ences to a number of authorities, in some clinical remarks by Bouchut, of Paris, which appear in the *Journal für Kinder Krankheiten* (Vol. 45, p. 281, 1865; and Vol. 46, p. 77, 1866). He has also a special article on it in the *Bulletin de l'Académie de Médecine;* and mentions it in the last edition of his work on the diseases of children.* Dr Jules Charles has written a thesis on the subject,† and in the article *Coqueluche,* by C. Devilliers, in the *Nouveau Dictionnaire de Médecine et de Chirurgie,* the ulceration is briefly referred to.

IV.—AN ANALYSIS OF 143 CASES OF POISONING WITH STRYCHNIA, WITH REMARKS ON ITS MODE OF ACTION, AND DETECTION, AND EXPERIMENTS ON AN ANTIDOTE.

By J. St Clair Gray, M.B., *Assistant to the Professor of Forensic Medicine in the University of Glasgow.*

(Read before the Medico-Chirurgical Society, 20th January, 1871.)

Physiological action.—The following remarks on the physiological action of strychnia are based upon an analysis of 143 recorded cases of strychnia poisoning which I have collected from various sources. I shall first endeavour to depict the succession of symptoms which I believe from this analysis to be typical of the action of the alkaloid; but as in different instances the phenomena occurring in the course of the same disease may differ very materially, so in the case of poisoning by strychnia there are certain modifications of and variations from the type, which require special consideration. Indeed, there is—as I hope to show—no one symptom present in every case which can be said to be absolutely characteristic.

After the exhibition of a poisonous dose of strychnia, an interval averaging from 15 to 20 minutes precedes the acces-

* Bouchut.—Traité pratique des maladies des nouveau-nes, &c. 5th edit. Paris, 1867.

——— Ulcérations de la langue dans la coqueluche. (*Bull. de l'Acad. de Méd.* 1858-9, t. xxiv., p. 994.)

† Des ulcérations de la langue dans la coqueluche, par le Dr Jules Charles, ancien interne des hopitaux de Paris. Paris, 1864.

sion of the symptoms. These are ushered in by a peculiar uneasiness, a disinclination to remain absolutely at rest; the muscles feel slightly stiff, and a sense of suffocation gives warning of the near approach of the more distressing symptoms. The breathing becomes short and hurried, the pulsations of the heart accelerated, while, after a short time, there are noticed slight tremors, affecting first the organs of locomotion, giving rise to an exceedingly curious and characteristic gait. These tremors then rapidly extend to the other voluntary muscles, and, increasing in intensity, they pass gradually into peculiar startings, in many respects resembling the effects produced on the muscular system by a powerful electric shock applied intermittently. During this period the heart's action, as indicated by the pulse, is not only increased in rapidity, but varies in character, beating at one time smoothly, sharply and clearly, and immediately afterwards irregularly and feebly, while the sensibility of the skin to slight impressions is highly increased, light pressure on the body, especially if applied suddenly, causing the appearance of the remarkable startings just described. Now, the symptoms completely change, and this change is heralded by a peculiar stiffening of all the muscles of the body, cessation of respiration, diminution of the strength and frequency of the pulse, pursing of the mouth, and the accession of an anxious yet startled expression of countenance. The balance of muscular power does not long remain so nicely adjusted, the extensor muscles generally prove the stronger, and coincidently the patient is so to speak thrown to the ground—sometimes emitting an inarticulate cry—in a spasm of a tetanoid character. During this spasm there is opisthotonos; the respiration is entirely suspended; the heart's action is rapid and fluttering; the face congested and livid; the expression anxious; the eyes protruded, suffused, and apparently starting from their sockets, pupils dilated; and as the congestion of the head increases, unconsciousness for the first time comes on. After a duration, varying from 2 to 5 minutes, the spasm passing off is succeeded by a period of

calm, during which the intellect is clear, the respiration and circulation comparatively free, the face more natural in colour and expression, though still anxious, the pupils natural, but the susceptibility of the skin to slight impressions still continues. It may be remarked concerning this abnormal excitability, that firm pressure rather tends to relieve the spasm when present, and does not tend to induce a fresh spasm if carefully applied in the interval. The calm of which we have just spoken does not, however, last long, a fresh spasm comes on, generally induced by some slight nervous impression. This spasm differs from the first only in intensity, though there is a greater probability of the occurrence of trismus, arching of the soles of the feet, and clenching of the hands. This alternation of spasm and repose may occur for some time, and may end in recovery or death, and should the latter occur, the hypersensitiveness above noticed becomes less marked, and just before death occurs reaction is totally abolished.

Such are the symptoms, which in the majority of cases are found to succeed a poisonous dose of strychnia, symptoms which of themselves are so characteristic as to be, apart from everything else, perfectly sufficient to stamp its real character.

But there are cases which present considerable variations from this type. Thus, the premonitory symptoms may be entirely awanting, as in a case published by Dr Harley, in the *Lancet* for 1861, Oct. 26th, of a girl aged 11 years, who died from the effects of strychnia, dose unknown, taken with a view to suicide, and in whom tetanoid spasms came on suddenly and without the occurrence of the phenomena generally noticed in the first stage. Also, in a case communicated by Dr Chippendale to the Abernethian Society, and quoted by Dr Part in the *Lancet* for 1861, vol. i., page 336, in which an adult male swallowed, for suicidal purposes, a dose of 4 grains of strychnia, with 4 grains of morphia. In half an hour violent tetanoid spasms appeared without any antecedent symptoms referable to the action of the poison. This patient ultimately recovered. Again, in a case

published by Dr Paley, of Peterborough, in the *British Medical Journal,* August 4th, 1860, a female between 17 and 18 years of age, after accidentally swallowing a quantity of a vermin killer, containing strychnia, was suddenly seized with a tetanic spasm, which, after a short time, passed off, leaving the patient comparatively free for such a length of time as permitted her walking, with the aid of two persons, a distance of 250 yards. This patient, however, shortly afterwards died. Again, in a case quoted in the trial of Palmer, and published by Dr Watson, of Glasgow, in the *Edinburgh Monthly Journal,* December, 1845, in which a girl aged 12 years, after swallowing $\frac{3}{4}$th grain of strychnia was suddenly, at the end of 20 minutes, seized with tetanoid spasms, which proved fatal in about three quarters of an hour. Again, in a case published by Dr Watson, of London, in his work on Practice of Physic, vol. i., page 553, and which occurred in the Middlesex Hospital, a man under treatment for paraplegia, received by mistake a dose of strychnia amounting to 1 grain made into pill with bread crumbs. He became suddenly tetanic, and although he recovered, the paraplegia was not much relieved. Also, in the case of Assistant-Surgeon Bond, reported by Dr Harley in the *Lancet* of November 16th, 1861, and in a very interesting case reported by Drs Cowan and Lawrie, in the *Glasgow Medical Journal* for 1857, page 162, the tetanic phenomena appear to have come on without any marked preliminary symptoms.

Another and very marked variation consists in the presence, along with the typical phenomena of the first stage, of cerebral symptoms, as in a case quoted by Dr Christison, in his work on Poisons, 4th edition, page 895, which was communicated to Dr Bardsley, by Dr Booth of Birmingham, of a man suffering from hemiplegia, for the relief of which, strychnia was prescribed in gradually increasing doses till $1\frac{1}{2}$ grains was reached. This last dose proved, however, too large, its administration being followed by great anxiety, excitability, stupor, and loss of speech, and ultimately tetanic spasms which led to a fatal result in three hours and three quarters. Also, in a case reported by M. Duriau in the

Annales d'Hygiene, vol. xvii. p. 28, the patient, a female, aged 38 years, suffering from diphtheritic paralysis, had $\frac{1}{6}$th gr. of strychnia by mistake; in ten minutes, giddiness and insensibility came on, followed by convulsions. Recovery in this case was not perfect weeks afterwards. In a case by Schüler, published in the *Gazette de Paris* for 1861, No. 6, a patient suffering from amaurosis, had several times an injection of $\frac{1}{10}$th grain thrown into the eye, but this being ineffectual in relieving the disease, $\frac{1}{20}$th of a grain was thrown into the lachrymal canal, and in three or four minutes there came on vertigo, inclination to fall forwards, and slight twitchings, with complete aphonia. This patient in a short time recovered. In a case reported in the *Lancet* of May 17th, 1856, giddiness was the first symptom observed. In a case reported by Dr Lüdicke in the *Medecinische Zeitung* for March 16, 1842, the patient was suddenly seized with vertigo, and fell to the ground in a state of perfect unconsciousness. Here the typical premonitory symptoms were replaced by those described.

As even a short summary of the cases which I have collected, would occupy too much space, I shall simply mention the number of those in which unusual symptoms were observed. Thus the first symptom noticed in four of the cases was the uttering of loud cries, accompanied by tossing of the arms, and a sense of suffocation; in four, spasms affecting the nape of the neck. In one case, that of Dr Warner, the first symptoms were a feeling of contraction of the throat, tightness of chest, and general stiffness of the muscles; in two cases, vomiting was the first symptom, and immediately afterwards spasms came on. In one case, the premonitory symptoms were replaced by a peculiar sense of burning felt universally over the whole body, and shortly afterwards followed by general tetanoid convulsions. In two cases, the only preliminary symptoms observed previous to the accession of the tetanic spasms, were great pain in the lumbar region and peculiar shooting pains passing from the small of the back down through the great sciatic nerve to the lower extremities. In one case, the only premonitory

symptoms was a general feeling of numbness extending over the whole surface of the body.

Passing now to the more marked symptoms, or what may be called the second or tetanic stage,—and first as to the face: this is during the spasm generally greatly congested, of a livid or bluish-red colour, eyes starting and prominent, the expression, though generally anxious, is sometimes wild, almost maniacal, as in two of the cases which I have collected. The eyelids are generally open, but in six cases they are described as being shut. As a rule, the eyes seem to be fixed, but in three cases the eyeballs were found rolling about under the eyelids, the irides being completely hidden behind the upper eyelids. As to the condition of the pupil, much variation of opinion exists, but this arises probably from the fact that there is considerable variation in different cases; thus in 22 cases in which the state of the pupils was recorded, seven had the pupils dilated both in spasm and repose, in one the pupil was contracted throughout, in two it was natural throughout, while in 12 the pupil was dilated in spasm and natural in the interval. Then as to the presence or absence of trismus: out of 110 cases trismus was reported present in 17, but at what stage is not stated; in one case it was present in the spasm but not in the period of quiescence, while in three it was noted as being absent. In the others no mention is made either of presence or absence.

As to the state of the respiration: dyspnœa is very common, being present in all the cases in which reference was made to the state of the chest; articulation was difficult in six; there was a feeling of constriction in the throat in five; respiration was suspended in the spasm in fourteen; laboured and gasping in six; cries or shrieks were uttered before the accession of the spasms in eleven; frothing at mouth was reported in eight; the risus sardonicus was present in two cases; in one the power of deglutition was lost.

There seems to be no regular rule as to the modifications which take place in the action of the heart as indicated by

the pulse; thus in 23 cases in which careful observations of the pulse seem to have been made, the pulse is described as small, weak, and frequent in 12; 150 and full in two; 74 and weak in one; 88 regular in one; unaltered in one; full and hard in two; and in four irregular and very compressible. In one case the impulse of the heart was noted as much increased in force and rate. Spontaneous vomiting was present in ten cases.

In 74 cases opisthotonos was recorded, the remainder not being noted; but from a manuscript of Dr Coghill, late demonstrator in the University, I find noted two cases of emprosthotonos, and one case in which emprosthotonos and opisthotonos occurred alternately.

In 19 cases the hands were firmly clenched, and in 16 cases the feet were arched; in one case the toes were inverted.

Sensation was exalted in two cases, and perverted in two cases. Of course this reference to sensation does not include the hyper-sensitiveness of the skin referred to in considering the type.

Consciousness was perfect in 19 cases, in one the patient was quite conscious until near the point of death, in 3 cases consciousness is noted as perfect in the interval between the spasms, but as lost in the height of the convulsions. There was stupor present in one case, perfect insensibility in two. Consciousness was questionable in one, and in one case insensibility was present only to a very slight extent.

In one case reported by M. Vigla, of the Hotel Dieu, in the *Gazette des Hopitaux*, of October 7th, 1848, a dose of strychnia equivalent to $\frac{1}{6}$th of a grain produced a peculiar train of hysterical symptoms, with hallucinations.

In another group of cases distinct from those above, in 33 of which the symptoms are recorded—spasms were present in the muscles of the neck first in two cases. The inferior extremities were attacked first in 14 cases. The feet were arched in 10. The hands clenched in 15. Arms bent spasmodically, generally across trunk, in 22. Complete opisthotonos in 31. Trismus in 11 cases, but always occurring late,

and never very severe. Risus sardonicus present to a slight extent in four. Dyspnœa present in 23. In 27 sensibility was perfect throughout. In two it was exalted, and in two the sensibility of the trunk and limbs seemed entirely lost during the intensity of the spasm. Respiration and circulation apparently ceased during spasm in 11 cases. Relief sought by change of position in five cases, and by rubbing in three.

Another point, and one of some interest, is the occurrence of an interval of considerable duration between the spasms. This was noticed in a case reported by Mr Nunnely, of Leeds, in the *British Medical Journal*, January 26th, 1856, in which there was an interval of about an hour, during which the patient was free from spasms. Also, in a case reported by Mr G. M. Jones, of Jersey, in the *Lancet* of September, 1856, in which also about one hour was observed to elapse between the spasms.

Such are the irregular symptoms which may be produced from the action of strychnia. As to the result—in 109 cases, there were 57 cases of death, and 52 cases of recovery. The average time of recovery is from 6 to 18 hours after the exhibition of the poison. When recovery takes place, it is generally perfect, but there are a few cases on record in which this was not the case. Thus in the case already adverted to, as having been reported by M. Duriau, irritation of the stomach persisted for six weeks, with a burning sensation at pit of stomach, and to such an extent as to necessitate the use of nutrient enemata. These symptoms were, however, followed by paralysis, so that after the lapse of three years, recovery was not perfect. Also, in a case reported by Mr J. T. Powell, in the *Lancet* for August 17, 1861, a case is narrated in which dyspepsia of several weeks' duration followed recovery from the more purely physiological symptoms of poisoning by strychnia.

Mode of action.—This question is of manifest importance in reference to the matter of treatment of cases of strychnia poisoning. The subject has been carefully investigated by Prof. Albert Kölliker, by Prof. Meyer of Zurich, by Magendie,

by Addison and Morgan, by Brown-Sequard, and many others. From the results obtained by these experimenters, strychnia, it appears, does not act on the peripheral nerves through the blood, a fact which can easily be proved by cutting the nervous filaments belonging to a limb either before the development of the spasms, or subsequent to their occurrence. Strychnia does not act on the sensory nerves. Muscular irritability and nervous excitability are in frogs almost destroyed, and in mammalia both are much deteriorated.

The question, however, though considerably limited by these restrictions, is still far from solved; but the opinion which seems to me that most worthy of acceptance is that strychnia acts on the grey matter of the nerve centres, these being brought into such a condition that any influence acting on the sensory nerves produces reflexly a spasm, and that convulsions may also be produced by an influence or impression emanating from the brain. In commenting on this subject, M. Claude Bernard writes:—"Let it (strychnia) be introduced into the circulating fluid,—supposing all the posterior roots which arise from the spinal cord to have been divided, no convulsions, of course, would be produced; but let a single root be left untouched, and through this single channel the necessary impulse will be given; the blood which circulates throughout the system, and conveys the toxic substance into every part, brings it in contact with the extremities of that sensitive root which alone remains uninjured and still communicates with the spinal cord, and general effects are at once developed." This M. Bernard writes with a view to prove the action of poisons through the nerves; but does it not rather give force to the opinion already stated that the change induced in the grey matter is such that the influences conveyed along the sensory filaments are sufficient to rouse the otherwise dormant powers, and thus cause reflexly the development of the spasms.

In an elaborate paper, by Dr Alexander Ingram Spence, read before the Medico-Chirurgical Society of Edinburgh, it

is stated that the mode in which strychnia acts, is through the motor nerve cells described by Jacubowitsch, and this statement is founded on an experiment, the details of which may be found in the *Edinburgh Medical Journal* for July, 1866. The brain was exposed, and nux-vomica applied to it, the circulation of the blood having been destroyed by excision of the heart. The nux-vomica, according to the theory here advanced, passes gradually downwards by interstitial absorption, and comes in contact with what are termed by Jacubowitsch, the intermediate nerve cells, which are thrown into a state of excitability, such, that when receiving any nervous impression from without, they agitate the motor cells, not only in their immediate vicinity, but farther down the cord, those first acted on losing their power of excitation apparently from paralysis or exhaustion, thus accounting, says the author, for the fact, that towards the end of an experiment such as he performed, reflex action could only be produced by irritating the lower extremities. The results here obtained, are, however, so much at variance with those obtained by Addison and Morgan, that repetition of the experiment on some other animals higher in the scale of being must be required in support of this theory.

The opinion advocated by Dr Harley appears to be that the action of strychnia is mainly if not entirely on the blood, rendering it incapable of supplying to the spinal nerves and the nerve centres especially, the quantity of oxygen necessary to the healthful discharge of their functions; or, in other words, the blood is so modified that it presents to the nerve centres oxygen in a form or in a manner such that it cannot be utilized.

Some physiologists would rather ascribe the tetanoid spasms to hyperæmia of the cord; but, as far as I can see, the facts do not afford any sure basis on which to rest this assertion.

Other hypotheses have, it is true, been advanced, but I believe that the explanation afforded by that first mentioned is the most satisfactory and the most worthy of acceptance.

Mode of death.—Such being the explanation of the production of the symptoms, I have now to consider the manner in which death is produced, and here, again, is a much contested point. There have been advanced the theory of nervous exhaustion—that of nervous paralysis—that of paralysis and spasm of the heart—that of asphyxia, each and all of which have their firm advocates; some however stating that several of these may co-operate. But there is no doubt in my mind, from the experiments which I have made, that death may, nay, does occur in all these different ways.

Apart from physiological distinctions, there are two great classes into which fatal cases may be divided, according to the mode of death—the cases in which death occurs during a spasm, and the cases in which a fatal result occurs during the state of repose. Of the cases which I have collected, 18 died during spasm, and six during repose, while the fact of the occurrence of death is merely stated in others.

Post-mortem appearances.—Here, as in the consideration of the physiological effects of this poison, I shall present my view of what constitutes a typical combination—supposing the examination to be made from 24 to 48 hours after death. The face is pale and tranquil, the eyes closed, pupils dilated, cadaveric rigidity is present to a marked degree, with opisthotonos, arching of the soles of the feet, clenching of the hands, and flexion of the arms across the chest. The dependant parts of the body livid—lungs congested, especially towards the posterior surface—the heart contracted, firm, and empty—the blood viscid, dark, and containing a few loosely formed coagula—liver, spleen, and kidneys slightly congested, bladder empty, mucous membrane of stomach congested in patches—brain and spinal cord together with their respective membranes much congested, with effusion into the ventricles and subarachnoid spaces. Such are the post-mortem appearances which may be regarded as typical; but the variations are considerable. Thus, in 31 cases in which the post-mortem appearances were recorded, the face was congested in six; in one case œdematous, in one livid and swollen; in one case it resembled the state produced by

strangulation; in ten it was pale, and expression calm; in one expression determined, in the other no mention was made of the condition of the features. In six cases the jaws were shut and fixed, in one fixed but half open, in two half open, and lips covered with bloody froth, in two open, and the lips covered with a white froth. The eyeballs were prominent in two cases, bright but not prominent in one. The pupils were natural in one case, semi-dilated in two, and dilated in five. Opisthotonos was present in four cases, feet arched in seven, and natural in one; toes drawn apart in one, and feet incurved in one; hands clenched in 11, and the arms crossed in three cases. The state of the heart seems to vary exceedingly. Thus it was contracted and empty in two cases, dilated in one case, flaccid and nearly empty in five cases; empty in four, filled with clotted blood in one, distended with blood in one, flabby, but containing an ounce of dark fluid blood in one, firmly contracted and containing a very small quantity of dark fluid blood in one, containing thin fluid blood in one. In two cases the right side of the heart was distended with dark fluid blood, while the left contained a little dark blood, with small coagula interspersed. In one case the heart was large, flabby, and collapsed, in the right ventricle of which was a semi-fluid clot weighing 1½ ounce. In another case the heart was large and flaccid, empty on left side and full of dark fluid blood on the right; and in another the right ventricle was contracted and empty, while the left contained half a drachm of blood. In two cases the presence of pericarditis was noted.

The lungs were congested in 16 cases, in two an apoplectic condition was noticed, while in four no unusual appearance was noticed, and in one case the lungs were pale and bloodless.

In four cases the bladder was empty, and firmly contracted. In four cases, full of urine. In four the kidneys were congested, in six the right kidney was more congested than the left.

In eight cases the stomach had on its mucous membrane patches of congestion, in two cases extravasation of blood was observed. In four the stomach was pale, in the others

natural. In eight cases the small intestines were inflamed. In one the duodenum was very pale, and in the others a natural appearance was recorded. In two cases the veins of the omentum were gorged with dark fluid blood.

In five cases the liver was large and congested, in two large, congested, and cirrhotic, and in one the left lobe was larger than the right. The spleen was congested in four cases.

As to the condition of the membranes enclosing the encephalon and spinal cord, these were congested in 12 cases, natural in six cases. In four cases the choroid plexus was gorged with blood. The brain was healthy in six cases, and the cord also healthy in eight cases. There was serous effusion present in the ventricles in five cases. The brain was softened in two cases, the cerebellum softened in one case; there was present in one case what is described as an apoplectic clot in the right corpus striatum; in one case there was effusion into the left lateral ventricle, and in three cases the arachnoid membrane was opaque. The cord was generally softened in two cases, in one congested and thickened opposite the seventh cervical vertebra, in one case there were on the arachnoid membrane red spots opposite the point of of origin of each nerve. In one case the cord was so softened as to be in several parts pulpy. In 12 cases there was serous effusion between, and great congestion of, the membranes of the cord, and in one case the canal was tense from serous effusion, while in nine cases the cord and membrane are noted as healthy.

Detection of the poison.—Having now considered the physiological effects of, and the post-mortem appearances found in, cases of poisoning by strychnia, and having seen that these may be, if typical, nearly conclusive evidence of poisoning by this substance, but that no conclusive evidence can be founded on them in every case, let us now consider what alone can be absolutely conclusive evidence, viz., the detection of the poison in the body, its tissues or fluids, or in material administered to the patient.

It is always necessary to employ, first of all, a separating

process, by which the alkaloid in a pure state is obtained. For this end many different modes of manipulation have been proposed and advocated, each experimenter having his own peculiar process, and as a review of these would occupy much time, I shall briefly state that which to me seems the most correct and simple, and which I have found the most efficient.

To the suspected matters reduced to a pulp with distilled water by bruising in a clean mortar, acetic acid is added in excess, and the materials allowed to digest for 24 hours, at a temperature of about 70° F. The materials are then thrown on a dialyser, and permitted to remain for 48 hours floating in ten times their bulk of pure distilled water. After the lapse of this time the dialysing frame is removed with its contents, and the clear fluid surrounding it evaporated to the bulk of one drachm, and then tested with blue litmus paper; if acid, it is agitated for five minutes in a test-tube with twice its bulk of pure chloroform, which dissolves the pure alkaloid, but not its salts; but if not acid to test paper, a slight excess of acetic acid is added, and it is then agitated with the chloroform. By this means every thing soluble in chloroform, especially fatty matters, is removed from the fluid, and, being the heavier, the chloroform gradually subsides, and can be removed by a pipette; or, better still, by pouring the mixed fluids, immediately after agitation, into a tube fitted with a glass stop-cock at its lower end, care being taken to have a small quantity of pure chloroform at the bottom. Then, by turning the stop-cock, after the liquids have perfectly separated, the chloroform is removed, and there is left behind the clear fluid containing the acetate of strychnia. This may be again treated in the same manner with chloroform, till, on evaporation of the chloroform, no deposit is obtained; and then, after being again separated, it is treated with ammonia in slight excess, and at once agitated, for five minutes, with four times its bulk of chloroform. The chloroform now contains the free alkaloid. The chloroform is again separated as before, care being taken to allow it to fall drop by drop on a

clean watch-glass or slip of glass plate, each drop being allowed to evaporate before another is allowed to fall, thus ensuring the accumulation of the alkaloid on one point of the glass. A sufficient amount of the alkaloid having been obtained on one slip, another piece of glass is substituted, and so on till the chloroform is exhausted. This process, as a separating process, is certainly as simple as any one can desire, and the success attending its adoption has with me been perfectly uniform. There is thus obtained on the glass a spot, it may be whitish, or in some cases mere wavy transparent elevated lines, the appearance of which, by transmitted light, is very similar to mother of pearl; and in order to determine the nature of the residue, a drop of pure strong sulphuric acid is added, and allowed to remain in contact with it for a short time. Should the spot not become dark there is added a small crystal of bichromate of potass, and should strychnia be present, there is developed a beautiful violet colour, passing into purple, then red, then reddish brown. This is a test which, if it succeeds, is perfectly distinctive of the presence of strychnia, as no other substance under similar circumstances developes the same colour reactions. But should there be a slight darkening of the spot on the addition of the sulphuric acid, due to the presence of extraneous organic matter, another drop or two of sulphuric acid should be added, and heat applied, till complete charring takes place, and, after neutralization with ammonia, the strychnia should be separated by agitation with chloroform, and then treated as above described.

Concerning this part of the subject much diversity of opinion exists among chemists, and it may be well to consider briefly a few points which seem worthy of notice. And first, it has been said by various authorities that oxalic acid, tartaric acid, sulphuric acid, hydrochloric acid, are preferable, but acetic acid is preferable because it has the peculiar property of coagulating casein and other albuminous materials. It does not tend to cause the conversion of starch and farinaceous matters into sugar, its excess is easily removed, and the acetate of the alkaloid is one of the

most soluble of its numerous salts. Hydrochloric acid should specially be avoided in this process, as it tends to induce some change in the strychnia the exact nature of which I have been as yet unable to make out, but a change by which its power of producing tetanoid phenomena is considerably impaired. This is best shown by digesting together strychnia and hydrochloric acid for some time, when the fluid, at first clear, becomes slightly smoked and ultimately brownish, while its power of producing physiological effects of a tetanic character becomes deteriorated The experiments on which this statement is founded might be detailed at length, but as they would occupy considerable time, I merely mention the deductions from them, and I may add that these quite agree with the experience of Prof. Rainy. As to the product, it is my opinion that its chemical relation to strychnia very much resembles that which apo-morphia bears to morphia, but this will require further investigation.

The material by which the alkaloid is to be dissolved out from the fluid has also created considerable discussion, some preferring ether, others benzole, but for my part I prefer chloroform, because strychnia is very soluble in it, and owing to its greater density it can easily be separated from the supernatant fluid, while its density also allows of its concentration on one part of the glass, thus permitting the effect of the colour-test to be more visible. Besides this test, by which the colour-reactions are produced by sulphuric acid and bichromate of potash, others have been recommended on the same principle, the bichromate of potash being replaced, as the case may be, by peroxide of lead, peroxide of manganese, ferricyanide of potassium, nitroprusside of sodium, peroxide of barium, iodate of potassium, iodic acid, chromic acid; but after many comparative trials with these I find that that which affords most uniformly a successful result is the bichromate of potash, next to which chromic acid, peroxide of manganese, and peroxide of lead may be ranked in order of delicacy of result.

Another and very striking experiment, on the same prin-

ciple, consists in treating the spot on which the strychnia is with sulphuric acid till dissolved, and then transferring the solution so obtained to a small cup of platinum foil, connected with the negative pole of a one-celled Smee's battery. The positive pole is then dipped into the solution, and at once the violet colour flashes out. This is perhaps as delicate a test as that with the bichromate of potassium, but is wanting in the character of simplicity. Should the materials, however, be within reach, the experiment should always be made.

The other chemical tests for the detection of strychnia are very numerous, thus with ammonia, potash and soda, it yields acicular prismatic crystals in considerable quantity, as also with their carbonates. On this point I have made numerous experiments, the results of which I shall briefly state. Free ammonia, potash, and soda give after a lapse of 24 hours, with a solution of a salt of strychnia, a precipitate of a crystalline character, when the proportion of strychnia does not exceed one part in 9000 of the solution; but if the carbonate be used the precipitate cannot be produced when the proportion of strychnia to the fluid exceeds one to 2000; the probable cause of this being that a carbonate is formed the solubility of which in water is greater than that of the alkaloid in a free state. With the view of ascertaining the accuracy of this point I prepared a solution of the acetate of strychnia in water in the proportion of one part of the salt to 1000 of water, and to this added monocarbonate of potash in excess. After the lapse of 24 hours a considerable deposit had formed, but to insure total precipitation, 48 hours were allowed to elapse, after which the precipitate was removed by filtration and the filtrate treated with caustic potash, and in 24 hours a crystalline precipitate, small, but perfectly distinct, was obtained. This experiment was repeated several times, the other alkalies being used, but the result was perfectly uniform. But still further, to prove this, the precipitate obtained with the alkaline carbonate was agitated with successive quantities of chloroform till no residue was obtained on evaporation, and after this the caustic alkali was added

and chloroform again agitated therewith, when it was ascertained that the chloroform solution so obtained yielded on evaporation a quantity of strychnia such as to give perfectly distinctly the colour reaction with the sulphuric acid and bichromate of potash. Hence, then, it would appear that the pure alkali is to be preferred to the monocarbonate in setting free the alkaloid from its combination with the acid.

Another test consists in the formation of a precipitate of sulpho-cyanide of strychnia from a solution of one of its salts by the addition of sulpho-cyanide of potassium. The results obtained by this process are also very satisfactory, a distinct precipitate being obtained when the proportion of strychnia does not exceed one part in every 7000 of water.

Besides these tests, strychnia yields a very distinct and characteristic precipitate with carbazotic acid, generally of a feathery appearance, and of a light yellow colour. The strength of the carbazotic acid solution should be for this experiment, one part in every 250 parts of water. Precipitates also may be obtained with solution of corrosive sublimate, bichloride of platinum, terchloride of gold, double iodide of potassium and mercury, with chloride of copper, perchloride of iron, iodic acid, iodide of potassium and iodine, also with tannic acid, palladio-chloride of potassium and phosphomolybdic acid.

The sublimation test proposed by Dr Guy is also worthy of notice, the experiment being conducted in the following manner:—In the centre of a crucible cover, a small crystal of the alkaloid, thoroughly dried, is placed, surrounded by a glass ring, and covered by a glass microscopic slide. The under surface of the crucible cover is then heated gradually, and as the temperature rises, a mist appears on the microscopic slide, and upon this mist there are developed successively, several small white crystals. These may be crystalline to the naked eye, or may require the aid of a magnifying glass. To the sublimate, the crystalline form of which is liable to considerable variation, the colour tests should be applied, the purity of the alkaloid being quite ensured by this process.

There is yet one test which especially deserves our consideration, a test which for simplicity of application, delicacy and accuracy of result, is certainly excelled by none, viz., the physiological test proposed by Dr Marshall Hall. This test is founded on the susceptibility of the frog to the action of strychnia, while the effects produced are so characteristic as to point conclusively to the substance by which they are produced. In the performance of this experiment, it is best to apply the poison by subcutaneous injection to the back, the animal being thereafter allowed to hop about under a bell-jar. After the lapse of from five to ten minutes, the animal suddenly throws itself on its back, drawing up its legs as far as possible, and in this position it remains for one or two seconds, and then the limbs are suddenly and violently extended, the head drawn slightly forward, the anterior extremities folded across the chest, while a faint croak or cry is emitted. In this position the animal remains for some hours, if the dose be considerable, and may even recover from very considerable doses. Thus several times I have seen a frog recover after the exhibition of $\frac{1}{20}$th of a grain of strychnia. With a view to determine the limit to which this test is to be trusted, I made last session numerous experiments, and found that the phenomena were produced quite distinctly with the $\frac{1}{10000}$th of a grain, provided the frog be not too large, and that it be just removed from the mud. One day, however, there was administered to a frog the $\frac{1}{500}$th of a grain of strychnia, and when the spasms were thoroughly produced, it was carefully covered with a wet cloth, and in 48 hours it had recovered, and was hopping about quite briskly. Through inadvertence on my part, however, the animal was left for 24 hours under a bell-jar on a dry plate, and on examining it at the end of that time it was found perfectly rigid; the cloth was then applied, and the animal ultimately recovered. This experiment I repeated several times, and found the results perfectly uniform. It then occurred to me that this was probably due to the action of a small portion of the strychnia retained in the system, the quantity being, however, too small to produce

the tetanoid phenomena, while the animal was strong; but whenever, by the deprivation of moisture, a certain degree of debility was induced, that then the action of the poison appeared. Hence I reasoned that if this degree of debility be induced previous to the administration of the poison, a more minute quantity still might be detected.

After many experiments, I have found the following process to answer extremely well. The frog is first dried as well as possible with a towel, and is then placed under a bell-jar, upon several layers of blotting paper, which rapidly absorb the moisture, and in 24 hours a very considerable degree of debility is produced. If, then, a dose of strychnia—equivalent to $\frac{1}{30000}$th of a grain—be administered to a frog, so prepared, the phenomena above described are in 15 minutes produced, but do not generally last longer than one hour, but this time is quite sufficient conclusively to determine that the symptoms are due to the action of strychnia.

Having now obtained this result, I made several experiments with the blood of animals, such as dogs, cats, and rabbits, previously poisoned with strychnia, the result of which was, that perfectly uniformly I was enabled to observe the tetanoid phenomena produced in a frog thus prepared, by the subcutaneous injection of 15 drops of the blood of animals so poisoned. Now, it appears, that to produce the phenomena of poisoning in any animal, a certain degree of saturation of the blood by the poison is required, and taking it for granted that this degree of saturation is nearly constant, we have here a test which, without any previous chemical manipulation with the materials, can yield from 15 drops of the blood of an animal so poisoned, a test perfectly distinctive of the presence of a particular poison, strychnia; and although this might be supplemented with the other tests, this is an experiment which I think ought always to be made when any suspicion of the administration of such a poison is entertained. It has at any rate this advantage, that the quantity required is very small, and that the attainment of the result renders the chemical detection a much more easy process.

Treatment and Antidotes.—The first procedure which ought to be adopted is the perfect evacuation of the stomach, and for this purpose emetics should be administered freely, and their action aided by the free use of demulcent liquids, as milk, gruel or warm water; the animal temperature should be well sustained by warm applications externally, while, after the evacuation of the stomach, a mild laxative, as castor oil or magnesia should be given. Great attention should be paid to the respiration, and should any tendency to asphyxia appear, artificial respiration should at once be begun, and continued, till respiration is properly re-established, or till it entirely ceases. Much discussion has taken place on the part of various writers on this subject as to the antidote for this poison, and there have at various times been proposed, woorara, tobacco, chloroform, charcoal, camphor, hydrocyanic acid, tannin, iodine, bromine, chlorine, morphia, coneia, aconite, albumen, kermes mineral, iodated-iodide of potassium, lard, and, latterly, the Calabar bean, and hydrate of chloral. Of these agents, those which demand special attention are woorara, chloroform, tannin, Calabar bean, and hydrate of chloral. I have at various times performed experiments with all these save tannin, but certainly from these experiments it appears extremely doubtful whether they possess any efficacy if administered subsequently to the accession of the tetanic spasms. Thus with woorara, chloroform, and Calabar bean, I have frequently succeeded in retarding the appearance of the spasms, and, as I thought, in mitigating their severity when produced, but in every experiment a fatal result ensued, apparently either from deficiency or excess of the supposed antidote. As to the efficacy of hydrate of chloral, I can say with certainty that in the frog at least it does not act as an antidote. After its administration the animal at once becomes flaccid, but very shortly thereafter the tetanoid spasms reappear, and the animal eventually dies, either from the effect of the strychnia or of the chloral, but in no case in my experiments did a successful result attend its exhibition.

While examining the contributions on this subject, it occurred to me that nitrite of amyl might, from its physiological action, prove an antidote, this idea being strengthened by the results which were obtained by Messrs Brown & Frazer in their experiments on the modifications produced on physiological action by chemical addition. With this agent I have made several experiments, which were confined to rabbits, as being the most easily obtained. The result, I may briefly state—20 rabbits being operated upon. Of these 10 died in the first spasm, and consequently the nitrite of amyl was not administered. In the others, the remission after the first spasm having appeared, the nitrite was exhibited in six cases by inhalation, in two by subcutaneous injection. Of these the symptoms were prolonged for 40 minutes in one case, for 43 minutes in another, for one hour in another, for one hour and 10 minutes in another, these however ending fatally. The other four recovered, one after the interval of one hour, another after an interval of one hour and a half, another in two hours, while the last, to which during four days a dose of the sulphate of strychnia, amounting to 10 grains, had been given in divided doses, recovered perfectly. With the exception of this last, the dose administered to the others was a quarter grain each of the acetate, irrespective of the size of the animal. To the two others there was administered a mixture of half a grain of strychnia, with 12 minims of nitrite of amyl, and in neither case did any marked symptoms appear, although carefully watched during three hours. There was at first a slight amount of apparent depression, but after the lapse of half an hour this had entirely disappeared, and they are at present alive and well.

Such are the results of these experiments, and I have only to regret that as yet I have not had an opportunity of experimenting with this agent upon dogs, which are not so liable to die in the first spasm. I intend, however, to pursue this subject further, and shall take an early opportunity of presenting to the Society the results obtained.

One fact, which at least is very curious, is, that the

animals to which the nitrite was exhibited seemed to experience considerable relief from its administration; and, I may add, that two of the students of the Forensic Class, who witnessed the experiments, noted, that whenever I removed the cloth by which the amyl was exhibited, the animal followed it as far as possible with its head, and maintained it in this position until the cloth was more closely applied.

V.—CLINICAL SURGICAL REPORT.

By George Buchanan, A.M., M.D., *Surgeon and Lecturer on Clinical Surgery, Glasgow Royal Infirmary; Professor of Anatomy, Anderson's University, &c.*

This paper contains an account of the surgical practice in the Wards of the Glasgow Infirmary under my charge from 1st January, 1870, till 1st January, 1871. The number of male patients admitted during the year was 330; female, 169; total, 499. This does not include the out-patients; great numbers of whom were admitted temporarily, and dismissed after their wounds had been dressed, or fractures put up, or dislocations reduced. Of the whole number of in-patients admitted, 470 were dismissed cured or relieved, and 29 died, —a mortality of 1 in 17·2, or about 5½ per cent., a very small proportion, considering the very serious nature of the injuries and diseases of the patients.

TABLE OF THE PRINCIPAL ACCIDENTS ADMITTED TO DR G. BUCHANAN'S WARDS DURING 1870.

Simple Fractures—		Compound Fractures—	
Thigh,	29	Thigh,	3
Tibia and Fibula,	18	Tibia and Fibula,	1
Tibia,	8	Tibia,	6
Fibula,	8	Fibula,	1
Patella,	1	Astragalus (excised),	1
Astragalus,	2	Humerus,	2
Humerus,	6	Fingers and Toes,	13
Radius and Ulna,	3	Skull (depressed),	3
Ulna,	1	Concussion and Compression,	6
Radius,	5	Dislocations—	
Clavicle,	7	Hip Joint, Sciatic,	1
Scapula,	2	Knee backwards,	1
Ribs,	9	Shoulder,	12
Spine,	1	Elbow,	3
Pelvis,	1	Rupture of Biceps Muscle,	1
Skull,	1	Of Ligamentum Patellæ,	1
Base of Skull,	3	Of Extensor Tendon of Knee,	1
Lower Jaw,	1	Scalp Wounds,	17
Bones of Nose,	1	Cut-throat,	2