TECHNIQUE OF APPLYING CATAPHORESIS SUCCESSFULLY.

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Like the reign of a "Sphere of Influence" in the ever-changing history of nations, cataphoresis in dentistry came like a rush for an Eldorado, and then almost as suddenly ceased to be used by the majority of the profession, but as truth always does, it has survived. While a few operators have used it with almost universal success, the great majority of the profession have as signally failed. Why has it been so? That an electric current will carry the alkaloid of cocain into all tooth structures except enamel is as much of a truism to-day as the laws of gravity or chemistry or physics, and not one

failure that has occurred has been because the current would not carry cocain into the tooth. I believe practically every failure to produce anesthesia in tooth structure with cataphoresis with the hydrochlorate of cocain has been caused by one of the following four reasons: 1st. The current not going through the part to be anesthetized (having to do with the insulation). 2d. The application itself producing pain (having to do with the controller and method of applying). 3d. The electro-chemical arrangement being wrong (by reversed current, or faulty solution in cavity, or soluble electrode, etc.). 4th. The tissues being immune to the action of the anesthetic (either true immunity or degenerated or suppurating pulp tissue). The last is the least, and the first and second the most common causes of failure. The subject is too large for an exhaustive treatment in a short paper, so I will hurriedly take up the principal points.

The electric current invariably seeks the path of least resistance. It would go to the moon and back on a trolley wire rather than go a small fraction of an inch through gutta-percha. The great majority of operators have not realized that the resistance through the tooth they wish to anesthetize is tens of thousands if not hundreds of thousands of ohms, while to the gums between the moist rubber and the tooth it is only a few ohms, often not ten. This would apply also to a metal filling or the clamp touching the gum. To make the current go through the tooth the resistance through other possible paths must be literally millions of ohms, and usually this can be accomplished only by applying some good non-conductor, like chloro-percha, gutta-percha, rubber, cement or sandarac, etc.

More failures have been caused by the inadequate apparatus than from all other causes. Without an exception, to my knowledge, the qualities of the apparatus available have been more nearly those of machinery for mechanics and not arts, than the qualities required for this most delicate operation on tissue so sensitive that it will respond with pain to sudden increases of a current only one-millionth of that required to ring an ordinary door bell. A satisfactory outfit will allow the current to be increased in steps less than the above with measuring instruments that will clearly show this small current. The majority of the cataphoric outfits available would increase the current in steps which were hundreds and sometimes

thousands of times too great. If the current passing through a tooth is increased gradually enough it will produce a mild sensation long before it could be called pain, though the amount of increase covering this whole range may be only from a few millionths to a few hundredths of thousandths of an ampere. The majority of apparatus will pass over very many times this amount of current in one step, so the first sensation is sharp shooting pain instead of a mild sensation like warm air in the tooth. In cataphoresis we are dealing with millionths of amperes instead of thousandths, as most have thought, and no suitable instruments for measuring these amounts have heretofore been available.

To make a satisfactory application of cataphoresis we must have instruments with the above requirements and qualities. In making the application, start by seeing that all the resistance is turned in, and the circuit is open, preferably by having no cells turned in. Apply the dam in every instance and dry it thoroughly, and make a barrier to the current in every direction except where you wish it to go, either with chloro-percha, gutta-percha, or other suitable non-conductor. It is usually wise to ligate the tooth involved to prevent the rubber being easily stretched away from the neck. If there are other fillings in the teeth to which the current may go, take a piece of dam; say one inch square, and punch a hole in it and slip it over the tooth in question. Remember, enamel is the only structure of the tooth that the current will not flow through more or less easily. If the cavity to be anesthetized has not sufficient retaining form to hold a pledget of cotton, as buccal cavities often are, make a wall of gutta-percha or stopping, sticking it warm against the tooth or on the clamp. Remove all the food and debris and decay you can, because the cocain will pass almost as slowly through them as through the dentin. Never hold the electrode in the tooth yourself nor have your assistant do it; use a very light, flexible, fine platinum wire electrode, the end of which will be rolled with pledget of cotton and packed into the cavity. Why platinum? Because the negative ion in this case is chlorid, which goes to the positive pole, and if it can will unite with it, forming a chlorid of that metal, which salt will at once go into solution and will at once take up the work of carrying the current, and because of its being a much smaller molecule will soon do the major part of the carrying of the current into the tooth instead of the cocain. In this way thousands

of failures have occurred by using German silver or copper or any metal that will form its chlorid.

A solution of cocain is easily broken up and the alkaloid destroyed by heating. It should never be heated much above a hundred degrees, and many failures have been caused by over-heating, as by passing it through the flame, etc.

Be sure the negative electrode, preferably a sponge, has plenty of surface and is placed where it will not be disturbed, else it becomes a source of shock by carrying the contact. To prevent the positive electrode (which should be insulated) which is in the tooth, from being disturbed, pass it under the dam holder before attaching the connecting cord. Turn on the current very carefully, starting with one cell, and gradually turn out the resistance until it is all out, or until the patient feels the slight sensation like very mild warmth or cold, as the sensation may seem to him. If you do not reach this point with one cell, turn in all the resistance again and add another cell, having the circuit open at the time. After the point of sensation is found you have by the milammeter the index to the tooth and you can easily avoid all possibility of the least shock, that is, of course, provided you have a suitable cataphoric outfit.

When you have found the pain limit, retreat just a little until the patient cannot feel the slight sensation just referred to. You will see by the milammeter that usually diminishing the current by the one-millionth part of an ampere will remove this slight sensation. If possible, arrange your work so that while waiting for the cataphoric process you can be making some other operation in the mouth, as filling another cavity, thereby saving to yourself and patient the time while waiting for the anesthesia, which will be from ten to thirty minutes. If your other operation is not completed in that time no harm will be done by leaving the current on, provided a little moisture is added every fifteen minutes or so, according to size of the cavity, to prevent the application from drying out. By a little foresight an operator can complete all the work in the mouth with a minimum of lost time and a minimum of pain in the preparation of cavities. The time required is the only objection or drawback, and in this way it amounts to almost nothing, in fact, time is usually saved, because the operator can go ahead and prepare the cavity so much more rapidly. The current should be increased

about every three or five minutes, always retreating just a little when the patient feels the slightest sensation.

There are many cases that are difficult to insulate, as the cervical margin of proximal cavities. If possible, get the rubber cloth beneath this margin and flow chloro-percha over it. Or make a barrier with gutta-percha, packing it so as to cut off all possible moisture. If you cannot do better, dry out the cavity, pack it full of gutta-percha or stopping, drill a hole through it to the sensitive tissue over the pulp chamber, make application through this opening, and anesthetize the whole pulp. This is easily accomplished. In all cases, since the current takes the path of least resistance, the part of the cavity towards the pulp will be the first anesthetized, and the other parts, as the dentin beneath the enamel of the occlusal surface, the last. This can be anesthetized in two ways, namely, by anesthetizing the pulp, thereby also the whole tooth, or by covering up the prepared surface over the pulp with a non-conductor, as gutta-percha, and forcing the current through the more resistant parts. Cases of erosion are usually difficult, both because of their high resistance and because of their shallow saucer-shaped cavities. Place a small piece of dry cotton on the surface and flow cement over it. Then puncture through the cement to the dry cotton and flow in the cocain solution and pack into the opening the flexible positive electrode.

Much misunderstanding has prevailed regarding the per cent and kind of solution to use. A saturated solution of the hydrochlorate of cocain in distilled water is probably the best. The purity of the solvent is of the greatest importance, otherwise the impurities themselves, as vegetable matter, are decomposed by the current and become the chief carrier of it. No difference would be found in the results in using a saturated solution of cocain or a two per cent, except that the two per cent would very soon become a one per cent, and soon there would be no cocain left to carry the current. It is only that part of the dissolved salt whose molecules have split up into positive and negative ions that enters into the carrying and migration, and this is only a fraction of one per cent, but as fast as these are used up new molecules split up, thereby lowering the per cent of saturation. When the hydrochlorate of cocain in solution—$C_{17}H_{21}NO_4HCl$—breaks up the chlorin forms the negative ion which goes to the positive pole, and the alkaloid, ordinarily quite

unstable, except when combined as a salt, is the negative ion and travels toward the negative pole. The amount carried is in direct proportion to the amount of current used. Great care should be exercised not to heat the solution of hydrochlorate much above blood temperature, for it is very easily broken down and the results will be failure. If the application is left on for a considerable time, as when making an extended operation elsewhere, a little fresh distilled water should be applied about every twenty minutes, according to the size of the cavity, to keep the cotton from drying out both from the warmth and electro-chemical action.

When operating on two cavities at once frequently one will be perfectly anesthetized and the other not. This is usually due to the fact that one tooth has much lower resistance than the other, thus allowing more current to pass. The relative amounts are universally in proportion to the resistance. In such a case prepare the cavity that is anesthetized and fill it with gutta-percha or stopping, and then proceed with the other. It will often be found when removing pulps with this method that in a tooth with more than one root the pulp may be removed painlessly from one root but not from another. This will be due to the greater resistance of one canal than the other or others, and the quickest method is to remove the pulp from the root that is anesthetized and place over it some gutta-percha or cotton with chloro-percha or sandarac, and reapply or use the pressure method for the other root. Sometimes the resistance through the apex will be so great that the current will mostly go to the gum through the pulp chamber walls, thus making it difficult to anesthetize the apex. This is not frequent, however.

One of the greatest requisites for success is to be able to recognize faulty insulation or leakage of current. That is impossible without *a very good milammeter,* one that can be read easily in hundredths or thousandths of amperes. Much assistance will come from experience and a knowledge of the usual conditions, and this can be most easily ascertained by keeping a record of cases. If you have faulty insulation the milammeter will probably read many times as much current as you should expect in that cavity with the voltage you are using, and this means that the resistance of the path is abnormally low, and the probability is that most of the current is not going through the tooth, but to the gum or the clamp or a filling, etc. If you suspect the clamp you can sometimes prove it by touch-

ing the clamp directly with the electrode and observing the reading with the same voltage. This is the most probable cause of failure (the insulation), and the operator must study his cases to get to know what would be a reasonable current for each particular cavity. The pain produced by too much current is usually at the apical foramen, and is generally heat. Overcoming the resistance in a small foramen will raise the temperature in it several degrees. Great damage is done occasionally without the use of a milammeter by using too much current in a tooth after it becomes anesthetized. That is not more pardonable than for a physician to give a dose of morphin ten times too great. It is just as easy to measure the dosage of current as the dosage of morphin. Never use more than three or four-tenths of a milampere of current if you expect the pulp to be kept alive. This amount will be perfectly safe, but twice this amount will not, and three or four times as much, which you might frequently be able to use, would be almost certain to do mischief. If you expect to remove the pulp you might safely use one milampere, bnt not more for fear of setting up an inflammation about the apex.

I should take up the probable sources of producing shock to the patient, but with a satisfactory outfit, properly managed, this is practically impossible. Use a very flexible positive electrode and be sure to never turn on another cell without first turning in the resistance.

I am asked how I know how much heat may be generated in the apical foramen of a tooth. It is a law of electricity that "in any circuit or any part of any circuit the heat generated is equal to the square of the current or amperage, multiplied by the resistance multiplied by 0.236 equals the degrees Centigrade rise in temperature," which will amount to a rise of several degrees in the dentin and in the apical foramen in an ordinary tooth. However, it is not essential that we know where and how the pain limit is determined so long as we do not encroach upon it, which we do not need to do. For those desiring the detail of this determination I refer you to a paper in *Items*, March, 1898. I have been mildly criticised in the discussion for not using more simple language. I wish it were possible to convey electrical ideas without using electrical terms, but it is quite as impossible as to explain astronomy or histology or algebra without using the terms which alone express the ideas involved. I have

tried to be as plain and simple in my language as possible, but the members of the profession have certainly to acquaint themselves, and that very early, or they will be ashamed to acknowledge that a very plain talk is "going over their heads."