Cerebral Disease. Affections of the head offer no obstacle to the administration of chloroform. I have given it to several patients who had suffered previously from an attack of apoplexy. Some of them still retained the paralysis resulting from their attack, but the chloroform has not been attended or followed by ill effects in any of these cases. The following case, in which alarming head symptoms had existed a few hours before the inhalation of chloroform, cannot fail to be interesting.

The 31st of October, 1854, was appointed by Mr. Fergusson to perform lithotrity on a gentleman, seventy-eight years of age, who had a phospathic calculus in his bladder. He was a patient of Mr. Propert, and Mr. Fergusson had removed a similar calculus by lithotrity, and I had given him chloroform at each of the operations, and it was arranged that he should have chloroform on the present occasion. Mr. Propert informed Mr. Fergusson and me, on our arrival, that his patient had had an attack the night before resembling apoplexy; he had been insensible, the breathing had been stertorous, the pupils dilated, and the face very red and congested. Mr. Propert had caused him to be cupped to fourteen ounces, and had given him calomel in the course of the night, and in the morning he was as well as usual, and remained so at the time of our visit. We considered the case with Mr. Propert, and as there were reasons for not postponing the operation, it was determined that he should inhale the chloroform rather than be subjected to the pain. The vapour acted very favourably; he recovered his consciousness a few minutes after the operation, and expressed himself as feeling quite well.

Mr. Fergusson crushed another calculus in this patient in March 1855, when I again administered chloroform, and in 1856 I understood that he was free from the complaint.

Insanity. Chloroform acts on insane patients just as it does on others, that is to say, they are made insensible by it, and, when its effects are completely subsided, it leaves them in the same state of mind as before. Insane people are, however, often so suspicious that they cannot be persuaded to inhale chloroform, and it can...
only be given to them by force. When once under its influence, however, I have seen teeth extracted, and other operations performed, which it would have been impossible to accomplish in the same individuals without resorting to inhalation. The use of chloroform in the treatment of mania will be alluded to in another part of this work.

Hard Drinkers. It was at one time alleged that hard drinkers of spirituous liquors were not susceptible of the influence of ether or chloroform, and for a long time there remained an impression that these persons were difficult to render insensible. I have always found that hard drinkers were rendered unconscious, and even comatose, by the same amount of ether or chloroform as other persons; but they sometimes have a morbid excess of sensibility in the nerves of common sensation, and do not lie still under the surgeon's knife except when the nervous centres are deeply narcotised, and the breathing almost stertorous. On this account, they sometimes inhale much more chloroform during a protracted operation than other persons.

AMOUNT OF VAPOUR OF CHLOROFORM ABSORBED TO CAUSE THE VARIOUS DEGREES OF NARCOTISM

Before proceeding to describe the mode of administering chloroform, it is desirable to treat of the quantity of it which produces its different effects. Without alluding to the facts and experiments which prove that all narcotics produce their effects by being absorbed into the circulating fluid, and so reaching the nervous system on which they act, it is only necessary to mention the following circumstances to show that this is the case as regards chloroform. In some experiments in which I assisted Dr. Sibson, we found that the vapour of chloroform produced its effects after both the pneumogastric nerves had been divided, exactly the same as before. Chloroform can be detected by means of chemical tests exhaling in the breath of those who have just previously inhaled it. It can also be detected in the urine after inhalation, and very readily in all the tissues of animals that have been killed by it, for several days after death.

The quantity of chloroform in the blood in the different degrees of narcotism might be estimated approximately from the amount used in inhalation, but I devised some experiments in 1848 for ascertaining the quantity with accuracy.* The experiments were based on the following circumstances.

When air containing vapour is brought in contact with a liquid, as water or serum of blood, absorption of the vapour takes place, and continues till an equilibrium is established; when the quantity of vapour in both the liquid and air, bears the same relative proportion to the quantity which would be required to saturate them at the temperature and pressure to which they are exposed.

This is only what would be expected to occur; but I verified it by numerous experiments in graduated jars over mercury. The intervention of a thin animal membrane may alter the rapidity of absorption, but cannot cause more vapour to be transmitted than the liquid with which it is imbued can dissolve. The

* Medical Gazette, vol. xli-ii.
temperature of the air in the cells of the lungs and that of the blood circulating over their parietes is the same; and, therefore, when the vapour is too dilute to cause death, and is breathed till no increased effect is produced, the following formula will express the quantity of any substance absorbed:—As the proportion of vapour in the air breathed is to the proportion that the air, or the space occupied by it, would contain if saturated at the temperature of the blood, so is the proportion of vapour absorbed into the blood to the proportion the blood would dissolve.

The manner in which the experiments were performed, was to place a small animal in a glass jar, so large that it formed a capacious apartment for it, and held much more air than it would require in the course of the experiment. The jar was covered with a closely-fitting lid, and a carefully-weighed portion of chloroform was allowed to diffuse itself through the air of the jar. The experiments were continued till the chloroform produced no further effect. I shall pass over a number of tentative experiments, and adduce only a few of those which were made after I had ascertained the quantities requisite to produce the desired effect. The results obtained in these experiments were entirely due to the degree of dilution of the vapour; for the quantity of chloroform employed was, in every instance, more than would have killed the animal in a much shorter time than the experiment lasted, if it had been conducted in a smaller jar. It is assumed that the proportions of vapour and air remain unaltered during the experiment; for the quantity absorbed must be limited to what the animal can breathe at the time, which is so small a part of the whole that it may be disregarded.

**Experiment 1.** A guineapig and a white mouse were placed in a jar holding 3,000 cubic inches, and fifteen grains of chloroform (0.4%) were introduced by a tube in the lid of the jar, which was closed immediately by a screw. The chloroform fell on some blotting paper suspended in the jar, and in a minute or two was converted into vapour and diffused through the air in the jar. The animals were allowed to remain half an hour, and were unaffected by the chloroform, except that they appeared to be a little less brisk than usual, during the first two or three minutes after their removal.

**Experiment 2.** A guineapig was placed in the same jar, and twenty-two and a half grains of chloroform were introduced in the same manner as before, being three-quarters of a grain to each hundred cubic inches of air (0.595%). In two or three minutes the chloroform was converted into vapour and diffused through the air in the jar. Six minutes afterwards the guineapig began to stagger, and soon afterwards was unable to keep on its legs. It was kept for half an hour in the jar, but did not become further affected. It was occasionally quiet, but always tried to walk when disturbed by moving the jar. When taken out, it flinched on being pricked, and tried to walk, although unable to support itself on its legs. It recovered from the effects of the chloroform in three or four minutes.

**Experiment 3.** Another guineapig was placed in the same jar, and thirty grains of chloroform (0.79%) were introduced. In three or four minutes the chloroform had evaporated and diffused itself through the air in the jar. In two minutes afterwards
the guineapig lay down, but stirred when the jar was moved. It was allowed to remain in the jar for half an hour, being asleep except when disturbed. When taken out it awoke and endeavoured to walk, but was unable to support itself at first. It flinched on being pricked. Recovered in three or four minutes.

Experiment 4. A cat was placed in the same jar, and the same quantity of chloroform was introduced. In three minutes it had evaporated, and, when ten minutes had elapsed, the cat began to stagger. Soon afterwards it was unable to support itself on its legs; and, when a quarter of an hour had elapsed, it seemed asleep, but raised its head when the jar was inclined. It remained apparently sleeping till the end of an hour, when it was taken out. It was unable to stand, but was sensible to the slightest pinch. It recovered gradually in the course of twenty minutes.

Experiment 5. Sixteen grains of chloroform were put into a jar holding 1,600 cubic inches, being one grain to each 100 cubic inches of air (0.8%). When it was converted into vapour, a white mouse was introduced by moving the lid a little to one side for a moment. After running about for a minute and a half, it began to stagger and to lose power, but it continued to run with little intermission till three minutes had expired. After this it lay still, except when the jar was inclined, when it always endeavoured to maintain its balance and to walk. It also moved its limbs now and then, when not disturbed. It was removed at the end of ten minutes, when it tried to walk, but was unable. It did not flinch when its tail was pinched, but flinched, half a minute after its removal, on one of its toes being pinched. It recovered in two or three minutes.

Experiment 6. A guineapig was placed in the jar holding 3,000 cubic inches, and 37.5 grains of chloroform were introduced in the same manner as in the former experiments, being a grain and a quarter to each 100 cubic inches of air (1%). The chloroform took three or four minutes to evaporate and diffuse itself in the jar; and by the end of this time the guineapig, which had been excited and running about, began to stagger, and in two minutes longer it was unable to walk, but endeavoured to keep its balance when the jar was inclined. At the end of a quarter of an hour it was lying still, but moved its limbs when it was rolled over by inclining the jar; but it made no voluntary effort. It was taken out when thirty-three minutes had elapsed. It moved its limbs as it was removed, though apparently not in a voluntary manner. Its limbs were not relaxed. It was quite insensible to prick-ing. It recovered in about ten minutes. The temperature in the axilla before it was put into the jar was 100° Fah., and immediately after its removal 96°.

Experiment 7. A guineapig was placed in the same jar, and forty-five grains of chloroform were introduced, being a grain and a half to each 100 cubic inches of air (1.2%). In four minutes after the chloroform had evaporated, the guineapig was unable to walk. In half a minute more it seemed asleep, but there was a tremulous motion of the hind legs, which continued till ten minutes had elapsed. Afterwards it lay still, but winked now and then spontaneously. When rolled over by moving the jar, it made no voluntary effort. It
was taken out twenty minutes after the chloroform had evaporated. It winked spontaneously, and also when the eyes were touched. It did not flinch when the ear was pricked, but flinched when the paw was pricked. The temperature in the axilla before the experiment was 100°, and immediately afterwards it was 96°. The guineapig recovered from the effects of the chloroform in ten minutes.

**Experiment 8.** A guineapig was put into the same jar, and 52.5 grains of chloroform were introduced, being a grain and three-quarters to each 100 cubic inches of air (1.4%). The chloroform evaporated in the course of four minutes, at the end of which time the guineapig was altered in its manner, as if partially inebriated. In two minutes more it was becoming drowsy. A little while afterwards it was lying down. Six minutes after the evaporation of the chloroform was complete, the guineapig made no effort when turned over by inclining the jar, but only moved its feet, as it were automatically. At the end of nine minutes, it was lying quietly and breathing naturally. When fifteen minutes had elapsed it was in the same condition, and was removed from the jar. It cried and flinched on the foot being pricked. The temperature in the axilla was 97°. In five minutes after its removal it was fast recovering, and in ten minutes was quite recovered.

**Experiment 9.** A guineapig was placed in the jar used in the last three experiments, and sixty grains of chloroform were introduced in the same manner, being two grains to each 100 cubic inches of air (1.6%). In four minutes it was all converted into vapour, and the guineapig was beginning to be affected by it. In two minutes more it was unable to stand or walk. In five minutes from the time when the evaporation was complete, the guineapig showed no sign of sensibility when turned over by inclining the jar; the breathing was natural. At the end of ten minutes it was lying still, breathing gently forty times in the minute. At the end of fifteen minutes it was in the same condition. From seventeen to twenty minutes, it stretched out one of its hind legs several times, and was doing so when taken out, at the end of twenty minutes. It showed no sign of sensibility when pricked. The temperature in the axilla was 96°. It began to recover gradually in a minute or two, and recovered completely in from ten to fifteen minutes.

**Experiment 10.** A cat was placed in the same jar, and the same quantity of chloroform was introduced in the same manner. It became quite insensible in a few minutes after the chloroform was introduced; and it was allowed to remain for twenty-five minutes when it was taken out. It was perfectly insensible to pricking, and its muscles were quite relaxed; it was breathing gently, and the pulsations of the heart were between sixty and seventy in the minute. It was immediately made the subject of another experiment of drowning whilst insensible, which need not be related in this place.

**Experiment 11.** Four grains of chloroform were put into a glass jar holding 200 cubic inches (1.6%), and when it had evaporated and was diffused through the air in the jar, a white mouse was introduced by momentarily removing the cover a little to one side. A minute after its introduction the mouse was lying, but it moved its legs for a quarter of a minute longer.
When four minutes had elapsed, the breathing became slow, and it was taken out. It was totally insensible for the first three minutes after its removal, and recovered during the two following minutes.

Experiment 12. Thirty-two grains of chloroform were diffused through the air of a jar holding 1,600 cubic inches, being two grains to each 100 cubic inches (1.6%) as in the last three experiments. A white mouse was introduced by moving the cover a little to one side for a moment. In one minute it was insensible, and did not make any effort on being rolled about by inclining the jar, but it moved its paws for half a minute longer. It remained insensible, breathing 160 times in the minute, till it was taken out at the end of five minutes. It was quite insensible to pinching. It began to walk in a minute or two. Its temperature before the experiment was 98°, and immediately afterwards was 92°. The temperature of the room was 68°.

Experiment 13. A guineapig was put into a jar holding 3,000 cubic inches, and 67.5 grains of chloroform were introduced on blotting paper suspended within the jar, being 2½ grains to each 100 cubic inches (1.8%). In four minutes, the chloroform had all evaporated, and the guineapig was becoming affected. In two minutes more, it was quite insensible. Eight minutes after the chloroform had evaporated, it was lying still, breathing forty times in the minute. During the next three or four minutes, it moved one or other of its legs occasionally. At the end of seventeen minutes, it was lying still, and the breathing was twenty-six in the minute. It was taken out at the end of twenty minutes quite insensible; in three or four minutes it began to try to walk, and in ten minutes, was quite recovered.

Experiment 14. Two white mice, one being full grown, and the other about three-quarters grown, were placed in the jar holding 1,600 cubic inches, and forty grains of chloroform were introduced on blotting paper, being two grains and a half to each hundred cubic inches (2%). In two minutes, the chloroform had evaporated, and the mice were much excited. In another minute, they were unsteady in walking; and in a minute more, the old mouse was lying insensible, and breathing deeply and laboriously. In four minutes more, i.e., six minutes after the chloroform had evaporated, the young mouse was insensible also, but was moving one of its hind legs. In another four minutes, the young mouse was breathing by slow gasps, whilst the old one continued to breathe deeply as before. Three minutes later, i.e., thirteen minutes after the chloroform had evaporated, the old mouse had begun to gasp, and the young one was gasping only at intervals. They were removed, and recovered completely in ten minutes. The young one recovered most quickly. Their temperature, on being removed, was about 90°.

(To be continued)