at the moment, increasing the quantity of chloroform which the
has been inhaled during the last inspirations, and this continues
muscles is suspended, there is still vapour in the lungs, which
brain and nerves of respiration, that the action of the respiratory
heart, by its direct influence, in animals of warm blood, when
chest of the animals whilst they were inhaling the chloroform,
and also in two experiments, in which I was assisted by Mr.
portance in relation to the accidents from chloroform—viz.,
that this agent has the effect of arresting the action of the
and also in two experiments, in which I was assisted by Mr.
I had ascertained the circumstance in nume-
and also in two experiments, in which I was assisted by Mr.
I pointed out also what I consider to be of the utmost im-
I pointed out also what I consider to be of the utmost im-
that the agent has the effect of arresting the action of the
or interrupted respiration. To take, for example, the fatal
time that respiration was not going on, it cannot be
supposed that he would use the force, and have the persever-
to remove the remaining sensibility of the cardiac nerves, and
so paralyse the heart, depends on the quantity of vapour in the
air last taken into the lungs. I find that when this quantity
has not much exceeded five per cent., the action of the heart
is not arrested by its direct influence, but when it reaches to
the influence of the chloroform, owing to the respiratory
exhibiting too long the vapour of chloroform suffi-
for twenty minutes, and that when the quantity of the
It is impossible to express the effect of giving it by in-
halation of chloroform, in which death took place so slowly as'
resemble that caused either by the complete or incomplete ex-
the absence of air might be still more nearly than in still smaller animal
exhaling the amount of the blood, which was held a little distance from the face, to allow the air
exclusive of air. If, therefore, any patient has died from the
breathing, caused by the pungency of the
began simply of asphyxia before they were brought under the
action of the heart, as well as the respiration, had been suddenly
from the pathological effects of this agent,
and Dr. Dunsmure says, "Those present who had an
lep surfaces of the heart, and I found it to be one
sensation of the eye than usual; her features were length-
nose, presented a purple tinge. The skin of the arms,
when the heart's action was
animals, such as cats, rabbits, and guineapigs, are made to
breath containing four or five per cent. of vapour of chlor-
from the chloroform. I showed
that this mode of dying did not depend on a want of power in
inhalation was left off when the man began to
exhaling the vapour by the skin, after the respiratory movements have
1See Edinburgh Medical and Surgical Journal, 1849, No. 180, and London
FURTHER REMARKS
ON THE
CAUSE AND PREVENTION OF DEATH FROM CHLOROFORM.
B Y J O H N S N O W , M. D.
I READ two papers before the members of the Medical Society
of London a few years ago,* on the Cause and Prevention of
Death from Chloroform, in which I pointed out that when
animals, such as cats, rabbits, and guineapigs, are made to
breath containing four or five per cent. of vapour of chlor-
form till they die, the breathing ceases a minute or two before
the circulation of the blood; and that during this interval,
in which the heart can be heard and felt to be still beating, the
animal could be easily restored by artificial respiration; and,
moreover, that at the moment when the heart's action was
cessing, the creature often gave one or more gasping inspira-
tions, which, in many cases, had the effect of causing re-
covery, if it had been removed from the chloroform. I showed
that this mode of dying did not depend on a want of power in
chloroform to arrest the functions of the heart by its direct
effects, but on the circumstance that it requires rather more of
this agent to stop the action of the heart than to arrest the
respiratory movements. I had ascertained the power of chlor-
form to act directly on the heart by blowing the vapour on
that organ when exposed, and by injecting a solution of it in
water into the coronary arteries, as well as by giving it by in-
halation. In some experiments on frogs, which go on absorb-
ing vapour by the skin, after the respiratory movements have
ceased, I was able also to ascertain the amount of chloroform
which was necessary to arrest the heart, and I found it to be one
eighteenth part as much as the serum of the blood is capable of
dissolving; whilst about one part in twenty-two of what the
blood will dissolve has the effect of arresting the action of the
muscles of respiration.
I pointed out also what I consider to be of the utmost im-
portance in relation to the accidents from chloroform—viz.,
that this agent has the effect of arresting the action of the
heart, by its direct influence, in animals of warm blood, when
they breathe air containing not less than eight or ten per cent.
of the vapour. I had ascertained the circumstance in nu-
merous experiments in which the stethoscope was applied to the
chest of the animals whilst they were inhaling the chloroform,
and also in two experiments, in which I was assisted by Mr.
Peter Marshall, where, the animals being kept alive by artificial
respiration after the heart was exposed, the chloroform was
administered by a tube inserted in the trachea, and its instant
effect on the heart could be seen.
The reason why the chloroform is thus able to act directly on the
heart, under certain circumstances, is as follows:—When
the vapour is breathed till such an effect is produced on the
brain and the respiratory action, the effective action of the
muscles is suspended, there is still vapour in the lungs, which
has been inhaled during the last inspirations, and this continues
to be absorbed into the blood which is passing through the lungs at
the moment of chloroform absorption in the quantity of the
blood already contains. Whether this additional quantity of
chloroform, which is absorbed into the blood during the first
few seconds after the breathing has ceased, shall be sufficient
* See Edinburgh Medical and Surgical Journal, 1849, No. 180, and London
Journal of Medicine, 1852.
patient had gone through the usual stages of excitement, &c., and the last dose was scarcerly used as she sank off, almost immediately after its application, into a state of complete insensibility, unattended with alarming symptoms. About five minutes had been occupied in the inhalation, and probably not more than a drachm and a half of the fluid really inhaled. The apparatus was now removed from the face, and the patient having been drawn into the proper position, Mr. Paget was about to perform the operation. Dr. Black, who throughout had kept his finger on the pulse, noticed it to have become extremely feeble and fluttering. Almost immediately afterwards, the patient's countenance was observed to be dusky, turgid, and congested, and the respiratory movements became difficult, without any indication of the presence of any long interval of unconsciousness. All efforts at respiration ceased about two minutes after the first indications of failure; the pulse, however, as a very feeble flutter was felt occasionally, for at least two minutes later."

In this case, also, the patient breathed the chloroform, and became quite insensible from it, when the heart became suddenly paralyzed, so far as to be unable to keep up the circulation. Out of forty-four deaths from chloroform which had been observed and recorded, seven took place after the patient was quite insensible, and when the surgeon was just about to begin the operation; twelve occurred during the performance of the operation, which was considered to have been completed in, at the latest, eight minutes; of short duration, was completed before it was discovered that the patient had expired. In two or three of these latter cases, it was thought that the patient was probably dead when the operation was about to be commenced, and that the remaining strength of life was at this time sufficient to delay the inhalation was discontinued during the period of its progress, owing to the sudden occurrence of alarming symptoms. In some of these cases, death took place quite early in the inhalation, before the patient had evinced any of the usual signs of the influence of chloroform, and it is extremely worthy of remark that, in every accident, the particulars of which are related, the symptoms of real danger set in suddenly, whether they appeared during the inhalation or after it was discontinued. "

The phenomena produced by chloroform in the human subject, the blood is found to be of a florid colour in the lungs, always be persuaded to inhale chloroform, the patient breathes ration directly after the heart has ceased to beat; and if fresh air is allowed to enter the lungs during these efforts, the circulation is in many cases restored, both in asphyxia and narcosis from chloroform."

"* See L'Union Médicale. 1855. No. 13."
Dr. Sibson made the remark, in 1848, that during the inhalation of chloroform the blood which circulates in the coronary arteries must be more highly charged with vapour than that in any other part of the body except the lungs, and that when chloroform is exhibited in a gradual and uniform manner, this circumstance is of no consequence, as the heart is capable of bearing a greater proportion of chloroform than the brain; but when the gas is given suddenly it, if it cause death more rapidly than tying the windpipe, or by immersing the head in cold water, the mode of dying would be the comparatively slow one of asphyxia. When an animal is placed in a jar of this gas, over water, the gas is seen to diminish considerably in volume, as the breath of the animal is absorbed into the blood. It is, however, a mistake to suppose that the danger from vapour not sufficiently diluted is greatest at the beginning of the exhibition of chloroform. A portion only of the blood was charged with chloroform. A portion only of the blood was charged with chloroform. A portion only of the blood was charged with chloroform. Sudden death from this cause may happen at any period of the exhibition of chloroform. In general, when the patient is first trying nearly twenty per cent. of air, and the return of a fluid in a hernia, and of the tumour itself. The capacity of the cavity becomes enlarged, and less resistance is offered, by the pressure of the viscera, to reduction than afterwards, in order that it may not be needlessly disagreeable to the patient; but there would be no danger in commencing at once with air diluted only with 100 per cent. of air, as I know by very numerous experiments on animals. The means which I employ to regulate the amount of vapour in the air breathed by the patient is by the following system. The patient, being in the attitude of asphyxia, was given air, or the air was supplied with chloroform, and the result was about the level of the outer ring. The taxis was ineffectually attempted, after a warm bath. When the child was fully under the influence of chloroform, the taxis was again done, and the child was perfectly reduced, and the swelling retired. Of the benefit of freezing mixtures and the topical application of ice, the London Hospital does not offer any substantial advantage. Of the benefit of freezing mixtures and the topical application of ice, the London Hospital does not offer any substantial advantage. Of the benefit of freezing mixtures and the topical application of ice, the London Hospital does not offer any substantial advantage.