TINJAUAN KEPUSTAKAAN

Mechanism of Acupuncture in Treating Obesity

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The efficacy of acupuncture in treating obesity has been widely known and proved in several clinical trials with significant results. Many weight reduction programs have included acupuncture in their programs. However, if asked about the mechanisms of acupuncture in weight reduction, many acupuncturists still find it hard to explain scientifically. There are still controversies over the efficacy and mechanisms of acupuncture in weight reduction. A nutritionist stated that acupuncture just makes it easier to diet and has no actual control over body's fat[1]. A scientific explanation of the mechanisms of acupuncture could perhaps clear up these controversies.

Obesity is the most prevalent, chronic, medical condition in our society and is directly or indirectly associated with a wide variety of diseases that collectively account for 15 - 20% of the mortality rate. In developed countries approximately 35% of the adult population is obese, and there are indications that the prevalence is increasing. Jellife and Jellife found that, in Britain, young and middle-aged men weighed 15 pounds heavier than 30 years before, with slight increase in height[2].

Obesity means an excess of body fat. Overweight means the body weight is in excess of some arbitrary standard. In most studies of prevalence, overweight is defined as 10% above the ideal body weight given in standard tables and obesity is defined as 20% above the ideal body weight. While being obese is being overweight, being overweight does not always mean someone has excess fat. The overweight may be due to muscle or other body constituents. Thus it is necessary to estimate the body fat not the weight if possible. Determining the Body Mass Index (BMI), obesity is defined as having BMI over 30. Body Mass Index equals weight devided by height squared ($BMI = W/H^2$). Measuring the triceps skinfold using calipers, obesity is defined as having triceps skinfold meansurement greater than one standard deviation from the mean, or if the measurement is greater than 15 mm for men and 25 for women.[3]

Obesity is classified anatomically into normocellular and hypercellular type. Obese subjects are classified as normocellular if their fat cells number is normal, and hypercellular if their fat cells number is increased. Fat cells increase in number during childhood and teenage. M abnormal increase in fat cells during childhood and adolescence predisposes to obesity in adulthood which is very resistant to treatment. Juvenile onset obesity can be classified into constitutional or genetic which starts early in infancy and symptomatic obesity which is a symptom of an underlying physical or emotional disorder. The latter may start any time in childhood and there may be precipitating factors. Obesity caused by emotional factors in childhood is also called developmental obesity in contrast to the obesity triggered by emotional factors in adulthood which is termed reactive obesity.

Based on pathogenesis, obesity can be classified into regulatory obesity which is associated with disorder of the mechanisms regulating food intake, and metabolic obesity in which there is an inborn or acquired error in metabolism. This last classification is useful for research and treatment whereas the former are useful for prevention of obesity.

Sun et al, got a 88,9% effective rate treating obesity with acupuncture,[4] Liang and Chen had a 84,8% effective rate using acupuncture,[6] Huang obtained a 76,9% effective rate using ear pressing combined with body needling,[7] Lau et al got a 74% result using auri acupuncture.[8] The long term effect of acupuncture was satisfactory after one course of treatment but improved after two or three courses of treatment. Liu et al reported that evaluation one year after the last treatment gave a 74,4% effective rate for one coui 91,7% for two courses and 100% for three courses of treatment.[9]

MECHANISMS OF ACUPUNCTURE IN TREATING OBESITY REGULATING FOOD AND ENERGY INTAKE

One of the pathogenesa of obesity is disorder in the mecha-

nisms regulating food intake, producing an increase in appetite and excess food intake.Acupuncture can treat this disorder in several ways:

1. Decreasing appetite by interfering with the serotonergic pathway in the brain.
2. Abatement of appetite via the vagus nerve in the conchae (auricular acupuncture).
3. Lessening nutrition intake by reducing hyperfunctioned gastric digestion and intestinal absoption.

Decreasing appetite by interfering with the serotonergic pathway in the brain

Anand and Brobeck postulated that food intake is controlled by regulatory mechanisms in the veñtromedial nucleus and lateral nucleus of the hypothalamus. It is known as the dual center hypothesis. According to this hypothesis the ventromedial serves as a satiety center and acts as an inhibitor of the feeding center located in lateral hypophysis.[2,10] Experiment in animal have produced results predicated by this hypothesis. Lesions in ventromedial hypothalamus made the animal hyperphagic, whereas lesions in lateral hypothalamus caused the animal to be aphagic. Injections of procain into the ventromedial area increased food intake. The Opposite results were produced by electrical stimulations of the lateral hypothalamus. At present amine theory is better received.

Amine theory postulates that lesions in the ventromedial and lateral hypothalamus cause the observed by interrupting amine pathways rather than by a local effect on the ventromedial or lateral hypothalamus. It states that satiety is controlled by the ventral noradrenergic system and the motivational aspects of food seeking behaviour are modulated by the nigrostriatal dopaminergic system.[2]

The nigrostriatal dopaminergic system which has its origin the substantia nigra and terminates in the neostriatum, modulates motivation to seek food through the involvement of dopamlne, gamma-aminobutyric acid (GABA) and serotonin. If the content of doparnine raises, there is less motivation to search for food. 'The person appears to be satisfied. If the content of the dopamin lowers, the person feels hungry and begin to seek food. The content of the dopamin here is checked by gamma - amino butiric acid (GABA) so that there is a constant level that can maintain the normal appetite. The satiety feeling after eating is provoked by the autonomic afferent input from the digestive tract and viscera to the hypothalamus. This input activates serotonergic pathway in the hypothalamus to secrete serotonin. The release of serotonin begins a series of reactions ending with the increase in dopamin secretion.

The stimulations of the point Cu San U (III, 36) in rabbits produced excitation of the lateral hipothalamus with the effect of inhibition of the hyperfuncti6n of the stomach.(11) Acupuncture activates the descending and ascending serotonergic pathways via the anterolateral tract. When acupuncture stimulation, particularly of high frequency, low intensity electrical stimulation (50-200 Hertz), is applied at correct points, neural impulses are received in the dorsal horn of the spinal cord via the type II and type III muscle afferent nerves (small diameter myelinated afferents). These impulses are conveyed to a variety of fibers in the anterolateral tract, several of which projects to the mid brain to, influence that descending and ascending serotonergic pathways.[12] The raphe magnus in the brainstem contains most of the serotonin cells in the brain. These cells have axons in the ascending tract which projects to the midbrain and forebrain besides the descending dorsolateral tract which plays important role in acupuncture analgesia. These impulses in the anterolateral tract also stimulate excitatory neurons in the hypothalamus to release serotonin. The increase content in the midbrain enhances the activity of the nigrostriatal dopaminergic pathway thus produces decreased appetite.

The system works in a cascade pathway. The serotonin released from neurons in the hypothalamus activates the methionin-enkephalin which is released in the ventral tegmental region. Here it inhibits the release of GABA from the substantia nigra. The inhibition of GABA increase the supply of dopamine in the ventral tegmentum. This in turn increase the direct effect of dopamine on the hippocampus through the amygdala which is the termination of the mesolimbic dopaminergic system The effect of dopamine increase in the nucleus accumbens and hippocampus is a feeling of satiety and loss of motivation to seek food. The amygdala and the hippocampus play important roles in the cascade system. It was found by Fonberg (1961) and Morgan (1960) that, in cat, stimulation of the basal lateral part of the amygdala inhibits food intake and destruction of the amygdala increases food intake.[2]

Perhaps there is no such thing as feeding center or hunger center in the lateral hypothalamus. What exist are the dopamine projections to the forebrain or the medial forebrain bundle. In fact this system does not only work for food seeking motivation, it controls other motivation as well, such as water and sex. Lesions to the bundle not only depressed food seeking behaviour but caused sensory neglect to all kind of stimuli.[14]

Is the high frequency, low intensity electrical stimulation the only way to produce reduction of appetite by acupuncture? What about the manual twirling of the needle and the low frequency electrical acupuncture stimulation? Can these and other modalities such as laser or ultrasound as well as the application of press needle lower the appetite? Hari discovered that the application of low frequency (2 - 15 hz) electroacupuncture stimulation on the points Cu San U (III,36) and San Yin Ciao (IV,6) on the hind leg of rabbits for 30 minutes produced a significant increase in the level of methionin-enkephalin in the hypothalamus.[15] This increase may be due to the direct effect on methionin-enkephalin or also through serotonin but the fact tells us that low frequency electroacupuncture stimulation is also able to activate the cascade system leading to the reduction of appetite. But it is not certain whether the effect is as good as that of the serotonin pathway. It was found out that lowering the content of intracerebral serotonin sharply decreased the analgesia producted by enkephalin.[16]

The lateral feeding center or the neurohumoral pathways that are responsible for food seeking behavior are active chronically where as the satiety is glucostatically active.[10] Consequently the effect of acupuncture on appetite is not just restricted to the duration on stimulation.

Abatement of appetite via the vagus nerve in the conchae (Auricular acupuncture)

The external ear or auricle is supplied abundantly with nerve endings, derived from the trigeminal, facial, glossopharyngeus, and vagus nerves.[17] The conchae is especially supplied by the auricular branch of the vagus nerve. It arises from the superior (jugular) ganglion and enters the temporal bone through a foramen in the lateral wall of the jugular fossa, traverses the tiny mastoid canaliculi, and emerges from the skull through the tympanomastoid fissure. The somatosensoric impulses from the surface of the ear canal and the conchae are transmitted by this branch of vagus nerve.

If a stimulation, be it mechanical, electrical or laser is produced on the conchae, neuronal impulses are sent to the central nervous system by way of the vagus. These impulses can interfere with the impulses bearing appetite signal coming from the gastrointestinal tract because of their common neuronal pathway to brain.[18] A hungry (empty) or full sensation is conveyed through the viscerosensoric pathway of the vagus. The impulses are received by nucleus solitarius and projected to the reticular substance of the brainstem. Then via the posterior ventral thalamic nucleus the impulses are projected to the cerebral cortex.[17] The appetite signal may be blocked to a certain degree by the sensory impulses from the auricular branch of the vagus nerve and the hunger is less felt and the desire for food decreases. The stimulation produces nerve fatigue. The efficacy of the continuous stimulation is less after a period of two weeks. A rest of 7-10 days should be given in order to obtain the previous result.[18]

Lowering Intake by reducing byperfunctioned gastric diges- tion and Intestinal absorption

The movement of the stomach and intestines and the rate of intestinal absorption, all determine the volume of nutrients the body gets. Hyperfunctioned gastric digestion and intestinal absorption provide more energy intake which if not utilised is turned into fatty tissue. Besides, the fast rate of stomach emptying time causes the individue to feel hungry faster and more often. This with the better energy intake factor lead to overweight and obesity. The movement of the stomach and intestine as well as the secretory function are regulated by automatic of vegetative nervous system which, based on the opposing but complementary functions, is classified into two structures: the sympathetic and parasympathetic nervous system. The peristalsis and the secretory are enhanced by the parasympathetic where as the sympathetic has the opposite effect.

The parasympathetic nervous system for the gastrointestinal tract is supplied by the vagus nerve.(17) The branch for the stomach is visceromototric and secretomotric, where as for the pyloric sphincter it has inhibitory function. The branch for the intestines is visceromotoric and secretomotoric for mucous glands smooth muscles of intestine, jejunum, caecum, ascending colon and most of the transverse colon. It has inhibitory function on ileocaecal sphincter. The myelinated preganglionic fibers of the sympathetic nerves which, innervate the digestive tract, leave the spinal cord at the 5th to the 9th thoracal segments following the anterior ramus and pass through the para ventebral ganglia to join the greater splanchnic nerve. It then synapses in the celiac ganglion. The unmyelinated postganglionic fibers then go to innervate the stomach and the intestines. The activation of the sympathetic nerves has effects on the digestive tract opposite to those of the parasympathetic. Together they maintain a tonic level of both which is termed autonomic tone. Because of the tone the activities of the intestines and glands can be increased either by an increase in parasympathetic input or by a decrease in sympathetic input or vice versa.(14,17) In fact it is like the Yin Yang phenomenon.

Most of the people with obesity has parasympathetic input higher than normal people and sympathetic input lower than normal people. in these people the digestive function is overactivated which can be seen from several parameters : the secretion of saliva, the activity of the salivary amylase and the acetylcholine esterase, the content of pepsinogen and blood amylase is higher than normal people. The excretion of d-xylose, which reflects the absorption function of the intestine, is also higher than persons that are not obese, whereas the content of norepinephrine is lower than normal than normal subjects. The norepinephrine are the neurotransmitters working in the neuromuscular synapses of sympathetic nerves. The postganglionic synapses of the parasympathetic use acetycholine as transmitter. The oral prostaglandin E_2 level is also lower than in normal subjects. This substance can relax gastric muscles, dilate the gastric antrum, delay of sympathetic nerves. The activity of the sympathetic nerves and the parasympathetic nerves must be in equilibrium. The equilibrium index of the vegetative nervous system (Y) can be calculated from Liang's regression equation: $Y= -28-O.194X_1 + 0.03\ 1\ X_2 + 0.025\ X_3 - 0.792\ X_4 -0.131\ X_5 + 0.649\ X_6$. The Y in obese subjects is often lower than that in normal subjects.(22)

After receiving acupuncture treatments with points tailored to diagnoses according to syndrome differentation, Liu et al, in several clinical studies found that the above parameters such as salivary amylase, blood amylase, pepsinogen, acetylcholone esterase and the xylose excretion rate in urine were lower whereas the norepinephrine, oral prostaglandin E_2 and Y value raised.These facts tell us that acupuncture can balance the previously imbalanced automatic tone. Perhaps it is through the automatic nervous systems that acupuncture exerts many of its actions which sometimes seem to be contradictory such as lowering the blood pressure in one person but raising the blood pressure in another.

The question is how acupuncture regulates the autonomic tone? Needle insertion causes tissue damage and repair reaction which produce bradykinin. Bradykinin excites A-delta and C unmyelinated fibers in the skin. This primary afferent depolarization produces impulses that are conducted via the tract of Lissauer and dorsolateral funiculus in the spinal cord. The dorsal root potential triggers a reflex which is antidromically fired through the sympathetic C fibers to viscera. This

viscerosomatic reflex affect the entire automatic the sympathetic C fibers to viscera. This viscerosomatic reflex affect the entire autonomic system. Both sympathetic and parasympathetic responses can be provoked through somatic stimulation induced dorsal root potential that can be produced by body and ear acupuncture stimulation. The same impulse crosses the contralateral side to periaqueductal gray.There are fibers that connect the periaqueductal gray to the intralaminar nuclei of the hypothalamus.[14]

Hypothalamus is the main regulator of the autonomic nervous system. In the periventricular nuclei there are neurons that project axons to the parasympathetic motor nuclei in the brainstem ad the sympathetic motor nude in the spinal cord. So acupuncture can treat obesity through its action on the autonomic nervous system.

Increasing energy expenditure

Increasing basal metabolic rate (BMR)

Energy is expended in 3 major ways : basal metabolism, specific dynamic action of food, and physical activity. The energy expense can be obtained from food ingested or from stored energy, primarily adipose tissue. Factors known to alter basal metabolic rate include age, sex,temperature, drugs, hormones, and nutritional status. Men have higher BMR than women. BMR decreases with age thus the percentage of fat content increases slightly with age. Changes of body temperature also affect BMR. One degree raise in body temperature either internally or externally generated, raises the BMR by 12%. Thyroid hormone, growth hormone, glucagon and epinephrine increase BMR and are termed calorigenic.(2) After an injection of tri-iodothyronine (T3) into a hypothyroid patient, the metabolic rate is not immediately affected. The peak activity occurs ito 5 days later. With thyroxine the delay is even longer, about 8 to 18 days later. The delays imply that it is through an indirect action, protein synthesis, that the metabolic rate is affected.

A recent theory states that thyroid hormone may increase the rate of ionic transport across cell membranes. Since perhaps half of the basal metabolism is involved in maintaining ion equilibrium between intracellular compartments, an increase in ionic transport across cells means increase in basal metabolic rate. ATP ase is the above ionic transport and to produce heat in the body. At present it is thought that the enhancing effect of thyroxin on ATP-ase level and BMR are lower in some obese subjects compared to normal subjects. It was found by Liu et al that acupuncture increased the thyroxin content in obese patients treated by acupuncture.[24] Thus it is suggested that acupuncture might increase BMR by enhancing the function of the hypothalamus-pituitary-thyroid axis and therefore stimulate the secretion of thyroxin which then raises the activity of ATP-ase.

The activation of the neurons in hypothalamus by acupuncture stimulation has been explained above. In the periventricular nuclei there are endocrine neurons that secrete thyrotropin releasing hormone (TRH) which is released and transported to the anterior pituitary through portal blood supply. Here it causes the cells to release thyroid stimulating hormone (TSH) to the blood circulation. In its target organ TSH stimulates the thyroid gland to produce thyroxin and tri-iodothyronine.[14]

Growth hormone is also calorigenic. It produces a small increase in BMR. Growth hormone concentrations are lower than normal controls in obese patients. It was demonstrated that 5mg. per day of growth hormone given to obese patients for 8 days produced an increase in oxygen consumption of 10%. Liu et al found that in obese patients successfully treated with acupuncture the levels of growth hormone are raised whereas in the failed group the levels are lower. 24 The growth hormone is secreted by the anterior pituitary by the control of the growth-hormone-releasing hormone (GRH) also produced in the periventricular nuclei of the hypothalamus.

In small doses, epinephrine is calorigenic as well. In the. body epinephrine is produced by the adrenal medulla which gets direct innervation from the sympathetic have. If the activity of the sympathetic is high more epinephire is produced. Acupuncture can produce higher BMR and more lipolysis by raising the sympathetic tone.

The activity of the ATP-ase is reduced by hypercholesterolemia. Acupuncture can also raise the activity of ATP-ase by altering lipid composition in the cell membrane which is influenced by high cholestereolemia.

Treating hyperinsulinism

Hypercholesterolemia is often associated with obesity. It appears that acupuncture can reduce hypercholesterolemia. Liu at al found that the values of total cholesterol, triglyceride, LDL-cholesterol, and VLDL-cholesterol were lower and the value of HDL-cholesterol was higher in obese patients succesfully treated with acupuncture. 24 insulin levels in these patients were also higher than normal controls. It was observed by several researches that there was pancreatic islet cell hypertrophy in obesity suggesting the possibility of altered insulin metabolism. Elevated fasting and postabsorptive insulin levels in non-diabetic obese subjects have been found by a number of investigators.[2] High insulin level means increase glyconeogenesis and lipogenesis which add more fat to the obese persons.

Hyperinsulinism is the condition where the body's insulin levels are permanently high but there is resistency to the effects of insulin. This condition promotes lipogenesis and with more adiposity the insulin resistency increases. Hyperinsulinism also provokes the liver to produce more LDL-cholesterol and VLDL-cholesterol leading to hypercholesterolemia and hypertriglyceridemia.[2,25] Acupuncture perhaps reduces hypercholesterolemia by acting on hyperinsulinsm. In the above study, insulin levels after acupuncture also decreased.

Acupuncture may affect the hyperinsulinsm through alpha-adrenergic and beta-adrenergic receptors found in the beta pancreatic cells.[26] The stimulation of the alpha-adrenergic receptors by noradrenaf which is the neurOtransmitter in sympathetic postganglionic synapses and also produced by the adrenal medulla in small amount, inhibits the secretion of insulin. Whereas the stimulation of beta-adrenergic receptors by adrenalin which is produced by the adrenal medulla increases insulin release.[14,27] There are also cholinergic receptors in the

beta cells but vagal stimulation only increase insulin content in the pancreatic venous effluent without any change in systemic insulin level. It seems that beside the blood glucose level, the factors that modulate the secretion of insulin both in basal condition or in the course of response to various stimuli are the balance between alpha-adrenergic and beta-adrenergic tonus.This tonus is regulated by the autonomic nervous system through which acupuncture can exerts its effects as has been described above.

CONCLUSIONS

Body and auricular acupuncture can treat obesity. The mechanisms are mainly through neurohumoral pathways. The hypothalamus and the autonomic nervous system play major roles in obesity and it is acting through these systems that acupuncture exerts its effects on obese persons. The actions of acupuncture in balancing disordered automatic tonus is typical of the traditional concepts of acupuncture. The most important and elementary is the Yin-Yang concept.

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Eat to live, but do not live to eat