PREVENTION OF THE DISEASE BY ACCELERATED MOTION BY INTRAVENOUS INJECTION OF SODIUM BICARBONATE

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PREFACE

What is termed here “The disease caused by accelerated motion” is the sickness caused by movements of carriages, such as sea-sickness, nausea caused on trains or airsickness, etc.

Rosenbach called it “Kinetosen” and Starkenstein termed it “Bewegungskrankheit”, which means sickness caused by undulation.

The research made by me and my collaborators recently, though, made it plain that the sickness is caused by acceleration, of movements generated in the undulation. That is why we have decided to call it “Acceleration Disease”. The acceleration generated in the movements of carrier bodies is mostly rectilineal acceleration, and works on human body through the “Otolith” in the labyrinth.

It has been found out that intravenous injection of sodium bicarbonate solution dissolve the “Otoliths”, abolishing the agency on which the acceleration movement works, in our experiments on animals. This fact taught us the way to prevent the “Acceleration disease” by sodium bicarbonate injection. It has shown us that intravenous injection at elbow of 40 cc 5% sodium bicarbonate will prevent the “Acceleration disease”.

Let me here narrate our observation and ask your further studies on the subject.

EXPERIMENTS ON ANIMALS

As an equipment for the experimentation, I had an apparatus made to give up-and-down undulation movement to animals. This was made to make 63 round trips a minute up-and-down, for the distance of 43 cm. The apparatus were to move along the grooves of iron posts standing vertically. The movement was run by the rotor fitted at the base of the post, that is, the vessel is coupled to the rotor by means of a crankshaft, and makes up-and-down movements with the rotation movement of the rotor. Being a simple harmonic movement, it generates acceleration.

For the experimentation, rabbits were employed for the observation purpose of the effects of up-and-down movements on them. The examination of blood pressure and pulse of Carotic artery revealed vivid rise in pressure and number of pulse as soon as the up-and-down movement began. In respiration, inspiratory quickening and increase of number was observed. In gastric and intestinal movements, they were found highly suppressed, and came to a stop ultimately.

When the undulation movement continues more than 15 minutes, changes can be observed in blood distinctly. In the examination, decrease of “lymphocytes” was noted.
In the blood plasma, decrease alkali stock was conspicuous. Sugar increased. Calcium began to decrease. Precipitation of blood sedimentation rate and quicker blood coagulation also was noticed. When the movement was continued several hours, changes in urination was clearly seen, such as decrease of urine quantity, increase in specific gravity, weakening of alkaline reaction, increase in acid and nitrate, increase in volume of "creatin" and "creatinin". Also sugar was extracted as abnormal substance. Besides, fall of temperature (of rectum) was noticed as an effect of the movement.

According to the text books, the above are described as phenomenon from the strain in sympathetic nerves. To ascertain if it is really so, we went on further experimentations. We examined the blood pressure, respiration, gastric and intestinal movements of animals whose Vagus was cut off, and sympathetic nerves cut off, placed in the oscillating vessel.

In animals whose Vagus was cut off, the above phenomenon appeared same as in cases of ordinary animals. But, in cases of animals with sympathetic nerves cut off (in cases of examining blood pressure and respiration, sympathetic nerves at the neck were extracted, and for gastric examination, intestinal nerves was cut.), the above stated phenomenon was entirely absent.

In the study and examination of blood cells, in animals with Vagus cut off, decrease of lymphatic cells occurs, but when the solar plexus, the sympathetic nerves governing the spleen, is extracted, the phenomenon did not occur. This shows that the phenomena caused by the undulation movement is based on the excitement of sympathetic nerves. This fact is also apparent on normal animals exposed to undulation movement for a long time.

When the movement is given over 100 hours (giving the movement 3 hours a day, stopping the experiment from time to time, repeating same for several months), degeneration of high magnitude appears in ganglion cells of sympathetic nerves at the neck and
abdominal cavity, but, such noticeable changes do not occur in ganglion nodosum of Vagus.

Next examination was made on animals whose labyrinth had been destroyed. The same undulation movement was given to the animals, and examinations were made on blood pressure, respiration, gastric and intestinal movements, blood and urine in the order named. Different from the cases in normal animals, though, no noticeable change occurred. Blood pressure was normal, respiration steady, gastric and intestinal movements went on usual. Blood cells and urine were also normal. This plainly indicates the fact that the strained phenomenon of sympathetic nerves at the time of undulating movement is caused by the strain giving by acceleration movement on labyrinth.

At Prof, Wittmaack's laboratory in Humburg, I once noticed that in the case of guinea-pig who was subjected to centrifugal movement and whose otoliths had come off, the rectilineal acceleration movement would not effect. I tried to give a test on rabbits, whose otoliths had been taken off by centrifugal movement, on the up-and-down movement. For the purpose, we had a steel centrifugal rotor for the rabbits. An iron rod of 75 cm length and 3 cm diameter was made the shaft, on which an iron plate of 79 cm x 17 cm was fitted, equipped with rabbit fastners. The shaft was made to revolve by a 1 H.P. motor. The shaft was made to make 30 revolutions per second in 5~6 seconds when switched on, to give a centrifugal force of about 360 g to the labyrinth of the rabbits. It was first ascertain that the otoliths of rabbits would come off by the use of this apparatus. Animals thus deprived of otoliths were subjected to the test on the up-and-down movement apparatus. As was expected, it was ascertain that the phenomenon of strain on sympathetic nerves did not occur. Observation of gastric and intestinal movements revealed continuation entirely normal and proper wriggling movement. Long how undulation did not produce changes in the contents and characteristics in urine.

As the result of a series of above experimentation, I came to consider that when otoliths are removed, the acceleration strain would not work on such animals, and
theoretically the acceleration disease would not occur. An interesting thing about this is that unusual thing does not happen to animals deprived of otoliths thus in their daily life. No change is noticeable in the equilibrium of their bodies. No difference is found in their upholding and movements of them compared with normal animals.

According to the hypothesis of Mach, Breuer and Crum Brown, otoliths are essential in perception of change of positions, and deprived of them, some obstacles are supposed to occur in the body equilibrium. But no such phenomenon occurred actually. This led to the thought that when otoliths are removed, that would not hinder one’s every day life, but would prevent “acceleration disease”. But it would be impossible to apply human beings to the centrifugal apparatus and remove the otoliths of him.

In our observation, to remove otoliths, we need centrifugal force of about 170 g for frogs, about 200 g in case of fish, about 290 g for guinea-pig, and about 360 g for rabbit. Such a force is applicable only for a short time. Otherwise it will endanger lives. In cases of rabbits who need strong force, 5~6 seconds are the limit. Over that time, it often induced hemorrhage of lung and would result in death by suffocation. Thus, the success of this means and the danger to life if facing each other in contradiction, this can not be practiced on men. Thus a requirement became apparent in which removal of the work of otoliths may be obtained without the risk of this kind of danger.

The specific feature of the ability of otolith membrane is in the weight of the otoliths attached to the membrane. That is, the ability of the otolith membrane is displayed by the usage of the force working on the otolith membrane. Thus, to nullify the ability of otolith membrane, it is sufficient to obliterate the crystal of the otoliths. Thus I began to study a way to chemically dissolve the crystal of the otoliths. Otoliths are the crystal of calcium carbonate, and the crystal of calcium carbonate has the faculty of dissolving in acid.

I experimented in giving 1 cc intravenous injection each of 0.5% diluted hydrochloric acid a day for several days continuously. Then I fixed the organism, and making a specimen of the system of the labyrinth, made microscopic examination which revealed not only the existence of the stone, but in more beautiful crystal than in normal condition. That is how the intravenous injection of sodium bicarbonate was accidentally experimented. The temporary theory was that if the intravenous injection of acid produced refining of otoliths, compound of chlorine might reverse the effect and weaken the ability of otoliths. Five cc of 5% natrium bicarbonate, thus, was injected in the vein of rabbit’s ears.

When the labyrinth reflection was examined after the injection was made, it was noticed that the rectilineal movement reflection was gone, same as in the case of animals whose otolith membrane was removed by the application of centrifugal rotations. Having had the specimen of labyrinth system made, I made the microscopic examination, and found the crystal of otoliths was gone, showed a fine mesh, leaving the glue substance between the crystal.

The above experimentation was done several times on several rabbits, and the result were same as in the case of first experiment. To assume myself, I examined the blood
pressure condition of the rabbits after putting them on the undulating movement on the apparatus. The result was that there was no difference between the rabbits that had the intravenous injection and those whose labyrinth were destroyed. No change was noticed in blood pressure.

Then, I made experimental test on whether the disappearance of the otolith crystal was the result of general characteristic of the compound of chlorine or not. Injection of sodium bicarbonate, sodium oxalic acid, etc., but the results showed the disappearance did not happen.

What makes the otolith dilute? It seem as if carbonic acid gas is generated from sodium bicarbonate works on the solum crystal of calcium carbonate, and produce dilutable calcium bicarbonate, same as in the case marble get diluted by efflorescence.

\[ \text{CaCO}_3 + 2 \text{NaHCO}_3 = \text{Ca(HCO}_3\text{)}_2 + \text{Na}_2\text{CO}_3 \]

To generate carbonic acid gas from sodium bicarbonate require a temperature of 150°C, or higher. This fact coincide with the animal experimentations. When sodium bicarbonate is sent in blood of frogs, cold blood animals, through their heart, their otolith crystal do not get diluted. It also a fact that when carbonic acid gas works on them, the otolith crystal gets diluted. I scratched the otolith membrane with a sharp spoon by inserting it in the labyrinth of frogs and had the substance thus taken in the water in test tubes. The transparent water became milky. The microscopic examination of the drop of the water revealed existence of innumerous crystal of various sizes floting on it. Insert a piper in the test tube and give a blow and allow carbonic acid gas to work in it. The milky liquid becomes transparent by degrees, and when this practice is continued for 30 minutes or so, the liquid becomes perfectly transparent and microscopic examinations will find difficulty in noticing the existance of otolith crystal. It is inconcievable, also, that the sodium bicarbonate, injected in vein, will generate carbonic acid gas at once and will reach the labyrinth and dilute otolith crystal. It seems likely that the sodium bicarbonate solution reaches the labyrinth, get to the cavity below the otolith membrane, and then, the work of carbonic acid gas is performed.

**APPLICATION ON HUMAN BODY**

By the experimentation on undulating apparatus, the fact that, when acceleration movement acts on living body, a phenomenon of strain on sympathetic nerves of various organs occurs and produces obstruction in regeneration, caused by strains in sympathetic nerves, in blood and urine, has become known. Now, would not this kind of phenomenon be noticed in the sickness, caused by undulation movements of vessels?

What is generally known as symptoms of sea-sickness are feeling of fatigue, depression, lessening of contemplative faculty, feeling of dizziness, paleness of face, breathing becoming difficult, nausea which sometime bring vomiting. Putting aside the symptoms that belong to mental phenomenon such as feeling of fatigue, lessening of contemplative faculty, nausea, feeling of dizziness, etc., other physical symptoms are phenomenons caused by strain on sympathetic nerves. For instance, paleness of face comes from contractions of blood vessels on face skin, caused by strain of blood vessel contraction nerve,
which is a sympathetic nerve. Also, the difficulty in breathing comes from deeper inhalation, making respiration hard, as anybody feels in sea-sickness experiences. This is inspiratory dyspnea, caused by strain sympathetic nerves as seen in the experiments. Vomiting is one of the most conspicuous symptoms that can be observed. This is also a phenomenon caused by strain in sympathetic nerves.

According to the study of predecessors, vomiting is a phenomenon caused by the opening of cardia, and the contents of the stomach being pushed out by abdominal pressure. In this case, pylorus is strongly contracted, with the result of the contents being adversely pushed out. According to the experiments by means of undulating apparatus, the movement of stomach is stopped by the stimulation of visceral nerve which is the sympathetic nerve of stomach, as stated before.

In such cases, slackening of wall of stomach was noted, and also, tightening of outlet of stomach was observed. The rise in abdominal pressure is cased by strong contraction of abdominal wall preceded by deep inhalation, causing diaphragm into a position of inhalation. I stated before that animals manifest inhalatory dyspnoea in the experiments in undulatory apparatus. In such cases diaphragm hold deep inhaling position. The contraction of abdominal wall seems to be caused by the strain on sympathetic nerves. The sinew of abdominal wall is of filbrae musculares. The contraction of the sinew is heightend by the stinging sympathetic nerves.

Thus, you know that symptoms of sea-sickness are all phenomenons caused by excitation of sympathetic nerves. Also, that the blood pressure get heightened by shakes of trains and automobiles is a well known fact. This coincides with the result of our experiments on undulating apparatus. There have been reported that made on increase of carbonic acid gas in blood, decrease of urine quantity, expulsion of sugar in urine, at the time of sea-sickness. These also coincide with the result of our experiments. Further, decrease in acidity of gastric juice and inclination to constipation at the time of sea-sickness are recognized symptoms, and these can be explained by the contraction of sympathetic nerves. Thus, the substance of sickness caused by undulation of vehicles, what we call acceleration movement disease, can be deemed as obstacles in autonomous nerves faculty of contracting sympathetic nerves.

In animal tests, decrease of tention of sympathetic nerves caused by acceleration can be prevented by intravenous injection of sodium bicarbonate solution. We have come to the stage of applying it on acceleration disease of human being. There were two points for me to solve before I would make the application of the theory on men. One was the doubt in the safety of injecting quite a big volume of sodium bicarbonate in one shot into the veins of normal persons, and the other was the fear it something unforeseen may not happen when the otoliths is diluted. The first one was not a big problem. I thought gradual increase of volume, beginning from small quantity would solve the question, but the second point was much graver in nature. While nothing untowards happened to animals in the experiments, in the balancing of body or in general daily life, there was fear or doubt if it would be just as safe in human being who were leading much refined and complex life.
Fortunately, though I happened to meet a man who dared to have such experiment voluntarily. He was a man of 21 years of age, and apt to get sea-sick easily. He was born in a fishman’s family, but was not able to take up the family occupation. Not only small boats, but riding on steamers, trainways would make him nauseate. Thus he had to be leading a very inconvenient life. That is why the test was made on him. Diagnosis found no physical irregularity, but when he was tasked to the test of rotating chair, his face became pale. He was knocked down by strong nausea and dizziness, and was in strong agony pretty long period. When he was induced to take an elevator ride, he complained of nausea and dizziness pretty strongly. When blood pressure and pulses were tested in the occasion, conspicuous heightening was notice, together with contraction phenomenon of sympathetic nerves.

To this man, application of intravenous injection at elbow of 5% sodium bicarbonate was slowly given, up to 40 cc. There was no accessory effects that was feared for. After the injection, he was subjected to do gymnastics, running up and down stairs, but no impediment in balancing power was noticed as feared. When made to undergo rotating chair test, he was entirely a different man. No change came into his complexion, little attack of nausea and dizziness. Elevator riding was indifferent. Blood pressure and pulse tests did not show such conspicuous heightening as they did before. He was made to take a trainway ride, but did not make any complaint of unpleasant effects. I decided to make him take a boat ride and observed him. The boat chosen was a small steamer going to the isolated island of his native place, with cruising time of 7 hours. He had been very much worried of the trip that had been vexing him very much, but this time, he was entirely indifferent. On that day, there was some wind and the boat rolled and pitched to some extent, but against the expectation, he went home quite happy and pleasant.

Treatment was given quite of ten after that to people who were apt to get sea-sick, to people who get sick easily on trains, and bus, etc. But here I will give the result of my observations made on collection of men in the Japanese army. This observation was made on 474 men of a battalion who were in Central China in war time. This battalion used to cruise on the river Yangtze-kiang quite of ten. It had 40 men who were very weak on boats, who would get sea-sick at a little undulation movement. There were, on the other hand, 6 men who were confident of his ability to weather the undulation movement, who claimed that did not get sea-sick even heavy weather on the Yangtze-kiang cruises. The balance of 428 were of no special feature, who would be called as average people toward sea-sickness. On them all, tests were given to ascertain Ashner’s phenomenon. Both eyes of them were pressed to the extent that they felt pain, and those whose decrease in pulses were 0~4 per minute were classed as sympathetic nerves tensioned; 5~9, as normal; 10~15 as para-sympathetic nerves tensioned. Of 40 who were weak on boats, 24 were of the first class and 16 were of the third class. Six men, who were confirmed sea-worthies, were all in the second class, the normals. Of 427 indifferents, 327 were normals and 101 were of the third class. From the above test, it may be said that sympathetic nerves tensioners are all subject to sea-sickness, there
are some who are apt to get sea-sickness, among para-sympathetic nerves tensioners.

After the close of the war, when the battalion was on the way to Sasebo in Kyushu
from Shanghai in China, the effect of sodium bicarbonate injection was studied. The
injection were given while in Shanghai, waiting for the repatriation boats. It was 20
Dec. 1945. The repatriation began on 1 Feb. 1946, 43 days after the injections were given,
by American steamer L.S.T. Injections were given to those who were apt to get sea-
sick, the balance to serve as references. Of 40 apt-to-get-sea-sick, half were given the
injections and the other half were left out for reference's sake. That is, 12 of 24
sympathetic nerves tensioners, and 8 of 16 para-sympathetic nerves tensioners were given
40 cc 5% sodium bicarbonate intravenous injection at elbows. It chanced that the
boat met a heavy storm on the way and the effect of the injections were fully proven.
The boat sailed at noon from Shanghai, and for some time the voyage was calm.

At around zero hour of 2 Feb., rain and wind storm began, and the boat was subjected
to heavy rolling and pitching, and many were sea-sick at once. Not only those who
were weak on boats and who were not given injections, but even some of those who
had been found indifferent and strong against sea-sickness laid themselves down, their
faces pale, and there were vomiting found in several quarters. Against this, those who
had injections made were all entirely calm.

The storm continued from 2nd to 3rd. The boat continued in hard voyage. Sea-sick
patients had become worse. Cabin well filled with filthy smells of vomits. Among such
circumstances, the 20 persons injected, were normal, took meals as usual and took care
of sick people. The boat loded with sea-sicker continued on her heavy voyage and
arrived in Sasebo at noon, 4 Feb., 24 hours behind schedule.

Though the fact that intravenous injections of sodium bicarbonate on rabbits would
dilute the crystal of otoliths and would, thence, diminished sting of acceleration force,
application was made on human being in prevention of acceleration disease by injection
of sodium bicarbonate, and thus, the fact that is effective has been recognized.

Another observation was made on whether it was by dilution of crystal of otoliths
in the case of human being. On a young man of 22 years of age, who was nearing to
his death because of nosesarcoma, the injection of sodium bicarbonate was given and
the examination of the labrinth was made after his death. The injection was made 2
weeks before his death, and as expected, the dilution of otolith crystal could be noticed.

Lastly, I would add that sodium bicarbonate injection can be applied to Menier's
disease. In this disease, movement of head induces heavy dizziness, and patients can
not move their head lying on beds. Yet, the sodium bicarbonate injection eases this
phenomenon. When one moves his head, accelerating stimulation is applied to labyrinth.
In the case of Menier's disease, the stimulation works exceedingly heavily. As the
stimulation is not generated even if the head is moved, this good effect is had. Dizziness
cased by wound in the labyrinth can be cured in the same way by the sodium
bicarbonate injection.

Although I have not started experiments yet, I am thinking that fatigue coming from
riding on vehicles could be prevented to some extent.