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Clinical significance of anatomical and functional connections of the stellate ganglion

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Abstract

This article is a review of anatomical and functional connections of the stellate ganglion on the basis of the study of modern scientific research. The relevance of the research is due to extremely rare application of osteopathic techniques on the stellate ganglion. The techniques available in the osteopath's arsenal are often used locally and are not widely used in practice.

Keywords: stellate ganglion, somatic dysfunction, osteopathy, anatomical-functional connections, autonomic nervous system.

The purpose of this work is to generalize and systematize the knowledge about the inferior cervical sympathetic (stellate) ganglion (LSG) and the available practice of influence on it, for specification of indications of specific techniques on LSG in osteopathy.

The stellate ganglion is formed by the fusion of the inferior cervical sympathetic ganglion and the first thoracic ganglion, and as a single structure is found in the population in 80% of cases [15]. The inferior cervical sympathetic ganglia are located at the level of the transverse processes of the seventh cervical vertebra, and the first thoracic ganglia are located in front of the heads of the first ribs. As a single structure, among the cervical ganglia it is inferior in size only to the superior cervical ganglia and averages 2.5 cm in length, 1 cm in width, and 0.5 cm in thickness [4].

The macroscopic structure of stellate ganglion is determined by the degree of its division into inferior cervical and first thoracic sympathetic nodes. The nature of interganglionic communication between these nodes also differs. It was found that in fetuses of the second half of the gestational period, newborns and children, nonseparated forms predominate, with those on the right being more frequent than those on the left. In young, mature, and old age, the stellate ganglion is more frequently split. The type of splitting indicated above determines the shape of the stellate nodes. Undivided nodes have rectangular or trapezoidal shape. If the separation is incomplete, it has an "hourglass" shape. In this case, two nodes are clearly visible. In some cases, the shape of conglomerates resembles "gymnastic dumbbells", with the ganglia separated from each other. When the stellate ganglia are completely separated into caudal cervical and cranial thoracic nodes, its poles take square, rectangular, rounded, oval, and triangular shapes. The general dynamics of the cervicothoracic ganglion dimensions in

the process of human ontogenesis is as follows: the dimensions increase 3-4 times; the maximum volume is in young age, then there is a gradual decrease in the dimensions by the old age [4]. The stellate ganglion is separated from the underlying bony structures by *the prevertebral fascia* and loose fibrous connective tissue. It is protected by three ligaments: *vertebro-pleural ligament, rib-pleural ligament, and transverse-pleural ligament* surrounding it like a pyramid (Fig. 1).

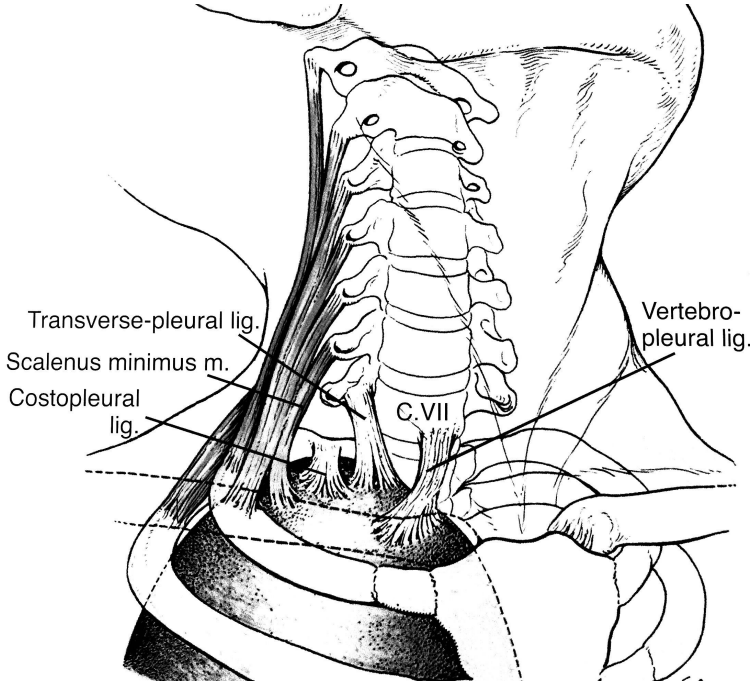

Figure 1. Ligaments of the pleural dome (by Stecco L., Stecco C., 2014)

The location of human cervicothoracic nodes is asymmetrical: the right cervicothoracic ganglion lies higher than the left one. The skeletotopic location of the cervicothoracic nodes depends on the type of physique: in dolichomorphic type of physique the ganglion location is higher. The skeletotopic location of the stellate nodes decreases in elderly people.

The subclavian artery is located in front of it. The subclavian loop is formed by branches emanating from the stellate ganglion. They circle the subclavian artery in front and return to the sympathetic trunk in the midcervical ganglion [12]. Dorsomedially lies the long neck muscle and laterally lies the ladder muscle group (Fig. 2). The variants of syntopic relations of the stellate ganglion and subclavian artery are determined by the type of human physique [4].

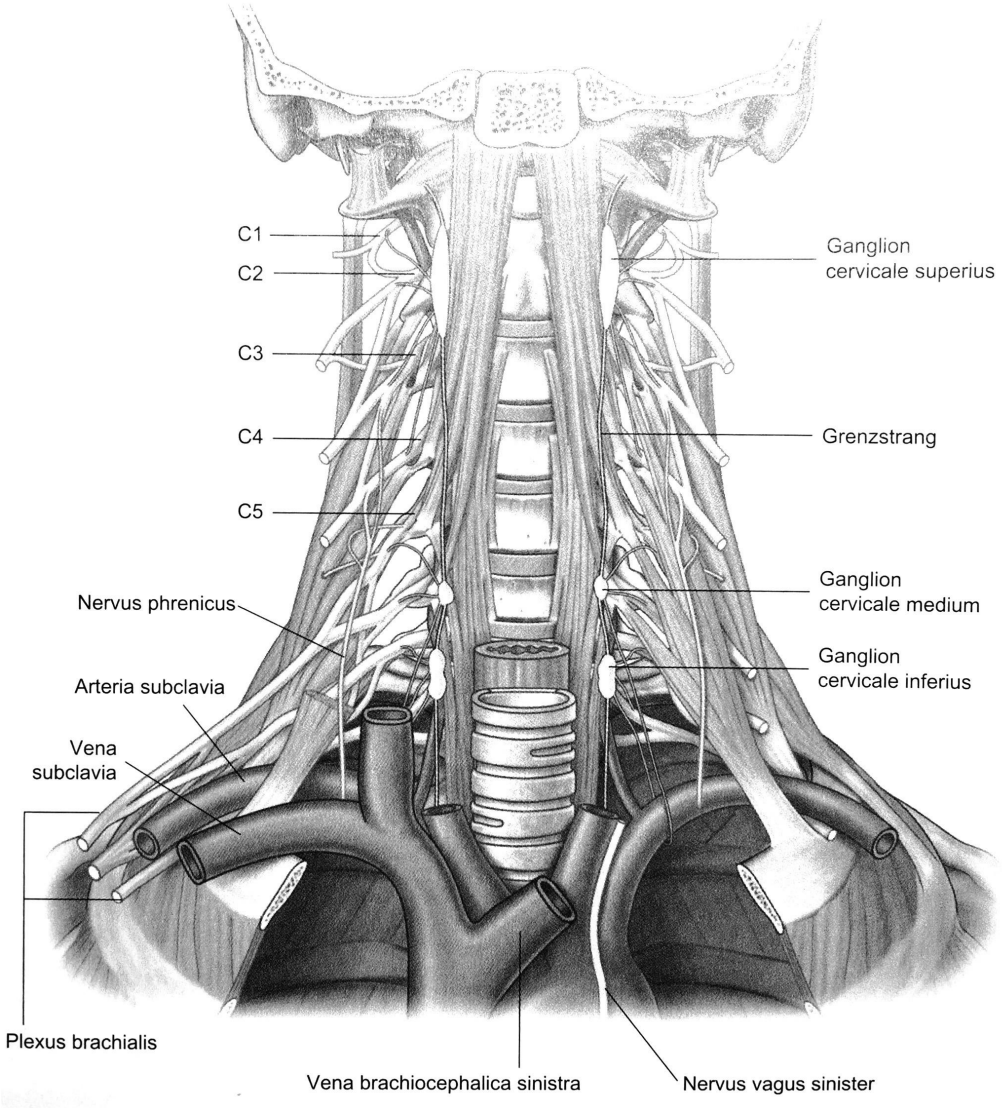

Fig. 2. Topographic anatomy of the stellate ganglion (according to Meert G.F., 2012).

The connective-tissue capsule of the stellate ganglion is represented by a two-layer structure. The thickness of the connective-tissue capsule of the ganglion increases more than 5.2-fold during ontogenesis, mainly due to the outer layer. The outer layer of the ganglion capsule is formed by loose fibrous connective tissue consisting mainly of collagenic, as well as reticular and elastic fibers that have no clear orientation and intertwine with each other [4].

The inner layer of the capsule is formed predominantly by collagen and elastic fibers, which are orderly arranged and oriented around the circumference of the ganglion. Connective-tissue septa, in which blood vessels pass, depart from the inner layer of the capsule. In adulthood and old age, the content of connective tissue in the ganglia increases due to fibers, while the number of fibrocytes decreases, the density of capillaries and the number of neurons decreases. However, in deceased patients with cardiovascular pathology, histological studies

revealed an increased number of neurons in ganglion, which correlated with the degree of myocardial fibrosis [28].

Stellate ganglion neurons can be divided into 4 types according to their function [6]:

1. Basic neurons (efferent).
2. Insertions (interneurons).
3. Sensitive (afferent).
4. Neurons performing paracrine functions.

Thus, the stellate node is the lowest reflex center. The stellate ganglion (SG) receives preganglionic axons from spinal cord segments C8 through Th10 [6], but the greatest number from Th1 through Th5 segments. Some form synapses with ganglion neurons, some transit to the middle and upper cervical ganglion. That is, all sympathetic innervation of the head, neck, and partially the upper extremities is carried out through this ganglion.

Sympathetic fibers of stellate ganglion fuse with diaphragm nerve and give off cardiac and pulmonary branches (pleural) innervating diaphragm, aponeurosis covering liver and gallbladder, adrenal gland (only on right side). Sympathetic branches innervate pleural dome, trachea, esophagus (rarely). The stellate ganglion gives motor branches, which innervate the prevertebral muscles, as well as articular and bony branches. From the inferior cervical ganglion follows the inferior cardiac nerve, which goes to the posterior cardiac plexus, and sympathetic fibers form the vertebral plexus (Frank's nerve).

Some sympathetic fibers from Th2-Th4, go to the upper extremities bypassing it [12]. Efferent fibers from SG neuron bodies go to the scalp, neck, and upper extremities, as well as to the vessels of these areas. Their role in innervation of vessels of vertebral-basilar system is especially significant [5, 7].

According to L.A. Orbeli and A.G. Ginetsinsky (1922) the effect of these efferents on skeletal muscles is carried out not only indirectly through vessels but also directly. The muscle vessels were filled with liquid vaseline: under these conditions, irritation of sympathetic nerves of the fatigued muscle restored its performance. Also the node carries out sympathetic innervation of the trachea, esophagus, heart, lungs, and thymus. To a lesser extent: thyroid gland and stomach [6]. There are efferent connections with brain stem nuclei [6].

Some postganglionic fibers are part of the vagus nerve. The following pathways transit through the SG: 1 Efferent preganglionic pathways from the lateral horns of the spinal cord to the postganglionic neurons of the middle and upper cervical ganglia. 2 Afferent transient

pathways formed by dendrites of spinal ganglion neurons. The following findings are not widely known: The node receives sensory information from axons of sensory neurons of the spinal ganglia C8 through Th9 (mainly from Th1-Th5), and from type 2 Dogel cells (metasympathetic neurons) located in the intramural ganglia of the thoracic cavity (trachea, esophagus, heart, aortic arch).

A large number of receptor apparatuses located both in the nerve and connective tissue of the node are found in the SG. Information from them goes to cerebrospinal nodes C8-Th9. The scheme of inter-neuronal interactions of stellate ganglion according to A.D. Nozdrachev (2002) is presented below (Fig. 3).

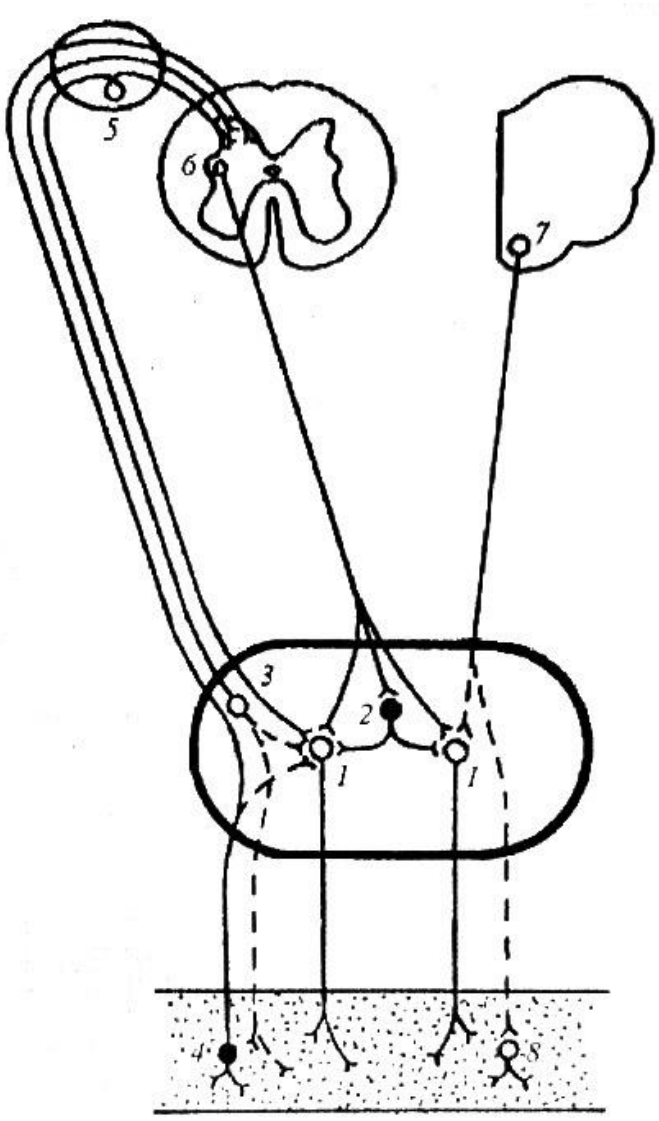

Fig. 3. Scheme of inter-neuronal relationships in the stellate ganglion of the cat and its connections with various parts of the nervous system (according to A.D. Nozdrachev, 2002). 1 - postganglionic sympathetic neurons of stellate ganglion; 2 - insertion neuron; 3 - sensitive neuron of

stellate ganglion; 4 - sensitive neuron of metasympathetic ganglion; 5 - sensitive neuron of spinal ganglion 6 - preganglionic sympathetic neuron; 7 - efferent neuron of reticular formation and motor nuclei of vagus nerve of medulla oblongata; 8 - efferent (postganglionic) neuron of vagus nerve. Solid lines represent established connections, dashed lines represent possible connections.

Now let's consider for which conditions the SG blockade is now successfully used.

Chronic regional pain syndromes and upper extremities [10, 13, 24, 26].

Vascular insufficiency and occlusive vascular disorders of the upper extremities [10, 13, 19, 24, 26].

Impaired lymph outflow and local edema of the upper extremities after mastectomy [9]. It should be noted that the effectiveness of blockades in these cases depends on the anatomical features of sympathetic innervation of the upper extremities. As mentioned above, some sympathetic branches can enter the upper extremities bypassing the VG.

Chronic regional chest pain syndromes after mastectomy. Postherpetic neuralgia [14].

Phantom pains, cardiac arrhythmias [29]. Ischemic cardiac pain. Neuropathic pain in cancer. Acute hearing loss and tinnitus [11, 21, 30].

Facial, neuropathic, and trigeminal pain [8, 20, 22].

Vascular headaches including cluster headaches and migraine headaches [16, 17].

If the phenomenon of sympathetic blockade effect on vessels, sweat glands and heart can be explained by the classical neurological model, the role of sympathetic system in the pathogenesis of pain syndromes remains a subject of discussions.

The effect of SG blockade on brain structures is also poorly explained by the classical model. Thus, SG blockade stopped epileptic and thalamic pains [18, 25].

Positive influence of blockades on the course of post-traumatic stress disorder is also shown.

The effect of SG on the thymus, an organ of the immune system, which is directly innervated by it, has not been studied, which opens certain prospects. In the therapeutic practice only suppression of GS is used, since the above-mentioned conditions are associated precisely with hypersympathetic innervation. This connection is not etiological but rather pathogenetic. Any tissue damage is accompanied by the release of inflammatory mediators and substances,

which stimulate sympathetic terminal branching and, getting into ganglia by retrograde axonal transport, cause new sympathetic neurons formation [28].

Production of proinflammatory cytokines (TNF, IL-1a, IL-1β, IL-6, IL-17), endothelial growth factor (VEGF) production is accompanied by small vessel overgrowth. Nerve growth factor (NGF) production is accompanied by myelin-free fiber overgrowth. Nerve growth factor (NGF), brain-derived neurotrophic factor (BDNF) causes activation of cationic channels of cerebrospinal ganglia. Depolarization of the channels can initiate discogenic and radicular pain.

Sympathetic ganglia are neuroplastic. The process is aimed at the attempt to compensate the disturbed function. Thus, ischemic damage of myocardium causes branching of sympathetic endings in it and increase in number of neurons in SG [28]. Due to hypersympathetic reinnervation, life-threatening arrhythmias occur, which are terminated by GS blockade.

When analyzing numerous studies on sympathetic blockades and sympathectomy, there is a false feeling that the sympathetic system in the pathogenesis always plays against the doctor. It should be kept in mind that these studies refer to neglected, severe forms of pathology with an organic component.

At research of changes of variability of a heart rhythm and arterial pressure at blockade SG on healthy volunteers, the fractal analysis has revealed the reduction *of* complexity of a rhythm and fluctuations of BP. Decrease of complexity is a sign of pathology and is used in cardiology for monitoring of patients for prevention of death from cardiac arrest [23].

Complexity is a necessary condition for adaptation to constantly changing environmental conditions, which is called health. Nozdrachev considers sympathectomies and blockades an "unacceptable luxury" in treatment [6], considering extensive and still insufficiently studied links of ST.

Osteopathic medicine provides alternative ways to influence these structures. The SG is accessible to direct mechanical action. It is located in an area often prone to somatic dysfunctions. The SG has extensive connections with the autonomic nervous system, both sympathetic and parasympathetic, with the somatic and central nervous systems, with the immune system, with the endocrine system (less so than the superior cervical system (HCSS). But it should be taken into account that all sympathetic preganglionic fibers entering the GSH pass through the GSH.

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Литература:

[1] Bigildinsky A.A., Novoseltsev S.V., Malinovsky E.L. Altered afferentation from somatic dysfunction as a possible mechanism of vegetative dystonia syndrome formation. A pilot study. Chiropractic, №3 (59), 2015. - C. 74 - 79.

[2] Bigildinsky A.A., Novoseltsev S.V., Nazarov V. Effect of indirect osteopathic correction of the superior cervical sympathetic ganglion on the biomechanical status, activity and reactivity of the autonomic nervous system. Chiropractic Therapy, №4 (64), 2016. - C. 45 - 51.

[3] Bigildinsky A.A., Novoseltsev S.V., Erofeev N.P. On somatic dysfunction as an object of osteopathy. Chiropractic Therapy, No. 2 (66), 2017. - C. 48 - 52.

[4] Kladko A.V. Laws of topography and structural organization of human cervicothoracic (stellate) nodes. D. thesis for the degree of Candidate of Medical Sciences, Barnaul, 2005. - 30 c.

[5] Novoseltsev S.V. Vertebral-basilar insufficiency. Possibilities of chiropractic diagnosis and therapy. Foliant Publishing House, St. Petersburg, 2007. - 208 c.

[6] Nozdrachev A.D., Fateyev M.M. Stellate ganglion. Structure and functions. Moscow: Nauka, 2002. - 238 c.

[7] Arbab M.A., Wiklund L., Delgado T., Svendgaard N.A. Stellate ganglion innervation of the vertebro-basilar arterial system demonstrated in the rat with anterograde and retrograde WGA-HRP tracing. Brain Res. 1988 Mar 29;445(1):175-80.

[8] Arden RL, Bahu SJ, Zuazu MA et al. Reflex sympathetic dystrophy of the face; Current treatment recommendation. Laryngoscope 1998; 108:437-442

[9] Bonica JJ. Sympathetic nerve blocks for pain diagnosis and therapy. Technical considerations vol. II. Block of stellate ganglion and cervicothoracic and thoracic chains. Published by Winthrop – Breon laboratories 1984; pp. 61-77

[10] Buckley F.P., Morricca G., Murphy T.M. Neurolytic blockade and hypophysectomy. In: Bonica JJ (ed). The Management of Pain, ed 2. Philadelphia, Lea and Febiger, Vol. II, 1990; pp. 2012-2014.

[11] Cook TG, de Sanctis CA, Plaza JA et al. Stellate ganglion block for sudden profound hearing loss. Anesthesiology 1981; 54:421-423.

[12] Elias M. Association of Pain Management Anesthesiologist Cervical Sympathetic and Stellate Ganglion Blocks. Pain Physician, Volume 3, Number 3, 2000, pp. 294-304.

[13] Elias M. The anterior approach for thoracic symphatetic ganglion block using a curved needle. Pain Clinic 2000; 12:17-24.

[14] Hogan Q, Abram S. Neural blockade for diagnosis and prognosis. Anesthesiology 1997; 86:216-241.

[15] Jamieson R.W., Smith D.B., Anson B.J. The cervical sympathetic ganglia an anatomical study of 100 Cervicothoracic Dissections

[16] Kapral S, Krafft P, Gosch M et al. Ultrasound imaging for the stellate ganglion block; Direct visualization puncture site and local anesthetic spread. A pilot study. Reg Anesth 1995; 20:323-328

[17] Lehmann LJ, Warfield, Bajwa ZII. Migraine headache following stellate ganglion block for reflex sympathetic dystrophy. Headache 1996; 36:335-337

[18] Liao C., Yang M., Liu P., Zhong W., Zhang W. Thalamic pain alleviated by stellate ganglion block. A case report. Medicine (Baltimore), 2017 Feb; 96(5): e6058

[19] Lofstrom B., Cousins M. Sympathetic neural blockade of the upper and lower extremity. In Neural Blockade in Clinical Anesthesia and Management of Pain, ed 2. Cousins M, Bridenbaugh PO (eds). London, J.P. Lippincot, 1988.

[20] Lynch ME, Elgeneidy AK. The role of sympathetic activity in neuropathic orofacial pain. J Orofac Pain 1996; 10:197-305.

[21] Ohinata Y, Makimoto K, Kawakami M, et al. Blood flow in the common carotid and vertebral arteries in patients with sudden deafness. Am Otol Rhinol Laryngol 1997; 106:27-32

[22] Saxen MA, Campbell RL. An unusual cause for sympathetically maintained facial pain complicating telangiectasia. Oral Surg Oral Med Oral Radiol Endod 1995; 79:455-458

[23] Taneyama C., Goto H. Fractal cardiovascular dynamics and baroreflex sensitivity after stellate ganglion block. Anesth Analg. 2009 Oct; 109(4):1335-40

[24] Waldman S.D., Winne A.P. Stellate ganglion block. Interventional Pain Management. Philadelphia, Dannemiller Education, WB Saunders Company, 1996;

[25] Wang S., Zhu Y. A case report of stellate ganglion block in the treatment of epileptic pain. Medicine (Baltimore), 2017 Feb; 96(6):e6044

[26] Wilkinson H. Percutaneous radiofrequency, upper thoracic sympathectomy. New technique. Neurosurgery 1984; 15:811-814;

[27] Wilkinson H. Neurosurgical procedures of the sympathetic nervous system. Pain Clinic 1995; 1:43-50

[28] Wood A., Docimo S. Jr, Elkowitz D.E. Cardiovascular Disease and Its Association With Histological Changes of the Left Stellate Ganglion / Clin Med Insights Pathol. 2010; 3: 19–24

[29] Yanagida H, Kemi C, Suwa K. The effects of stellate ganglion block on idiopathic prolongation of the Q-T interval (the Romano-Ward syndrome). Anesth Analg 1976; 55:782-787

[30] Yanagita N, Innafuku S, Suzuki Y. Stellate ganglionblock for perceptive tinnitus. Jibinkoka 1971; 43:989-999.