells except for marked edema. Neuronophagia was not observed. The other layers of the retina were without notable alterations with the ordinary stains.

Practically all of these victims of acute methyl alcohol poisoning had given evidence of visual disturbances of varying degrees. It seems apparent from the examination of the eyes that in the earlier stages the dimness of vision was largely due to congestion and edema, a reversible process if early removal of congestion is accomplished, as has been noted in a considerable number of instances (Fenton;[5] Mathewson and Alexander[6]). Ziegler,[7] in reporting fourteen cases of blindness from drinking Jamaica ginger, observed that the loss of vision may be early, sudden and complete. Recovery may be lasting or it may be incomplete with gradual failure of vision and ultimate blindness. Ziegler found on physical examination sluggish, dilated pupils, variable reaction to light and accommodation (usually absent in severe forms), deep pain on rotation of the globes and tenderness on pressure, with occasional paralysis of the extra-ocular muscles, associated diplopia and ptosis of the lids. On ophthalmoscopic examination he noted swollen disks (2 diopters of swelling, resembling influenzal papillitis), edema, dilated veins and shrunken arteries. Ziegler also pointed out that the late insidious manifestations consisted of retrobulbar neuritis and shrinkage of the nerve head. While such clinical observations are of interest, there have been no studies of the corresponding minute alterations. Gettler and his associates saw marked degeneration not only of the optic but also of the vagus and splanchnic nerves. Scott and his associates noted in animals changes such as were described by MacDonald[8] in man. It appears that in neither human beings nor animals acutely poisoned with methyl alcohol are changes in the optic nerves demonstrable even with special neurologic technic. It is the consensus that the injuries in the inner layers of the retina are due to direct action of methyl alcohol or of its by-products and not to circulatory stasis.

Lungs.—The lungs were monotonously uniform in appearance. There was marked anterior and marginal emphysema, with posterior engorgement of varying

5. Fenton, R.: Northwest Med. **19**:22, 1920.
6. Mathewson, G. H., and Alexander, B.: Canad. M. A. J. **26**:679, 1932.
7. Ziegler, S. L.: J. A. M. A. **77**:1160, 1921.
8. MacDonald, cited by Scott and others.[4]

intensity. In every case the lungs almost completely filled the thoracic cavity and covered the cardiac area. There was no gross evidence of pneumonia or of other noteworthy pulmonary disease.

Microscopically, there was seen marked engorgement of the larger blood vessels, as well as of the capillaries, in the sections from the posterior halves, while anteriorly thin-walled anemic alveoli, free from cells and albuminous material, were noted. In only one instance was there acute bronchitis, and in another there was terminal hypostatic pneumonia simulating the influenzal type. The changes in the lungs (emphysema) were in accord with the clinical phenomena of labored breathing and final asphyxia from respiratory failure. The prostrations and deaths were too rapid to permit development of more serious lesions in the lungs.

In considering the reasons for the respiratory phenomena, Rabinovitch [9] pointed out that neither saturation of the venous blood with oxygen nor formation of methemoglobin occurs. In experimental animals local manifestations in the lungs may be in part attributed to direct injury (inhalation of fumes). The altered condition of the nerve trunks (including the phrenic and vagus nerves), the edema of the brain, and the herniation of the brain stem are concerned in the respiratory difficulties and final cessation. Gradinesco [10] stated that small doses of alcohol (C_2H_5OH) produce increased weakening of respiration, with augmentation of the amplitude, whereas large fatal doses cause inhibition and complete arrest, with the typical phenomena of asphyxia. Gradinesco regarded this as due to (1) diminishing circulation in the respiratory center, (2) involvement of the motor centers of the costothoracic nerves and (3) later involvement of the phrenic nerve centers, with resultant agonal asphyxia suddenly replacing the primary weakening of respiration. These factors undoubtedly are also of importance in acute methyl alcohol poisoning.

Livers.—It is notable that only one of the livers showed evidence of atrophic cirrhosis, and that this was of a minor grade. There was increased moisture about the livers. Many were enlarged; one weighed 2,920 Gm. They appeared yellowish brown and had smooth capsules. The gallbladders were all distended, being markedly filled with very watery brownish bile. The cut surfaces of the livers were generally wet, bloody and greasy. There were no distinctive focal lesions nor was there an increase in the bile content.

Microscopic examination disclosed the cirrhosis in the one instance to be, as stated, of a low grade. While three of the livers showed most marked parenchymatous degeneration with only small fat vacuoles, the remaining nineteen were all strikingly fatty. In the latter instances the sinusoidal structures were almost obliterated, and few normal-appearing cells were seen. The size of the fat vacuoles, as well as their extent, probably indicates the cumulative effect of previous consumption of alcohol. There was no evidence of infection. Sections of the gallbladder disclosed nothing but edema and postmortem changes. No focal necroses were seen in the livers such as have been noted in experimental methyl alcohol poisoning.

9. Rabinovitch, I. M.: Arch. Int. Med. 29:821, 1922.
10. Gradinesco, A.: J. de physiol. et de path. gén. 32:363, 1934.

Stomachs and Intestines.—Most of the stomachs were found contracted and empty except for small amounts of viscid bloody mucous material. In only one was food mixed with the secretion. The mucous linings were in general engorged, stippled with punctate hemorrhages and granular but free from acute or chronic ulcerations. The walls of the stomachs were edematous and hyperemic. Similar conditions were observed in the duodenums. Beyond their upper ends, the small intestines were uniformly edematous and hyperemic, while varying but small amounts of feces were present in the large intestines. No other noteworthy gross pathologic changes were found in the gastro-intestinal tracts. The esophagi were free from gross changes except for increased glistening of the mucosas, which were well preserved; in one, a small chronic ulcer was seen.

Microscopically, the stomach uniformly disclosed superficial necrosis, with varying condensation of the underlying defensive wandering cells in the area at the base of the zones showing acute destruction. These cells comprised large numbers of plasma cells, eosinophils, monocytes, polymorphonuclear leukocytes and lymphocytes, with a frequency in the order named. In addition there was considerable desquamation of the epithelium of the mucous glands, with cytoplasmic edema and disintegration. Marked mucous distention of mucosal cells was evident. Deeper in the gastric mucosa were varying concentrations of lymphocytes with accumulations of fibrous connective tissue and alterations of the glands, indicating long existing chronic gastritis. In the duodenums, similar acute and chronic changes were noted. The gastric changes observed were probably in part due not only to the direct action of the poisonous liquor but also to reexcretion of the poison through the stomach and intestines (Gettler). The recurrence of abdominal pains and final paralysis may be explained by this phenomenon.

Kidneys.—The kidneys were all slightly increased in weight, engorged and firm. The surfaces all showed normal markings, but there were increased graying and moderate bulging of the parenchymas beyond the edges of the capsules.

Microscopically, the renal tissues were in an excellent state of preservation. There was little evidence of glomerular or tubular damage, either recent or old. While there was some edema, only a few kidneys disclosed moderate parenchymatous degeneration of the tubular epithelium. None showed arteriolosclerosis, and only a few had atherosclerotic changes in the large vessels.

No remarkable changes were found in the hearts, spleens, pancreases and other organs of these bodies either grossly or microscopically except for moderate degrees of dilatation of the right ventricle of the heart. There were no pathologic changes suggestive of hypertension in any of the bodies.

COMMENT

The aforementioned clinical and pathologic changes occurred in men who accidentally partook of concentrated methyl alcohol. These addicts had been accustomed to drinking various preparations of denatured methyl alcohol over a period of years. Certain drugstores were known as "dehorn" joints where addicts customarily got their "shots" by the glass or bottle, which liquor was diluted with water, lemon juice or milk. These men usually ate sparingly of canned foods, such as beans and sardines, while drinking. Apparently the only effect of such consumption was to produce hilarity and drunkenness. A number of addicts when questioned revealed an intensive craving and decided pref-

erence for this kind of alcohol rather than for good whisky. As Ziegler pointed out, the frequent use of methyl alcohol as a beverage is due to the refinement, the cheapness and the extensive use in the arts, making it readily available. The reduction of the percentage of methyl alcohol from 10 to 2 in the denaturing of ethyl alcohol also encouraged its use, especially during the period of prohibition in the United States.

The accidental consumption of methyl alcohol which caused the death of these twenty-two men was due to the injudicious sale of pure methyl alcohol by an uninformed workman of a certain paint company to several drugstores engaged in the nefarious practice of supplying denatured methyl alcohol to customers.

A toxicologic examination of available samples collected by the police and of the tissues of two unembalmed bodies was made by the late Harold B. Myers, professor of pharmacology. The basic chemical tests and refractometer readings showed that a sample bottle labeled "denatured grain alcohol" obtained from a certain drugstore contained pure methanol. Many of the bottles found near the dead bodies were dry, while others contained pure concentrated methanol. All of the twenty-two men who died had undoubtedly consumed diluted pure methanol, which was also found in the complete toxicologic examination of the tissues from the two bodies referred to.

It is well recognized that the seriousness of the consumption of methyl alcohol is due to the retention of this alcohol by the tissues and its slow oxidation into formic acid, which is about six times as toxic as the alcohol itself. This results in generalized acidosis, demonstrable in the blood and urine (Haskell and co-workers [11]). Once consumed or inhaled, methanol is quickly dispersed to all tissues of the body, having no selective affinity (Yant and Schrenk [12]) but apparently injuring by direct action the more highly specialized tissues of the retina, brain, kidneys and liver and to a lesser extent the other tissues and organs.

The variable clinical manifestations are undoubtedly due to the toxic effect of methanol on nerve tissue. Gradinesco and Degan [13] showed that in weak concentrations (from 5 to 10 per cent) methanol first causes excitability and then diminution of response, going on to complete paralysis. With strong concentrations (from 15 to 30 per cent) there is usually rapid paralysis. The effect undoubtedly varies with the rate of oxidation in different persons; hence the peculiar and varying clinical episodes.

11. Haskell, C.; Hillman, S. P., and Gardner, W. R.: Arch. Int. Med. **27**: 71, 1921.

12. Yant, W. P., and Schrenk, H. H.: J. Indust. Hyg. & Toxicol. **19**:337, 1937.

13. Gradinesco, A., and Degan, C.: J. de physiol. et de path. gén. **32**:826, 1934.

SUMMARY

In twenty-two instances of fatal poisoning from pure methanol, accidentally sold but maliciously dispensed to men with an addiction to denatured alcohol, the outstanding pathologic changes consisted of marked edema, hyperemia and necrosis of the stomach, intestines, liver, brain and retinas. Clinically the victims showed intense nerve excitability, evidenced by excruciating abdominal pain, muscle twitchings, rapid respiration and rapid cardiac action, with final paralysis, cessation of pain, dimness of vision, fixation of pupils, labored respiration and death from respiratory failure. Such changes as were noted in the retinas and brain, in particular, and in other organs, are not regarded as selective but accidental in more highly specialized tissues. The minute pathologic changes in acute methanol poisoning are secondary in importance to the gross alterations in causing clinical manifestations. Except for the fatalities from the accidental massive doses of pure methanol, there was nothing grossly discernible in these unfortunate addicts to show that the consumption of small (?) quantities of methanol in denatured alcohol over a period of time produced in them either an increase in their susceptibility to disease or an untoward accumulation of pathologic processes such as are so frequently observed in the more discreet and discerning members of society of the same age and environment. While they may have been unproductive and unmoral, their resident physical properties seemed admirably protected and preserved in spite of their addiction to impure alcoholic beverages.