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THE VALUE OF THE GALVANIC METHOD OF TESTING THE FUNCTIONS OF THE INNER EAR AND EIGHTH NERVE.*

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There are but three known methods of testing the function of the inner ear: the caloric, the rotational, and the galvanic. The first two methods are applicable to the semicircular canals only; the last mentioned is applicable not only to the canals, but also to the cochlea. There is but one method of testing the eighth nerve, and that is the galvanic. Accordingly, the galvanic test has a wider scope of application than either of the other two methods or both combined.

Let us next consider the relative accuracy and value of these three methods as applied to the semicircular canals in the order in which they are mentioned.

First, the caloric. This method has been tried out by numerous investigators and clinicians sufficiently to permit us to draw some definite conclusions. The caloric method is quite reliable when properly conducted and under favorable circumstances—when, at most, it can tell us that the labyrinth is either completely out of function or that it is not. If there is diminution of function, short of complete loss, we have no way of determining the fact by the caloric test, nor are we able to determine the presence or absence of an irritative process within the labyrinth; for instance, congestion, which so often precedes actual inflammation.

The caloric is by no means a quantitative test, in spite of the attempts of Ruttin to make it such. It can give us no information as to the amount of function or hyperfunction that may be present in the labyrinth. Its only value, there-

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fore, as previously stated, is to determine whether the inner ear or, rather, the semicircular canals, are completely out of function or not. In making the caloric test the technic as practiced by the average clinician is faulty, in consequence of which errors of judgment may happen.

The average otologist selects cold water and syringes the affected ear with the patient's head upright, when he expects to obtain a rotatory or mixed rotatory and horizontal nystagmus to the opposite side if the inner ear is intact, and no reaction if it is destroyed. This was the method preferred by Bárány, and generally adopted by others. Since most of the cases to which the caloric test is applicable are those of acute labyrinth suppuration, where the patient already manifests a spontaneous nystagmus to the opposite side, it becomes a question of nice judgment to tell whether the cold water has increased the nystagmus or not. To overcome the possibility of mistaken judgment I have suggested the plan of syringing the ear with cold water with the head inclined to the opposite side, with the face forward, so that the ear to be tested is directed toward the zenith. Cold water will then produce a horizontal nystagmus of wide excursions to the affected side if the semicircular canals are reactive, while no effect will be produced if the canals are out of function. With the head in this position there is nothing like the possibility of mistaking the reaction that there is when the head is upright. A substitute for this method is to syringe the ear with head erect and subsequently turn the head to the side position, when a positive reaction may be expected to show itself by the same wide-excursioned horizontal nystagmus to the same side. One advantage the caloric test has over the rotatory test is that it is distinctly a unilateral test. Like the galvanic test, it can be applied to each ear separately.

There are certain circumstances under which the caloric test may not work altogether smoothly; however, with persistent effort they may occasionally be overcome. Among these may be mentioned large polypi in the external canal, large cholesteatoma obstructing the entrance of water into the middle ear cavity, foreign bodies in the canal, atresia (partial or complete, inflammatory or otherwise), excessive congestion, intact membrane, with tympanic cavity filled up with secretion.

etc. Anyone who has had a fair amount of experience can recall instances where one or other of these obstacles has hindered him in making the caloric test.

A partial correction of these conditions, when possible, followed by a second attempt with the caloric test, may result in the finding of a positive reaction when the first effort resulted in a negative reaction. None of these factors act as a hindrance to the galvanic test. Thus far it has been shown that the galvanic test possesses the one advantage claimed for the caloric test, and at the same time carries with it none of the handicaps.

Next the rotational. The one big disadvantage of the rotational test is that it is impossible to eliminate the fellow ear, which is overcome by the caloric and galvanic tests. Its one advantage over the caloric test is that it is a quantitative test; so, too, is the galvanic. The rotational test is a quantitative test of the two ears considered together, while the galvanic is quantitative for an individual ear.

The rotational test is of relatively greater value in testing a single ear when the function of the fellow ear is known to be normal, but when both are affected, either similarly or dissimilarly, allowances must be made accordingly. Even where these unfavorable conditions do not exist, it becomes difficult at times to figure out from the findings the exact conditions in the semicircular canals. It was originally claimed that the after-turning nystagmus in one-sided labyrinth destruction was reduced to eight seconds to the affected side, and to sixteen seconds to the unaffected side. But this is true only in case the semicircular canals on the unaffected side were functioning normally. In some cases we find both ears affected with chronic middle ear suppuration; in other cases, a previous neuritis or other pathologic condition that may have reduced the function in the supposedly unaffected ear, when the figures will be lower.

Let us cite three types of cases which are not uncommon:

Case 1.—Right side. An acute middle ear suppuration, followed by acute labyrinth suppuration. Left side normal. After-turning nystagmus to the right, eight seconds; to the left, sixteen seconds.

Case 2.—Right side. Chronic middle ear suppuration, fol-

lowed by acute labyrinth suppuration. Left side, chronic middle ear suppuration, in the course of which there has been a secondary plastic inflammation of the internal ear, with partial loss of function in semicircular canals. After-turning nystagmus to the right, five seconds; to the left, ten or eleven seconds.

Case 3.—Right side, chronic middle ear suppuration, followed by acute labyrinth suppuration. Left side, chronic middle ear suppuration, with congestion of labyrinth on the verge of inflammation. After-nystagmus to right, ten seconds; to the left, twenty seconds.

Other cases might be cited. However, it is not necessary for our purpose.

If we are to assume that a case is one of right-sided labyrinth suppuration because the after-nystagmus is eight seconds to the right and sixteen seconds to the left, our assumption is correct only when we can be sure that the left semicircular canals are in normal function. If the function of the left canals is impaired, then the reaction eight and sixteen seconds would be too high, and the probability would be that the function of the right canals is not entirely lost. On the other hand, if there exists hyperfunction on the left side because of a congestion, it would lengthen the after-nystagmus to both sides, in spite of the fact that the right side may be entirely destroyed.

It was because of these very factors that so much confusion existed among authorities in the early days (1906 and 1907), and still exists somewhat to the present day. Another factor that led to confusion on the part of some investigators, and came nearly putting this method of testing the labyrinth into bad repute, was the faulty technic which I had the privilege of pointing out to this society a year ago.

If we were to accept Bárány's exceedingly variable figures for after-turning nystagmus in normal individuals, the rotational test is surely a very unreliable method for examining the function of the semicircular canals.

The rotational method has been merely touched upon, but sufficient has been developed to show that at best it is a quantitative test of semicircular canal function of the two sides taken together, while the caloric method is a qualitative test of semicircular canal function of either side considered separately.

Eight years have passed since the writer first published the results of his investigations with the galvanic method. The figures which were then published, together with the conclusions, have been generally accepted, while Neumann assumed the credit, at least this is the impression to be gathered from certain American textbooks and the hearsay of returning students who have visited Vienna. To the best of my knowledge, Neumann never conducted experiments similar to mine, nor even published anything of a similar nature, nor had any direct or indirect connection with my experiments or publications of the results of those experiments. If wrong in a single statement of these facts, I shall be grateful to the one who points it out to me, and shall make public announcement of it with an apology to Neumann.

Coming back to the subject of the galvanic method of examination of the semicircular canal function, there is very little to add to what I have already published on the subject. During the last eight years where an examination called for a test of semicircular canal function, the galvanic method has never been neglected—and it might be added that there have been numerous calls for the test. Hardly any ear case that presented itself for treatment escaped the test. It has been tried repeatedly when the patient was too sensitive to submit to the caloric and rotational tests. The average case that balks at the caloric or turning test after the first attempt, consents readily to the galvanic. All other things being equal, this fact alone should give the preference to the galvanic method.

The next question to suggest itself is the value of the galvanic test from the standpoint of accuracy, as compared to the other two methods. It has been pointed out already that the caloric test is quite accurate in selected cases, but may not be in others. Should the examiner fail to recognize certain unfavorable factors (mentioned above), it is possible that he might be led to believe the semicircular canals are out of function when in fact they are not. Acting according to the findings under such circumstances, he might not do what is best for the patient's interest. Such a mistake could not happen with the galvanic test.

If we were to accept Bárány's figures for after-turning nystagmus, we are forced to conclude that the rotational method

is to be mentioned only to be condemned. We find Bárány's figures for after-turning nystagmus to vary from one to one hundred and twenty seconds, with marked variations on different days, and marked variations on two sides on the same day. His figures in disease overlap considerably those in health. I am less pessimistic—or, rather, the results of my experience lead me to look more favorably upon the rotational test than it is possible for anyone else to, who accepts Bárány's figures as conclusive.

Up to the present time I have been occupied in pointing out certain limitations and inaccuracies of the caloric and rotational tests; now let us consider the galvanic test from the standpoint of accuracy; its wider application compared with the other two methods having already been referred to when discussing the caloric and turning methods.

In making the galvanic test certain essentials are required:

- (a) A suitable electrical apparatus with clean contact points.
- (b) Even more important is an accurate milliamperemeter.
- (c) A reversing switch under the control of (d) a capable assistant who controls the polarity, the amount of current, and observes the milliamperemeter. (e) Two electrodes, one about two inches square and flat, and the other a small ball electrode (about a quarter inch in diameter, although one-half inch will work satisfactorily). Both electrodes should be wrapped snugly in moist cotton or gauze.

Before starting the test, examination should be made to see if the patient has any spontaneous nystagmus. Its presence or absence should be noted on the patient's record. After soaking the electrodes and the parts to which they are to be applied with warm salt solution, we are ready to begin. The large flat electrode is held by the patient—it does not signify in which hand. The patient's head is tilted slightly backward to permit of better observation of the eyes by the examiner, while he is directed to look straight ahead, which in effect is slightly downward, considering the position of the head inclined backward. The examiner elevates the lid of the eye to be observed with the thumb of the left hand when applying the ball electrode with his right hand to the patient's left ear, and vice versa. To be accurate, I will emphasize the fact that the ball electrode is applied to the tragus, and the tragus

is pushed into the external canal. I am anxious to make this clear, since someone recently, in a meeting of the Philadelphia Laryngological Society, claimed he could not get the results he had hoped for with the galvanic test. Upon questioning him he answered that he applied the electrode to the patient's mastoid, after the manner indicated in my book, which evidently he had not read carefully.

In making the test my back is more or less to the instrument. I do not permit myself to know the polarity used. The moment a reaction is noted it is called out to the assistant with the polarity, and the assistant calls back that the polarity is correct and announces the milliamperemeter reading, when a record is made of it. The polarity is switched or not as the assistant sees fit, the important point is that he is not to indicate it in any way to me, the object being to eliminate the possibility of any guessing. Including my published experiments of eight years ago and those conducted since, there have been examined and recorded a few thousand cases. Among these cases are included normals, deafmutes, one-sided labyrinth destructions, acute and latent labyrinth suppurations, old cases of plastic labyrinthitis, unilateral and bilateral, recent as well as old cases of meningitis, some with complete and others with partial loss of function, hemorrhage into the labyrinth, fistulas of the labyrinth, internal auditory canal tumors, herpes zoster, multiple neuritis of the cranial nerves, early and late syphilis of internal ear and nerves, skull fractures, gunshot wound of the ear, cases with middle ear catarrh, others with middle ear suppuration with hyperemia of labyrinth. Many of these cases have been reported singly from time to time during the last eight years.

As a result of these experiments I am led to conclude that the normal reaction from the combined inner ear and nerve is:

Right Ear: Kathode 4 ma., nystagmus to the right. Anode 4 ma., nystagmus to the left.

Left Ear: Kathode 4 ma., nystagmus to the left. Anode 4 ma., nystagmus to the right.

That is to say, the kathodal reaction of one side balances with the kathodal reaction of the opposite side.

That the anodal reaction of one side balances with the anodal reaction of the opposite side.

That the kathodal reaction balances with the anodal reaction of the same side, and that the average reaction for normal individuals requires a current strength of about four milliamperes.

In the case of recent labyrinth suppuration, say in the first week, right side affected and left side normal, we have:

Right Ear: Kathode 7 ma., diminishes the existing nystagmus to the left, while kathode $8\frac{1}{2}$ ma., produces nystagmus to the right. Anode 1 ma., increases the nystagmus to the left.

Left Ear: Kathode 1 ma., increases the existing nystagmus to left. Anode 7 or 8 ma., arrests the nystagmus to left, or may throw it slightly to the right.

The explanation of this reaction I have given elsewhere, but will repeat it. Since the normal tonus is equivalent to four milliamperes, it takes four milliamperes suppression (with the anode) to permit the normal tonus of the untouched side to pull the nystagmus over to its side. For instance, in the case just cited above it takes from seven to eight and one-half milliamperes on the right side to overcome four milliamperes loss of tonus from labyrinth suppuration. Since the tonus of one side must excel the antagonist by four milliamperes, it takes four plus four milliamperes, or eight milliamperes. Since the right labyrinth is destroyed by suppuration, the reaction with one milliampere anode applied to the right side must have exercised its influence on the nerve, showing that the nerve is reactive for some time after the labyrinth is destroyed.

At a later date, which varies from a few weeks to several months, the galvanic reaction changes, and we find:

Right Ear: Kathode—10, 12, 20 milliamperes, or even more, in fact, using the strongest current the patient can stand, produces no reaction. Anode—with the strongest current there is no reaction.

Left Ear: Kathode 1 ma., produces a distinct nystagmus to the left, or it will increase the nystagmus where it was present spontaneously. Anode 8 ma., occasionally causes a spontaneous nystagmus to the left to disappear, otherwise there is no reaction. Twenty milliamperes or more will not produce a nystagmus to the right.

The reaction just cited corresponds to the findings of a total loss of function on the right side that occurs after destruction of the nerve following neuritis or tumor of the internal audi-

tory canal, so that we may conclude, with some feeling of certainty, that all cases of labyrinth destruction, whether from suppuration or otherwise, is followed eventually by secondary degeneration of the nerve.

Another reaction which I have found and recently reported to the Philadelphia Laryngological Society corresponds to a case of eighth nerve neuritis of mild degree in which the reactivity of the affected nerve is excessive. For instance, take a case of right sided neuritis with hypersensitiveness.

Right side: Kathode 1 or 2 ma., nystagmus to the right. Anode 6 ma., nystagmus to the left.

Left side: Kathode 6 ma., nystagmus to the left. Anode 1 or 2 ma., nystagmus to the right.

The explanation is that the right nerve was affected with a pathologic irritation which required less than the normal kathodal stimulus to throw a distinct nystagmus to that side. Whereas, because of the hyperirritability of the affected nerve, it took more than the usual current strength to suppress the total tonus with the anode and throw the nystagmus to the opposite side. Further report of this case will be reported later.

In cases of labyrinth congestion which occasionally accompanies acute middle ear suppuration with membrane intact, we may find a similar reaction, when it becomes a clear indication to operate promptly for the relief of pressure because of the danger of a supervening labyrinth suppuration.

The case of neuritis referred to above developed a more aggravated form later, when the reaction changed entirely, and with it the spontaneous nystagmus jumped to the opposite side. The value of the galvanic test in this case was to point out the fact that the case was getting worse instead of improving. I might have been able to ascertain this fact by other methods, but they would have been more painful and less accurate. Fortunately, in the treatment of eighth nerve neuritis we are more often able to record a change in the opposite direction, indicating improvement and eventually restoration of function. This favorable turn occurs quite frequently in cases of syphilitic affections of the inner ear and nerve during the late secondary or early tertiary stage.

My first inclination in presenting the subject of the galvanic

method of examining the function of the inner ear and eighth nerve before this society was to consider the subject exhaustively, listing experiments and classifying cases. Later it occurred to me that such a paper would tend less toward creating an interest in the subject than would one that should be a summary of conclusions reached from a fair experience with this and other tests of the labyrinthine functions, hoping thereby to invite criticism which would tend more certainly to bring out points of interest and more vividly than I could hope to do otherwise.

CONCLUSIONS.

1. That the galvanic test is more accurate than either the caloric or rotational test in determining the function of the semicircular canals.

2. Besides being more accurate, the galvanic test is the least annoying to the patient, the most sensitive, and the easiest to control of the labyrinthine tests.

3. That the galvanic test can be applied as a unilateral test of semicircular canal function in all sorts of pathologic conditions, which is an advantage that cannot be conceded to the caloric.

4. That the galvanic test is applicable to cases of suspected unilateral labyrinth suppuration with obstruction in the external canal where the caloric may fail us.

5. That the galvanic test is a unilateral quantitative test of semicircular canal function, which is a distinct advantage over the rotational test, which at best is a bilateral test.

6. That the galvanic test is the only one we possess for testing the function of the eighth nerve in cases of neuritis or cases of secondary degeneration following destruction of the inner ear.

7. That the galvanic test is the only one we possess whereby we can make a differential diagnosis between labyrinth destruction, pure and simple, and eighth nerve neuritis.

8. That the galvanic test is the only test available for determining the progress of eighth nerve neuritis, whether favorable or unfavorable.

In pointing out the greater applicability and value of the galvanic test as compared to the other tests, I do not wish to

be misunderstood as condemning in any way the other methods; on the contrary, I find them of considerable value and use them in every instance where it is possible. My intention is rather to show that the galvanic test is, from every viewpoint, the best, and is the one of choice where a single method is to be used.

Concerning opening and closing nystagmus, nothing has been said in this paper, for the reason that it is of secondary importance and does not cover the object of my paper. It would therefore be redundant.

No reference was made to the fistula test, since it does not belong to the class of tests for comparison. It is applicable to a more limited field, and really deserves a separate consideration.

The spirit that prompts the writing of this paper is to awaken interest in the subject, to invite criticism and to urge the more general use of this method, for no examination of the labyrinth can be considered complete where the galvanic test has been omitted.