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matter. At this point it must be remembered that the industrial worker is usually a member of a family group who eat together at the same table. In addition, any practical diet plan must take into account the fact that families have some preferences in the choice of foods: the plan must be adjusted to fit the pocketbook, and the food should be attractive and pleasing.

The foods common in this country can be classified into about a dozen major groups. Suitable quantities of foods in these several groups can be combined to provide adequate nutrition over a period of a year, a month or a week for individuals of different age, sex and activity. Of course many combinations of these twelve major food groups can be worked out so that all the nutritive requirements which have been discussed in this paper will be amply provided. As an example of such a combination, table 1 shows the respective quantities of food in each group that will provide these nutritive essentials over a period of one year, listed opposite the descriptions of each type of family member. This particular combination of major food groups is one that can be provided at a relatively low cost. When the family composition is known it is a simple matter to read off in each of the twelve columns the quantities of foods that will supply the nutritive needs of individual members of the household. Simple addition of these quantities will provide the totals required by the family during the period of one year. If each of the sums is divided by 12 the results will give the quantities of foods in each major food group required by the family for one month; if divided by 50, the result is the approximate weekly quantities needed by the family.

If a family consisted of one moderately active man, one moderately active woman, a 5 year old daughter and an 8 year old son, this family's food requirements could be adequately met by weekly supplies of the kinds and quantities of foods (shown separately for each member of the family) indicated in table 2. These weekly allowances of food provide for the approximate daily intake of calories, protein, fat and carbohydrate as well as certain minerals and vitamins in the quantities shown in table 3.

The weekly cost of this food for these four persons would vary somewhat depending on current prices of food in the particular locality in which the family lived. According to prices reported in 1935-1936 by families of wage earners and clerical workers living in a wide range of localities in the United States, with adjustments made in accordance with trends in price levels obtained from the Bureau of Labor Statistics, this family's total food bill for one week during the period January to October 1938 would have varied (depending on the locality) between $6 and $9.50.

This diet plan provides for choice in eight of the twelve food groups as to which particular foods in the group the family elects to eat. For reasons discussed earlier, the family is urged to introduce as much variety as possible in its choices within those food groups which provide for choice. According to surveys based on about 4,000 records of weekly food consumption, Stiebeling and Phipard[3] report that approximately 50 per cent of employed wage earners and clerical workers in various cities of the United States actually spent enough money for food to obtain diets of this nutritive quality. Although they actually spent enough money to get a diet as good as the one suggested in table 1, the actual food selection of many of these families was such that the nutritive value fell short of this plan. The remaining 50 per cent did not spend enough money to obtain a diet with as good nutritive value as that suggested for a good low-cost diet in table 1. The practical problem of good nutrition is often, as was shown in these studies, a combination of educational and economic factors.

The plan of food selection outlined in table 1 is offered merely as a sample plan to show how the industrial workers and their families might solve the problem of adequate nutrition without undue expense.

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## PRESENT STATUS OF BENZENE

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In order to dispel any confusion concerning the present status of benzene, it is necessary to have a very definite differentiation between benzene and benzine.

Benzene (benzol $C_6H_6$)[1] is a single chemical substance obtained by distillation of coal tar and is purified by redistillation at from 70 to 80 C. Gasoline, or benzine,[2] is obtained from the distillation of petroleum and is a mechanical mixture of hydrocarbons ranging from $C_5H_{12}$ to $C_6H_{14}$. Its composition varies according to the boiling point. At 36.3 C. it contains from 60 to 70 per cent of pentane, $C_5H_{12}$. Substances distilling between 30 and 70 C. produce what is commonly called gasoline.

Benzene is obtainable in several grades in commerce:

1. Benzene. Chemically pure (U. S. P. XI, p. 85) 95 cc. distils between 79.5 and 81 C.

2. Benzene 90 per cent: This is 90 per cent of the distillate up to 100 C. Composition from 80 to 85 per cent benzene, from 13 to 15 per cent of toluene, 2 or 3 per cent of xylene and 1 per cent heavy residue.

3. Benzene 50 per cent: This is 50 per cent of the distillate below 100 C., 90 per cent below 120 C. Composition from 45 to 50 per cent benzene, heavy residue of olefins, paraffins and complex bodies and some toluene.

4. Solvent naphtha. Consists chiefly of xylene, a small amount of toluene and thiophene.

A thorough knowledge of the difference between benzene and gasoline will, I believe, explain the diminishing number of cases of poisoning by the volatile hydrocarbons of the benzylic series. Benzene, toluene, xylene, naphthalene, anthracene and phenanthracene belong to the benzylic series and contain one or more carbon rings. Gasoline, on the other hand, does not belong to this series but to a lower unsaturated carbon-hydrogen combination commonly called the marsh gas series.

Pure benzene is a chemical entity, while all gasolines vary over wide ranges in composition. Commercial benzene has the following impurities in varying amounts: xylene, toluene, phenol, thiophene, carbon bisulfide, acetonitrile, pyridine and traces of many other substances.

Gasolines have no definite composition; for example, gasoline from Pennsylvania contains pentane, hexane, heptane and paraffins while gasoline from California and Texas contains cyclopentanes, cyclohexanes and cycloparaffins.

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Read before the Section on Preventive and Industrial Medicine and Public Health, at the Ninetieth Annual Session of the American Medical Association, St. Louis, May 19, 1939.

1. Benzene ($C_6H_6$ or $PhH = 78.08$; benzol (German), benzide (French), phenylhydride, cyclohexatrienene, phene) is a colorless liquid or crystals with a density at 20 C. of 0.879, melting point 5.5 C., boiling point 80.3 C., insoluble in water and miscible with alcohol and ether, acetone and glacial acetic acid.

2. Benzine, or gasoline is a mixture of hydrocarbons obtained from the second portion of the fractional distillation of crude petroleum which consists of the fraction boiling between 70 and 90 C. A clear colorless liquid with a density of from 0.640 to 0.675.

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### USES

Benzene has the following uses:

1. As a solvent for paints, lacquers and varnish, rubber and fats.
2. In color printing.
3. As a cleaning agent for clothes.
4. As a motor fuel.
5. In the chemical manufacturing industry.

Both benzene and gasoline are poisonous but benzene is quicker in its action, and the intensity is much greater. There are three avenues of entrance of benzene into the body: (1) the respiratory system, (2) the alimentary system and (3) the skin.

It is my opinion that in from 90 to 95 per cent of cases the benzene enters by way of the respiratory system, the incidence of cutaneous absorption being very small except in those cases in which the hands and arms are immersed in solutions containing a large percentage of benzene or when the hands are washed in benzene to remove grease and rubber. This procedure, however, should be condemned.

Absorption by way of the alimentary system is not great but often occurs when materials are introduced into the mouth or food that has been in the same room with the benzene is eaten or tobacco that has been exposed to benzene fumes is put into the mouth. A small percentage of benzene is dissolved in the mucous secretions of the mouth and throat and swallowed. The greater the concentration of the fumes, the greater the amount absorbed by the skin and the alimentary tract, but under controlled conditions these two avenues of absorption are practically negligible.

The human system can tolerate minute amounts over a period of many months if proper aeration and elimination are instituted. In other words, a small factor of immunity develops through an equilibrium between intake and output of absorbed material. Just as soon as a minute increase of intake over output develops, symptoms begin to appear.

The following clinical symptoms seem to me to be the most predominating after observing and examining between 6,000 and 7,000 men and women who have worked with the various compounds containing benzene or its homologues for the last twenty years:

1. Peculiar brackish taste.
2. Slight giddiness.
3. Unsteady vision and slight headache.
4. Nausea and vomiting.
5. Dizziness, "benzene jag," odor of benzene.
6. Weakness. Benzene breaks down the body defense against acute infections and many secondary conditions develop, such as (*a*) gingivitis, (*b*) boils, (*c*) pustular conditions of the skin, (*d*) frequent colds, (*e*) arthritis and (*f*) infections of the gastrointestinal tract. Hektoen has done much work on the effect of benzene on antibody formation.[3]
7. Increased nervousness with increased pulse, nosebleed, uterine bleeding, bleeding from the gums.
8. Slight temporary increase in blood pressure.
9. Excessive fatigue at the end of eight hours' work.
10. Marked tremors of the hands.
11. Loss of equilibration in the dark.
12. Gastric and intestinal disturbances.
13. Paresthesia—numbness, tingling.
14. Insomnia—in the first stages drowsiness and in later stages insomnia.
15. Loss of weight, benzene pallor.
16. Benzene purpura, nosebleed, anemia.
17. Menstruation every two or three weeks by female employees.
18. Dermatitis.
19. Nephritis.
20. Labored respirations and coma.

With reference to anemia under paragraph 16, it may be said that many thousands of blood counts have shown that this is one of the main factors that the industrial physicians must rely on to show the effect of benzene on the individual. There first develops a slight leukocytosis, later a slight leukopenia, and erythropenia with a slight reduction in hemoglobin content. With increased absorption this progressively gets worse, and the following develops:

1. Increased leukopenia.
2. Increased erythropenia.
3. Lymphocytosis.
4. Development of few transitionals. A point is reached when the blood forming organs are nearly suppressed and the new cells do not form rapidly.
5. Decrease in coagulation, caused by a decrease in prothrombin and thrombin.
6. Decrease in blood calcium.
7. Decrease in antibody formation.
8. Severe decrease in hemoglobin formation with increase of hematin in the urine and decrease in blood platelet formations.
9. The beginning of endothelial lining cells to appear in the blood stream. The appearance of these cells indicates the serious if not the fatal stage of poisoning.
10. Complete cessation of formation of new blood cells.

I have observed in a few cases a condition of vacuolation in the leukocytes, but this is not a constant factor. It probably is due to the inability of the cells to retain fatty compounds, and I believe that fatty substances are either extracted or prevented from forming in the nerve tissue, thus producing the nervous complex. The effects of benzene are accumulative, more lasting and more severe than those of gasoline.

Temporary exposure to slight concentrations of benzene or gasolene are transient, and complete aeration causes the effects to disappear. It is the constant absorption of small amounts daily that produces the detrimental effects.

In October 1935 Yant and Sayers and their associates[4] presented a new method for controlling exposures to benzene by the determination of urine sulfates. Since Dr. Yant and his associates advocated this method of detection of the absorption of benzene, I have inaugurated it as a routine procedure for all patients who work with benzene. During the last ten months I have studied 650 workers with the inorganic sulfate method in conjunction with blood work, physical examinations, analysis of the air and any other clinical examinations which I thought might throw some light on this method. From my experience I have found several factors, which I shall mention:

1. In most industries using large quantities of benzene the fire hazard is great; when it is possible, some other solvent is combined with benzene to reduce the flash point of the benzene. The nature of the solvent determines the accuracy of the test. For example, carbon tetrachloride is often used; it causes the opposite effect from benzene on the sulfates and therefore, unless there is an extreme reduction, the results are not useful as a diagnostic factor. Ethylene dichloride is another solvent that is used with benzene and changes the results.

3. Hektoen, Ludvig: J. Inf. Dis. **19**: 69 (July) 1916.

4. Yant, W. P.; Schrenk, H. H.; Sayers, R. R.; Horvath, A. A., and Reinhart, W. H.: J. Indust. Hyg. & Toxicol. **18**: 69 (Jan.) 1936.

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2. There is some variation on different days in the same individual working under the same concentrations. I have found that in some cases the inorganic sulfates in the urine are as low as 50 per cent one day and a recheck the following day at the same time and with the same concentration shows them to be 80 per cent. If this were a single case I would say that the discrepancy was due to technic, but a careful check of all reagents was made and controls were run to eliminate the possibility of error. I have made it a regular rule to have all urines below 70 per cent rechecked, and if this concentration persists I know that there is something wrong in the ventilation or that the individual is absorbing benzene from some other source.

3. Atmospheres containing from 100 to 115 parts per million in eight hours have but little effect on the inorganic sulfates, but over a period of time there is a slight change of from 8 to 10 points. I have not noticed any change in the blood when the concentration has ranged between 100 to 125 parts per million.

4. Alcohol and certain foods cause a change in the daily sulfates.

5. It has not been determined how long a person can work with inorganic sulfates below 50 per cent before a change in the blood occurs. I have several workers who have been working for one year and four months, with their inorganic sulfates fluctuating from 56 to 82 per cent, and their blood and all other examinations normal. These men are examined completely every month, and at the slightest change in the blood picture they are removed from contact with benzene. On several occasions I have found the inorganic sulfates between 8 and 10 per cent when the person had been cleaning clothes with benzene, but in two days, after there was no contact with benzene, the inorganic sulfates were up to 75 per cent.

However, may I impress the point of rechecking all cases in which the ratio is less than 70 per cent; if the percentage is 50 per cent or less two courses must be taken: The person must be removed from contact with benzene and the ventilation must be corrected until air samples show from 100 to 115 parts per million.

The accompanying table shows one of the numerous surveys made and the correlation between the concentration of benzene, inorganic sulfates and the blood picture.

This experiment shows the value of making frequent urinary sulfate determinations for the control of benzene absorption.

### PREVENTIVE AND CORRECTIVE MEASURES

1. *Ventilation and Safety Devices.*—This is one of the most important factors. To keep the concentration of benzene in the atmosphere below a certain point one must recognize the fact that benzene fumes are heavier than air and that they are very diffusible. Ventilation from the floor by means of suction is preferable to overhead ventilation. Ventilation must be general, for benzene fumes form pockets. Benzene fumes liberated on one floor may produce a rather high concentration on a floor below if suction ventilation is not used.

2. *Healthy Persons in Operations Using Benzene.*—My experience has shown that undernourished, anemic persons or those afflicted with bronchitis, any pulmonary condition or cardiac or kidney infections should not be placed where they come in contact with benzene or gasoline fumes. Female help, as far as possible, should not be placed where there is a very high concentration of any of these fumes, for no matter how healthy they are they begin to have menstrual disturbances after some absorption.

A certain group of persons can tolerate a large amount of benzene and show but little physical effect. Those who are shallow breathers seem to be less affected than the deep breathers. There appears to be some relation between the permeability of tissue diffusion in the lung tissues and the amount of absorption which causes physical symptoms to appear. Persons addicted to alcohol seem to tolerate benzene or gasoline fumes to a greater extent than others. I attempt to place only those in fine physical condition on operations in which benzene or any allied product may have to be used, and I believe that it has been worth while.

3. *Education Program.*—Proper instructions to the supervisors and the workers in all departments in which any volatile substances are used, such as benzene, gasoline, carbon tetrachloride or other such substances, are very important. They should be told of the properties of the substance they are using, what conditions might develop from excessive inhalation or exposure to it and how these conditions can be successfully prevented by taking precautions and obeying the instructions given.

*Correlation Between Concentration of Benzene, Inorganic Sulfates and Blood Picture* *

| Sample Number | Position | Sampling Time, Min. | Volume of Sample, Cc. | Parts per Million | Comment |
|---|---|---|---|---|---|
| 1 | Between D 1 and 2 neutralizers | 25 | 150 | 980 | Filter overflow returning to D 1 |
| 2 | D and press | 19 | 150 | 490 | Filtering |
| 3 | Platform front of C and D units | 21 | 150 | 330 | |
| 4 | Between C 1 and 2 neutralizers | 22 | 150 | 1,171 | Leak in benzene line on C 2 |
| 5 | C unit press | 17 | 100 | 440 | Filtering |
| 6 | Same as No. 1 | 24 | 150 | 360 | Doors closed |
| 7 | Same as No. 2 | 24 | 150 | 44 | Doors closed |
| 8 | Floor half way between presses | 25 | 200 | 117 | Both presses filtering |
| 9 | Between C and D reactors | 19 | 150 | 194 | |
| 10 | Between C and D spreaders | 21 | 150 | 117 | |

* All tests were taken at a working level of from 4 feet 4 inches to 5 feet 6 inches, where the operator's nose is most apt to be when at work. These figures were taken from the rubber industry. C 1 and 2 and D 1 and 2 designate machines.

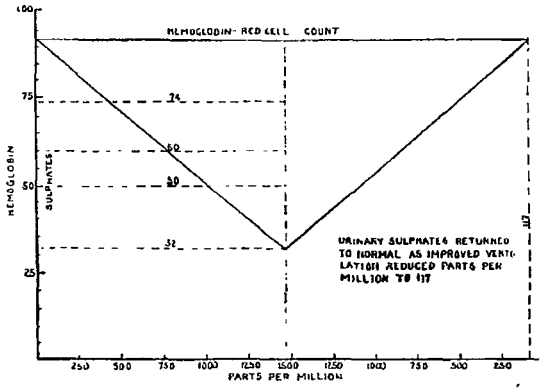
4. *Frequent Examinations.*—All persons should be examined before being allowed to work in these departments. They should have examinations every thirty to ninety days, according to the concentrations of the vapor in the various departments. If examination of the blood, urine, blood pressure, vision, sensation and equilibration shows any indications of absorption, the person should be transferred to some other job. Workers are advised of general health principles and methods of elimination of absorbed benzene.

5. *Substitution Products in Place of Benzene.*—Many substitutions have been tried to replace benzene, such as its higher homologues toluene, naphthalene and xylene and other solvents of the unsaturated hydrocarbons. My experience has been that gasoline is less poisonous and will eventually replace benzene in nearly all operations until a better nonpoisonous solvent is found.

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Batchelor [3] has done some remarkable experimenting with benzene and some of its higher homologues by using intraperitoneal and subcutaneous injections and inhalations in groups of animals. His conclusions are that toluene, xylene and hi-flash naphtha are vastly superior from a toxic standpoint and are practically devoid of the industrial hazard involved in the use of benzene. This statement is true with regard to the relations of the toxicity, but I do not believe that toluene, xylene and hi-flash naphtha can be so lightly considered.

It is not occasional exposure to these compounds that causes the harm but the daily exposure over long periods of time. Various mixtures, under commercial names, have been tried for solvents in order to reduce the flash point, thereby reducing the fire hazard. These invariably contain carbon tetrachloride. Carbon tetrachloride in small quantities, when inhaled, causes extreme nausea and often severe vomiting and should be used only in closed systems of ventilation. I have found that gasoline works almost as well as benzene in most operations, and the number of cases of dizziness and nausea has been reduced to a minimum.




Hemoglobin and red cell count not affected, insufficient exposure; exposure controlled by urinary sulfate determinations.

Many things must be considered before the use of a substitute product in industry is advocated:

1. Is it injurious to the human being?
2. Is its operation more or less efficient?
3. Is its operation more or less expensive?
4. Does it require a large outlay of expense to install?
5. What is the competitor using and what is the quality of his product?

It requires very close cooperation between the medical department, the chemical department, the safety department and the production efficiency department to arrive at a proper conclusion.

### METHODS OF CORRECTING CONDITIONS

The methods of correcting conditions when volatile substances are used resolve themselves into a very definite procedure:

1. Experimentation and research made on the substance used as to its detrimental effects on the human system. If such a substance causes detrimental effects, three main recommendations should be made:

A. Discontinuance of the substance, and if this is not possible, then

B. Substitution of an allied substance not so detrimental, and if this is impossible then

C. Use of the substance in a closed, airtight system, which prevents dissemination of the gases, or institution of suction ventilation, depending on the nature of the substances as to whether its gaseous form is heavier or lighter than air.

2. The rotating of the individuals who work with the substance to other jobs.

3. Use of gas marks. This has not proved very practical in industry.

4. Frequent examinations: Removal from the job of any one showing signs of poisoning, such as: (1) persistent urinary sulfates below 70 per cent; (2) slight purpura or hemorrhage from mucous membranes or other organs; (3) reduction in white cells of 1,500 below normal (a 7,000 count is assumed as normal); (4) reduction of red cells of from 10 to 15 per cent below normal; (5) reduction of hemoglobin below 80 per cent, and (6) slight variation in coagulation time.

### TREATMENT

A person who, on examination, shows any effects of a solvent such as benzene or its homologues, gasoline or its derivatives or carbon tetrachloride, is immediately removed from contact with the substance. The treatment proper of benzene consists of: (1) elimination; (2) aeration, oxygen inhalations; (3) treatment of gastric disturbances; (4) treatment of secondary anemia; (5) supportive measures for the heart and protection of the kidneys; (6) stimulation of the blood-forming organs by use of iron compounds, reticulogen, liver and spleen substances, transfusions and roentgen therapy to the long bones; (7) nourishing food with an excess of animal fats; (8) increase of the calcium intake, and (9) intravenous saline and dextrose.

### CONCLUSION

Experience has shown that benzene and its derivatives present a very definite and serious industrial health hazard. The primary effects of these substances are produced on the blood and blood-forming organs with secondary involvement of the nervous system and other organs. In high concentrations they cause acute poisoning, often with sudden death, and in low concentrations a slow but chronic poisoning. The hazard can be perfectly controlled by certain definite procedures:

1. Proper ventilation
2. Substitution of less poisonous solvents.
3. Frequent examination, and the early removal of any one showing slight symptoms of poisoning, as detected by a low urinary sulfate determination.
4. Proper education of the supervisors and workers.
5. Close cooperation between the production and medical departments.
6. Establishment of physical standards for those who are going to work with benzene or any of its homologous compounds.

633 East Market Street.

### ABSTRACT OF DISCUSSION

DR. A. G. CRANCH, New York: The warning is still timely not to confuse benzene with benzine. The two products are different technically and in toxicity. There are also various impurities in commercial benzene. With regard to early case finding, much emphasis is often placed on blood counts showing reduction in leukocytes and red cells. Dr. Davis has warned of the leukocytosis which sometimes precedes the leukopenia and may be misleading. Urinary tests furnish a practical guide, but Dr. Davis well emphasized the pitfalls: the

[3] Batchelor, J. J.: The Relative Toxicity of Benzol, Am. J. Hyg. 7:1-37 (May) 1927.

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errors due to mixed solvents, the daily variations which may occur in the individual case and the failure at times to obtain a significant test even in the presence of dangerous exposure. In preventive work it is well to remember the heaviness of the fumes. This condition is present with many industrial solvents and calls generally for lateral or down draft for its removal. I would stress the value of education. I have had good results by particularly instructing workers not to inhale the fumes recklessly, and in case of an unusual or temporarily increased exposure they almost involuntarily withdraw and cease to breathe deeply. There are dangers in substituting other solvents for benzene, as sometimes the substitute may prove to be equally or more toxic. This is true also in some cases in which benzene has been diluted with other solvents. I would ask Dr. Davis what he can tell us as to recurrence of serious symptoms among patients who had apparently returned to normal after treatment for benzene poisoning. Such apparently cured persons with a normal blood picture after a slight intercurrent infection like influenza sometimes seem rapidly to grow worse. Is this usually the case? Something to bear in mind with regard to benzene poisoning is that in the patients' subsequent life great care should be exercised to avoid the exposures which might reactivate their symptoms.

DR. LOUIS SCHWARTZ, New York: As Dr. Davis stated, the use of benzene in industry is diminishing and its place is being taken by solvent naphtha or some other agent which is less toxic. Toxic symptoms usually occur from inhalation of these substances and not from contact with the skin. Dr. Davis has said that 95 per cent of the cases of benzene poisoning are due to inhalation. That is true because when these substances are inhaled they are inhaled in minute proportions and taken into the body; they do not irritate the mucous membranes or the skin. If the skin is exposed to them in concentrated form, it is defatted and blistered and its absorptive qualities are impaired. This is true of all the volatile solvents; those substances do not inflame the skin but penetrate it, and they are more likely to cause toxic reactions than those which inflame the skin. Most of these volatile solvents take the fat out of the skin. Persons who have greasy skins can withstand their action much better than those who have dry skins. This brings up the point of how to prevent dermatitis from these substances. When a person handles them he should rub olive oil or some other animal or vegetable fat into the skin to replace whatever fat has been taken out by the solvent. Another way of preventing dermatitis from these substances is to wear gloves; rubber gloves ordinarily do not withstand the action of these solvents and are easily soluble in them, so synthetic rubber should be used because that stands up much better. I should like to ask Dr. Davis what his experience has been in noting symptoms of dermatitis in cases of benzene poisoning. He will probably tell you that dermatitis is not common among those who suffer with benzene poisoning, and those who suffer from dermatitis are not so likely to have benzene poisoning.

DR. P. A. DAVIS, Akron, Ohio: In answer to Dr. Cranch's question in regard to the recurrence of symptoms with some concurrent infection, I do not believe that the patient has been discharged as completely cured before he has this condition. For instance, I had occasion recently during an epidemic of influenza to observe several men who, while they had a low urinary sulfate level, around 60 or 70 per cent, were taken off the job and subsequently contracted an influenza infection. They returned to normal slowly, probably because benzene absorption had produced some effect on the myelogenous tissues and on the spleen and prevented the normal return of the blood cells. I recall a case in which a man had had acute benzene poisoning and there developed definite leukopenia and erythropenia; his urinary sulfates returned to normal in three weeks and his blood to 95 per cent. The red and white cells returned to normal. He was not put back in contact with benzene but was placed in another position entirely free from any volatile substances, and influenza developed. After his influenza apparently cleared up he still seemed to have benzene poisoning, and the only explanation I have for that is that the blood-forming organs had not returned to normal before he had a subsequent infection or some other involvement. It takes a long time for the blood-generating organs to return to normal antibody formation. They remain as a stationary factor for some time after the blood picture and the urinary sulfate picture have assumed a normal status. With regard to the dermatitis caused by benzene, acute benzene poisoning does not necessarily show up as a skin condition at all. The dermatitis from benzene is contact dermatitis and not systemic dermatitis. In only a few cases does systemic dermatitis result from benzene poisoning. With regard to protection of the workers, I have a hard time convincing the engineers that, since nobody has been killed or poisoned while manufacturing these materials, no one should be poisoned or killed while using them. If proper protection is given, whether against benzene, a halogenated compound or any other volatile substance with toxic effects, by masks or whatever safety devices are available, I do not think any trouble will be experienced. The organization with which I am connected has instituted the use of a wax ointment. Men who are going to work with benzene smear it all over their hands, arms and faces. This ointment is not soluble in benzene, so they have little absorption but sufficient skin protection. I think there must be external protection against all these substances if acute absorption is to be avoided.

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# THE CARDIOPATHOLOGY OF HEATSTROKE

GALE WILSON, M.D.

SEATTLE

Under the term "heatstroke" are herein included four deaths from hyperpyrexia, one caused by insolation or "sunstroke," and three from artificially induced pyrexia by the so-called fever machine.

Historically this affliction is as old as Biblical times, being described in 2 Kings (Osler[1]). The early Arabians felt that Sirius, the Dog Star, in some way was responsible for the symptomatology and called the disease "siriasis." During the British occupation of India and subsequently, heatstroke has received considerable attention, but the pathologic condition in the fatal cases has apparently been decidedly secondary to the clinical manifestations. Osler[1] dispenses with the morbid anatomy in these few words: "Rigor mortis occurs early and putrefactive changes may come on with great rapidity. The venous engorgement is extreme, particularly in the cerebrum. The left ventricle is contracted (Wood) and the right chamber dilated. The blood is usually fluid; the lungs are intensely congested. Parenchymatous changes occur in the liver and kidneys."

Webster[2] also dismisses death from heatstroke with this concluding sentence: "The autopsy findings will be those due to either syncope or asphyxia." From the condition at autopsy of the four cases to be presented it would appear that the cardiac lesions found in all the cases closely approximate those found in death from electricity or lightning as described by Kratter (quoted by Webster) and consisting of "subendocardial ecchymotic extravasations combined with bloody emphysema of the larger bronchi." Wood[3] adds nothing to Osler's description of the morbid anatomy.

1 Osler, William: The Principles and Practice of Medicine, ed. 10, New York, D. Appleton & Co., 1927.
2 Webster, R. W.: Legal Medicine and Toxicology, Philadelphia, W. B. Saunders Company, 1930.
3 Delafield and Prudden's Textbook of Pathology, revised by Francis Carter Wood, New York, William Wood & Co.

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