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ON ASPHYXIA, AND ON THE RESUSCITATION OF STILLBORN CHILDREN.

[Read at the Westminster Medical Society, October 16, 1841, by JOHN SNOW, M.R.C.S.]

RESPIRATION, in a limited sense, signifies the mutual change which takes place between the oxygen of the air and the blood; and this is not strictly a vital process, but only an operation of organic chemistry, since it continues after death as well as before, when the mechanical advantages for access of air remain the same. The celebrated Spallanzani, in his work on Respiration, has shown that snails and other animals, which respire chiefly by the surface of the body, continue after death to absorb to some extent the oxygen of the air, and replace it by carbonic acid until the time when putrefaction commences. When insects are poisoned by prussic acid, they come to life again after a little time, because respiration has been going on by the tracheal tubes without any effort of the animal. We know likewise that venous blood can be changed to that of arterial tint by agitation with air out of the body, producing in the air the same change as respiration.

Respiration seems essential to the life of the whole animal kingdom, and when it is arrested from any cause the state called asphyxia is induced. Asphyxia in the human being, and the higher class of animals, after the fœtal circulation is lain aside, presents the following phenomena:—The blood at once ceases to be changed in color whilst passing through the lungs, and venous blood circulates in the arteries; but in a very little time the blood is refused admission through the capillaries of the lungs, and the circulation is arrested. The blood accumulates in the pulmonary arteries and the right side of the heart, whilst the pulmonary veins and the left side of the heart become empty. The heart continues to act for some time, and would propel the blood through the system if it would pass the lungs. Consciousness and voluntary motion soon cease, generally in from one to three minutes after the stoppage of respiration: convulsive motions and attempts at inspiration supervene, and continue for a short time, but all signs of life soon disappear.

It is a question whether insensibility is occasioned by the circulation of venous blood, or by the stoppage of the circulation. Bichat concluded that venous blood acted as a poison on the nervous centres and animal textures generally, and thus destroyed life, in which view he, no doubt, went rather too far, since no ill effects remain from the circulation of dark blood, if respiration be renewed in time. Dr. Kay and others conclude,

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from some experiments, that venous blood, although not so good a stimulus to the brain as arterial, yet tends to maintain life; but the ordinary venous blood which they injected was not so utterly deprived of its arterial properties as the blood of an asphyxied person, which has circulated twice or thrice round the body. They might indeed have spared themselves the trouble of their experiments, if they had but considered that newborn animals in which the foramen ovale and ductus arteriosus are open, that all these, except a few species which are born in a very immature state, with the eyes closed, die when drowned, nearly as quickly as adults, although venous blood continues to be sent to the brain and all parts of the system: the action of the heart being the last sign of life to disappear. Moreover, Dr. John Reid, of Edinburgh, has lately shown, by direct experiment, that voluntary motion ceases in asphyxia before the force of the circulation is diminished. It is clear, then, that blood which has totally lost its arterial properties, is unable to maintain sensibility or even vitality. The arrest of circulation at the lungs, however, may probably shorten life by some seconds, or even by a minute or two.

It has been a subject of conjecture with physiologists whether the carbonic acid gas produced by respiration is formed in the lungs by direct union of the oxygen of the air with the carbon of the blood, or whether the oxygen is absorbed and dissolved in the arterial blood, and unites with carbon in the capillary circulation of the system, where the blood becomes venous, forming carbonic acid, which is given off in the state of gas into the air-cells of the lungs. The latter theory has been shown to be the correct one by the experiments of Spallanzani, repeated by Dr. Edwards, on respiration in hydrogen gas, and by the experiments of Professor Magnus on the blood. The formation of carbonic acid by respiration is no doubt the chief if not the sole cause of animal heat. The quantity of heat developed just about equals the caloric that would be given out by the union of oxygen and carbon under any other circumstances to form the amount of carbonic acid produced by respiration, and the development of carbonic throughout the animal kingdom bears always a direct proportion to the quanity of carbonic acid evolved. On these considerations respiration has been compared to combustion, and the lungs to a furnace; but as we have seen that the carbonic acid is really produced in the capillary circulation of the system, and only evolved by the lungs, the whole body ought to be compared to the furnace, and the lungs to the draught and chimney department—a view which better explains the uniform diffusion of warmth throughout the body. It may be asked whether asphyxia is occasioned by want of oxygen in the blood, or by the poisonous effects of the carbonic acid detained in it? The former is the correct view, since asphyxia takes place in nitrogen or hydrogen gas the same as if respiration were stopped, notwithstanding the mechanical process is continued, and the carbonic acid continues to be given off from the lungs.

Several theories have been advanced to account for the arrest of the circulation through the lungs, but that of Dr. Alison is by far the most satisfactory; viz., that the motion of the blood in the capillaries is assisted by the vital attractions connected with the chemical changes which

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are constantly going on to effect nutrition and secretion; and that consequently, when the supply of oxygen is cut off, and the chemical change of the blood is prevented, the heart of itself is unable to propel the blood through the capillaries of the lungs. This opinion has lately been strengthened by the discovery of Dr. J. Reid, that there is in asphyxia an impediment likewise to the passage of the blood through the capillaries of the greater circulation, when the opposite change would be taking place in the blood if it were not already in a carbonized or venous state.

A consideration of great practical importance in the study of asphyxia is, the influence of the temperature of the medium in which it takes place. Dr. Edwards, of Paris, by a most extensive and beautiful set of experiments, has proved that throughout the animal kingdom asphyxia is much more sudden at a high than at a low or moderate temperature; and that even cold-blooded animals, which will linger for hours deprived of oxygen at a low temperature, will die as quickly as mammalia or birds in water at blood heat: even fishes will die in a few seconds, or at most two minutes, in water at 100 degrees Fahrenheit, that has been deprived of its air by boiling, although this temperature would not injure them with sufficient air. He found that newborn mammiferous animals die most slowly in water at about 60 degrees, which is ordinary cold water, and that they die much more quickly as the water approaches blood heat. Dr. Edwards advises that persons in the state of suspended animation should, amongst other measures, be exposed to the cool air; and that the application of heat should be avoided, unless indeed just a momentary application, to endeavor to arouse sensibility. The Royal Humane Society, however, directs the application of warmth in all practicable ways, not only as an auxiliary to artificial respiration, but even to commence with, if the means for the latter are not in readiness; and most authors, I believe, coincide with the views of the Humane Society. Dr. Edwards considers it is by its effects on the nervous system, and through that on the heart, that a high temperature produces its effects. I think that, although the nervous system may be affected, and is probably the channel of its impression, yet that the deleterious effects of an elevated temperature, when respiration is stopped, depend on its stimulating the capillary circulation of the system, and thus promoting the deoxygenation of the blood, that change which is antagonistic of respiration, which rules its extent under all circumstances, and which, in fact, constitutes the necessity for having a respiration. But, whatever view we take of this point, the fact of the influence of temperature on asphyxia proves that the application of heat ought to be avoided until respiration is thoroughly established, when it will, no doubt, be a useful auxiliary to restore sensibility and renovate the patient.

The number of children that die of asphyxia at the time of birth is very considerable. Writers on midwifery have stated that one-twentieth of the children brought forth are stillborn, and of these a large proportion are asphyxiated, from various causes, often at the very moment of birth. The first measures that are generally and very properly adopted, when a child is born in a state of suspended animation, are to admit the cool air to its skin, to dash a few drops of cold water on it, and use simi-

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lar means to arouse sensibility, more especially that of the nerves of respiration. From the great vascularity and sensibility of the skin, and the thinness of the cuticle of newborn children, great benefit may be expected from the access of air to the surface of the body. Immersion in warm water is sometimes had recourse to, and I have seen it completely successful in two or three instances, after the means just enumerated had failed; but this is a dangerous measure, one which, if it do not succeed, will quickly extinguish any possibility of recovery which may exist, as we have already seen. The great object in this, as in every case of asphyxia, is to establish respiration; and if the patient cannot be roused to perform natural breathing, artificial respiration must be had recourse to as quickly as possible.

Several eminent authors on midwifery recommend breathing into the lungs of the child, if other means are not at hand; but not much good can be expected from a measure which would undoubtedly suffocate a living child, and where there is any disposition to natural breathing this will be decidedly injurious. Allen and Pepys found that air which had been once breathed contained about 8 per cent. of carbonic acid, and that if the same air were breathed over and over again, till suffocation was felt, it would contain but 10 per cent. of the same gas.

The apparatus in ordinary use for artificial respiration is the bellows; but this, although much better than blowing with the breath, is liable to many objections: first, there is danger of injuring the texture of the lungs by over distention; then there is a difficulty of expelling the air from the lungs after it has been injected; and the delay occasioned by thus expelling the air, by pressing on the chest and abdomen, renders it impossible by means of bellows to imitate natural respiration, in which there is a constant current of air to and fro in the lungs.

Mr. Read was introduced to this Society three years ago, by Dr. James Johnson, when he laid before us an invention for performing artificial respiration much superior to the bellows. It consisted of a syringe for exhausting the lungs by the mouth, the nostrils in the meantime being held, when, on removing the pressure from the nostrils, the chest expanded again by the natural elasticity and resiliency of the ribs, muscles of respiration, and pulmonary tissue, causing a tendency towards a vacuum; and the air instantly entered by the nostrils, from atmospheric pressure, as in a natural inspiration; when it was again withdrawn by the syringe, and became renewed in the same manner. I at that time considered whether the same plan could not be adopted for the restoration of stillborn children; but there were insurmountable difficulties. The lungs were in this case empty, to begin with; and even if one should commence by an artificial inflation, the chest could not be expected to take on all at once that resiliency which it acquires in after life, no doubt from the fact of the lungs never being again emptied after respiration first commences. So the matter rested until a short time ago, when Mr. Read, knowing I took an interest in the subject, called to show me an improvement in his apparatus, which indeed he had brought to such perfection, that the use of it on himself would supersede his natural respiration for an hour together without inconvenience. I then suggested that he should

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make a little instrument on exactly the same plan, adapted to the size of newborn children. It consists of two syringes, one of which, by a tube adapted to the mouth, and closing it, withdraws air from the lungs, and the other syringe returns the same quantity of fresh air through a tube fitted to the nostrils. The two pistons are held in the same hand, and lifted up and pressed down together, the cylinders being fixed side by side, and each having two valves. When the pistons are raised, one cylinder becomes filled with air from the lungs, and the other with fresh air from the atmosphere, which can be warmed on its way by passing through a tube and metal coil placed in hot water. When the pistons are depressed, the latter cylinder is emptied into the lungs, and the air in the former is ejected into the atmosphere. In this way a constant current of air to and from the lungs is maintained, as in natural respiration. The introduction of warm air is no doubt a great advantage. The objections to the application of heat during asphyxia cease, so soon as there is a proper supply of air to the lungs; and in introducing heat in this way, it must be remarked that we are only warming that blood to which we are at the same time imparting its arterial properties. This artificial respiration should be persevered in for some time, say an hour at least, before we give up in despair; and if our efforts be successful, we should still persevere until the child is completely revived, and capable of carrying on a full and effective respiration of its own: for the secondary asphyxia which so often comes on, arises, in my opinion, from an efficient respiration not having been established, whence the blood remains in a badly oxygenated state, and does not rouse the nervous system to its full sensibility, but allows it to remain in a condition, so to speak, of not truly appreciating it own want of respiration. I know an instance where the breathing of a child was accidentally interfered with just after birth; and although not to the extent of producing asphyxia, respiration was never properly performed, and the child died after a few hours.

Comparing the weight and size of the lungs of a newborn child to those qualities of adult lungs, the former may be expected to contain nine or ten cubic inches of air. Each cylinder of the instrument before the Society contains an ounce and a half by measure, or somewhat less than three cubic inches; it can consequently be used without the lungs ever being either empty or distended. In the case of a stillborn child, I should recommend that the exhausting syringe be used first to remove any mucus there may be about the fauces; then, since the lungs are empty, a little air may be injected with the other syringe, before beginning with the pistons raised to work the two syringes together.

An accoucheur can scarcely be expected to have an instrument with him at every labor: but it fortunately happens that the danger of asphyxia to the child is frequently foreseen, sometimes before the conclusion of labor; since it may be apprehended in all preternatural presentations, in cases of hemorrhage, in difficult parturition, and from various other causes. The instrument may be useful likewise to perform artificial respiration in poisoning with opium, ardent spirit, or prussic acid, in sudden death from fits in children, and in other cases which will suggest

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themselves. The syringes can be separated and used as stomach or enema pumps, with the appropriate pipes that are supplied.

Oxygen gas is sometimes mixed with the air to be thrown into the lungs of asphyxiated persons. I imagine that with a good artificial respiration, such as this instrument will supply, atmospheric air will be sufficient without additional oxygen: if, however, it be deemed advisable, oxygen gas can be generated in great purity, in a few minutes, from chlorate of potash, by means of a spirit-lamp and a small retort, and can be mixed in any quantity with atmospheric air in one of the bags belonging to the instrument. No harm can arise from thus using oxygen, unless it should be continued for some time after recovery.

With respect to electricity, the form of galvanism is the most convenient one in which to apply it; and there can be no harm in administering slight shocks after these other means have failed. But the chief intention of electricity is to excite the respiratory movements; and this is fulfilled by an efficient artificial respiration. I believe that oxygenating the blood in the lungs is the most effectual means to restore the action of the heart; and that it will restore it if that organ retain any irritability, and the blood be not coagulated. The elasticity of the pulmonary arteries will probably enable them to expel a little of the blood with which they are distended through the capillaries, so soon as the re-establishment of the chemical changes will allow it to pass; and this reaching the left side of the heart, may restore the functions of that organ. As an instance how long the heart may retain its muscular irritability, and the effect of respiration on it, I may mention an observation I made on a Guinea pig which I drowned. It died in two minutes; and when it had been dead an hour, I opened the chest, and found the right side of the heart distended with blood, the left side not containing much, and the heart was perfectly still. In a little time the surface of the lungs became changed in color, from the air imbibed through the pleura pulmonalis; and I was surprised to observe a slight vermicular motion in the right auricle. I divided the trachea, and performed artificial respiration, and shortly observed that the ventricles began to move, and that some bright red blood was visible through the coats of the left auricle. Rhythmical contractions of the heart continued for three quarters of an hour, at the rate of twelve in the minute. The contractions, however, were not complete, and the blood was not expelled from the heart. I found, on opening that viscus, that there was coagulated blood in all its cavities.

Physiologists have amused themselves in speculating on the cause of the first respiration; but doubtless it is the same as of the second and third, and all the succeeding respirations; namely, a sensation or impression arising from a want of oxygen in the system, and conveyed to the medulla oblongata, either by the blood circulating in it, by the nerves in connection with it, or by both causes. The placenta undoubtedly performs for the fœtus the office not only of the lungs, but of all the great excretory organs; and so long as the placenta performs its functions, the fœtus is perfectly at ease and feels no need of respiration; but whenever this communication between the child and its mother is interrupted, at least in the latter months of pregnancy, the child, as every accoucheur

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has experienced, makes convulsive efforts at inspiration, similar to those made by a drowning animal; efforts which would be successful inspirations provided the child were in an element which would be admitted by the glottis. Moreover, I have remarked that even a strong child does not always begin to breathe the minute when it is born; but if the umbilical cord be pressed between the fingers it will instantly draw an inspiration.

It is an interesting question how long a complete interruption of the placental functions may have place in a child at full term, before all signs of life will disappear, and a state of suspended animation be produced. Moralists have often asserted that human beings come into the world in a more puny and helpless condition than any other animals; but in this they are mistaken; for, without including marsupial animals, the young of cats, and all those that are brought forth with their eyes closed, cannot maintain life without artificial heat, which they receive by lying close to the mother: in fact they can scarcely be said to have a proper temperature of their own. A child born at the full term, on the contrary, can maintain its temperature if well protected from cold. Now Dr. Edwards has proved that the necessity of respiration is intimately connected with the power of generating caloric: kittens and puppies will linger for half an hour or more in water at a favorable temperature; but those young that are able to maintain their own warmth do not possess much advantage over adults in their power of resisting asphyxia. But even newborn kittens, in water of the heat of human blood, do not live more than ten minutes; so that a fœtus in the uterus, at a temperature of one hundred degrees, or rather more, must be very soon reduced to a state of complete asphyxia; and the experience of medical men, I believe, pretty well coincides with this conclusion. With a seven-months fœtus it will be somewhat different, as it is more in the condition of those young that require artificial heat. The newborn child, however, from its open foramen ovale, and the great vascularity and sensibility of its skin, probably possesses some advantages over the adult in its capability of being restored from apparent death.—*Lon. Med. Gazette.*

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