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DR LONSDALE'S INQUIRY REGARDING
THE HYDROCYANIC ACID.

(From the Edin. Med. and Surg. Journal, No. 138.)



An Experimental Inquiry into the Physiological Action, the Poisonous Properties, and the Therapeutic effects of the Hydrocyanic Acid. By HENRY LONSDALE, M. D. Member of the Royal College of Surgeons, London, &c.

I. *On the Physiological Action of Hydrocyanic Acid.*—It is unnecessary to remind any one conversant with the history of the hydrocyanic acid, that much discordancy exists between the statements of those who have, or are said to have, pursued an experimental inquiry, to elucidate its physiological action. And since no agent can with confidence be applied therapeutically of whose effects on the healthy functions we are ignorant, it is almost superfluous to say that questions of doubt have arisen in the mind of the physician, upon the reputed medicinal power of this substance, on the grounds that satisfactory physiological data have not been furnished him.

Many deplorable sacrifices of human life, and a vast number of experiments on the lower animals, have fully established the accuracy of the announcement made by Schröder of Berlin in 1802, that prussic acid is a poisonous agent. Three years after, Emmert's Inaugural Dissertation was published at Tübingen, containing numerous experiments and original facts.* Coullon, ignorant of what had been done in Germany, selected the same subject for his Thesis, when about to graduate at Paris, † and was amongst the first in France who observed the effects of this acid on vegetables. Ittner pursued the same investigation in Germany. ‡ M. Weicht § published an essay at Strasburg in 1813, in which he gave an analysis of what had previously been done by others. The inquiry now excited the attention of experimentalists, and more particularly in France; for it appears that no less than three separate essays || were published in the same number of years.

On observing that great authorities were opposed in opinion to each other on one essential point, viz. the manner in which the vital functions are arrested, I deemed it requisite to test by a further appeal to experiment such of their statements as appeared to wear an aspect of contradiction or uncertainty. These experiments were, of course, made on the lower animals, which can afford only analogical evidence of the effects of a poison on the hu-

* Dissertat. Inaug. Medic. de Venenatis Acidi Borussici in animalia effectibus, Tübingae, 1805.

† Considerations Médicales sur l'Acide Prussique. Diss. Inaug. Paris, 1803.

‡ Beiträge zur Geschichte ver Blausaure.

§ Essai sur l'Acide Prussique, Strasbourg, 1813.

|| M. Robert, Annales de Chimie, Tome xcii. Oct. 1814; M. Gazan, Essai sur les effets de l'Acide Prussique, Diss. Inaug. Paris, 1815; M. Callies, Essai sur l'Acide Prussique, Diss. Inaug. Paris, 1817.

man species, however it may be remarked in support of the inferences I have drawn from such a source, that the greatest similitude is observed in the physiological action of the prussic acid on man, and some individuals of the class *Mammalia*.

The experiments are divided into three classes. 1. Those made with the diluted or medicinal acid of this country, which contained $3\frac{1}{2}$ per cent. of anhydrous acid. 2. Those made with acid containing 12 per cent. of pure acid. 3. Those with the anhydrous acid. Twelve experiments were made with the diluted acid on dogs, cats, and rabbits.

EXP. 1.—A cat of moderate size was made to swallow twenty drops of the acid. It walked a few yards in a sluggish manner and then fell; in thirty seconds convulsions were observed, followed by slight *emprostotonos*; the respirations were deep and slow, accompanied with a general trembling over the whole body. Before a minute had elapsed, the animal became insensible and motionless. The respirations were at long intervals; there were slight convulsions with an attempt to swallow, and urine was voided; the head was thrown backward; the animal ceased to breathe at the end of the second minute.

The chest was immediately opened, and the heart found contracting more feebly than natural. A vein in the vicinity was cut through, and no sooner had the blood poured out, than the contractions of the heart increased. As the blood flowed, these regular contractions became more active and forcible, until the end of the fifth minute, when the movements of the heart became irregular. At the tenth minute the ventricles were separated from the auricles and placed on the table; in two minutes, their contractions ceased, but the auricles left in connection with the blood-vessels continued to contract without the aid of a stimulus for at least four minutes after the ventricles had been removed. On pinching the brachial plexus with the forceps twenty minutes after the cessation of respiration, violent movements of the anterior extremities followed; the intercostal muscles contracted sometime after this even without the aid of a stimulus. The vermicular movements of the small intestines were observed an hour after the cessation of respiration.

EXP. II.—To a full-grown rabbit two drops were given. The animal was little affected, merely exhibiting a listlessness in its movements for a minute or so, and then recovered. Eight drops were now placed in the mouth, and in two minutes there was complete insensibility in all parts of the body with slight *opisthotonos*. This state continued for three minutes, when the hind-legs were observed to move, and the ears change in direction: in three minutes more apparent signs of recovery manifested themselves. The respiration and circulation were very little affected from the natural standard. Four drops were now thrown

upon the eye, he staggered, and the limbs were thrown into convulsions, and after two or three shrieks he became insensible. Respiration soon ceased; yet the heart was felt through the chest beating for two or three minutes with some slight irregularities.

In the remaining ten experiments the same phenomena were observed as related above. In some the heart was scarcely at all affected, whilst in others, the contractions were arrested within five minutes after the cessation of respiration.

From the above experiments it may be safely inferred that the diluted or medicinal acid does not kill by arresting the heart's movements, or, in other words, does not produce death in the way of syncope. Since it is obvious that this acid does not exert any special influence on the heart's action, we look for some other explanation of the cause of death, which fortunately soon suggests itself on a due observance of the symptoms. That it must act on the central organs of the nervous system, the brain and spinal cord, is fully shown by the convulsive movements, vertigo, tetanic spasms, loss of sensibility and volition. And that coma is also the result of this action is readily apparent from the fact, that the respiratory acts are performed slowly and imperfectly. It is believed, then, that death takes place in the way of coma from the respiration being ultimately arrested; and although the circulation continues for some minutes scarcely unaltered, the venous blood gradually becomes impeded in its passage through the lungs, and consequently the further progress of this fluid to and from the right side of the heart is suspended.

The numerous experiments of Coullon and those of Emmert, Ittner and Gazan, as quoted by Coullon,* agree with those I have related; and the symptoms induced in wolves, bears, and vultures, by poisonous doses of prussic acid, as experimented upon by Jæger,† resemble in every essential point those observed in dogs and rabbits.

The Dublin Committee of the British Association appointed to ascertain the causes of the sounds of the heart frequently made use of the prussic acid in their experiments,—a sufficient proof that the movements of the heart continued after the respiration had ceased.

The poisoning of a great number of dogs at the police office of this city in the summer of 1835, showed that the heart's action was very slightly affected, and never *directly* arrested in these animals by Scheele's prussic acid, but only *indirectly* from the suspended respiration and consequent stoppage of the circulation

* Coullon, *Recherches et Considerations Medicales sur l'Acide Hydrocyanique*, p. 130, et seq. Paris 1819.

† *Journal Complementaire*, Tom. xxvii. p. 330.

of the blood through the pulmonary tissues. The large dose of an ounce was sometimes given.

Magendie, who ranks among the first of the experimental physiologists on the continent of Europe, appears very satisfactorily, (although some authors seem to think otherwise,) to support the inferences which I have been led to deduce from my experiments. It is evident from the quotation * given below, that this physiologist must have been operating with a diluted acid, and, allowing that he has somewhat exaggerated the time, "plusieurs heures," during which he saw such curious phenomena exhibited by animals dosed with acid, the positive statements he has made regarding the respiration and circulation cannot be called in question. As Magendie has made no mention of the means employed by him to prove the complete extinction of irritability and contractility, I am inclined to think, from collateral circumstances, that he had contented himself with watching the respiration and circulation, the animal having lost sensibility and power of volition, as witnessed in many experiments which I might detail, where doubtless he might suppose, from the quiescent state of the extremities, that the voluntary muscles had lost all contractility. The respiration is said to have continued easy; now it must assuredly be admitted, that the movements necessary to respiration could not be carried on without the aid of muscular contraction.

Orfila has remarked in his *Toxicology*, that first the contractility of the voluntary muscles, then that of the heart and intestines, is annihilated immediately, or a short time after death. † This statement, so opposed to all my observations, demands some notice. Let it be remembered that M. Orfila has copied verbatim from Coullon, nor does he add one single observation of his own; and yet he has hastily written, "it results from what has preceded," (viz. Coullon's own words) "and other facts that the irritability of muscular fibre is destroyed." What these other facts were, we are not informed. Lest it should appear I am dealing too harshly with the writings of this deservedly great authority in toxicological science, I will do him all justice by copying from the 157th page of his work, the following paragraph, which is evidently taken from Coullon. ‡ "Inspection of the dead bodies shows that the muscular organs, especially the heart, and in the latter almost always the right auricle and ventricle, remain

* "En étudiant les phénomènes de l'empoisonnement par l'acide prussique, j'ai souvent observé des animaux qui n'offrant plus de trace de sensibilité, ni de contractilité musculaire locomotrice, conservaient pendant plusieurs heures une respiration facile et une circulation en apparence intacte bien que très accélérée, et qui, pour ainsi dire, étaient morts par leur fonctions extérieurs et vivaient par leur fonctions nutritives." Magendie, *Recherches Physiol. et Cliniq. sur l'emploi de l'Acide Prussique*, p. 8, or *Annales de Chimie et Physique*, Tom. vi. p. 351.

† *Traité des Poisons*, 3d ed. Tom ii. p. 165.

‡ Coullon, *Recherches, &c.* p. 146.

long irritable; and the intestines are long agitated by the peristaltic motion."

Dr Granville favoured the profession, some time ago, with a volume on the Prussic Acid, leaving us to judge of its strength, by informing us that it was made at Gardens, in Oxford Street. It can only be inferred from the doses and medicinal use, that it was the diluted acid; yet how does he describe its action? "If the dose be large, and the animal in the full enjoyment of health and strength at the time of taking the acid, a sudden cessation of vitality takes place, quicker than thought can imagine, or words describe. It is as sudden as the cessation of motion in a watch when the finger is applied to the balance—yet none of the machinery is put out of order! No convulsions follow."* The statement, that there are no convulsions is, as far as I am aware, without a parallel in the history of the acid, and in no case of my observation was the animal free from convulsions. But Dr Granville in the succeeding sentence writes, "In some instances the animal whirls round once," which certainly implies something like disorder in the "machinery." It would be unprofitable to proceed further with Dr Granville's account of the physiological action of the acid, as the highly figurative language in which his expressions are couched, render them quite inapplicable to the purposes of a scientific paper.

2. Two experiments were made with the 12 per cent. acid.

An aged bitch swallowed twenty drops, and ceased to breathe within the minute. A large dog formed the subject of the second experiment. An ounce was poured down his throat: the contents of the bottle were scarcely emptied, when the animal cried out and experienced convulsions, and in less than twenty-five seconds respiration had ceased. The heart of both animals contracted regularly for three minutes. Allowing the blood to escape from the *vena cava*, renewed the contractions some time after respiration had ceased, in the first experiment, so late as the fifteenth minute. In the second experiment the heart was more decidedly affected.

It may be well to notice here the experiments of Schubarth, which have been reported by some of our British authors as showing that the contractility of the heart is destroyed by the hydrocyanic acid. The experiments, eleven in number, were made with Ittner's acid, which contains 10 per cent. of the pure acid. It is certainly true that Schubarth has in one place stated that the irritability of the heart is destroyed,† but on contrasting this with

* Granville, Historical and Practical Treatise on the Hydrocyanic Acid, 2d edit. p. 86.

† Bemerkungen über die Wirkungen der Blausäure. Hufeland's Journal der Praktischen Heilkunde, lii. i. p. 83.

other remarks by the author, in the same paper, on the manner in which certain symptoms were developed, and death followed the administration of the poison, I am inclined to suppose that he has expressed himself too hastily in the passage to which we refer. For in page 77, he says, "if the animals die slowly, the first symptoms, after from fifteen to twenty seconds, were giddiness, then the breathing and action of the heart became exceedingly hurried." In a foot-note to the same page it is remarked, that in all cases the breathing or play of the lungs first ceased, then the heart moved for a short time, and when this ceased, there continued for a quarter of an hour an involuntary contraction of the muscles on exposing them, and peristaltic movements of the small intestines. And in alluding to the experiments where the dose was sufficient to cause immediate death, in which giddiness directly followed the administration of the acid; and the animals fell down senseless, had tetanic spasms, often gave a short but piercing cry, and then died, he writes, "Respiration completely ceased after from two to three minutes; the heart beat violently and convulsively about from four to sixteen minutes; and all signs of life then ceased."* Now, if the heart was primarily acted upon, as is stated in page 83, what are we to infer from the paragraph just quoted, in which we are told that the heart was acting violently and convulsively for two or three minutes after respiration had ceased?

As the diluted acid is that which concerns the practitioner and the toxicologist, it would be unnecessary to make experiments with the concentrated acid, were they only to prove its fearful activity as a poison. It is, however, in reference to the action of the pure acid that so much altercation has arisen between British and foreign authors, and further experiments therefore seem necessary.

Magendie remarks of the pure acid, "that its activity is truly frightful, even to persons accustomed to observe the effects of poisons."† In support of this statement he relates the following experiment. A drop of the acid diluted with four drops of alcohol having been injected into the jugular vein of a dog, the animal "instantly dropped down dead as if he had been shot or struck by lightning."‡ In a preceding experiment he says it was impossible to find in the "locomotive" muscular organs any trace of irritability. May not Magendie in these experiments have taken the same test to prove the presence of irritability as in the numerous cases where he administered the diluted acid? Indeed,

* Bemerkungen, &c. Hufeland's Journal, lii. i. p. 79.

† Recherch. Physiol. et Clin. p. 4. or Ann. de Chim. et Phys. vi. p. 349.

‡ The expressions "quick as thought," frappe de la foudre, &c. &c. have of late become fashionable terms in medical literature. Such phraseology seems more adapted to astonish the vulgar, than to throw light on physiological phenomena.

he admits in a foot-note written after the Memoir had been read to the Academy of Sciences, that he had frequently seen traces of irritability in animals poisoned by the pure acid. Nowhere in the memoir do I find this physiologist mention the effects of the acid on the heart, and Coullon concluded from a great number of experiments that the effects of the acid of Gay-Lussac in small quantities are similar to those obtained by a large dose of Scheele's acid.* M. Robert's experiments† merely point out the rapidity with which animals die when exposed to the vapour of the acid.

We give Dr Christison's experiments in his own words. "In eight experiments on cats and rabbits with the pure acid, the heart contracted spontaneously, as well as under stimuli for sometime after death, except in the instance of a rabbit killed with twenty-five grains, and one of the cats killed by three drops applied to the tongue. In the last two, the pulsation of the heart ceased with the short fit of tetanus which preceded death; and in the rabbit, whose chest was laid open instantly after death, the heart was gorged, and its irritability utterly extinct."‡

Large doses of the diluted acid appear to act as rapidly as smaller doses of the pure acid, as the experiments of Macaulay and others at Leicester prove.§

3. The acid I employed in the third class of experiments was made according to Gay-Lussac's method; by decomposing bicyanide of mercury with hydrochloric acid. The beak of the retort contained fused chloride of calcium and dry carbonate of lime: the receiver was kept quite cool. On Mr Kemp's authority the acid so prepared was perfectly anhydrous.

Exp. I.—Twenty drops were given to a middle sized cat. The animal jumped off the table, cried out, and became convulsed: opisthotonos succeeded, and the respiratory movements ceased within ten seconds. On opening the chest, the heart was observed to act more feebly than in the experiments with the diluted acid. Opening one of the large veins in the vicinity of the heart renewed its contractions. The voluntary muscles and intestines retained their contractility for several minutes.

Exp. II—VIII.—Three rabbits and four cats were poisoned by doses of from twenty to thirty drops of the same acid. These eight experiments with the strong acid offered the same results; the symptoms bearing the closest analogy to those observed to follow the administration of the dilute acid, with the exception of its acting

* Coullon, Recherches, &c. p. 207.

† Annales de Chimie et Physique, xcii. p. 98.

‡ Christison on Poisons, third edit. p. 697.

§ London Medical Gazette, viii. p. 797.

more energetically on the heart in these last experiments. Being satisfied that the pure acid administered by the mouth, even in doses of twenty drops, though it enfeeble, does not destroy the irritability of the heart or voluntary muscles. I resolved to inject it into the trachea.

EXP. IX.—Having exposed the trachea in the middle of the neck of a young rabbit, and made an opening sufficiently large to admit the point of a syringe; nearly a drachm of the pure acid was injected. Before the syringe could be withdrawn the animal was affected with convulsions, which cast him with force from the table (3 feet high) upon which he was placed at the commencement of the experiment. He ceased to breathe at the seventh second. On exposing the chest, which was done very rapidly, the heart was seen enormously gorged on its right side, not so much so on the left. With great confidence in the renewal of its contractions by relieving the distension, I punctured the superior *vena cava*; the blood spouted forth with considerable force, but there was no movement of the heart, not even of its right auricle, nor could any be excited on the application of a feeble degree of galvanism.

Before attempting to explain the cause of deviation in the phenomena observed in this experiment, from those already related, I beg to offer, with due deference to the authority of Magendie, my humble opinion, that no poison, however powerful, could act more rapidly, than the hydrocyanic acid did in this case; as is sufficiently proved by the fact, which was observed by all present, that the rabbit was under its influence before the syringe was emptied of its contents. Notwithstanding this almost instantaneous action of the acid upon the nervous system, as indicated by convulsions, &c. the respiratory movements did not cease before the seventh second, and I am at a loss to understand how death could follow within a second of the administration of a single drop of the same acid.

From the sudden fall on the floor which the animal suffered, it appeared probable that the brain had suffered concussion, and thus influenced the contractility of the heart; but in a second experiment, where the animal was held firmly on the table, and twenty drops thrown into its trachea, the same result followed, therefore the annihilation of the contractile property of the heart in these cases, may be fairly attributed to the effects of the acid. The only explanation that can be given, for the more destructive agency of the acid when thrown into the trachea, appears to me to rest on anatomical grounds. Since the epithelium, which lines the cavity of the mouth, extending along the gullet, and terminating in the human species at the cardiac orifice of the sto-

mach, must be considered like the epidermis, an inorganic layer lying between the minute ramifications of blood-vessels, lymphatics, and nerves distributed on the mucous membrane, and the substance applied to these membranes, it is obvious that the action of the acid must be much more rapid when applied on the mucous membrane of the lungs, where, if the epithelium exists at all, it is so thin as not to be recognized by our senses, than when applied to such a membrane as that of the mouth.* The extreme thinness and great extent of the membrane which lines the minuter ramifications of the bronchial tubes, over the surface of which the acid must be rapidly spread on the first inspiration of the animal, affords another reason for its more powerful action. It is also possible, that the acid may be carried directly from the lungs, by the pulmonary veins, to the inner surface of the heart, and thus destroy its irritability.†

With a view to determine the quantity of acid which, thrown into the trachea, destroys the contractility of the heart, I poisoned two cats, three rabbits, and a dog with doses varying from one to fifteen drops. From these experiments, it appeared that any dose beyond ten drops injected into the trachea, will so influence the contractility of the heart as to suppress its movements within a minute. In some of these experiments we had an opportunity of testing in another way the effect of the strong acid on the system. On exposing the interior of the chest, the blood in the left cavity of the heart was observed to be imperfectly arterialized, and very shortly became quite venous. The venous blood now circulated in the system as well as the pulmonic heart. Whereas in those cases where the acid was thrown into the trachea, and the movements of the heart completely arrested, the left chambers of the heart contained purely arterial blood, and no change was observed to take place in its colour.

In imitation of Magendie's experiment, I made the following experiment. One drachm of 3 per cent. acid was injected into the jugular vein of a large-sized dog towards the heart, care being taken to prevent any loss of blood. The respiration ceased within a minute, but the heart continued to beat against the ribs for three minutes, and some time after this we observed its feeble movements.

What deduction, then, ought to be drawn from these experi-

* Whether the acid produces its poisonous effects on the system by acting on the nerves of the part, or from being carried into the circulation, matters not in regard to this explanation; for whatever favours the one, is no less favourable to the other, as the same inorganic membrane which covers the blood-vessels and retards absorption must also prevent its application to the expanded extremities of the nerves.

† This is further confirmed by our observing that the contractility of the voluntary muscles and intestines are not more affected in these cases than where the dilute acid was given.

ments made with the strong acid? The experiments exceed in number, so far as I am aware, those performed by any single experimentalist in this country, and are, I hope, amply sufficient to enable us to arrive at some satisfactory conclusions, as to the action of this powerful substance on the animal economy. The accession of vertigo and convulsive action of the extremities, while the movements of the heart continue with a greater or less degree of regularity, distinctly show that the brain and spinal cord are directly affected. The diluted acid, as has already been shown, has an influence on the heart's action; but that exerted by the strong acid, as might be anticipated, is more marked and powerful. It must be distinctly understood, that when it is stated that the heart is affected, it is at the same time maintained, that the more direct action of the acid is on the sensorial functions. That the heart should be influenced, is not surprising when we remember its close connection with the central organs of the nervous system, and the facility with which its functions are disturbed by causes acting directly on the brain, as exemplified by the phenomena attending concussion.

We do not expect any necroscopic appearances to prove a local influence of the acid on the brain, an organ which can only be affected from nervous or vascular connection with the part to which the poison is applied. It may also be remarked that, in some cases of simple apoplexy and other diseases terminating suddenly, in certain forms of jaundice, and *ischuria renalis*, where the bile and urea are not eliminated at their respective organs, but remain in, and are carried along with, the blood to the brain, and there act as poisons, exciting convulsions and coma, symptoms similar to those which follow the administration of the hydrocyanic acid, we find nothing on dissection indicating any disease of the cerebro-spinal axis.

Dr Christison states, with regard to two experiments which he performed, where the acid was given by the mouth in large doses, and destroyed the contractility of the heart, at the same moment that he believes idiosyncrasy may affect the results. As a farther explanation of these cases, I am inclined to add, what appears extremely probable, that some of the vapour of the poison was drawn into the lungs during a sudden inspiration of the animal.

From a careful review of the preceding facts, I am constrained to believe, that the immediate effects of the anhydrous acid are exerted on the brain and spinal cord, and that it also indirectly enfeebles, to a greater or less extent, the contractility of the heart. Cases may occasionally be met with (but I feel assured that they will be few in number) which may lead an experimenter to doubt the accuracy of my conclusions; but I think

I may venture to say, that, if he performs as great a number of experiments with the substance as I have done, he will be satisfied that such instances are rare, and must be ascribed to individual idiosyncrasy.

II. *Is Hydrocyanic Acid a Cumulative Poison?*—An interesting question connected with the physiological action of every poisonous agent is to ascertain whether it possesses a cumulative property, that is to say, whether, when taken for a certain length of time in small or medicinal doses, and without manifesting any morbid action, its toxicological effects may suddenly become developed, as is well known to be the case with some substances, *e. g.* mercury and digitalis.

A case is related by Dr Baumgärtner of Freyburgh, which is looked upon as illustrative of the cumulative power of the hydrocyanic acid. A man who had been taking ten drops of Ittner's acid daily, for a period of two months, without any poisonous effects being developed, was found one morning labouring under all the symptoms of poisoning with the acid. Tetanus and coma supervened. Venesection seemed to relieve the spasms and remove the tendency to delirium, but more than thirty hours elapsed before he recovered his sight.* The duration of the symptoms along with other circumstances render the case equivocal in reference to the subject under consideration, and the most probable explanation is, that the person had taken a larger dose than usual. It has been remarked by Dr Graves, that leeches soon perished when applied to the epigastrium of a person who had for some time previously been taking the hydrocyanic acid.† Such an occurrence, however, is no proof of the acid being the deleterious agent; for how often do these animals die when applied to the human skin, without our being able to discover the cause?

The great volatility of hydrocyanic acid is a property incompatible, in my opinion, with the power of accumulating in the system. For as the acid is absorbed into the circulation, it must soon arrive at the lungs, where, from the extreme tenuity of the membrane separating the blood in the serous capillaries from the air filling the pulmonary cells, it must escape from the body along with the carbonic acid in the expired air. This opinion, naturally adopted on theoretical grounds, is amply confirmed by experiment. In animals which lived some minutes after a fatal dose had been given, the air forced out from the lungs during the violent respiratory movements was so strongly impregnated with the odour of the acid, as to be perceived a few inches from the mouth of the animal; and from the odour being only sensible during

* *Medizinisch-Chirurgische, Zeitung*, i. 377. Quoted by Christison, p. 703.

† *London Medical Gazette*, xiv. p. 588.

expiration, it evidently did not depend on the state of the mouth. This statement was frequently verified, and many of my friends can bear testimony to its correctness. Moreover the same phenomenon has been observed in at least one individual of the human species poisoned by the prussic acid.*

That Baumgärtner's case is to be viewed as a casualty, seems obvious on the following grounds. It was not at all uncommon in Magendie's practice to administer the diluted acid for a period of two months and even longer without the appearance of any bad symptoms. The same might be said of many cases treated by British practitioners; and certainly the Italian professors would have observed cases evincing a cumulative property from the large and frequently repeated doses they have prescribed, had the substance possessed any such property.

III. *Medico-Legal Questions.*

After an elucidation of the physiological effects of the hydrocyanic acid, it seems necessary to allude, however briefly, to those circumstances which bear most directly upon legal medicine.

The examination of a medical jurist in a case of poisoning with this substance may be resolved into three questions; 1. What time elapses between the taking of the prussic acid and the first appearance of untoward symptoms? 2. Within what period does this poison prove fatal? 3. Are the symptoms induced in man by a poisonous dose of prussic acid always uniform and characteristic?†

Since the previous habits and idiosyncrasy of the individual,—the state of the stomach in regard to quantity and quality of contents, are all circumstances tending to modify the poisonous agency

* The case alluded to in the text is exceedingly interesting, as showing the successive stages of the symptoms produced by a dose, which, although large, was not destructive of life. Dr B. of Rennes took two teaspoonfuls of Vauquelin's acid:—in a few seconds he felt as if thunderstruck. An apothecary administered ammonia, but in small quantity, as the teeth were closed. The first symptoms were, insensibility, trismus, with noisy and rattling respiration, cold extremities, distortion of the mouth, and the exhalation of an odour of bitter almonds, small pulse, countenance and neck bloated and swelled, pupils fixed and dilated, in short, the state of an apoplectic about to die. He continued in this state for two hours and a half, at the end of which time his senses returned and he uttered, "J'ai pris de l'acide prussique, donnez-moi de l'air et laissez moi mourir." He then asked for coffee, but the irritable and ulcerated state of his mouth would not allow him to take it. A purgative lavement was administered, which produced five or six evacuations: at each evacuation by stool a quantity of gas, having the odour of the acid, was discharged from his mouth. No symptoms of paralysis. (*Revue Medicale*, 1825, i. 265.)

† This question has been entirely overlooked by English and foreign authors, (Beck, Christison, and others.) Its importance, however, is strikingly illustrated in the trial of Captain Donnellan for the murder of Sir Theodosius Boughton in the county of Warwick, England. The evidence of the late John Hunter is more particularly deserving of attention, for an abstract of which, vide Beck's *Med. Jurisprud.* 5th ed. p. 897.

of the hydrocyanic acid, it is impossible to lay down general conclusions on the first of these questions. From a careful calculation of the ages, weight, &c. of several animals, and the doses administered to them as compared with man, I think it probable that a drachm of Scheele's acid would affect an ordinary adult within the minute, and a dose exceeding this, suppose three or four drachms, would exert its influence within ten or fifteen seconds. When the acid is stronger, and the quantity larger, we are pretty certain of its immediate action and consequent annihilation of the sensorial functions.

2. As to the time at which the acid proves fatal? There are records of cases of the human species poisoned by the prussic acid where death occurred as early as the second minute, and as late as the forty-fifth minute. Should proper measures be adopted for the recovery of those poisoned, it seems probable that those who survive the fifteenth minute may recover. Most physicians will agree with me in thinking that the Parisian epileptics, if properly attended to, would have lived; and it deserves remark, that a smaller dose than that which they took is not likely to prove fatal. The dose amounted to 20 drops of the medicinal acid, which, allowing the acid to be of $3\frac{1}{3}$ per cent. strength, would contain about two-thirds of a grain of pure acid.*

3. What symptoms are characteristic? The loss of consciousness and voluntary motion, the slow, deep, and heaving respiratory movements, whilst the circulation gradually becomes enfeebled, the fixed and insensible iris, in short, all the characteristics of apoplexy, were observed in the lower animals, and the same were observed in the physician at Rennes. It is far from improbable that a person may have a dose of prussic acid given him, so proportioned as to induce a simulated apoplexy, which, if the medical man was unaware of the cause, might be mistaken for the real disease. For it must be remembered that when doses not rapidly fatal are administered, the convulsions and tetanic spasms soon subside, and the animal lies in the apoplectic state for some time. So far then there is some difficulty in the way, and a knowledge of the general symptoms would be inadequate. But there is one circumstance which has received no attention from medico-legal writers, and that is the exhalation by the breath of the acid vapour. This has been observed in the human species, and numerous animals experimented upon by me, as already mentioned, and certainly would be sufficiently characteristic of the poison having been taken.

After a due attention to the symptoms, and the time and mode

* Dr Geoghegan (*Dublin Journal of Med. Science*, Vol. viii. p. 309,) relates a case of poisoning, where about the same dose was taken, yet, by the application of remedial agents, the person recovered.

in which death takes place, it becomes necessary to detect by chemical analysis the presence of the noxious agent introduced into the animal economy. The small quantity of hydrocyanic acid necessary to prove destructive, its great volatility in an uncombined state, and facility of decomposition by substances with which it may come in contact in the stomach, are circumstances which have been, and always will be, great obstacles in the way of proving its presence.

Much attention has been paid to the chemical means of detecting the presence of the hydrocyanic acid. The experiments of Leuret and Lassaigne are the most extensive. They found that in animals poisoned by small doses of the prussic acid it was not possible to demonstrate it by chemical means, after three days of exposure to the air after death.* Krimer states that he found the acid in the blood of an animal which died in 36 seconds.†

My chemical examination of the blood, brain, and contents of the stomach, according to the method recommended by Leuret and Lassaigne, leads to the following conclusion;—that from the fourth to the eighth day after death, although the odour is sufficiently strong so as not to be mistaken, yet careful distillation and the usual tests fail to prove the presence of the acid in animals which have been kept in the apartment where they were poisoned. These results coincide with what has been observed by Leuret and Lassaigne, who state that, when there was a strong odour of the acid in the brain and chest, they could not succeed in proving the presence of the acid by chemical analysis.‡ The odour was very considerable in the contents of a stomach examined by Dr Turner, yet the quantity obtained by chemical analysis was very minute. § The person had taken a strong dose of the acid. In Chevallier's case, however, the poison was detected as late as the seventh day, although the trunk of the body had never been buried, but found lying in a drain. || Gazan and Vauquelin state that the odour is sufficiently sensible in the stomach, although they could find no trace of the acid. ¶

Various are the opinions which toxicologists have formed of the continuation of the odour after death. Magendie states that it is distinct for "several days."** Schubarth†† observed the odour to be distinct in the blood, heart, lungs, and cavities of the brain for several hours after death, provided the animal died within from

* *Journal de Chim. Med.* ii. 561.

† *Journal Complement.* xxviii. 10th experiment. I observe in the fourth conclusion which Krimer has evidently drawn from this experiment, that minutes are used instead of seconds, which we give in the text. It deserves mention that Krimer distilled the blood to dryness.

‡ *Annales d'Hygiene*, Publ. iv. 422.

§ *Elements of Chemistry*, 5th ed. p. 428. || *Annales d'Hygiene* Publ. ix. 337.

¶ Coullon, *Recherches*, &c. p. 135.

** Magendie's *Memoire*, p. 6-7.

†† *Bemerkungen*, &c. p. 84, 88.

four to ten minutes. When the dose was so small as not to cause immediate death, it was found that not only a few hours after death, but almost immediately afterwards, no trace of the prussic acid could be found in the above-mentioned parts, viz. stomach, lungs, and brain. A horse died in thirty-two minutes. The dissection was made immediately after death, but no odour was distinguished.

Schubarth's experiments appear to show that, if life is prolonged beyond fifteen minutes after the poison is taken, we need not look for the odour. The bodies of the Parisian epileptics are said to have emitted no odour, which fact is seemingly in favour of Schubarth's statements. There can be no doubt that, if the animal survive some time after the administration of the poison, the acid may escape by the lungs or some of the excretions; but the data we possess at present on this point are insufficient to enable us to determine the time at which this may take place. It must, however, be remembered that Schubarth's dissections were made where there was a free current of air; indeed, he seems sensible of the fallacy arising from this source, by wishing to avoid such circumstances in future experiments. The temperature, situation, and exposure to which the body is subject during life and after death, require to be carefully considered as modifying the results.

With the view of ascertaining the duration of the odour after death, I caused several animals which had been poisoned by the acid to be kept in a room at the temperature of 50° Fahrenheit, during seventeen hours of the day, and others to be buried in light garden soil six inches below the surface. The results of these experiments (fifteen in number,) which were tested by at least three individuals in each case, lead me to expect the odour as late as the eighth or ninth day after death, even where life is prolonged to the eighth minute after a dose of the hydrocyanic acid.*

It has been stated by Coullon that animals poisoned by the prussic acid resist putrefaction. Emmert is of the same opinion.† Leuret and Lassaigne state that, on the exhumation of bodies (dogs and cats,) fifteen days after death, and even at the end of a month, putrefaction had not made very rapid progress.‡ The examination of human bodies and the fluid state of the blood in many cases reported by Coullon himself, do not support those who maintain the antiseptic powers of the acid. As it can only be by an extensive series of experiments that we can arrive at

* From a review of the experiments alluded to above, I certainly believe that the odour is much less distinct where death is protracted for a few minutes, than where it immediately follows the exhibition of the poison, which to a certain extent corroborates the opinions of Schubarth. However, it was sufficiently sensible for at least twenty-four hours even in the case of a dog which lived twenty-five minutes, and in several others which lived a shorter time for four or five days.

† Coullon, *Recherches*, &c. p. 133. ‡ *Journal de Chim. Medic.* ii. 561.

any thing satisfactory on this head, I refrain, for the present, from giving place to my limited observations.

IV. *On the Treatment of Poisoning with Hydrocyanic Acid.*—Impressed with the terrible rapidity with which hydrocyanic acid acts as a poison, many have argued that it is vain to think of antidotes, or any treatment that may be advised, proving sufficient to counteract its baneful agency upon the system. But several cases might be adduced where the action of the acid was more slow, and where sufficient time intervened between the exhibition of the poison and the fatal result to admit of the trial of restorative means. It is obvious from the nature of the poison that no remedial measures can be expected to prove beneficial unless they are energetic, and promptly had recourse to.

Ammonia is the antidote most generally recommended. Dr Mead appears to have been the first to observe its good effects.* Plenck ranks the *spiritus salis ammoniaci* amongst his antidotes to the cherry-laurel.† But the experiments which have led to its adoption as an antidote are those of Mr Murray and Professor Buchner. A dose of prussic acid, which killed one rabbit in ten minutes, was given to another, at the same time that ammonia was applied to the mouth on a sponge. The animal experienced no bad effects. From these and other experiments Mr Murray offered to take a fatal dose, provided some one stood by to administer the remedy.‡ Experiments made with prussic acid on a cat, spiders, and flies induced Buchner to believe that ammonia was useful in restoring them from the convulsive stage.§ Fremy|| and Dupuy¶ confirmed these experiments. Orfila formerly looked upon ammonia and all antidotes to the prussic acid as useless; more lately, however, he has made experiments, which are similar in result to those of Murray. Dr Herbst, whose experiments with the cold affusion will be presently noticed, says, ammonia ceases to be of service after the first doses, and is only useful in the first stage of symptoms or convulsions. From three experiments I have witnessed, I am inclined to support Dr Herbst in his opinion.

It is to be remembered that ammonia itself is an active poison, exciting inflammation of the Schneiderian membrane, in some

* Mead's Medical Works, p. 131.

† Plenck, Toxicologie, 2d ed. p. 97. Vienna, 1801.

‡ Edin. Philosoph. Journal, viii. 124. Mr Murray supposed the hydrocyanate of ammonia to be inert, hence his strong recommendation of this antidote. The experiments of Schubarth have shown that this opinion is incorrect, as the hydrocyanate of ammonia is scarcely less active than the prussic acid itself.

§ Buchner's Repertorium für die Pharm. xii. p. 145-6.

|| Journ. de Chim. Med. i. 482.

¶ Ibid. ii. 356.

cases causing bronchitis, and even death. A good illustration of its pernicious effects even when used as an antidote is to be found in the case of a physician at Rennes, * who laboured under inflammation and ulceration of the mouth for several days after recovering from the effects of the prussic acid. Such instances may well lead us to ask whether the poison or the antidote is more to be dreaded.

Chlorine was first proposed as an antidote by Riauz, a chemist at Ulm, in the year 1822, who rested his recommendation on a single experiment made on a pigeon. Buchner confirmed Riauz's experiment.† MM. Simeon and Dauvergne,‡ at the Hospital of St Louis, have also advised the use of chlorine. MM. Persoz and Nouat have been anxious to prove that the chlorine was absorbed into the circulating system, and there reacted on the hydrocyanic acid.§ Orfila deems this remedy the most powerful antidote we possess.||

If animals live to the fifteenth minute (as in the experiments related by Orfila, which are alone worthy of attention,) after a poisonous dose, it is probable that stimulants of a much milder nature may restore the animal to health, or, perhaps, in some instances, even spontaneous recovery might take place. Chlorine like ammonia is highly poisonous when used incautiously. Were this substance really an antidote, it would seldom be within reach in cases of emergency.

The cold affusion has been strongly recommended by Dr Herbst of Gottingen.¶ His experiments appear to show the good effects of this practice during the "spasmodic period" of the symptoms. Dr Herbst believes that the effects of the acid, even when introduced into the organism in quantity more than sufficient to produce death, may be combated with success by affusions of cold water upon the body generally. Orfila speaks favourably of the cold affusion, but considers it to be inferior to chlorine. Dr Banks relates the case of a young girl (aged nineteen) who took forty drops of dilute prussic acid, and fell into a state of insensibility and convulsions. Stimulants were useless, but cold water poured from a pitcher on the head restored her to sensibility.**

From these experiments it appears that the cold affusion is a useful remedy in cases of poisoning with prussic acid. It certain-

* *Revue Medicale*. 1825, I. 265.

† Buchner, *Repertorium für die Pharm.* xii. 141.

‡ *Journ. de Chim. Med.* v. 406.

§ *Anal. de Chim. et de Phys.* xliii. p. 324.

|| *Annal. d'Hygiene Publiq.* Tom. i. p. 525.

¶ *Archiv. für Anatomie und Physiologie*, 1828, p. 208, or *Journal Complement.* xxxiii. p. 13.

** *Edin. Med. and Surg. Journal*, July 1837.

ly possesses advantages which few antidotes can boast of, viz. that of being always at hand and readily applied.

Various antidotes have been recommended in addition to those just detailed. Ittner and M. Chancel* rely on the sulphate of iron united to potass. Oil of turpentine, introduced as an antidote by Emmert,† and at one time supported by Orfila, has been shown by the experiments of Coullon‡ to be quite inefficacious.

Though the value of those remedies commonly advised has been considered at some length, I am strongly impressed with the belief that an important part of the treatment of such cases still remains to be noticed. Looking at the mode in which death takes place,—the continuation of the heart's action for a short time after the respiration has ceased,—the gradually increasing distension of the right side of the heart by venous blood, and then the final arrestment of the movements of this organ;—the renewal of the contractions of the pulmonic heart after the withdrawal of a small quantity of blood from its auricle, are all circumstances of the utmost importance, as suggesting the principles of treatment. It has already been stated, that the acid, although having a direct influence on the central organs of the nervous system, also affects the contractility of the heart, and that this effect on this organ varied from a slight diminution to complete suspension of its contractility, according to the amount of the dose and other circumstances. In those cases in which coma is induced, without much, if any diminution in the contractile power of the heart, the blood, notwithstanding, becomes congested in the right side of that organ, from the imperfect manner in which it is transmitted through the lungs, as occurs in all cases where the respiratory movements are imperfectly performed: bleeding from the jugular, by relieving the engorged state of the right side of the heart, may be expected to favour the remedial agent, such as dashing cold water upon the face, applying ammonia to the nostrils, &c. employed to revive the patient and cause him to breathe. It also appears that when the effects of the acid upon the heart are transitory, and produce only a temporary diminution of its contractility, the right side of the heart becomes engorged during the partial suspension of its movements, and that when it would renew its usual contractions, it is prevented from doing so by the mechanical distension of its walls. By opening the jugular, in these circumstances, we may hope to relieve the engorgement of the right side of the heart, and thus materially favour the renewal of its contractions. It needs no remark, that in those cases where the

* Dictionnaire des Scien. Médic. Tome xlv. p. 573.

† Buchner, Repertorium für die Pharm. xii. 143.

‡ Coullon, Recherches, &c. p. 255.

acid acts with sufficient energy to arrest primarily the contractility of the heart, all remedial agents will be applied in vain.

I have often observed that the puncturing of the subclavian vein in the lower animals had the desired effect, and am therefore led, *à priori*, to believe, that the opening of the jugular vein in the human subject will serve the same purpose,—that of unloading the right side of the heart. But Haller has shown by experiment which was afterwards confirmed by Spallanzani, that the right side of the heart could be emptied of its blood by opening the jugular vein. This was attributed by Haller entirely to the derivation of blood, as is observed in the flow of this fluid from vessels opened at a great distance from the heart. These experiments of Haller have been more fully illustrated by my friend, Dr John Reid, in the 127th number of the Edinburgh Medical and Surgical Journal. He is of opinion that the flow of blood from the lower orifice of the jugular vein depends on the contraction of the right side of the heart; but in cases where the heart is extremely congested, he believes the derivation of Haller to come first into operation. Connecting Dr Reid's observations with what I have witnessed in thirty experiments, there appears little doubt in my mind as to the mode of proceeding in cases of poisoning with hydrocyanic acid. But as in practice we must be governed by more than theoretical opinions, experiments were instituted to ascertain the value of bleeding from the jugular vein. Before detailing these, it may be well to notice the opinions of authors. Hume observed that bleeding was useful in "relieving the violent symptoms" in a dog poisoned by the acid under consideration. Of its *modus operandi* we are not informed. Orfila repeated Hume's experiments, but without success.* Dr Paris says, "bleeding seems a decidedly fatal measure;"† while Dr Christison remarks, that "venesection is probably indicated by the signs of congestion in the head."‡ The discrepancy of opinion stated by the above authorities appears to be attributable to the want of physiological data.

EXP. I.—A ligature was passed around the left jugular vein of a small, lean dog, of the bull-terrier breed, five months old. The animal was made to swallow ten drops of prussic acid, § he became violently affected before the thirtieth second, and in ten seconds more there was complete tetanic rigidity of the whole body, with expulsion of the urine. As these two symptoms were very generally observed to be the immediate precursors of death, the jugular was now freely opened, and the blood flowed in a forcible stream to the extent of two ounces, when it was stopped.

* Orfila, Toxicolog. General. 3d. ed. ii. 167.

† Paris and Fonblanque, Med. Jurisprud. ii. 406-7.

‡ Christison on Poisons, 3d ed. p. 715.

§ The acid employed in this experiment contained $4\frac{1}{2}$ per cent. of the anhydrous.

As the ligature had been drawn tight before the vein was opened, the blood could only come from the larger venous trunks leading directly to the right side of the heart. After the bleeding, we felt more distinct contractions of the heart, and the respiration returned. In three minutes the respiration became more active, and there were some signs of returning sensibility. In ten minutes his state resembled that of drunkenness. Before the twenty-fifth minute he walked across the room; and in half an hour he was perfectly recovered.

In this remarkable experiment there was realized more than my most sanguine reliance on the treatment by venesection had ever anticipated. The dose, as proved by previous experiments, would have produced death in two, or at the farthest three minutes after being taken. That bleeding in this experiment was not beneficial by relieving cerebral congestion is quite apparent, because the ligature on the vein prevented the return of blood from this quarter.

In a second experiment, where a ligature was also placed on the jugular vein as in the previous experiment, bleeding was equally successful. It was observed in a third experiment where the dose of the acid was so large as to preclude all hopes of recovery, that bleeding from the jugular vein prolonged life, and thus afforded time for the application of other remedial agents.

The following experiment was made by Drs J. Reid and Duncan, and Mr Spence. To a large sized dog, a strong dose of diluted acid was given. The animal was soon affected with convulsions, which continued for two or three minutes, and he was apparently dying. The cold affusion had little or no effect. The external jugular vein was now opened, and the blood had scarcely commenced flowing, when the convulsive movements began to diminish, and continued to diminish rapidly, during the flow of the blood from the vein. After losing a few ounces of blood the animal recovered.

Dr J. R. Cormack has detailed a similar experiment, in which the effects of relieving the distension of the heart are strikingly illustrated. After the acid was administered the animal seemed to be in the agonies of death, but whenever the jugular vein was opened it began to revive, and seemed quite well at the end of an hour.*

From these experiments, I feel no hesitation in saying, what might indeed be inferred *à priori*, from an acquaintance with the physiological action of the poison, that bleeding from the jugular vein is of essential service in the treatment of poisoning with hydrocyanic acid. It evidently acts by unloading the congested cavities of the right side of the heart, which enables this viscus to renew its contractions until the coma subsides.

The following case, related by Magendie, is further confirmation

* Cormack's Prize Thesis, On Air in the Organ of Circulation, p. 38, Edin. 1837. Dr C. has, in his Treatise on Creosote, (pp. 84 and 92, Edin. 1836,) mentioned analogous experiments in which creosote was the deleterious agent employed.

of the utility of bleeding from the jugular vein. A young lady, eighteen years of age, through the neglect of her physician, swallowed a large dose of an extemporaneous mixture containing prussic acid. A few minutes afterwards, she was seen by Magendie, who found her labouring under drowsiness, convulsions, and "cerebral congestion." A large quantity of blood was abstracted from the jugular vein, and several drops of ammonia diluted with water were administered: these measures were followed by a sensible amelioration; consciousness and tranquillity returned.*

In my opinion, the relief of cerebral congestion was not what proved of advantage, for when a ligature was placed above the opening of the vein, as in two of our experiments, benefit resulted. There cannot however be the slightest doubt that bleeding is rendered still more efficacious by allowing some blood to come from the head.

V. *Therapeutical Properties of the Hydrocyanic Acid*.—To enter upon an historical account of the hydrocyanic acid as a therapeutic agent would serve no beneficial purpose. I shall therefore proceed to notice those diseases in which it has been recommended or found useful.

1. The practice of administering prussic acid in the diseases included in the order "Febres" seems entirely confined to the physicians of Italy, who recommend it on the same principle as the tartrate of antimony, viz. as a contra-stimulant. No one in this country, as far as I am aware, has adopted the Italian practice. From repeated trials of the medicine in hectic fever, Dr Granville speaks favourably. †

2. Professor Brera extols the acid in pneumonia, and it is probable that the large doses (above forty drops in the day) which he prescribed, might so far impair the sensibility as to "calm the movements of the heart and diminish febrile irritation." ‡ Dr Caspari recommends its use in the *phlegmasiæ* of the mucous membranes and glandular organs. He also relates several cases of puerperal peritonitis, cured by small doses of Ittner's acid every hour. § Cases of metritis are reported by Plattner, Dall' Oste, and Granville, as having been treated successfully by prussic acid. || Dr A. T. Thomson is inclined to believe that, as the general sensibility is morbidly increased in phrenitis, the hydrocyanic acid may be useful as an adjuvant to other remedies. ¶ Dr Guerin of Mamers obtained beneficial results in two cases of brain fever. ** Caspari and his colleagues have treated gastritis and enteritis

* Magendie's Formulary, translated by Gregory.

† Granville, Treatise, &c. p. 59. ‡ Prospetti Clinici, p. 29.

§ Rust, Magazin, xxii. 2e Cah. or Journ. des Progres des Scien. Med. ii. 63.

|| Granville, Treatise, &c. p. 264, &c.

¶ Cyclop., of Pract. Med. Art. *Sedative*.

** Magendie's Formulary, p. 92.

with doses of hydrocyanic acid, and, as they say, successfully. As acute gastritis under an idiopathic form is exceedingly rare, it seems more probable that the medicine has been found useful in those chronic inflammatory conditions of the mucous membrane of the stomach;—cases which are not unfrequent in the higher classes of society.

A host of instances are brought forward by Granville to show the great utility of the acid in bronchitis, pneumonia and pleurisy. But since in all these cases we find the lancet to have been used, it is impossible to say how far the hydrocyanic acid assisted, if it assisted at all, in effecting a cure. There are cases of acute inflammation of the chest occurring, in which, after profuse bleedings and evacuations have not succeeded in arresting the disease, when the patient has become excessively weak and restless from want of sleep, and where depletion cannot be carried further with safety, that something of a soothing nature is required. Under those circumstances, the exhibition of the prussic acid may be attended with considerable advantages, and probably possesses a superiority over the strictly narcotic medicines.

Cases of rheumatism have been frequently treated by prussic acid. Mr Taylor ranks it as a specific. *

3. In hemorrhagies this medicine has been much lauded by Granville. “In *passive* hemorrhagies, no advantage,—in *active*, much confidence can be placed in the internal use of the hydrocyanic acid.” † Dr Elliotson does not speak so favourably of its employment. ‡

4. *Stomach and Bowel Complaint*.—Under this head will be noticed the several forms of dyspepsia, and likewise dysentery, in which the hydrocyanic acid has been found useful. Dr A. T. Thomson was the first in this country to administer this medicine in cardialgia. He ascribed its good effects to its “reducing the morbid irritability of the secreting surface of the stomach, thereby enabling the juices of the organ to be more slowly secreted, and of a more healthy character.” § Dr Granville has found it successful both in public and private practice. In 1820, Dr Elliotson published a pamphlet on the Efficacy of the Hydrocyanic Acid in Stomach Complaints; arranging these into classes. He relates seventeen cases where the chief symptom was “pain about the pit of the stomach.” Many had tried the usual remedies with no relief. The acid effected a cure. This medicine relieved a variety of symptoms connected with the pain of the stomach, such as flatulency, loss of appetite, and depression of spirits, &c. Several cases of pain at stomach, attended with pyrosis, were treated with

* Edin. Med. and Surg. Journ. xix. p. 399.

† Cyclop. Pract. Med. loc. cit.

‡ Cases by Elliotson, p. 49. § Granville's Treatise, p. 366.

equal success. From the reports of many of the above cases, it does not appear necessary that the bowels be lax or in a particular good state before the medicine can display its good effects. In four cases defined by Dr Elliotson, "in disorders of the stomach occasionally resembling some of the heart in the occurrence of sudden pain especially on motion, about the præcordia, and in the circumstance of the left shoulder and arm being affected," the alleviating power of the hydrocyanic acid was strikingly shown. The symptoms exhibited by those patients appear to me to differ little from those of *angina pectoris*; and if the pathological seat of this disease be proved to depend sometimes on affections of the stomach, as supposed by Drs Brera and John,* we might then hope to relieve those who unhappily suffer from this complaint. Dr Prout informed Dr Elliotson that the prussic acid failed only in one case out of several in which he tried it. † Dr Macleod recommends it strongly where there is much pain in the stomach, or anomalous feelings about the chest and heart. ‡ Many authorities and isolated cases might be quoted from the different periodicals of the day in proof of the efficacy of the acid in dyspepsia. My friend, Mr Hodgson of Carlisle, who has tried it in more than a hundred cases, remarks in a note to me, "This medicine seems to have a peculiar sedative action on the mucous membrane of the stomach, particularly when affected with that very common disorder, morbid irritability." As an apprentice, I have had frequent opportunities of witnessing the effects of the hydrocyanic acid in his hands; and although I omitted to take notes, I have a distinct recollection of one case in which the acid was eminently useful. It was that of a female relative who laboured for several weeks under pain of epigastrium, anorexia and vomiting, which were not at all relieved by the remedies usually prescribed. The hydrocyanic acid given in two drop doses two or three times a-day, soon enabled her to take a hearty meal without the least inclination to vomit. One of the best proofs of the acid being the remedial agent, is drawn from the circumstance of her having a relapse, which readily yielded to a few doses of the mixture previously employed.

Vomiting, a symptom arising from many morbid conditions, appears to be much relieved by the prussic acid. Excepting the strictly inflammatory states which give rise to this symptom, I am inclined to think, from numerous observations, that this medicine will be found highly useful in chronic vomiting, and may be ranked next to creosote in value. Several practitioners in London and elsewhere found it useful in arresting the vomiting which so invariably attended cholera.

* Elliotson's paper, p. 33. † Ibid. p. 43.

‡ Lond. Med. and Phys. Journal, Vol. lix.

There can be no doubt but that pyrosis, and the other unpleasant symptoms associated with the different forms of dyspepsia, owe their origin to some particular state of irritability, over which the prussic acid exerts a speedy and remarkably beneficial influence.

The hydrocyanic acid has been recommended in dysentery by Dr A. T. Thomson, who attributes its good effects to the allaying of irritation. During the last summer I tried the acid in two or three cases with marked benefit. In one case, that of a female aged thirty, in her seventh month of pregnancy, affected with the ordinary symptoms of slight dysentery, I prescribed leeches, calomel, and opium, &c. with fomentations to the belly, for three days, with so little success, that the friends of the patient lost confidence in my recommendations. The prussic acid was now ordered, more with the view of changing the treatment than any great prospect of success, but in this I was agreeably disappointed, for on calling the next day I found the patient sitting up comparatively free from pain. When the uneasy griping sensations threatened her, she had recourse to two table-spoonfuls of a mixture, which contained a scruple of Scheele's acid to eight ounces of distilled water.

As hypochondriasis depends on so many different causes, few practitioners will be found to support the statements of those who boast of the efficacy of the hydrocyanic acid in every form of the disease. Cases originating in derangement of the stomach, or kept up by morbid state of the chylopoietic viscera, may be advantageously treated by this medicine.

5. The violence of the paroxysms in tetanus has been allayed, and, according to Elliotson, a perfect cure of chorea established by the employment of the hydrocyanic acid. This medicine, like many other remedies prescribed in epilepsy, has now fallen into disuse,—partly from its inutility in the hands of numerous practitioners, and partly also from the recollection of the dreadful affair at Saltpetriere in Paris. Since epilepsy depends so frequently on organic affections of the brain, it is obvious that, in these cases at least, the prussic acid cannot be of the slightest advantage in arresting the disease.

Having pursued so far pretty closely the arrangement of Cullen, we may here, perhaps, advantageously deviate from this, and classify those diseases of the chest which cannot be so conveniently arranged under former heads.

6. *Some Catarrhal and Spasmodic Affections of the Respiratory Organs.*—With the exception of the purely inflammatory affections of the lungs, there are no diseases to which so much attention has been paid by the several writers on the prussic acid as catarrhal and spasmodic affections of the respiratory organs. The highly eulogistic strain of language in which many authors have

recommended its employment in those diseases can hardly find a parallel in the history of medicine. Brugnatelli recommended the acid so early as the year 1807, in angina, tubercular cough, catarrh, &c.* and Borda, Brera, and Heineken† have used it very generally in pectoral complaints. Magendie, who has perhaps investigated the therapeutical action of the prussic acid more than any physician in France, states it to be useful in the great number of cases of the nervous and chronic cough affecting females. In some cases where opium seriously incommoded the patient, and where no rest had been obtained for several days, the prussic acid calmed the cough in a few hours. Encouraged by this success, Magendie made repeated trials of the medicine in phthisis, and he states, that he found it “diminish the intensity and frequency of the cough, moderate and facilitate the expectoration, and in fine procure sleep without exciting the colliquative sweats.” M. Lermnier, at the suggestion of Magendie, administered the acid in one-twentieth of the cases of phthisis admitted into the Hospital La Charité with great relief to the cough expectoration and watchfulness. Magendie seems fully confident of the curative effects of the medicine in the first degree of phthisis pulmonalis.‡ The Italian professors, according to Manzoni’s thesis, have lauded the acid in every disease of the respiratory organs. Dr A. T. Thomson thinks the prussic acid valuable as a palliative in the early stages of phthisis, by “diminishing the hardness and frequency of the cough, and lessening the general hectic tendency.”§ Dr Nancrede of Philadelphia,|| Dr Kergaradec of Paris, ¶ and Dr Frisch of Nyborg,** confirm Magendie’s statements. Dr Granville has devoted no less than a hundred pages of his treatise to cases of phthisis treated by himself and others, and seems to think that recovery may be expected even at an advanced period of the disease, if the acid be employed. It is well to remember, that at the time these reports of “incipient” and “confirmed” consumptive cases were drawn up, the stethoscope was almost unknown in this country, and must have been entirely so to Dr Granville, as may be seen by referring to the 206th page of his work. It need hardly be remarked, that severe catarrhal affections of long standing induce very unfavourable symptoms, which might easily be confounded with phthisis.

Some authors are less sanguine of the utility of the prussic acid in phthisis, amongst whom is Dr Elliotson, who has frequently

* Granville’s Treatise, &c. p. 123.

† Nouveau, Journ. de Med. Aout 1821.

‡ Magendie’s Memoire, *passim*.

§ Cyclop. Pract. Med. *loc. cit.*

|| Philadelphia Journal, May 1821, or Lond. Med. and Phys. Journ. Vol. xlvi.

¶ Magendie’s Memoire, p. 59.

** Ibid. p. 92.

tried it even at the commencement of the disease, but with no success.

From the conversation I have had with a number of medical practitioners, I am inclined to suppose, that few physicians place much, if any, confidence on the acid in the treatment of catarrh and phthisis.

As medicinal agents may retard in some degree the first breaking up of the tubercular deposits in the pulmonary tissue, it is possible that the prussic acid may effect this purpose by allaying the irritability of constitution, cough, &c. which are usually present, at the same time attention is paid to the restoration of the healthy functions of the body by exercise and regimen. Should the tubercular ulceration be no longer a matter of doubt, we can only look for palliative remedies, and watch for any inordinate action of the circulation, which, if unsubdued, frequently leads to the fresh deposition and ulceration of tubercles. As opium and the strictly narcotic medicines frequently disagree with the patient, by affecting the head, exciting night-sweats, and disturbing the natural action of the alimentary canal, they are objectionable. On the other hand, the hydrocyanic acid, by subduing morbid sensibility, allaying cough, and promoting expectoration, without exciting the nocturnal sweats, becomes a useful palliative; but, as Dr Elliotson has remarked, "to extol it as a remedy is only doing an injustice to a most useful medicine."

The laurel water and free hydrocyanic acid are considered by Dr A. T. Thomson as almost specific in *phthisis trachealis*.

Opium often fails to relieve the paroxysms of asthma, and hence the numerous other narcotics recommended by practical writers on this disease. We have a mass of evidence in favour of the employment of the hydrocyanic acid in at least the spasmodic form of asthma. Granville recommends it in what he calls the "catarrhus suffocativus," and, according to Thomson, the acid acts almost spontaneously in the spasmodic asthma by relieving the oppressed state of the pulmonary circulation.* This it can only do by allaying the spasm upon which many of these alarming symptoms depend, and not from any peculiar action on the respiratory organs themselves. Magendie, Elliotson, and others speak highly of this medicine in the spasmodic form, where it certainly appears to be of great advantage. As asthma is frequently connected with, and aggravated by, organic diseases of the heart and lungs, we cannot expect any permanent relief from the acid in such cases.

Pertussis.—Dr Fontaneille, who saw much of this disease, and was amongst the first to try the prussic acid, states that

* Cyclop. Pract. Med. loc. cit.

he obtained wonderful results from the prussic acid.* He had tried the antiphlogistic treatment along with various narcotics, but without success. The disease was viewed by him as having its particular seat in the nerves of the mucous membrane of the lungs. Dr Kergaradec relates three cases.† In a review of Dr Macleod's cases in which the acid was employed, it is stated that, of upwards of one hundred cases of whooping-cough, only three proved fatal, the remainder having recovered under the use of the prussic acid, with the exception of twelve cases.‡ Granville, Thomson, and Caspari § deem the acid to possess great advantages when early resorted to. As pathology has not as yet thrown much light on the proximate cause of whooping-cough, we can only trust to observation and experience in the recommendation of any medicine as a cure. In Fontaneille's cases there was no inflammation, and in twenty-three cases examined at Trevisa in 1816, the trachea was constantly found healthy, although lined with a frothy, blackish and adhesive mucus.

The hydrocyanic acid has been tried in colic, hysteria, and hydrophobia, but without much success, and although much lauded by Caspari, Taylor, and others, in neuralgia, it appears to be useful only where the deranged state of the stomach is the primary cause.

7. *Skin Diseases*.—Caspari recommends the acid in erysipelas. According to Dr A. T. Thomson, it may be used as a lotion in three species of lichen,—in prurigo to allay the vexatious itching, and in lepra, where the skin is very irritable. In impetigo, where there is much vesication, and ointments are too irritating, the hydrocyanic acid properly diluted with the addition of the acetate of lead, was found highly serviceable. Ecthyma, eczema, and acme seemed also much benefited.|| Dr Schneider diluted the acid with alcohol, and used it as a lotion in prurigo and herpes.¶ Dr Baganini employed it with great success in painful affections of the skin.** The experience of Dr Elliotson on the external application of the acid does not afford such beneficial results.

To give a summary of what has been written on the therapeutical properties of the hydrocyanic acid, it may be stated that this medicine is proved to be of some importance in certain forms of dyspepsia, in spasmodic affections of the respiratory organs, and in those cutaneous diseases attended with itching and irritability. That it may form a useful adjuvant to other remedies in allaying

* Description de la Varicelle qui a régné épidémiquement et conjointment avec la Variole dans la ville de Millau (Aveyron) en 1817. Montpellier, p. 21.

† Magendie's Memoire, p. 63. ‡ Lond. Med. and Phys. Journ. Vol. xlvi. p. 361.

§ Journ. des Progres, loc. cit.

|| Atlas of Delineations of Cutaneous Eruptions.

¶ Rust's Magazin, quoted in Journal des Progres, Tome iii. p. 228.

** Bulletin General de Therapeut. Fevrier 1834.

those of the troublesome symptoms of phthisis, in mild dysentery, where irritability is the principal cause, and in some neuralgic affections.

The observations of numerous authors, combined with what I have myself frequently observed in the administration of the acid in dyspepsia, &c. lead me to believe that it is not necessary that the physiological action of the medicine should be induced before its therapeutic effects are manifested.

VI. *In what manner does Hydrocyanic Acid act as a Poison?*—This question, although of minor importance in practical medicine, is exceedingly interesting in a toxicological point of view. As it is only through vascular or nervous connection that a poison applied to one part of the body can produce its effects on the body generally, I may set out by stating that the hydrocyanic acid acts either by being taken into the circulation, and carried by that medium over the whole system; or by its direct impression on the nerves of the part to which it is applied, and so affecting sympathetically the other organs of the body.

However plausible the opinion may be, that the hydrocyanic acid acts on the system in the latter mode, or by *sympathy*, it must be admitted that not a few writers, even of authority on this subject, have adopted the former, or that of *absorption*. Many of the conflicting opinions on this subject are to be traced to the physiological doctrines in vogue at the time; others to preconceived notions of the authors; and not a few are derived from experiment. These latter alone deserve attention; but the limits of this essay allow only an epitome of the results of the experiments.

The experiment of Coullon, with which those of Emmert coincide, induced these observers to believe that the prussic acid does not act by means of the nervous system. The principal experiments were made on the brain, spinal marrow and nerves. Those on the brain are certainly objectionable, as part of the acid came in contact with the cut edges of the integuments. The second and third series of experiments proved nothing more than that a local action was exerted by the acid on the respective parts of the spinal cord and nerves, by which they were disabled from propagating (to the muscles they supplied) the impressions made on their poisoned surface.

These physiologists found that a tight ligature applied between the wounded part and the centre of the circulation, prevented the poisonous influence of the prussic acid. This is easily accounted for on the fact, that the limb was not in its natural state;—the circulation being obstructed, the nerves, even if not compressed, would have their functions annihilated for the want of due nutrition. Emmert's experiment of tying the aorta, and applying prussic acid to the posterior extremities without injury to the animal, is quite

inconclusive. Coullon placed the cut ends of three branches of the brachial plexus in prussic acid without the animal experiencing any symptom of poisoning, which experiment certainly proves that the divided nervous trunks do not transmit the influence of the acid to the system.

The experiments of Krimer are the most extensive in support of the doctrine of absorption. From six experiments, he concludes that the acid does not act as a poison, neither when applied to the neurilema, nor to the nervous pulp itself; and that it exerts no greater influence on the brain and spinal cord than an equal quantity of alcohol. He cut the nerves going to the tongue of a dog, and applied the acid next day to this organ, and death soon followed. Apparently suspecting the fallacy of this experiment, he went still further, and not only divided the nerves of the tongue, but also the *par vagum* and sympathetic nerves in the neck of a dog, and then applied the acid as in the former experiment, and with an analogous result.

If Krimer had confined the acid to the tongue by proper apparatus, his experiment would have been conclusive, that absorption was necessary; but no mention is made of his having done so, therefore there is an evident source of fallacy. For allowing that all the nerves of the tongue were cut, have we not branches of the sensitive portion of the fifth pair distributed on the lining membrane of the mouth, and the inferior palatine coming from Meckel's ganglion, supplying the arch of the palate upon which nervous extremities the acid, from its great volatility, would soon come in contact, and induce its usual effects on the system?

The decapitation of an animal, or removing the brain from its cavity, to try the effects of a poison when given by the mouth, as has been practised by Emmert, requires no comment.

Ligatures placed on the arteries of an extremity, whilst the nerves remain entire, preventing the poison applied to the limb from acting on the system, was to be expected from the imperfect vitality of the isolated limb. The reverse of this experiment, viz. the dividing of the nerves, and keeping the vessels entire, proves that the acid is carried by these vessels into the general circulation, but not that the poison acts in this way.

If the above experiments can be relied on, they show that the acid has no influence on the system, when applied to the trunks of nerves,—the spinal cord or brain. But do these facts militate against the opinion, now very general, that the prussic acid acts by nervous transmission?

In reference to the nerves, it may be briefly remarked, that, from the mechanical arrangement of the filaments of the nervous trunks and expanded extremities, impressions made on the latter act more energetically than when applied to the former,—a fact which leads us to believe (what the above experiments go to prove) that

the operation of poisonous agents is upon the sentient extremities, not the trunks of the nerves. The experiments made on the brain, instead of supporting the doctrine of absorption, are actually more in favour of sympathetic action? Granting even that the blood was carefully wiped from the parts of the brain to which Emmert applied the acid, how is it possible that the acid could escape the mouths of the divided vessels, and be prevented from reaching the general circulation. Or if there were no open mouths, we should certainly expect it to permeate the coats of the blood-vessels themselves.

Having shown that there is a source of fallacy in the experiments which Coullon, Emmert, and Krimer instituted to prove the action of the prussic acid by *absorption*, it is necessary to state the facts which may be adduced in support of an opposite doctrine, or that of action by *sympathy*.

I shall commence by noticing those local effects of the poison, where no alteration of structure takes place in the part to which it is applied, and which are sufficiently well expressed by the term "nervous impressions." Robiquet observed, that when the finger was applied to the open end of a glass tube containing the vapour of the acid, it became benumbed, and remained so longer than a day. I have experienced a similar sensation, though in a slighter degree, from keeping my finger over the opening of a flask which contained the pure hydrocyanic acid. My friend Dr Howe, who kindly assisted me in many of my experiments, kept his thumb for some minutes upon the aperture of a flask containing three drachms of the strong acid. In a short time the sensation of numbness was perceptible, and continued for some hours. Professor Traill informs me that he has tried the same experiment several times, and with analogous result. Coullon's experiments on the hearts of frogs satisfactorily show the local action of the acid. The heart of one frog immersed in prussic acid lost its contractility entirely at the end of eighteen minutes, whilst another, left exposed to the air, continued contractile for several hours. He plunged one of the hind legs of a frog into the acid, and left the other free. The first became palsied in thirty-five minutes, whilst the other retained its contractility perfectly.*

Numerous are the instances recorded in works on toxicology, of persons who have been knocked down, or otherwise speedily influenced by a single inspiration of the vapour of the acid. The astonishing rapidity of the action of the acid in the experiments of Robert,† Macaulay,‡ Christison, and some of my own, appears incompatible with the opinion, that it must be absorbed before it

* Coullon, *Recherches*, &c. p. 179.

† *Annales de Chim et Phys.* xcii. p. 98. The experiments were made with the vapour of the acid. Robert states that a bird had its beak applied to the opening of the matrass in which the acid was forming, and became instantly ("à l'instant") motionless. A rabbit and cat died almost as suddenly.

‡ *London Med. Gazette*, viii. 797.

can produce its effects, even supposing the investigations of Hering, which seem to show that substances are transported with great rapidity along the vascular system, to be correct. The single experiment made on the jugular vein, which I have detailed at page 47th, did not imply a more speedy action of the acid introduced into the system in this way, than by the trachea, which we should have expected according to the doctrine of absorption.

The experimental investigations of Morgan and Addison have elicited important facts in support of the sympathetic doctrine of poisons generally. At the same time I doubt much if these physiologists are correct in stating it to be *their own* theory,* if by this it is to be understood that it is entirely new. Fifty years have elapsed since Fontana was labouring hard to overturn the same theory, or rather, we should say, that view which Morgan and Addison are apparently inclined to adopt; for they have not explicitly stated whether it be the sentient extremities of the nerves found in the blood-vessels, or other parts of the body, that serve as the medium of communication between the poisonous agent and the brain. Fontana informs his readers, † that he found in some authors a great difficulty in favour of the influence of the nerves in opposition to the transmissible power of the blood-vessels, in the case of opium injected into the latter,—in the circumstance, that the action of the substance is conveyed suddenly in opposition to the nervous extremities of the red vessels even, and hence the whole of the nervous system.

Having stated both sides of this intricate question, and as far as my limits afford to an equal extent, I am willing to believe that, although the hydrocyanic acid is absorbed and carried into the circulation, its *modus operandi* upon the sentient extremities of nerves seems most probable.

* Essay on the Operation of Poisonous Agents, p. 60. Lond. 1829.

† *Traité sur le Venin de la Vipere*, Tom. ii. p. 367. Florence, 1781.