

of congenital syphilis in which other children of the family or the mother are definitely positive; and (3) cases in which, although there is no clinical suspicion of syphilis, suspicious or positive reactions have been obtained. An extensive selection of negative controls is also highly desirable; these might best be obtained voluntarily from among laboratory workers.

#### Conclusion.

In the absence of an ideal antigen the present results indicate that a proportion of weak positive reactions will be missed if only a single antigen be employed in performing the Wassermann test. Hence it is advisable always to use both antigens. Since all laboratory tests are productive of the most valuable results when the clinician and the laboratory worker collaborate intimately, the desirable procedure would appear to be that, where tests are performed with only one antigen, all sera should be preserved (e.g., by freezing), so that if a positive reaction fails to be obtained in cases which are clinically suspicious, the test may be repeated with the other antigen. Of course, when the reaction is being tested for the control of treatment both antigens should be employed.

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## THE RELATIVE CONTENT OF ANTISCORBUTIC PRINCIPLE IN LIMES\* AND LEMONS,†

TOGETHER WITH SOME NEW FACTS AND SOME OLD  
OBSERVATIONS CONCERNING THE VALUE OF "LIME  
JUICE" IN THE PREVENTION OF SCURVY.

### A.—EXPERIMENTAL INQUIRY,

By HARRIETTE CHICK, E. MARGARET HUME, AND  
RUTH F. SKELTON.

### B.—HISTORICAL INQUIRY,

By ALICE HENDERSON SMITH.

(From the Lister Institute, Director's Department.)

#### Introduction.

A BELIEF in the antiscorbatic virtue of the preserved juice of the West Indian lime has long been cherished by the public. Such a faith is, however, not universally shared by those having experience, in recent years, of the value of lime juice for prevention or cure of scurvy. This scepticism is first found in the writings of the Arctic explorers at the end of the nineteenth century (see Jackson and Harley, THE LANCET, April 28th, 1900). It has also been expressed recently by many observers who, confronted with scurvy in one or other of the recent theatres of war, have declared that they found lime juice of no avail as a prophylactic or therapeutic agent. Nevertheless, the literature<sup>1</sup> upon this subject appearing in the eighteenth and early nineteenth century is full of the praises of "lime juice," and there appears to be every reason for believing that the use of so-called lime juice was responsible for the disappearance of scurvy from the British Navy in the first decade of the nineteenth century. The naval records of the period have been carefully searched and the result of the inquiry forms the subject of the second section of this paper. A sufficient explanation of the anomaly will be found to lie in the fact that at this early date the term "lime juice" included the juice of lemons from the Mediterranean, whereas for the last 50 or 60 years it has been applied to the preserved juice of the West Indian lime.

#### A.—Experimental Inquiry.

A study of lime juice has formed an important item in a comprehensive investigation of the antiscorbatic properties of various foodstuffs which has been carried out by a group

of workers in this institute during the past two years.<sup>2</sup> This inquiry has confirmed and extended the researches of Holst and his co-workers,<sup>3</sup> published in 1912. Scurvy, in accordance with the view of ancient tradition, has been shown to be a deficiency disease, occasioned by absence in the diet of an unknown accessory food factor, or "vitamine." This factor is present in living vegetable and animal tissues, in largest amount in fresh fruits and green vegetables, to a less extent in root vegetables and tubers. It is present in small amount in fresh meat and milk, and has not been detected in yeast, fats, cereals, pulses. The antiscorvutic food factor is sensitive to high temperatures and suffers destruction when the living tissues in connexion with which it is produced are disorganised by drying and other methods of preservation. The expressed juices of fresh vegetables rapidly become impotent in respect of antiscorbatic properties, but Holst and Fröhlich (1912) detected a distinctly greater stability in this respect in the expressed juices of acid fruits.

#### Experimental.

In studying the distribution of the antiscorvutic vitamine among the various foodstuffs the general aim of the experimental work has been to assign to each a definite quantitative value in respect of its antiscorbatic properties. The work has been done mainly with guinea-pigs, though later confirmatory experiments have been made with monkeys.

Young, growing guinea-pigs, 300–350 g. in weight, were selected for the work. If all greenstuff is removed from the diet, and they are nourished on grain (oats and bran) alone, symptoms of scurvy appear after 10–20 days and death takes place in about 30 days. If, in addition, they receive a daily ration (60 c.cm.) of milk, heated at 120° C. for one hour to reduce its original antiscorvutic value to a minimum, the general condition of the animal is much improved and growth is maintained for 15–20 days; the onset of scurvy is not, however, materially influenced and death takes place after 30–40 days. (See Chick, Hume, and Skelton, 1918.)<sup>4</sup> The value of fruit juices and their preparations was estimated by adding them in various amounts to this "scurvy diet" of oats, bran, and autoclaved milk, and determining the minimum daily ration required to maintain the animal in health and prevent occurrence of scurvy for a period of 90 days. At the end of this period the animals were killed with chloroform and careful post-mortem examinations were made, followed by histological study of the bony tissues.

There is evidence that the guinea-pig is more susceptible to scurvy than many other mammals, including both monkey and man, and needs a greater proportion of antiscorbatic food in its diet to obtain adequate protection from the disease. But there is every reason to believe that the relative value of different foods, as determined experimentally by this means, will remain the same for all, and the results obtained with guinea-pigs have found abundant confirmation in the available historical records of the worth of human diets from the standpoint of antiscorvutic value.

*Preserved lime juice.*—Four samples which had been supplied for official use were placed at our disposal at different times by the authorities. Two were the purified juice of West Indian limes preserved with rum (14 per cent.), one contained no preservative, and the fourth was a sample of Bombay lime juice, preserved with salicylic acid and alcohol. To our great surprise we were unable to detect any significant protection in a daily ration of from 5 to 10 c.cm., which was as large a dose as could be tolerated. It was possible that the age of the samples might be responsible for their inefficiency. The process of "purification" consisted of a lengthy sedimentation and a separation of all pulpy matter expressed from the ripe fruit; this alone involves several months, a fact which, when added to the length of time taken in transport, &c., renders it likely that this lime juice, when consumed, may be many months, even years, old.

*Crude lime juice.*—Accordingly a series of samples of crude juice were examined; the samples were cloudy and contained a considerable proportion of oily and pulpy matter. They were of various age, but some, at least, were fairly fresh and were examined immediately on their arrival in this country. In two samples only was any antiscorbatic value detected, and in these instances partial protection only was conferred by a daily ration of 5 c.cm.

*Fresh lime juice.*—In order to eliminate the question of age and to obtain a satisfactory basis for comparison we

\* *Citrus medica*, var. *acidula*.

† *Citrus medica*, var. *limonum*.

investigated the juice of the fresh fruit expressed in the laboratory. This we were enabled to do through the kindness and generosity of Messrs. L. Rose and Co., who supplied us with regular monthly supplies of fresh fruit, specially imported for the purpose. The fresh, ripe fruit † was cut in half and the juice pressed out by hand upon an ordinary glass lemon-squeezer, there was little admixture of rind products. It was used as fresh as possible, being kept in a refrigerator. On the arrival of the next consignment of fruit the remainder was rejected and the fresher juice employed; the expressed juice was never more than two months old when administered. Protection from scurvy was obtained with a daily ration of 10 c.cm.; with doses of 5 c.cm. and 2.5 c.cm. a definite degree of protection was manifested, but it was neither constant nor complete. The details of the above results are all summarised in Table I.

TABLE I.—Antiscorbutic Value of Lime (Citrus Medica, var. Acida) Juice and Lemon (Citrus Medica, var. Limonium) Juice.

Experiments with guinea-pigs.—Cabbage was removed from the normal diet of oats, bran, and greenstuff and replaced by the fruit juices investigated. A daily ration of 60 c.cm. cow's milk (heated to 120° C. for one hour to destroy anti-scurvy properties) was added to improve the nutritive value of the diet.

Antiscorbutic material.	Dose c.cm. daily.	Age of juice (months).	Preservative.	Result.	Degree of protection against scurvy.
<b>LIME JUICE.</b>					
<i>Preserved.</i>					
1. Army sample, Nov., 1916.	5	Uk.	Rum, 14%	Animals died of scurvy.	0
2. Navy sample, March, 1917.	5	"	Rum, 14%	"	0
2A. Navy sample, March, 1917.*	10	"	0	"	0
3. Bombay samples (Willcox brand), Oct., 1917.	5	2 to 4	Alcohol and sal. acid.	"	0
<i>Crude.</i>					
1. From Lewis and Peat, Feb., 1917.	5	Uk.	None.	Animals died of scurvy.	0
2. From A. Riddle and Sons, April, 1917.	5	About 14	"	"	0
3. From L. Rose and Co., May, 1917.	5	6 to 7	"	Some protection in 2 cases out of 4.	+
4. From L. Rose and Co., Sept., 1917.	5	3 to 6	"	Scurvy, but considerable degree of protection.	++
5. Bombay crude juice, Oct., 1917.	5	2 to 4	"	Animals died of scurvy.	0
5A. Bombay crude juice, Oct., 1917.	10	4 to 5	"	"	0
<i>Fresh juice. †</i>	2.5	0 to 2	"	Scurvy in all cases, but some protection.	+
	5	0 to 2	"	Scurvy in 4 cases out of 6.	++
	10	0 to 2	"	No scurvy.	+++
<b>LEMON JUICE.</b> <i>Fresh juice.</i>	0.5	0 to 2	None.	Scurvy in all cases, but definite protection.	+
	1.5	0 to 2	"	Protection almost complete in 2 cases out of 4.	++
	2.5	0 to 3	"	No scurvy.	+++
<b>FRESH RAW CABBAGE LEAVES.</b>	Grm. 0.5	Fresh	—	Scurvy symptoms, but definite protection.	+
	1.5	"	—	Protection.	+++
	2.5	"	—	"	+++

\* Without addition of rum.

† Limes imported monthly from Dominica, squeezed in laboratory, and preserved in refrigerator.

Uk., Unknown. Sal. acid., Salicylic acid.

+++ = Complete. ++ = Definite. + = Slight. 0 = No protection.

‡ These limes were about 4 to 8 weeks in transit owing to war conditions of transport, and it has been suggested to us that this duration of time may have influenced the condition of the fruit unfavourably. We hope in the future to investigate the juice of limes only 2 to 3 weeks old, in order to see if the minimal protective dose for guinea pigs may not be lowered a little with juice obtained from fresher samples of fruit. It is unlikely that any significant alteration in the antiscorbutic value of the juice will be obtained, as all the fruit employed in the above experiments appeared to be in sound condition. Nevertheless, the point seemed to merit investigation.

*Fresh and preserved lemon juice.*—Fresh lemon juice was found to be much more potent in respect of antiscorbutic properties. Marked degree of protection was discovered by a daily ration of only 0.5 c.cm., and this was almost complete in some cases with a dose of 1.5 c.cm. With a daily ration of 2.5 c.cm. complete protection from scurvy was attained. The value of fresh lemon juice was therefore estimated at about four times that of fresh lime juice. The lemon juice was roughly of the same age as the lime juice in the above experiment. The lemons were squeezed in the laboratory, the juice was kept in a refrigerator, and its age varied from a few days to two months.

Our experiments with preserved lemon juice are still incomplete, but it appears probable that preservation with sulphite will prove satisfactory in retaining a considerable measure of the original antiscorbutic value. One sample of imported lemon juice from Messina, kindly provided by Messrs. L. Rose and Co., was found to afford distinct protection from scurvy in a daily dose of 5 c.cm. when at least 7 months old.

Experiments with Monkeys.

The question was of sufficient importance to warrant a series of experiments with another experimental animal, and young growing monkeys were selected. After observation for a month or more, to be assured that they were in normal satisfactory health, they were placed upon a generous diet, consisting of various cereal foods with nuts and abundant autoclaved milk, the antiscorbutic element being provided solely by the ration of fresh fruit juice provided. In case of limes the whole fruit was minced in order to include all constituents and the resulting mass squeezed in strong muslin of coarse mesh, yielding a somewhat thick liquid containing pulpy and oily matter. This was done immediately after delivery and at the same time, fresh lemons were procured and their juice expressed. Both supplies were kept in a refrigerator room, until the arrival of the next consignment of limes, when a fresh supply of lemon juice was also prepared. It was thus arranged that the lime and lemon juice used in the experiments (detailed in Table II.) should be comparable as far as possible.

TABLE II.

Experiments with monkeys.—The diet consisted of wheaten biscuit, peanuts, boiled rice, wheat germ, and autoclaved milk (120° C. for one hour) *ad libitum*. The antiscorbutic food factor was provided only by the ration of fresh fruit juice.

*Fresh Lime Juice.* *Fresh Lemon Juice.*

Exp. No.	Average daily ration.	Initial weight.	Duration of diet.	Exp. No.	Average daily ration.	Initial weight.	Duration of diet.
	c.cm.	g.	days.		c.cm.	g.	days.
1	10	2340	35	8	10	1660	93
2	10	2010	91	9	10	3130	92
3	10	3500	54	10	5	1900	49
4	5	3650	115	11	5	3500	171
5	3.5	2620	120	12	5	1750	66
6	2.5	1910	101	13	2.5	2010	122
7	2.5	2010	163	14	2.5	2030	123

Results of Experiments in Table II.

*Fresh Lime Juice.*

1. Good health, until sudden death from acute, undiagnosed illness.
2. Poor health, no symptoms of scurvy, death due to dysentery. P.M. no macroscopic signs of scurvy, histological evidence of slight scurvy.
3. Good health.
4. Acute scurvy, symptoms first noticed 49th day; cured with daily dose of 5 c.cm. lemon juice, beginning 115th day.
5. Scurvy, symptoms first noticed 45th day.
6. Incipient scurvy. Death from dysentery complicated by a worm infection of large intestine. P.M. definite signs of slight scurvy, hæmorrhage in synovial membrane, incipient periosteal hæmorrhage, deformity of rib-junctions.
7. Slow chronic scurvy, complicated with intestinal worm infection.

*Fresh Lemon Juice.*

8 to 14. Good health.

The fruit juice was, as a rule, acceptable to the monkeys, and the necessary ration, diluted with water and sweetened with sugar, was readily sucked from the nozzle of a syringe. This was not always the case with lime juice, the animals sometimes grew tired of it, and some coaxing was necessary in order to get the ration successfully administered.

The experiments are set forth in Table II., and the results may be summarised as follows: with young, growing monkeys, of 2000-3500 g. weight, daily rations varying from 2.5 c.cm.-10 c.cm. lemon juice never failed to prevent scurvy over periods of time as long as 4 to 7 months. The animals were in excellent health and spirits, and grew in a normal manner.

In case of lime-juice the result was otherwise, and the general health of the animals was distinctly inferior. In one case a ration of 10 c.cm. lime juice daily afforded protection from symptoms of scurvy for as long as three months. At the end of this time, however, the animal died of dysentery, and a histological examination of the bony tissues revealed some degree of abnormality. In Experiments 4-7, where the daily ration was 5 c.cm. to 2.5 c.cm., scurvy to a more or less severe degree ensued in every case. Most of these experiments are still in progress.

Experiment 4 is of particular interest. In this case very severe scurvy developed, accompanied by progressive loss in weight. The lower limbs became helpless, wrists and ankles were swollen and tender, the teeth became loose, the gums spongy and hæmorrhagic, and there were distinct follicular hæmorrhages on the face at the base of the whiskers. Finally, blood was passed in the stools and death appeared to be imminent. The lime-juice ration was changed to an equal ration of lemon juice of equal age. In 7-14 days the teeth became firm; gradually all tenderness vanished in the limbs; the animal regained activity and improved in weight. The cure was slow, but the curative dose of lemon juice was small in comparison with the severity of the case.

The relative value of these two fruit juices, deduced from the trials with monkeys, is therefore in accord with that obtained in the experiments with guinea-pigs—i.e., *the value of fresh lemon juice is approximately four times that of fresh lime juice.*

In conclusion, our best thanks are due to Messrs. L. Rose and Co. for generously providing us with a regular supply of fresh lime fruit from Dominica, in spite of the difficulties of transport, &c., occasioned by war-time conditions. We desire also to record our appreciation of their willing coöperation in supplying numerous special samples of crude and preserved juices, and for the accurate and detailed records made on our behalf of the methods used in their preparation. Without this assistance the above research would have been impossible.

#### B.—*Historical Inquiry*, by ALICE HENDERSON SMITH.

The lime juice now issued to the Navy and Army for their use as a preventive of scurvy is the juice of the sour lime (*Citrus medica*, var. *acida*) grown in the West Indies. To it has long pertained the reputation made in the Navy 125 years ago by the "lime juice" used then. But that "lime juice" was not the juice of the sour lime.

The citrus fruits first used by the Navy came from the Mediterranean, largely from Spain. They did not include the *sour* lime, which is not grown in Europe; they did probably include the *sweet* lime (*Citrus medica*, var. *limetta*), but consisted principally of lemons (*Citrus medica*, var. *limonum*). In 1796 the war cut off Spain as a source of supplies and lemons were brought from Lisbon; the supply was uncertain, insufficient, and very expensive until 1803, when contracts were first made through the naval representative at Malta. Thereafter, for many years, an annual contract secured an ample quantity of the juice of lemons grown in Malta and Sicily. This enabled the Admiralty to employ "lime juice" much more widely than had been done before, and for some years the issue was a general one and not confined, as before, to the sick and to the crews of ships on foreign service. Together with the improvement in victualling and in the general conditions of living on board ships of war this was successful in expelling scurvy from the Navy in the course of a very few years, and by 1810 the records of scurvy cease. From that time the disease has occurred only in isolated and exceptional cases.

Before the middle of the nineteenth century complaints were made about the quality of the lemon juice sent from Malta, but by that time opportunities for the trial of it therapeutically were rare in the ordinary service of the Navy. On the return of Sir James Ross from the Arctic regions in 1849, however, it was shown what disastrous results might follow from a deficiency in the supply. In order that other ships

then about to leave England on Arctic service should be assured of a reliable protection from diseases the Medical Director-General caused lemons to be squeezed at Deptford for them, and this provision proved fully adequate. Arrangements were made for the careful supervision thenceforward of all lemon juice bought in Malta.

About 17 years later, when the development of the lime cultivation in the West Indies made available a quantity of lime juice, the Admiralty transferred its contracts, and thereafter issued the juice of limes instead of that of lemons. The essential inferiority of limes to lemons in antiscorbatic power was not suspected, and the new supply was believed to be far better than the old. It was produced by English firms under such conditions as would secure its soundness and purity.

Polar exploration again provided the test of its value; and by comparing the experience of the ships provided with the pure lemon juice in 1850 with that of the first Arctic expedition that took out West Indian lime juice we get a very satisfactory human experiment, demonstrating the relative value of the two fruits. The setting of the comparison is made more precise than is generally to be looked for in historical evidence by the following facts.

The lemon juice for the 1850 expedition was prepared at Deptford, and much attention was paid to the best method of preserving it and for obtaining its maximum value when consumed at sea. The juice was issued to the ships under regulations which insured accuracy and definiteness in the quantity consumed by each member of the crew. The daily ration, 1 oz., was issued to each man individually, and drunk by him in the presence of an officer. In 1875, when Sir George Nares's ships, the *Alert* and the *Discovery*, sailed to discover the North Pole, Sir Alexander Armstrong, who had been medical officer on the *Investigator*, was Medical Director-General of the Navy. So satisfied had he been with the results of lemon juice during the voyage of the *Investigator* that he gave directions that the juice should be issued in precisely the same way on the *Alert* and the *Discovery* as on the previous expedition, that is, in the same quantities, and with the same safeguards against any variation in the consumption of it. But the juice issued to Nares's ships was the "lime juice" from the West Indies.

The two expeditions were so near to one another in time that the general conditions of diet, &c., were very similar; but the later one did enjoy certain improvements of diet suggested by accumulated experience, including double vegetable and fruit rations, additional meat, sugar, &c., and a reduction in the amount of alcohol allowed. In casual supplies of fresh game and herbs there was no outstanding difference. Indeed, every detail of the conditions is very nicely adjusted for the comparison, any difference there was being in favour of the lime juice ships.

And the result was not only clear, but emphatic. Nares's ships, supplied with West Indian lime juice, went out in May, 1875; they had their first case of scurvy in January, 1876. Premonitory scorbutic symptoms showed themselves in a further number of the crews in early spring, but they were not recognised, as scurvy was never thought of as a possible danger. With the starting of the sledge expeditions early in April, 1876, scurvy developed with great severity in the sledge crews and three deaths occurred; concurrently there was a development, only less serious, among the men who remained on the ships. The expedition came home to England in October, 1876.

On the other hand, the *Investigator*, supplied with lemon juice, left England in January, 1850, and got into the ice during the following summer. Throughout the next winter and the spring sledging she had no scurvy. In autumn, 1851, her rations were reduced to two-thirds and her lemon-juice ration was halved, and she still had no scurvy through the following winter and spring. Only in May, 1852, her first case developed, 27 months after leaving home and after seven months of short rations and reduced lemon juice. Other 15 months passed before her crew were rescued, and in that whole period of three and a half years she had three deaths from scurvy, the same number that occurred on Nares's ships within one year.

The conclusion suggested by the history of this long immunity from scurvy during the voyage of the *Investigator* is supported by the history of other ships of her time, while the failure of the lime-juice ration to prevent scurvy on the *Alert* and the *Discovery* is repeated in later cases where it

has been relied on as a protection. In the absence of any other satisfactory explanation of the contrast afforded by the experience of these two expeditions—and the prolonged examinations of the Scurvy Commission of 1877<sup>5</sup> discovered none—it must be accepted as a very convincing piece of evidence that lemon juice is far more effective than lime juice in the prevention of scurvy. It fully confirms the results of the laboratory experiments which have determined more exactly their relative value for this purpose.

#### Summary.

1. The antiscorbutic value of the juice of fresh limes (*Citrus medica*, var. *acida*) has been compared experimentally with that of fresh lemons (*Citrus medica*, var. *limonum*) and has been found to be distinctly inferior. Volume for volume fresh lime juice possesses a potency of about one-fourth that of lemon juice. In one instance severe scurvy developing in a monkey on a diet containing a small daily ration (5 c.cm.) of fresh lime juice was cured by an equal ration of fresh lemon juice.

2. Preserved lime juice was found useless for the prevention of scurvy by the method employed. Experiments with preserved lemon juice are still in progress, but give promise of better results.

3. The experimental results are fully confirmed by a historical study of "lime juice" in connexion with human scurvy. At the period when scurvy was eliminated from the British Navy by its agency the term was used to express the juice of lemons, and it was not until the second half of the nineteenth century that the juice of West Indian limes was adopted in the Navy and Mercantile Marine. The history of two Arctic expeditions, that of the *Investigator*, 1850, and that of the *Alert* and *Discovery*, 1875, has been carefully investigated. The former, supplied with lemon juice, experienced remarkable immunity from scurvy during the first two years of great difficulty and privation; the latter, supplied with lime juice, suffered severely from scurvy at the end of the first winter spent in the Arctic regions.

It should be noted in connexion with these facts that scurvy is a disease with a long period of development. As much as four to eight months upon a defective diet may elapse before definite symptoms of scurvy can be observed.

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## A CASE OF REPEATED CESSATION OF THE HEART BEAT.

By E. P. POULTON, M.D. OXON., F.R.C.P. LOND.,

ASSISTANT PHYSICIAN, GUY'S HOSPITAL;

AND

H. M. STEWART, M.D. CAMB.

ARREST of the heart for so long as 30 seconds is very uncommon; we have only been able to find an account of one case in which the heart stopped repeatedly.<sup>1</sup> The notes of our case are given below.

The patient, a man, aged 67, was seen by us on March 27th, 1918. He had been healthy all his life; had recently been excited over the war. He had been in the habit of taking plenty of exercise, bicycling up hills, &c. Just before his illness he was carrying some heavy portfolios about the house. No history of specific disease. On March 13th he complained of giddy attacks. His pulse was noticed on one occasion to be 30. He stayed in bed two or three days, but then he got up feeling quite well, but stayed upstairs. During this time he was having two or three short fainting attacks each day. On March 25th, at 2.30 P.M., he began having repeated fainting attacks till 4.30 P.M. The attacks began again at 5.30 and lasted till 7.30. He then got some sleep, but the attacks began again at 10 P.M. and lasted

nearly without intermission till his death in the afternoon of March 28th. During the fainting attacks the heart stopped beating.

*Clinical features of the attacks.*—Between the attacks the patient was sitting up in bed talking perfectly normally. The pulse was bounding; radial artery palpable, but not calcified. On one occasion the pulse-rate was counted at 84 per minute, soon after it had recommenced beating after an attack. It remained at this rate for about 50 or 60 seconds and then it gradually became slower, the rate falling to about 60 or slightly less, the strength being fully maintained. In 86 seconds from the start the pulse suddenly stopped. Immediately the patient grew pale and there was slight cyanosis. The patient went on talking for 2 or 3 seconds, but then fell back on to his right side with a groan. In 5 to 7 seconds consciousness had certainly been lost, but it was impossible to be certain exactly how much earlier this had occurred. Loss of consciousness was followed by contractions of various muscles, and there were involuntary movements of the limbs.

Breathing became gradually deeper and more convulsive, all the accessory muscles of respiration being brought into play. After about 20 seconds the respiration was at the rate of 44 per minute and was extremely deep. This rapid deep breathing was the most noticeable thing about the case at this period. It was more marked than we have either of us ever observed in other pathological conditions. It can only be compared with the convulsive panting which occurs in the severest kind of muscular work. The patient's face was livid and pale. There was no corneal reflex or light reflex.

After 39 seconds, during which no pulse had been felt at all, it suddenly started again, at first rather weakly, but in 5 or 10 seconds it had regained its normal strength, the rate being sometimes over 80 and sometimes between 75 and 80. Within two or three beats the face flushed bright red, and beads of sweat were visible, the conjunctivæ were congested, and there was excess of lacrymal secretion, and very soon afterwards consciousness was completely restored.

The total length of the cycle was on this occasion 125 seconds. On other occasions it was 115 seconds. Roughly it may be said that during every two minutes the pulse completely stopped for 40 seconds. This sequence of events continued with regularity all the time we were examining the case, some 45 minutes.

There was no obvious abnormality about the heart.

The patient was emphysematous and the apex beat barely palpable. There were no murmurs. When the pulse stopped no beat of the heart was audible with the stethoscope; nor was there any sound suggestive of auricular beats. No venous pulsation in the neck was observed. It was unfortunate that no polygraph tracing could be obtained in this case.

Various attempts were made to interrupt the events of the cycle. The patient was told to take some deep forced breaths during the conscious period, but without effect. He then breathed backwards and forwards through a piece of hose pipe, so as to increase the dead space and increase the CO<sub>2</sub> content of the lungs which might stimulate the heart; but again there was no effect. Firm pressure was exerted on the vagi in the neck, smelling salts were applied to the nostrils while the patient was unconscious but without effect. Sal volatile diluted with an equal volume of water was administered by the mouth. Vomiting was produced and the attacks ceased for about 20 minutes, but then they recurred. He died with signs of cardiac failure.

*Post-mortem.*—Lungs: Congested and oedematous. Aorta: Atheroma, particularly in descending thoracic part. Heart: Hypertrophy of both left and right ventricles; they contained rather more blood clot than usual. The heart muscle was rather mottled, but did not look very unhealthy; some moderate degree of fibrosis was suspected. The coronary arteries were atheromatous but patent. The aortic and mitral valves were slightly thickened.

*Brain.*—The vertebral, basilar, internal carotid, and cerebral arteries were all very atheromatous. The brain substance looked healthy.

The abdominal viscera were not examined.

Dr. P. P. Laidlaw very kindly examined some microscopic sections for us.

Sections of the medulla were cut at the middle and upper part of the vagus nucleus. Numerous small hæmorrhages were found throughout the sections, but they were more striking in the immediate neighbourhood of the vagus nucleus. One in particular involved the nucleus itself, but had not destroyed the nerve cells at this point. The vagus nerve cells showed very poor Nissl bodies and the nucleus was occasionally excentric. A few of the cells were vacuolated. The cells form a very great contrast to those of the hypoglossal nucleus alongside. It is doubtful, however, if the appearances indicate a nuclear lesion, since the apparent chromatolysis and the position of the nucleus are both conditions so frequently found in the vagus nucleus that they can be termed normal post-mortem appearances. The vacuolation is, however, abnormal.

Since the hæmorrhages are numerous it is suggested that they are secondary to the repeated asphyxial periods which occurred before death and are not primary. It is impossible to be certain on this point. The arteries at the base of the medulla showed a little atheroma, but this did not appear very advanced, and the smaller vessels appeared normal.

Sections were also taken at regular distances over the lower part of the medulla. No abnormality was seen, and there was no appearance seen similar to those in Neubürger and Edinger's case.

Sections of the vagus nerve trunk did not show any sign of degeneration or any cellular infiltration suggestive of neuritis.

Sections of the heart muscle which were cut failed to show the auriculo-ventricular bundle. It is thus impossible to say whether this was normal or not. The heart muscle showed a little fibrosis at the upper part of the interventricular septum. The largest artery in this region showed considerable fibrosis of the muscle and also some intimal overgrowth.

<sup>1</sup> Neubürger and Edinger: Berl. klin. Woch. (1898), xxxv., p. 69, 100.