

ART. VIII.—*An Inquiry into the Nature and Pathology of Tetanus; with a view to decide the question as to the propriety of Amputation or other Surgical Operations in Traumatic Cases. And Remarks on the Peculiar Action of Chloroform, Nicotine, and the Wourali Poison*^a. By S. HENRY HOBART, A. B., M. B T. C. D., &c., Medical Officer, Cork Dispensary.

LONG as tetanus has been under the consideration of medical men, it must still be admitted to be a decided "opprobrium medicorum;" few diseases being more universally fatal, or less amenable to treatment. Hippocrates, Plato, Galen, Aretæus, &c., have all written on the disease, and shown a very intimate acquaintance with the subject. The latter writer speaks of the three varieties,—emprosthotos, opisthotonos, and tetanus; he, also following Hippocrates, distinguishes between tetanus from a wound and that coming on from cold, &c., and fully recognises the greater severity of the traumatic cases, for he says that, "spasm from a wound is fatal;" and in another place:—"But if spasm be connected with a wound, it is dangerous, and little is to be hoped." With regard to difference of age, he says, "children are frequently affected, but do not often die." Under the head of treatment he recommends general blood-letting in moderation, but judiciously advises gentleness in the operation, for fear of exciting spasm; at the same time he administers soft, nutritious food to support the strength; he applies cupping instruments to the occiput and to each side of the spine; assafoetida and castor, on account of their antispasmodic properties, he also extensively employs. Paulus Ægineta speaks of almost the same treatment as Aretæus; he approves of cupping with scarifications, but considers dry cupping injurious. Celsus is doubtful of the propriety of venesection, forbids the early use of wine, and approves of cathartics. All the ancient authors have a high opinion of emollient applications, such as bladders containing warm oil being applied to the parts most affected; also a bath of warm oil (which appears to have been a rather expensive remedy) and enemata were in common use.

Now, when we compare this, the state of the subject over a thousand years ago, with our knowledge of it at the present day, we are constrained to admit that little has since been done beyond confirming the propriety of the treatment of the ancients, and showing that they sometimes did, as if by accident,

^a Read before the Cork Medical and Surgical Society.

what has since appeared to be indicated by pathology; thus, the propriety of Aretæus' plan of cupping the occiput, &c., is supported by the fact of congestion being so often found in the membranes of the medulla oblongata, &c. And indeed, with the exception of Larrey's suggestion, to amputate the injured limb in traumatic tetanus, very little novelty has since been introduced. It is to this course of treatment, which, after a short career, has now almost fallen into disuse, that I desire to call the attention of the profession, as, notwithstanding the prevalent opinion of the day, which too often influences individual conviction, I feel by no means satisfied that a sufficient trial has been given to the practice to warrant our condemning it, if indeed its utility has not been already fully proved. An almost universal cry has been raised against amputation, because several cases so treated have terminated fatally, and in some the disease has been aggravated, and the fatal result materially hastened; but will this justify our condemning a practice in other instances attended with the best effect? As well might a surgeon condemn the operation for strangulated hernia on the plea that it is not always a successful one, and that death is sometimes hastened by the shock of the operation. In the above remarks I wish to be understood as contending for the utility of amputation, merely as *one of the means* of severing the communication between the injured part and the sensorium; and in the following observations I shall refer to cases illustrative of the advantage to be derived from the various plans that may be adopted for attaining the same object. Dr. Copland (who, in his "Dictionary of Medicine," gives the most able article on tetanus that I have seen) is of opinion that the disease may be produced in different ways:—

First, that irritation at the peripheral extremity of the nervous sphere may be propagated by sentient nerves to the nervous centre, and be reflected thence on muscular parts by motor nerves.

Secondly, that in certain cases, as in the idiopathic variety, inflammation or congestion of the medulla oblongata, or medulla spinalis, or their membranes, occurs, and that the tetanic symptoms are in those cases the manifestation of the early stage of this inflammatory change.

And thirdly, that when tetanic spasms are produced in the first manner, viz., by irritation transmitted and reflected, the inordinate contraction of the muscles causes an increased demand upon the circulation supplying the nervous centres which actuate these muscles; and that this increased vascularity quickly leads to congestion or inflammation.

In reference to the first of these theories it is right to mention that it, or at least an identical one, in connexion with chorea, convulsions, &c., was put forward by Dr. Copland two years before the first writings of Dr. Marshall Hall on reflex action appeared; and the latter author has since ably contended that all convulsive diseases are caused by reflex action. Though reflex action, excited by local irritation, may appear at first sight scarcely adequate to produce all the symptoms of tetanus, the following facts will go far to prove that it is, in some instances at least, the only apparent cause. Let us take, for example, the well-known case related by Professor Robinson, of the negro who scratched his thumb with a bit of broken china, and actually died of tetanus in a quarter of an hour afterwards; or one which Dr. De Ricci so well describes^a, in which the symptoms of tetanus were well marked in four hours after the receipt of the injury; in either of these cases it appears almost incredible that inflammation could have been set up, or that any pathological change could have occurred in the nervous centres in the short time that elapsed between the occurrence of the accident and the appearance of the symptoms; and without some such change there is no way in which we can explain the production of tetanus but by this system of reflex action.

Again, it is universally admitted that convulsions in children are commonly caused by the irritation of teething, or of worms in the intestinal canal. This is evidently the result of reflex action; on which account it is that these alarming symptoms are so often immediately cured by the removal of the cause of irritation. If, then, convulsions can be caused by reflex irritation, why should not tetanus—a disease so very analogous—be produced in a similar manner? And if it be admitted that this cause is capable of producing the disease, no man can dispute the advisability of amputating in the early stage of traumatic cases, or of otherwise removing the source of irritation, so long as there is reason to hope that no other lesion exists: moreover, cases of recovery from tetanus, where amputation had been performed for the arrest of the disease, have been related by Larrey, Valentin, White, Howship, and others. Dr. Curling states that it was resorted to in eleven of the cases in the Table which he gives, and of these, seven were cured.

Though the cases related by Baron Larrey have been over and over again referred to by various writers, they appear so

^a Dublin Quarterly Journal, August, 1850.

important, as bearing on the subject, that I make no apology for the following short allusion to some of them. I quote from Cooper's "Surgical Dictionary." It would appear from the following extract that his attention was first directed to the subject more by accident than by preconceived opinion:—"The equally *unexpected and entire success*," observes Larrey, "obtained by the amputation of the injured limb, in the person of an officer attacked with chronic tetanus, leads me to propose the question,—Whether, in this disorder occasioned by a wound, it would not be better to amputate the injured limb immediately the symptoms commence, rather than expect from the resources of nature, and from very uncertain remedies, a cure which so seldom happens"^a? &c. In another case he repeated the experiment "where acute tetanus had set in: the symptoms were stopped, as if by enchantment; the patient passed twelve hours in perfect ease, but, being exposed to damp, cold air, the disorder returned and carried him off"^b. He likewise adduces an interesting example, in which speedy relief and a cure followed the cutting off of all communication between the nerves of the wounded part and the sensorium, by a suitable incision. He has also recorded some convincing proofs of the benefit sometimes arising from the division of the trunk of the injured nerve. In one instance tetanic symptoms followed an injury of the supra-orbital nerve, but were immediately stopped by division of some fibres of the occipito-frontalis and the nerves and vessels down to the bone. In another he suspected the disorder to proceed from a principal branch of the crural nerve being tied together with the femoral artery, and he cut the ligature. The relief was only partial and temporary; the cautery was therefore applied deeply to the whole surface of the stump, a marked amelioration took place a few hours after, and the patient recovered.

A very interesting case is related by Dr. De Ricci, in the paper from which I have already quoted, in which amputation was had recourse to by Mr. B. Cooper, in Guy's Hospital. The operation was performed at 4 o'clock, p. m., and next morning the man was perfectly free from any appearance of tetanus, though the symptoms had set in with considerable severity, had increased rapidly up to the time of operation, and gave every indication of running a rapid course. Dr. Murray describes the case of a midshipman who trod on a rusty nail, which penetrated the left foot; he had to keep watch on deck after the accident, and was exposed to wet and cold in the

^a Mémoires de Chirurgie Militaire, t. i. p. 262.

^b Ibid., p. 263-69.

night air. This occurred at 9 in the evening; at 8 next morning tetanus had set in. Other means having failed, Dr. Murray cut down on the posterior tibial nerve, and divided it. Though the patient was unable to articulate before the operation, he immediately opened his mouth with an exclamation, and expressed himself already much relieved; and although the symptoms returned afterwards in a mitigated form, he completely recovered in the end^a. Mr. Samuel Cooper states, that the practice of nearly surrounding the wound by a deep incision has been had recourse to in University College Hospital, "and that most of the cases have been in favour of the plan"^b. Dr. E. Phillips relates a case of severe tetanus, of several days' standing, from gastric irritation. After a variety of other means had failed, the patient was given a turpentine enema; in five minutes a copious stool was discharged, and the tetanic symptoms were quite relieved; next morning an intestinal worm was expelled, and the patient quickly recovered^c. Dr. Mitchell mentions a case of tetanic spasm of the tongue and muscles of the face, caused by extraction of some carious teeth; and he alludes to a similar instance which occurred under the care of Dr. Thompson^d.

The above facts are, I conceive, amply sufficient to show that tetanus is in several cases—at least in the early stage—entirely dependent on local irritation, transmitted along the nerves to the sensorium, and that the removal of the local irritation, or the prevention of its being transmitted to the sensorium, is in some instances capable of putting a stop to the disease, and in others of greatly mitigating the symptoms.

But, on the other hand, it has frequently happened that amputation has been resorted to, or the source of irritation otherwise removed, and the disease has not been cured; on the contrary, the symptoms have been occasionally aggravated. In those cases there must evidently have been some pathological condition established capable of keeping up the disease after the local irritation had been removed; and this is exactly what we might expect if we adopt the theory to which I have already alluded, as suggested by Dr. Copland, that when the tetanic convulsions have lasted for some time (as the result of reflected irritation), congestion or inflammation of the medulla oblongata, or of its membranes, sets in; and that this state, when produced, is adequate of itself to keep up the symptoms

^a Dublin Journal of Medical Science, vol. v.

^b Surgical Dictionary, p. 1232.

^c Medico-Chirurgical Transactions, vol. vi. p. 65.

^d Library of Medicine, vol. ii. p. 241.

of tetanus. Now, in order to render this theory convincing, it is necessary to consider the following points:—

1st. Is inflammation or congestion of those parts capable in itself of giving rise to tetanus?

2ndly. Is the condition likely to arise either as the result of violent muscular action, or of the transmission of irritation to the nervous centre? And—

3rdly. Have we sufficient reason to believe that it does arise in the course of the disease?

It is scarcely necessary to consider the first question at all, every writer on spinal meningitis speaking of the occurrence of symptoms which at least very strongly resemble tetanus. Dr. Bennett, in describing the symptoms, says^a:—"As the disease advances there are convulsive contractions of the neck and posterior part of the trunk; sometimes there is complete opisthotonos." Again:—"In other instances there is trismus." Again:—"When the tetanic spasms are intermittent," &c. In comparing cerebral meningitis of the base of the brain with that affecting the upper surface, the same writer says:—"There is a greater prevalence of spasm, tonic and clonic. These pathological features are ascribed to the disease being seated in the immediate neighbourhood of the medulla oblongata and cerebral centres in general. . . . While a higher degree of vascular turgescence, by irritating the excito-motor nerves, induces spasms"^b.

"Among the commonest symptoms of inflammation of the meninges of the cord," Dr. Watson mentions "rigidity or tetanic contractions, and sometimes violent spasms of the muscles of the back and neck, amounting, in some instances, to perfect opisthotonos."

Though tetanic symptoms are here attributed to the spinal meningitis, it may be fairly questioned whether those symptoms are the result of the meningitis at all, or whether they may not be caused by some peculiar condition of the medulla oblongata itself, commonly accompanied by congestion of the membranes; but as the meningitis is an obvious lesion, while the peculiar condition of the medulla (if such exist) has never been demonstrated, it appears allowable to attribute the symptoms to the former, though the difficulty of understanding how any affection of the membranes could cause spasm (while a like affection of the cord itself has not that effect) may lead us to suspect the existence of some intermediate cause. Of course this question applies equally to all cases of idiopathic, or such

^a Library of Medicine, vol. ii. p. 189.

^b *Ibid.*, p. 34.

cases of traumatic tetanus as are supposed to depend on congestion or inflammation of the spinal meninges.

With regard to the second question, whether congestion or inflammation of those parts is likely to arise in the course of tetanus depending on reflex irritation,—I have already alluded to the opinion of Dr. Copland, but upon this point I may be permitted to quote his own words:—"That in cases which arise from irritation in some distant part, transmitted to the nervous centres, and reflected thence upon contractile structures, and in which inflammatory action is either absent, or its existence is problematical, at an early period of the malady at least, we cannot infer, agreeably with what we know to take place in the animal economy, that inordinate or continued contraction of muscles can exist without an increased demand being made upon the circulation supplying the nervous centres which actuate these muscles, and hence we may conclude that increased vascularity, or even the earlier stages of inflammation of these centres and of these membranes, may be the *necessary consequence* of the continued and inordinate muscular action constituting the disease." Nor can there be the least question of the fact, that increased duty being required of any organ is necessarily attended with increased vascularity; neither does it appear inconsistent with analogy that the same cause may lead to decided congestion, or even inflammation.

Again, it may be asked,—May not the irritation, transmitted to the centre from the injured parts, be capable in itself of exciting inflammation, just as a particle of dust irritating the conjunctiva will produce a like condition of that membrane? And further:—May not the irritation thus applied lead (in some cases) to this lesion of the spinal meninges, without producing any muscular contraction as the result of reflex action, but this condition, when established, cause the first symptoms of tetanus; for how can we otherwise account for the fact that tetanus occasionally makes its first appearance after the wound itself has completely healed^a? That this, however, is not always the course of the disease, has been already proved.

The third question is as easily answered as the first, it being universally admitted that at least congestion, if not inflammation of the medulla oblongata, and of its membranes, is by far the most common pathological condition found in fatal cases, being present in the majority of instances, particularly if examined sufficiently soon after death.

From the above facts I have no hesitation in coming to the

^a Library of Medicine, p. 236.

conclusion that our first duty, on being called to deal with a case of traumatic tetanus, is to consider by what means we can best remove the source of irritation. Should it be caused by a bad injury, such as would of itself materially endanger the limb, independently of the complication with tetanus, let amputation be at once resorted to; but should the injury be of a less serious nature, and be so situated that the nerves leading from the part can be readily divided, then by all means let the preference be given to this milder course; but, notwithstanding the success attending this plan of treatment in Dr. Murray's case, and the high opinions entertained of it by some writers^a, yet it must be admitted that, though a milder operation, it is applicable to comparatively few cases: we can but seldom be sure of what nerve, or how many of them, may be in error; nor, even should this be decided, would it be always possible to divide those that we should wish, without the risk of leaving a paralyzed and useless limb, or of wounding some other important part. In other cases the wound may be very trifling, one affecting merely the skin, in which case no demonstrable nerve may be ascertained to be injured. Under such circumstances we may resort to the expedient referred to by Mr. Cooper as being so successful in University College Hospital, and also spoken favourably of by others, namely, almost surround the parts with deep incisions, or, what would appear still more satisfactory, excise the injured parts altogether, and bring the edges of the new wound together. And, indeed, should this operation not prove almost immediately successful, we ought then to consider what nerve supplies this portion of integument, and at what part of its course can it be easily and safely divided. I would venture still to hope that this secondary operation might be attended with benefit, even after the excision of the injured part had failed, on the supposition that inflammation may have extended up the nerve for a short distance; and that this may, in some instances, be capable of keeping up the disease, on the same principle of reflex action, while yet the medulla oblongata had not suffered any injury; and the fact that the nerves of the affected limb have been often found in an inflamed condition shows the possibility of this theory.

The success of any of the above means must, of course, mainly depend on the promptitude with which it is under-

^a Dr. Bennet says: "It is a singular fact that this practice, which our knowledge of pathology and physiology shows to be necessary, and likely to be successful, has only, as far as medical records go, been performed four or five times, but in all these with perfect success."—*Library of Medicine*, vol. ii. p. 242.

taken: if done in the very early stage, we may fairly hope that the disease will be thereby quickly arrested, but this can occur only in case the local irritation is still the sole cause. But suppose the secondary cause has already commenced in the medulla oblongata, may we not expect that some advantage may still be derived from the same treatment? If irritation "transmitted to the nervous centre," &c., be in the first instance capable of producing the disease, it must, after another cause for the same is established, be still calculated to produce the same result. And thus, there being two causes in operation, the effect must be doubled, but when the primary cause is removed we have then but one condition to treat, namely, that of the nervous centre, which we may hope to cure by appropriate treatment, without the danger of its again returning, whereas, had we even succeeded in curing it while the primary cause remained, it would, in all probability, be again renewed by the same means by which it was first excited.

Several cases of tetanus have, from time to time, been related, in which surgical means have been used to cut off the source of irritation, with the effect of producing complete relief from the symptoms for some hours; but, after an interval of apparent health, the disease has again returned, and though in some instances in a mild form, has occasionally proved fatal. The most rational explanation of this appears to be, that, previous to the removal of the injured part, inflammation (or whatever the peculiar condition of the nervous centre may be) had just commenced, and that, though its exciting cause was removed, it still continued to advance, until it reached that state at which it was capable of producing tetanic symptoms. Again, in some of the cases above alluded to, the relief of the symptoms does not appear to have immediately followed the performance of the operation, but to have occurred in some time afterwards; in that, for instance, where Larrey suspected the nerve to have been included in the ligature with the femoral artery, and when, after the failure of other means, he applied the actual cautery, the improvement is said to have taken place a few hours after the operation; and in that reported by Dr. De Ricci, as operated on by Mr. Cooper, it is said that next morning the man was free from tetanic symptoms, showing that the relief did not occur at once, but probably at some period during the night. Were either of those cases to occur under the observation of a man prejudiced against operative interference, while, at the same time, some favourite form of treatment was put in practice, it is not improbable that the recovery would be attributed to

the latter, because it was not the *immediate* effect of the former. But are we justified by analogy in expecting that the removal of the local irritation should always be immediately followed by the cessation of the spasms, even when undoubtedly caused by that irritation? By no means; for we frequently meet with cases of convulsions in children, resulting from the presence of intestinal worms, where, after the expulsion of the worms, the convulsions still continue for some time, and finally subside without the administration of any further remedy, or the expulsion of more worms; as if such a state of excitation became established in the nervous system that it required time to regain its natural condition. Indeed, I have little doubt that the result of many of the cases of tetanus that have from time to time recovered has been (in part, at least) due to the fact of the local irritation having ceased to act, either from the wound having taken on a healthy action, or from the sloughing of the part; but that the connexion between this change and the first amelioration of the symptoms not being sufficiently striking, the cure was attributed to the treatment adopted. Thus there are three cases referred to in Sir James Mac Grigor's Report on the Diseases of the Army, where venesection was fairly tried, and the only one in which recovery took place was one where hospital gangrene attacked the injured hand^a.

Here the recovery might be attributed to the treatment by blood-letting; but it appears much more rational to suppose that the sloughing of the part removed the local irritation; in fact, it amounted to exactly the same thing as amputation of the portion of the limb that sloughed.

I have already referred to the fact, that some cases of tetanus have been met with, in which the disease has been aggravated by surgical interference; in some instances the muscles, on being cut through, have been rigidly retracted, so that it has been impossible to keep the soft parts in contact, though the bone had been very freely cut away, while the patient's sufferings can be better conceived than described; this is caused by the greatly increased sensibility of the excito-motor system, so often observed in tetanus, the least cold draught frequently leading to violent convulsions; and when, under these circumstances, so very painful an operation as amputation is resorted to, it appears no way strange that the effect would be thus severely felt; but with such an agent as chloroform at our command, capable of arresting this morbid

^a Medico-Chirurgical Transactions, vol. vi. p. 455.

sensibility, we need no longer fear this ill consequence ; and thus the principal objection which has been urged against operation is at once removed.

With regard, however, to the more extensive use of chloroform, as also of nicotine, the wourali poison, and similar medicinal agents, I would be very cautious of pronouncing any of them deserving of the name of a cure for tetanus. They will arrest the spasms, and thus relieve from much suffering, and if the system be brought early and fully under the influence of any one of them, and its effect be kept up unremittingly, until the source of irritation is removed, it may possibly prevent the development of the secondary lesion in the nervous centre. But should this condition of the nervous centre (or the secondary cause, as I have termed it) have already set in, it is quite evident that no remedy of this class can have any effect in curing it. But though such agents can remove neither the primary nor the secondary cause of tetanus, the fact of their allaying suffering, and the hope that they may prevent the development of the secondary cause (though they cannot cure it) renders them well worthy of our close attention. Let us inquire, therefore, which of those agents is the best suited to our purpose, which will act most directly on the disease, and which has the least ill effect on the system generally? The object in all cases is to produce paralysis of the voluntary muscles; this is accompanied, where chloroform is used, by a complete loss of consciousness, preventing the patient from describing his own feelings, a most important guide as the case advances; he is also unable to call for food, or to take it if offered to him, unless he be allowed to recover, in some measure, from the effect of the anæsthetic, and then, as soon as consciousness begins to return, the muscular contractions reappear in equal proportions. There is another objection which I conceive exists against the use of chloroform in cases of tetanus, namely, that of causing congestion of, and even effusion into, the bronchial tubes, upon which points I have made some remarks in describing a case of tetanus, in another part of this Journal^a. Nicotine, on the other hand, seems to be capable of producing the desired effect without interfering with the mental faculties; in fact, it brings the system into a state almost the direct reverse of tetanus. It appears also from recent experiments that it is likely to prove useful as an antidote against strychnia. Professor Haughton has lately read before the Irish Academy an account

^a See Proceedings of the Cork Medical and Surgical Society, in Part iii.

of some experiments performed by him, on this question, with the following results:—Frogs placed in a solution of nicotine were quickly paralyzed, and died in a state of complete relaxation; others, placed in a solution of strychnia, died of convulsions; but when others were placed in a combined solution of the two agents, though this was amply strong to cause death by either, it only caused slight convulsions, and that after a long immersion, and the frogs, on being removed from the bath, soon recovered; and had it contained a little more nicotine, there is little doubt but that the effect of the strychnia would have been completely neutralized. Now, as the symptoms of tetanus and those of poisoning with strychnia are almost identical, it may fairly be expected that nicotine would be equally useful in the one as in the other. Still, there is one strong objection to the use of this medicine in such cases, namely, its extremely depressing effects on the circulation.

Now, tetanus itself so debilitates the system, that quina, wine, and broth, are of late among the most favourite remedies; and when we attempt to cure such a disease with, perhaps, the most debilitating agent in the *Materia Medica*, the risk must be obvious. It therefore remains to inquire, are the same objections applicable to the use of the wourali poison, or is it capable of paralyzing the voluntary muscles without interfering with the action of the heart? On this point I would refer to an experiment by Dr. Pavy, of Guy's Hospital, the principal features of which were as follows:—A pup, four or five months old, had a small quantity of the poison introduced under the skin of the back: the animal soon became weak, and shortly was quite unable to stir; the limbs and the body became perfectly flaccid, and at last all appearance of life ceased. Meanwhile, a tube had been introduced into the trachea, and as soon as the animal was unable to breathe naturally, artificial respiration was established, and the heart's action, which had previously become very feeble, was quickly restored, and it continued to act firmly and regularly so long as artificial respiration was continued, showing that wourali kills by paralyzing the voluntary muscles, and, among others, those of respiration; death therefore resulting from asphyxia, while the heart's action is not at all affected, except as the result of impeded respiration. By another experiment he found that, under the influence of strychnia, also death by asphyxia was the result; but in this case the thorax was fully inflated and rigidly fixed, while with the wourali it was collapsed and flaccid. This rigid condition of the chest was found to render artificial respiration very difficult; but on raising the sternum,

and allowing the pressure of the air to act on the lungs and assist in expiration, it was easily established, and, as in the former experiment, the heart, which had almost ceased to act, quickly recovered in the same manner^a. The opposite and counteracting effects of strychnia and wourali have been more fully illustrated by Dr. George Harley^b, viz.:—"1st. A frog was poisoned with 1-500th of a grain of wourali. Three minutes after he had become perfectly insensible, 1-120th of a grain of strychnia was injected: in five minutes he became tetanic. 2nd. A frog was poisoned with 1-120th of a grain of strychnia: three minutes after, tetanus was strongly marked. He was punctured with 1-500th of a grain of wourali: in seven minutes tetanus disappeared. 3rd. 1-500th of a grain of wourali, and 1-40th of a grain of strychnia, were injected into the abdomen of a frog: in five minutes it became very tetanic, in twenty minutes more it was perfectly flaccid, and next day was perfectly well." These experiments again would encourage us, from the analogy already alluded to, to hope that wourali might have a like influence on tetanic spasms.

There is another question, however, which arises in considering the value of each of those agents, namely,—By what means do they occasion paralysis? Is it by their action on the nervous system, or by some influence over the muscles themselves, independently of all nervous supply? That chloroform and nicotine act on the nervous system there can be no doubt, but the *modus operandi* of wourali is much less known, as being a rarer and more novel agent. Dr. Pavy states that it acts on the nervous system; for that, if any of the nerves be irritated, or an electric current be passed along them, no muscular action is produced, but that if a current be passed through the muscles themselves, they immediately contract. He does not appear, however, to have proved this himself by any particular experiment, but only states it as a fact. I have good reason to know, however, that by a series of experiments lately conducted in Paris, and which will be shortly published, it has been proved that on this point Dr. Pavy is in error, as I have been informed by an eye-witness, that in the experiments alluded to, electricity, passed through the muscles of an animal under the influence of wourali, did not cause the slightest contraction; but that when the muscles of an animal paralyzed with nicotine were electrified in the same way, they contracted freely. In either cases irritation of the nerve, or

^a Guy's Hospital Reports, Third Series, vol. ii. p. 408.

^b Braithwaite's Retrospect, vol. xxxiv. p. 430.

electricity passed along a portion of it, did not cause contraction. This proved that either the nerves or muscles were paralyzed; in the case of the nicotine the muscles were proved not to be affected, as they contracted when the stimulus was applied directly to them; and in the case of the wourali it was shown that they were affected, as they did not contract. We may therefore conclude that wourali acts on the muscles, but has no influence on the nervous system. I regret that I am unable to enter more minutely into those experiments, but as they have not yet been made public by the investigator, I am not at liberty to speak more fully.

This question, as to the *modus operandi* of wourali, &c., is, I conceive, a matter of no small moment in the treatment of tetanus. But in order to explain its importance, I must here beg to revert to Dr. Copland's theory, that the secondary cause of tetanus (that affecting the nervous centre) is caused by the violent action of the muscles, &c., for in this he appears to be in some measure in error, though until we come to consider the action of such a medicine as wourali, the errors appear to be merely technical. Thus he looks upon the muscular contractions as demanding an increased supply of *vis nervosa*, and that, to supply this, increased energy was necessary on the part of the nervous centre, and hence the increased vascularity, as if the muscular contractions were the cause of the nervous force being developed; whereas, if we consider for a moment, we must see that it is the irritation transmitted from the injured part that induces an increased excitement of the nervous centre, which then develops the nervous fluid in unwonted quantity, and that the fact of the muscles not contracting under the influence of this nervous force, either in consequence of their being paralyzed by wourali, or any other cause, cannot diminish the excitement of the nervous centre, nor prevent the development of the secondary cause of tetanus. But as nicotine and chloroform have at least some action on the nervous system, they may be capable of rendering it insensible to the irritation transmitted from the local injury, in which case they would prevent the development of the secondary cause as long as their influence was fully kept up. I would, therefore, recommend that if it be impossible to remove the local irritation (i. e. the primary cause), one of those agents should be used, but if this be got rid of, the preference should be given to the wourali, in consequence of its not acting on the heart or other involuntary muscles. The surgeon should, however, be fully prepared to keep up artificial respiration in the event of that function becoming seriously embarrassed.

If, however, we hope to cure tetanus after the secondary cause has commenced, we must not depend on those agents alone. We should use one or other of them on account of the good effects already alluded to, but we must at the same time pay due attention to the nervous centre, and remember that this is the part now chiefly engaged. It must be admitted that many cases of tetanus have been treated very actively for myelitis and spinal meningitis, and that the result does not warrant our pronouncing it a more successful plan than some others; but then it is to be remembered that while this was being attended to, other means were neglected; whereas, I have no doubt that if ever tetanus be brought to rank as a disease amenable to treatment, it will be by the adoption, not of any one plan of treatment exclusively, but by a combination of all the means that are indicated in its different stages:—

First, the removal of the primary cause (the local irritation).

Secondly, in the event of this not proving efficacious, our attention is to be turned to the consideration of the secondary cause, and meanwhile we must endeavour in all stages to allay the convulsions by the most appropriate agents; nor are we to be unmindful of such means as the peculiarities of each case may require, as stimulants, antiphlogistics, tonics, sedatives, purgatives, &c.