STELLATE GANGLION BLOCK

Techniques - Indications - Uses

By

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DEDICATION

To Toby, my wife, whose understanding, patience, devotion and ability to keep our home happy has contributed indescribably to this and other publications.

Introduction

For approximately the past 35 years, stellate ganglion block has been known to the medical profession. Its usefulness in many clinical conditions has been only contemplated, yet in others its efficacy has been proved. In cases in which stellate block is indicated, it may shorten the duration of the disease as well as produce cures and improvements which normally would not be obtained.

Stellate ganglion block has been advocated in the treatment of a large number of diseases. Yet, it became obvious while studying the literature, both American and foreign, that more clinical and experimental research is needed before statistically significant conclusions can be obtained regarding the results of stellate ganglion blocks in many of these disease entities.

It would appear that foreign physicians, particularly the French, have employed stellate ganglion block to a greater extent than we American physicians. Likewise, it is interesting to note that often foreign authors report more satisfactory results following stellate ganglion block therapy than do American physicians. Could it be that the awareness of the usefulness of stellate ganglion blocks by foreign physicians has resulted in a greater proficiency of execution of the block? In general, the majority of American physicians are unaware of the many diseases in which stellate ganglion block may be of value. Therefore, they have not been interested in mastering its technique. Furthermore, the complications of stellate ganglion block are often stressed in the American literature to such a degree that the average physician hesitates to perform it. As with any other technical procedure, the more a physician performs stellate ganglion block the less likely are complications.

It is the purpose of this book to stimulate the interest of physicians in the usefulness of stellate ganglion blocks in various disease entities and to encourage them to learn one of the techniques for performing it. While the author prefers the anterior (paratracheal) approach, complications associated with any approach may be kept to a minimum if the technique is carefully followed. If complications do occur, they may be treated adequately provided the relatively inexpensive equipment and the drugs necessary for resuscitation are available.

It is hoped that by stimulating interest in stellate ganglion block our knowledge of the diseases in which it is indicated and those in which it is contraindicated may be advanced.

Acknowledgments

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D.C.M.

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CHAPTER 1

Fundamentals

DEFINITIONS

Cervico-thoracic Portion of the Sympathetic Nervous System.—The expression *"cervico-thoracic sympathetic nervous system"* refers to the sympathetic nervous system of the head, neck, upper extremities, and chest. *This system receives its preganglionic fibers primarily via the first through the fourth or fifth thoracic sympathetic ganglia.* The *stellate ganglion* is part of the cervico-thoracic portion of the sympathetic nervous system and is the structure formed by the complete or partial fusion of the inferior cervical ganglion and the first thoracic sympathetic ganglion.

Stellate Ganglion Block.—The term *"stellate ganglion block"* refers to chemical paralysis of the stellate ganglion by a local anesthetic agent deposited in the vicinity of the ganglion. Actually, when 10 cc. to 15 cc. of a block agent is injected correctly, *the middle cervical ganglion, the intermediate ganglion (when present), the stellate ganglion and the second, the third and usually the fourth thoracic ganglia* are also directly paralyzed. This can be demonstrated by injecting a 35% Diodrast (iodopyracet) solution containing the blocking agent, preferably the crystals of a local anesthetic drug, and then taking both an antero-posterior and a lateral roentgenogram of the region (see Chapter 9, page 76). Furthermore, the superior cervical ganglion is also blocked as the fibers which form it pass through the above ganglia. In other words, a stellate ganglion block correctly and carefully executed is essentially a block of the cervico-thoracic portion of the sympathetic nervous system.

The terms *"stellate ganglion block," "block of the stellate ganglion"* or *"cervico-thoracic sympathetic block"* are synonymous when used in this book, and they denote a block of the *superior cervical ganglion, the middle cervical ganglion, the intermediate ganglion (when present), the stellate ganglion and the second, third and fourth thoracic ganglia* unless otherwise noted.

Thoracic Sympathetic Ganglia and Thoracic Sympathetic Trunk.—The terms *"thoracic sympathetic ganglia"* or *"thoracic sympathetic trunk"* as hereinafter used will arbitrarily refer only to the upper four or five thoracic sympathetic ganglia and their rami communicantes and adjacent main trunks. These ganglia supply sympathetic fibers to the thoracic viscera and are, of course, the source of the fibers to the cervical sympathetic trunk. The remaining more inferior thoracic sympathetic ganglia and main trunks give origin to the greater and lesser splanchnic nerves. While these latter arise from the thoracic trunk, they are primarily destined for the supply of the abdominal viscera. Therefore, in this text these structures are arbitrarily not included in the expression "thoracic portion of the sympathetic nervous system."

THE RESPONSIBILITY OF THE PHYSICIAN LEARNING TO PERFORM STELLATE GANGLION BLOCK

The Use of Short and Long-acting Blocking Agents.—Under no circumstances should long-acting blocking agents be used by physicians learning to perform a stellate ganglion block. *Mastery of stellate ganglion block with short-acting blocking agents is an ABSOLUTE PREREQUISITE before using such agents as phenol or alcohol.* Complications from these two drugs are permanent or at least prolonged and may lead to medico-legal difficulties. On the other hand, complications from short-acting blocking agents are in most instances reversible within a few hours and, while such complications may be embarrassing, they are seldom permanent provided the means to treat them are readily available. In most instances, blocking with agents of long duration should be delegated to the regional block specialist whose reputation can act as a buffer to compensate for complications and poor results.

PRE-BLOCK CONSIDERATIONS

General.—The patient may be blocked in either the office or hospital, but regardless of where the procedure is done, equipment for treating its complications must be available immediately.

All patients should have a complete history, physical examination, pertinent x-rays and laboratory work. A definite diagnosis must be made before executing a block. Treatment should be applied after diagnostic study and should be based on logic rather than empiricism.

Regulation of Oral Intake.—It is impractical to restrict the diet prior to this block because: (1) Most of these patients can be treated as outpatients free to go about their daily routines. (2) Changes in routine eating habits tend to make some patients unnecessarily apprehensive at the prospect of the block. (3) If the recurrent laryngeal nerve is paralyzed temporarily, swallowing may be difficult and, if fluids and food are restricted before the block, the patient may subsequently become hungry and dehydrated. (4) While the complication of nausea and vomiting with aspiration is a distinct possibility when any blocking agent is injected into the body, its occurrence during or after stellate block is practically negligible. Therefore, if resuscitation equipment (which should be routinely available to every physician performing block procedures) is on hand, the problem may be easily solved.

Explanation of the Procedure to the Patient.—The physician should always take time to explain to his patient all phases of the block with emphasis on its side effects, i.e., laryngeal paralysis, stuffy nostrils, Horner's syndrome and brachial plexus involvement, to forestall apprehension. Likewise, he should tell the patient how long these side effects may persist. It is usually wise also to explain each step as it is about to occur. Only if long-acting blocking agents (phenol or alcohol) are being employed is it necessary to explain possible permanency of the above complications prior to doing the block. The patient should be assured that little or no pain will be felt during the procedure and that his cooperation is very important.

Position of the Patient for the Block.—The patient should be blocked in the supine position on an operating table, cart, or examining table. Under no circumstances should the patient be blocked while sitting in a chair. If a sitting position is absolutely necessary (a thmatics, etc.) and facilitates the block, the patient should sit on the edge of a table. Then, if a reaction occurs, the patient can be placed supine immediately.

Premedication.—For a highly nervous patient or one who is to receive an alcohol or phenol injection, medication with barbiturates, opiates and belladonna derivatives may be indicated. However, in most cases no premedication need be given because: (1) The anterior approach to the stellate ganglion which the author favors is not painful. Other approaches in which periosteum is repeatedly stimulated or the brachial plexus is struck may be more painful, but the degree of pain seldom warrants premedication provided the patient anticipates it. (2) Most people are treated as outpatients, and they are allowed to leave within one hour after the block. However, if premedication is given, these patients should stay in a recovery room for two to four hours and then must be escorted home.

POINTS TO REMEMBER DURING BLOCK PROCEDURE

Opening of Tray.—*Sterility* should be observed when the block tray is opened; the mixing graduate and medicine cups should be handled with sterile forceps. The sterilizer control should be examined routinely.

Solutions should be arranged so the germicides will never be passed over the anesthetic solution. If any alcohol is dropped unnoticed into the anesthetic solution, a slough of the tissue or a neurological complication may ensue.

Asepsis.—The same sterile precautions should be taken as for any surgical operation. It is debatable whether a sterile hand-scrub is necessary. The block field should be draped carefully with sterile towels to assure asepsis. However, the drapes should not conceal the landmarks or the perspective. For the illustrations in this book the patients were intentionally left undraped so that landmarks and positions could be demonstrated for illustrative purposes. The doctor should wear sterile gloves for at least two reasons: (1) They are no more a hindrance to a doctor performing the block than to a surgeon performing a delicate operation, and in addition they do insure asepsis. (2) When a doctor executes a large number of regional procedures, it is advisable for his own protection to wear gloves as cutaneous sensitivity to local anesthetic agents is not uncommon (Figure 1, page 7). Lane and Luikart[1] believe that local anesthetic agents are an occupational hazard and point out that a recent survey of dentists showed a "rather high proportion" had become "sensi-

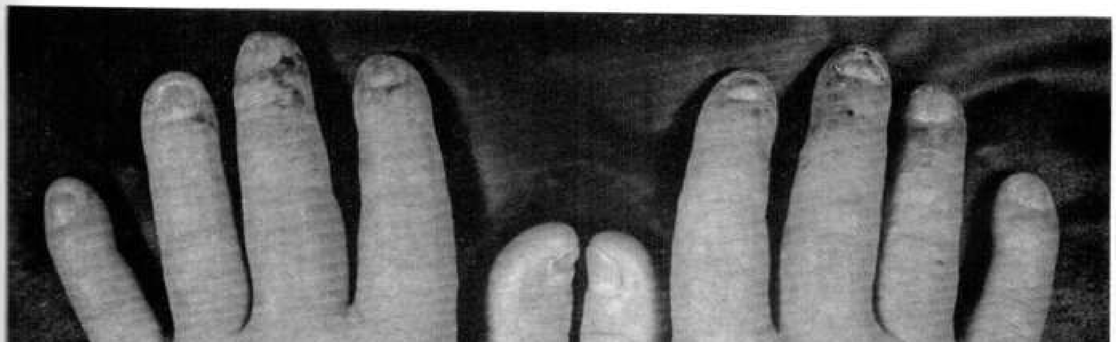

Figure 1. Hands of a physician allergic to Novocaine (procaine) from use of the drug without gloves and in whom Novocaine was inadvertently injected.

tized" to the local anesthetic drugs which they employed in their practice.

The patient's skin should be prepared with one of the routine surgical preparations (i.e., tincture of Merthiolate or tincture of Zephiran). If the patient is to leave the office or hospital following the block and cosmetic appearance is a factor, either 5% iodine solution washed off with alcohol, or aqueous solutions of Merthiolate or Zephiran may be used.

Landmarks.—*Superficial* landmarks may be felt or seen and consist of bones, cartilage, muscles, tendons and blood vessels. *Deep* landmarks cannot be seen or palpated and may be felt only with the point of the needle. They are usually bone, periosteum, fascial planes, tendons or blood vessels. The accuracy in identifying these landmarks depends for the most part on the educated touch of the physician's fingers.

Checking of Needles.—All needles should be checked for patency and weakness before insertion. Most needles break at the junction of the shaft and hub. If a needle shaft breaks off, surgery may be required to remove it. This problem is serious and may be avoided if security bead needles are employed. If a needle is broken in the tissues, every effort including surgery should be made to recover it. The needle point should also be checked for sharpness and, of course, all burred points must be eliminated.

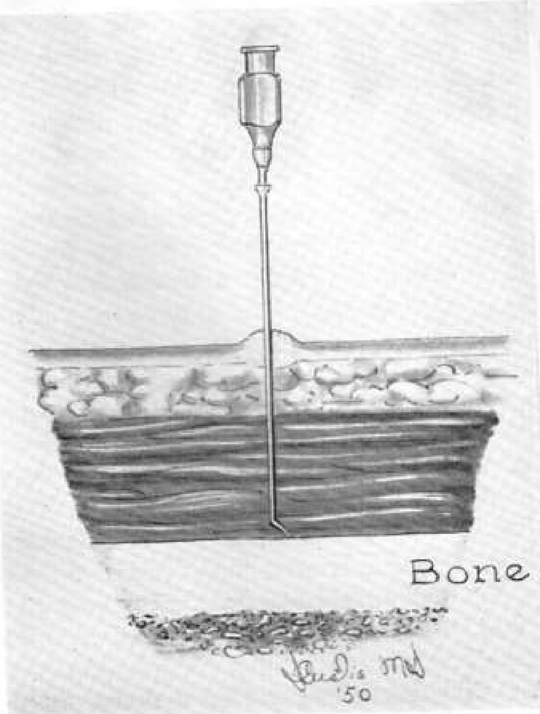

Figure 3. Needle point bent on bone by too rapid or forceful insertion of the needle when seeking a bony landmark.

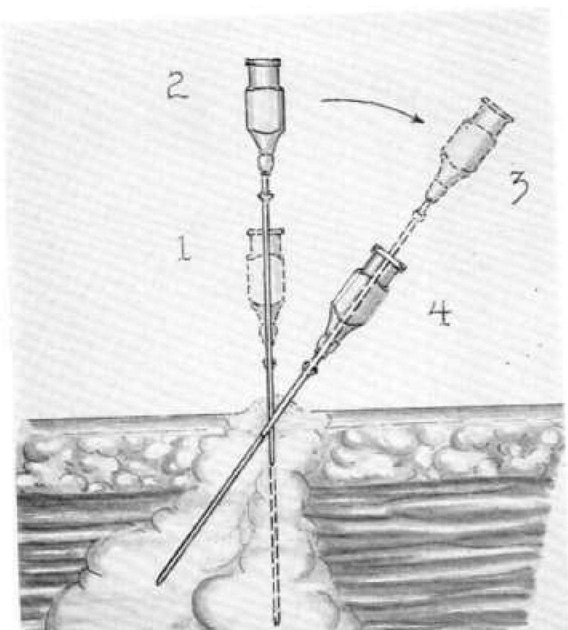

Figure 2. Correct method of changing direction of a needle: (1) Needle deep in tissue. (2) Needle withdrawn to subcutaneous tissue. (3) Direction of needle changed. (4) Needle reinserted.

Handling of Needles.—When changing the direction of a needle, the point should be brought back to the subcutaneous tissue and aimed again rather than attempting to change its direction by bending (Figure 2, page 8). Bony landmarks should be approached slowly so as not to burr the point of the needle which would then tear the tissue on withdrawal (Figure 3, page 8). If a short-beveled point is used, there is less chance of bending or breaking the point on a bone.

Aspiration Tests.—In any nerve block procedure, whether a large or a small amount of solution is employed, it is imperative to attempt to aspirate for blood or spinal fluid in at least two, and preferably four, planes.

POST-BLOCK CONSIDERATIONS

Care of the Patient.—The patient must be carefully observed for *at least 30 minutes* following the block to be sure that major complications do not occur. If the physician cannot do this himself, a nurse should be in attendance. Generally, the patient need not remain in the office for any extended period of time following the block, but should a complication arise, some type of accommodation should be available. Patients rarely require hospitalization following this block unless a long-acting blocking agent has been employed. However, when major complications occur, it may be necessary to hospitalize the patient overnight for the patient's as well as the physician's protection.

Instructions to the Patient.—As noted before, the minor complications and side effects of the procedure should be explained to the patient. Otherwise, he will often become alarmed, refuse another block, and make repeated telephone calls to the physician. He should be told that on arising he may feel dizzy and have a tendency to veer to the blocked side when walking. For these reasons it is best to have the patient escorted from the office to his home. However, since this may be impractical at times, the patient, cognizant of the problem, usually copes with it satisfactorily.

HEMORRHAGE FOLLOWING STELLATE GANGLION BLOCK

Anticoagulant Therapy or Blood Dyscrasia.—If a stellate ganglion block is used when the bleeding time is increased or the clotting time decreased, the risk of profuse hemorrhage into the tissues from a punctured blood vessel is always present. The use of a 22-gauge or smaller gauge needle lessens this complication but even with a small gauge needle the block should be undertaken only after careful evaluation (see Chapter 13, page 127).

REFERENCE

1. Lane, C. G. and Luikart, R.: Dermatitis from Local Anesthetics, with a Review of One Hundred and Seven Cases from the Literature. *J.A.M.A., 146*:717-720, 1951.

CHAPTER 2

Anatomy of the Cervical and Upper Thoracic Portions of the Sympathetic Nervous System

ROENTGENOLOGICALLY-CONTROLLED stellate ganglion block studies have proven conclusively that in a correctly executed stellate ganglion block the solution bathes the upper three or four thoracic sympathetic ganglia and their rami and the cervical sympathetic chain as high as the level of the fifth cervical vertebra (see Chapter 9, page 77). Since the cervical sympathetic trunk above the level of the first thoracic vertebra has been shown to lack any direct connection with the spinal cord by way of the rami communicantes, it can be assumed that the fibers to the entire cervical sympathetic trunk are paralyzed as they ascend through the areas bathed by the blocking solution.

It should be constantly borne in mind that all of the sympathetic pathways described, not only carry the expected visceral efferent fibers that are secretory to glandular structures and motor to both smooth and cardiac muscle, but that each branch or trunk of the sympathetic system also may carry visceral afferent fibers which are important not only in exciting visceral reflexes but also in the mediation of visceral sensibility including pain. The stellate ganglion, the upper thoracic sympathetic trunk and the cervical sympathetic trunk may be considered an *anatomic funnel* through which all sympathetic fibers must flow on their way to the head, neck and thorax. Specific emphasis must be placed on the anatomical relationships in the region of the stellate ganglion because it is there that the attempts to block the cervico-thoracic portion of the sympathetic nervous system are most frequently made.

The *classical descriptions* of these regions as found in well known anatomy books in common use are summarized below.[1, 2, 3, 4, 5, 6] Variations from the classical description as well as comments on additional individual studies will follow this standard textbook description.

THE COMPONENTS AND DISTRIBUTION OF THE THORACIC PORTION OF THE SYMPATHETIC NERVOUS SYSTEM

The thoracic portion of the sympathetic nervous system is derived from the thoracic cord segments one to four via their anterior roots and the respective upper four thoracic sympathetic trunk ganglia (Figure 7, page 14). The exact number of ganglia involved may vary because of the coalescence of two ganglia. The ganglia rest against the heads of the ribs and are covered by the costal pleura (Figure 4, page 11). This relationship to the pleura is constant except in the region of the first thoracic vertebra where the cupula of the lung separates from the neck of the first rib and the body of the vertebra (Figure 5, page 12). *This close relationship of the pleura must be kept in mind when the posterior thoracic approach to the stellate ganglion is used. It is this relationship which may cause the physician to have a relatively high incidence of pneumothorax with the posterior approach.*

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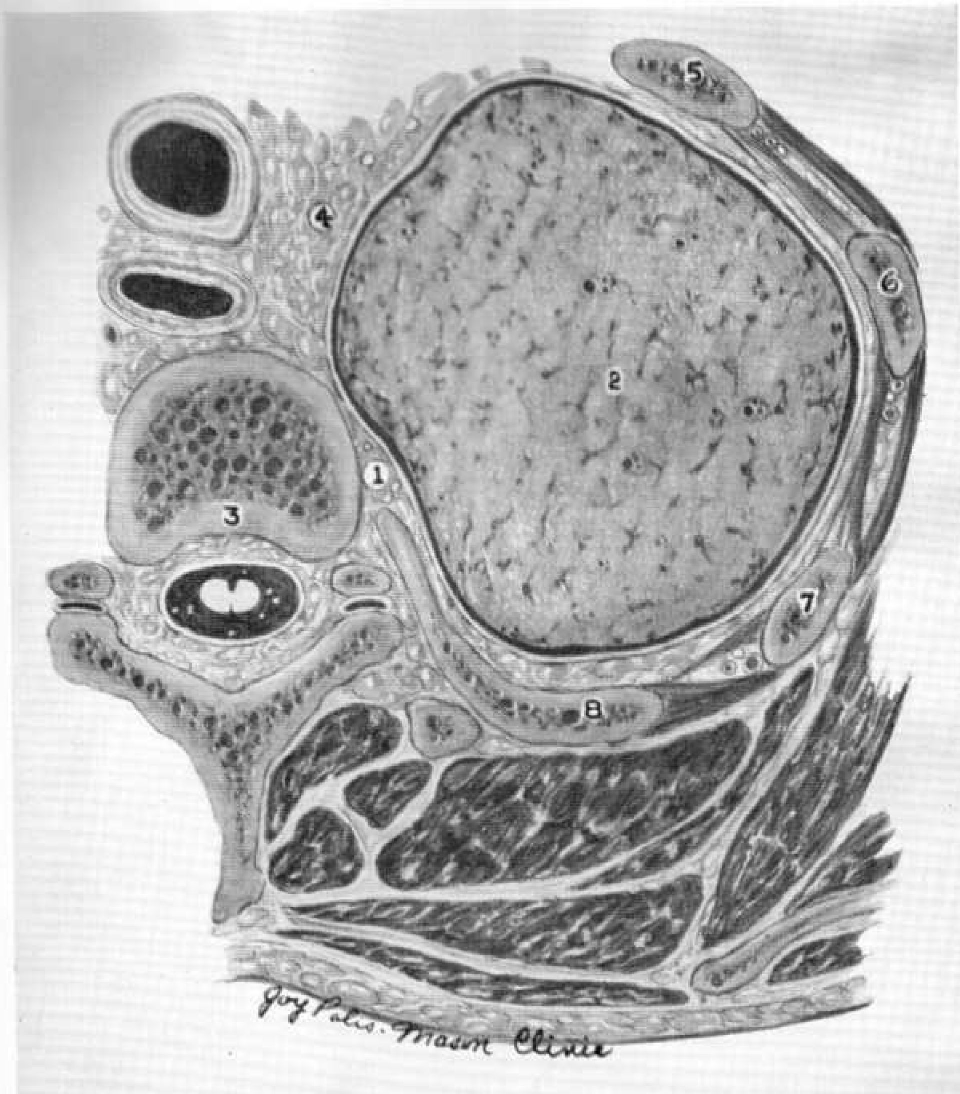

Figure 4. Cross section at the level of the lower part of the body of the third thoracic vertebra. 1. Sympathetic ganglion. 2. Lung. 3. Third thoracic vertebra. 4. Vagus nerve. 5. Fifth rib. 6. Second rib. 7. Third rib. 8. Fourth rib.

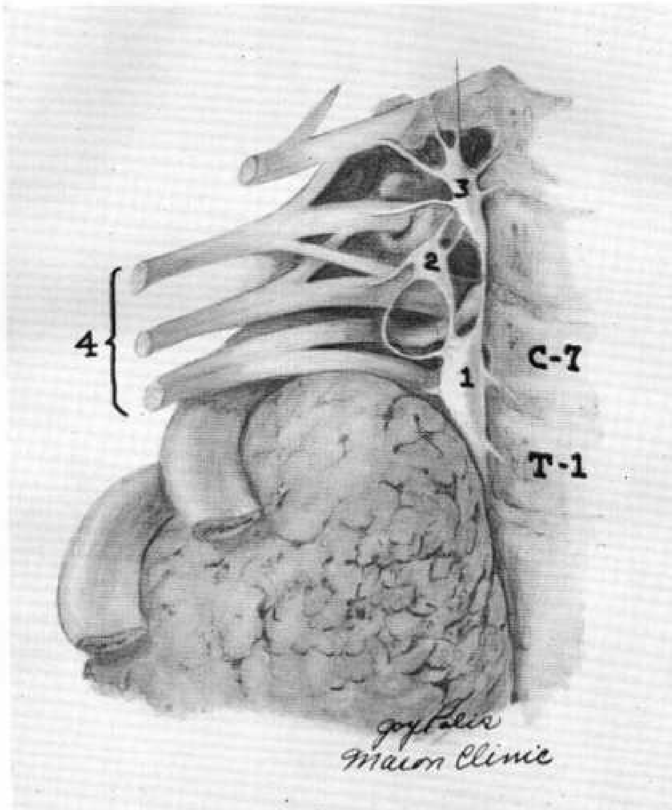

Figure 5. Anterior view of the relationship of the lung to the cervico-thoracic portion of the sympathetic nervous system, taken from an anatomical dissection (life size). 1. Stellate ganglion. 2. Intermediate ganglion. 3. Middle cervical ganglion. 4. Brachial plexus.

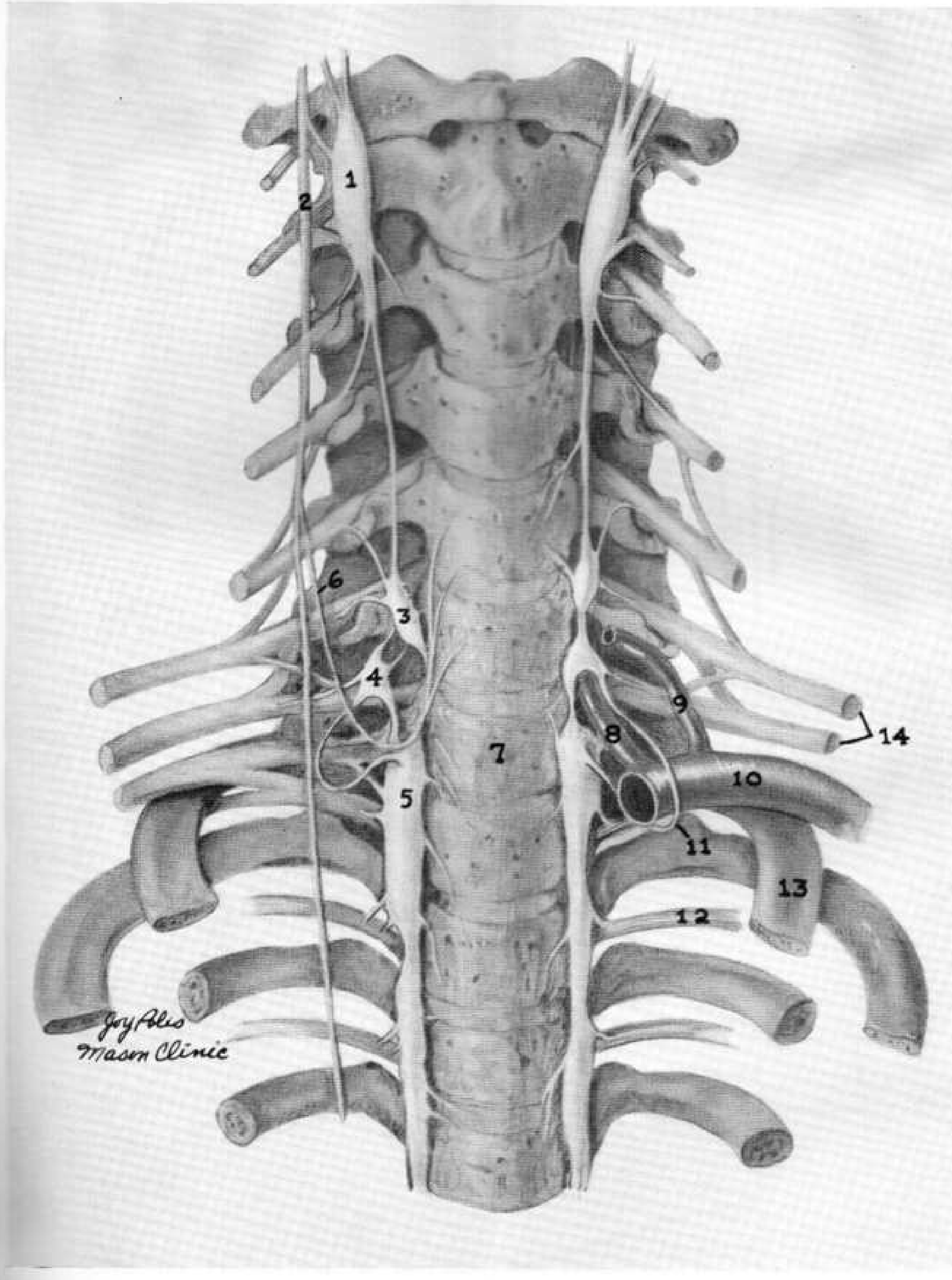

Figure 6. Anterior view of the cervico-thoracic portion of the sympathetic nervous system taken from a cadaver dissection (life size). 1. Superior cervical ganglion. 2. Vagus nerve. 3. Middle cervical ganglion. 4. Intermediate ganglion. 5. Stellate ganglion. 6. Recurrent laryngeal nerve. 7. Seventh cervical vertebra. 8. Vertebral artery. 9. Inferior thyroid artery. 10. Subclavian artery. 11. Ansa subclavia. 12. Second intercostal nerve. 13. First rib. 14. Part of the brachial plexus.

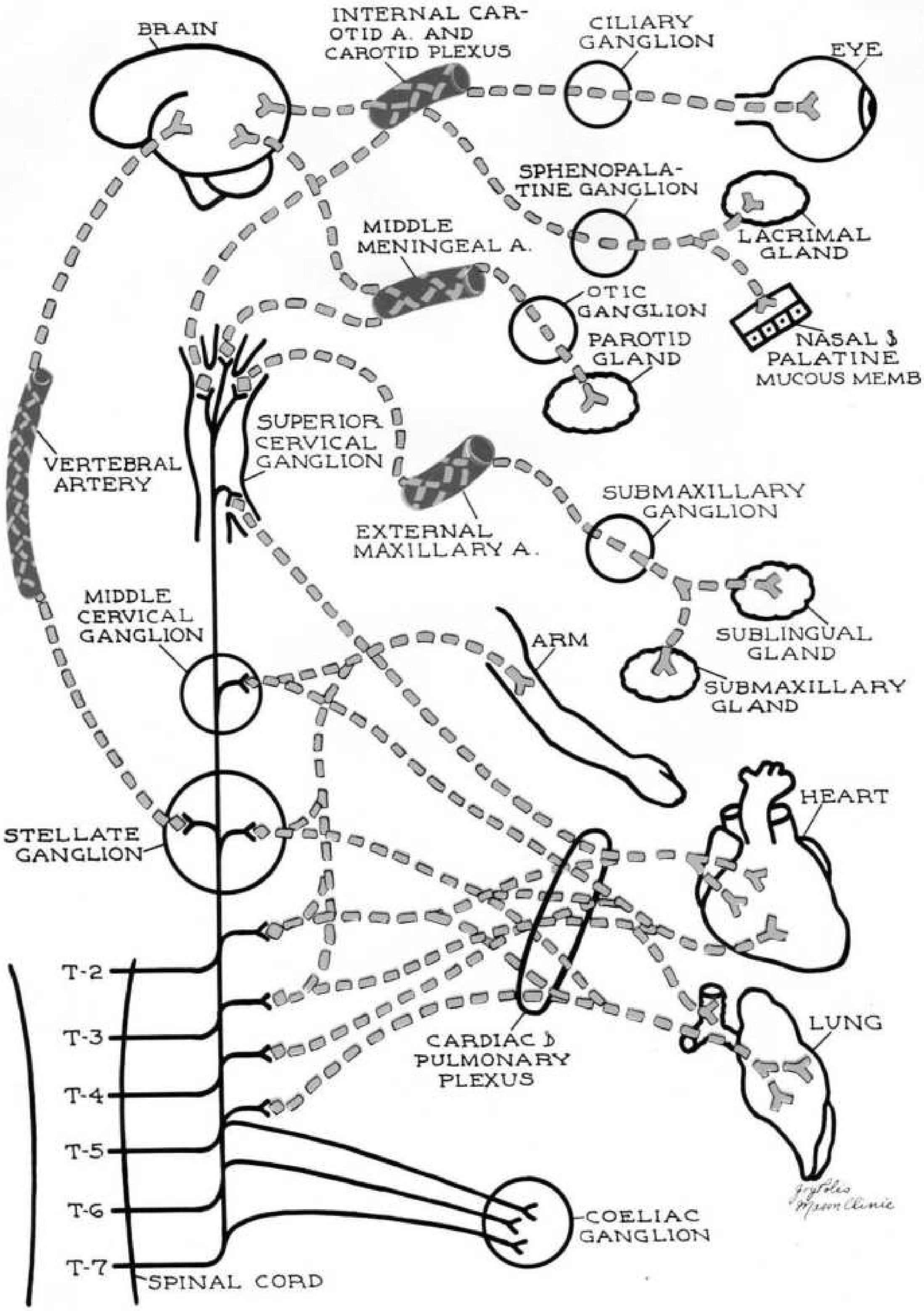

Figure 7. (After McDonald, Green and Lange.[13]) Schematic drawing of the origin and outflow of the cervicothoracic portion of the sympathetic nervous system.

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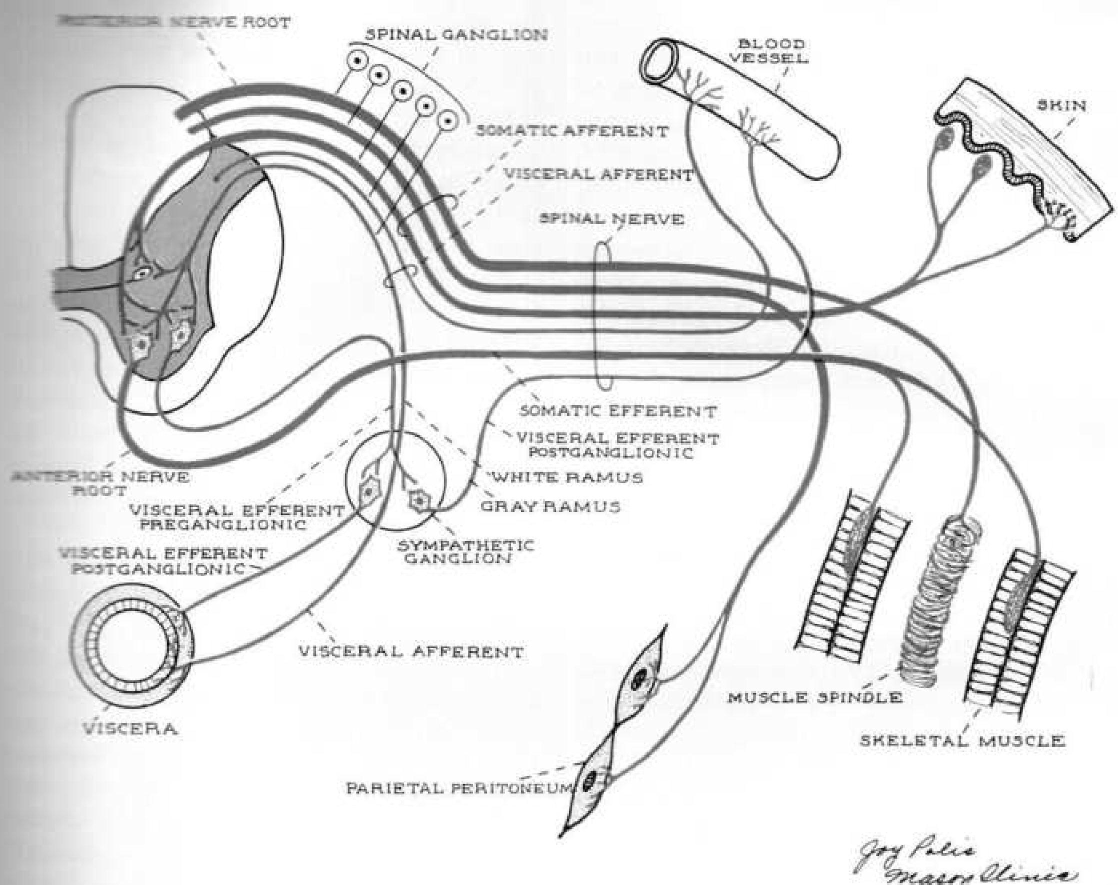

Figure 8. (After Gray.[1]) Cross-sectional schematic drawing of a spinal nerve showing the sympathetic ganglion and its connection to the spinal cord via the rami communicantes.

The thoracic sympathetic ganglia are small and grayish-white. The first thoracic sympathetic ganglion and the inferior cervical ganglion may unite to form the stellate ganglion. When this fusion takes place, the resulting ganglion usually measures 2.5 cm. x 1 cm. x 0.5 cm., and it is larger than the individual thoracic sympathetic ganglia and the middle cervical sympathetic ganglion, but smaller than the superior cervical sympathetic ganglion (Figure 6, page 13). The visceral nerves, from the upper four or five thoracic ganglia, supply filaments to the plexus on the thoracic aorta and other branches terminate in the cardiac plexus (Figure 7, page 14). These are the direct thoracic cardiac nerves and carry not only cardiac accelerator fibers but also pain fibers from the heart. Filaments from the second, third and fourth ganglia enter the pulmonary plexus and are responsible for carrying the afferent impulses from the lung as well as "broncho-regulatory" fibers. Each thoracic sympathetic ganglion is connected to its spinal nerve by a white ramus communicans and a gray ramus communicans and thus contributes sympathetic fibers to the upper chest wall (Figure 8, page 15). Twigs from the second and third thoracic sympathetic ganglia often go directly to the upper extremity, by-passing the stellate ganglion (Figure 10, page 21, and Figure 11, page 23). These aberrant twigs are sometimes known as the "nerve of Kuntz." The thoracic sympathetic trunk is continued cephalad into the neck as the cervical sympathetic trunk.

THE COMPONENTS AND DISTRIBUTION OF THE CERVICAL PORTION OF THE SYMPATHETIC NERVOUS SYSTEM

This portion of the sympathetic nervous system is a direct continuation cephalad of the thoracic portion of the sympathetic nervous system. It is the consensus of anatomists, neurosurgeons and other scientific investigators doing clinical and experimental research, that no connection between the cervical sympathetic trunk and the spinal cord exists except through the thoracic portion of the sympathetic nervous system.[1, 3, 5]

The cervical portion of the sympathetic nervous system consists of the inferior cervical ganglion which, fused with the first thoracic ganglion, is known as the stellate ganglion, the intermediate ganglion (not always present), the middle cervical ganglion, the superior cervical ganglion, the branches from the ganglia and the main trunk connecting the ganglia (Figure 6, page 13).

Inferior Cervical Ganglion and/or Stellate Ganglion.—The inferior cervical ganglion lies at the inferior border of the base of the transverse process of the seventh cervical vertebra (Figure 6, page 13). In more than 50% of the cases it is fused with the first thoracic sympathetic ganglion to form the stellate ganglion. The stellate ganglion may extend from the inferior edge of the base of the transverse process of the seventh cervical vertebra to the level of the cephalad portion of the base of the transverse process of the second thoracic vertebra.

The inferior cervical ganglion and/or stellate ganglion gives off the following branches (Figure 6, page 13; and Figure 7, page 14): (1) Gray rami communicantes to the brachial plexus via the seventh and eighth cervical and the first thoracic nerves. (2) The inferior cardiac nerve to the cardiac plexus. (3) Branches to the vertebral artery which presumably follow the artery, thus reaching the cranial cavity (although there is some experimental ground for denying this concept).[7] (4) Other peripheral branches are contributed to the inferior thyroid plexus, the subclavian plexus and occasionally there is a twig to the phrenic nerve.

The intermediate ganglion has been variously interpreted by different authors being most commonly regarded as either an individual and independent ganglion of the cervical trunk or as a low type of middle cervical ganglion (Figure 6, page 13). Its close proximity to the inferior cervical ganglion renders it difficult to distinguish from the latter in some instances. When it is absent, its cell bodies will reside in either the middle or inferior cervical sympathetic ganglia and hence its branches will, in those instances, spring from these respective ganglia.

The Middle Cervical Ganglion.—The middle cervical ganglion is the smallest of the three cervical ganglia and is connected to the inferior or to the intermediate ganglion by the main trunk (Figure 6, page 13). It usually lies anterior to the transverse process of the sixth cervical vertebra (Figure 6, page 13). The inferior thyroid artery may lie either anterior or posterior to the cervical sympathetic trunk and is usually quite close to the middle ganglion as it passes medialward (Figure 6, page 13).

The middle cervical ganglion gives off the following branches (Figure 7, page 14): (1) Gray rami communicantes to the brachial plexus by way of the fifth and sixth cervical nerves. These nerves carry sympathetic components to the blood vessels, sweat glands and superficial muscles of the arm. (2) The middle cardiac nerve. This is the largest of the cardiac nerves and courses down the neck to the deep part of the cardiac plexus. (3) Twigs to the thyroid gland by way of the inferior thyroid artery.

Superior Cervical Ganglion.—This is the largest of the cervical ganglia and is located opposite the second and third cervical vertebrae (Figure 6, page 13). It varies in shape but it is thought to be formed by the fusion of the upper four cervical sympathetic ganglia. It lies in front of the transverse process and the longus capitus muscle and behind the internal carotid artery and internal jugular vein. It is connected to the middle cervical ganglion by a single trunk (Figure 6, page 13).

The branches of the superior cervical ganglion are (Figure 7, page 14):—(1) Gray rami communicantes to the upper four cervical nerves. (2) Twigs to the ganglion nodosum of the vagus, petrous ganglion of the glossopharyngeal nerve, jugular ganglion of the vagus, and the hypoglossal nerve. (3) The internal carotid nerve. This passes with the internal carotid artery into the skull forming the internal carotid plexus and the cavernous plexus. (4) The left and right superior cardiac nerves. These go to the superficial part of the cardiac plexus and the deep part of the cardiac plexus, respectively. (5) Filaments to the carotid sinus and carotid body. (6) Communicating branches to the glossopharyngeal, external laryngeal and vagus nerves for the pharyngeal plexus. (7) Branches to the external carotid artery. These form the external carotid plexus.

From the internal and external carotid plexus, the sympathetic fibers reach the structures of the head via the blood vessels. The internal carotid plexus, situated on the lateral side of the artery, sends branches to the abducens nerve, the tympanic branch of the glossopharyngeal nerve, the lacrimal gland and the naso- and oropharynx by way of the sphenopalatine ganglion, and the semilunar ganglion (Figure 7, page 14).

That portion of the internal carotid plexus situated along the carotid artery as it lies within the cavernous sinus sends branches to the three nerves of the ophthalmic division of the trigeminal nerve, to the dilator pupillae by way of the nasociliary nerve and ciliary ganglion, to the vessels of the pituitary body, to the orbit by way of the ophthalmic artery, and to the eyeball, the conjunctiva and the nose, via the communicating branches of the cavernous plexus (Figure 7, page 14).

The external carotid plexus supplies fibers to the vessels, cutaneous muscles and sweat glands of the face, to the submaxillary gland via the facial artery, and to the parotid gland via the plexus along the external carotid itself (Figure 7, page 14).

THE BOUNDARIES OF THE FASCIAL COMPARTMENT IN WHICH THE THORACIC SYMPATHETIC AND CERVICAL SYMPATHETIC NERVOUS SYSTEMS ARE FOUND

This is of great importance if the diffusion pattern of an injected blocking solution in the region between the fourth thoracic and the fifth cervical vertebra is to be clearly understood. Hovelacque [8] described the stellate ganglion as lying in a fascial plane which is limited inferiorly by the posterior aspect of the cupula of the pleura, medially by the portion of the vertebral column covered by the longus colli muscle, laterally by the scalenus anticus muscle mass, anteriorly by the subclavian and vertebral arteries and posteriorly by the anterior surface of the transverse process of the seventh cervical vertebra, the anterior surface of the neck of the first rib and the interspace between these two structures. The stellate ganglion lies in soft adipose and areolar tissue and can be easily dissected out. Likewise, Hovelacque stated, concerning the fascia in the lower part of the neck, that there exists a prevertebral fascia and a deep or visceral fascia. The prevertebral fascia covers the prevertebral muscles. The deep, or visceral, fascia envelopes the viscera and the vessels before it is applied to the prevertebral fascia. This relationship exists to the level of the inferior thyroid artery; below that there is no definite enclosure. The cellular tissue is loose in front of the prevertebral fascia in the whole inferior region of the neck. Hovelacque's description of the anatomy in the region of the stellate ganglion explains why solutions injected in this area diffuse rapidly. Also, it elucidates the reason for the pattern which is seen when Diodrast solutions are employed in stellate ganglion blocks (see page 77).

de Sousa Periera [9] in his technique for injecting the stellate ganglion places the patient in the sitting position so that the solution will gravitate from the region of the injection via the above described space to the region of the stellate ganglion. From roentgenologic studies it is highly doubtful that gravity has much to do with this spread (see Chapter 9, page 65). If the needle point is placed in the correct fascial plane and 10 cc. to 15 cc. of solution injected, the pressure created by this amount of injected fluid accounts for most of the spread. The use of Diodrast (iodopyracet) and x-ray substantiates this (see Chapter 9, page 77).

RELATIONSHIP OF THE CERVICO-THORACIC SYMPATHETIC TRUNK TO OTHER ANATOMICAL STRUCTURES AT THE LEVEL OF THE SEVENTH CERVICAL AND FIRST THORACIC VERTEBRAE

Anatomical relations in this area are described because most of the approaches used are directed at placing the needle in the region of the stellate ganglion located at this level. It is a well-chosen spot for the injection because it is approximately midway between the fifth cervical and fourth thoracic vertebra, and it is known from roentgen studies that the solution diffuses both superiorly and inferiorly to these levels (see Chapter 9, page 76).

Relationship of the Stellate Ganglion to the Somatic Nerves.—The stellate ganglion usually lies in front of the eighth cervical nerve and the first thoracic nerve (Figure 6, page 13). Therefore, when using the posterior approach these nerves are more often stimulated, resulting in sensations along the inner aspect of the forearm. Stimulating these nerves with the needle, though quite painful to the patient, is in no way detrimental to the results of the block nor should the block be discontinued because of pain. The paresthesias from these somatic nerves signal to the physician that the needle point is too far posterior when the lateral, antero-lateral or anterior approach is being employed. These paresthesias indicate that the needle point is not far enough anterior if the posterior approach is being attempted. The patient should be forewarned about paresthesias and reassured that no harm can result from them.

Relationship of the Stellate Ganglion to the Blood Vessels.—The carotid artery lies over the sympathetic chain and must be drawn laterally to expose it when the anterior (paratracheal) approach is used (Figure 9, page 19).

The subclavian artery as it arches over the dome of the pleura lies in front of the stellate ganglion (Figure 6, page 13). The subclavian artery gives off the vertebral artery, the inter-

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Figure 9. Cross section at the level of the seventh cervical vertebra (life size). 1. Stellate ganglion. 2. Vertebral artery. 3. Esophagus. 4. Trachea. 5. Thyroid gland. 6. Spinous process of C_6. 7. Seventh cervical vertebra. 8. Vagus nerve and carotid vessels.

nal mammary, the costocervical trunk and the thyrocervical trunk. The inferior thyroid artery arising from the thyrocervical trunk and the superior intercostal artery arising from the costocervical trunk are seldom, if ever, punctured during the placement of the needles. *The vertebral artery on the other hand is quite vulnerable as it often lies within or close to the mass of nervous tissue comprising the stellate ganglion* (Figure 6, page 13). When the stellate ganglion is divided into a first thoracic ganglion proper and an inferior cervical ganglion, the cord connecting the two lies behind the vertebral artery. When the intermediate ganglion is present, it usually lies directly in front of the vertebral artery and is connected below with the stellate ganglion or the inferior cervical ganglion by a divided main trunk which twines about the vertebral artery as it descends. It is also connected to the stellate ganglion by the ansa subclavia. The vertebral artery is a direct path to the medulla oblongata, and an injection of a *large* amount (5 or more cc.) of the blocking agents into it may result in a rapid catastrophic reaction characterized by immediate loss of consciousness, thready pulse, and low or undetectable blood pressure.

Relationship of the Stellate Ganglion to the Lungs.—The cupula of the lung lies in front of the sympathetic chain (Figure 5, page 12). The superior part of it reaches the level of the clavicle anteriorly and the level of the first thoracic vertebra posteriorly on the right side. On the left side the superior edge of the lung is lower by ⅜ inch (1 cm.) to ¾ inch (2 cm.) so that it is less likely to be punctured. The cupula of the lung in the supra-clavicular region of the average healthy patient does not lie as close to the vertebral column as it does at the level of the inferior edge of the first thoracic vertebra. This is demonstrable in x-ray films where Diodrast (iodopyracet) block solutions have been injected (Figure 35, page 74 and Figure 38, page 77). In the embalmed cadaver this may not be demonstrable. While a pneumothorax may occur during any approach to the stellate ganglion, depending on the skill of the physician in the placing of the needle, it is less likely to occur with the anterior (paratracheal) approach because of this lateral curve of the cupula away from the vertebrae.

Relationship of the Stellate Ganglion to the Trachea and Esophagus.—The trachea and esophagus lie in the midline medially and anteriorly to the right and left sympathetic trunks (Figure 9, page 19). The esophagus, however, may curve slightly to the left. This curve in the esophagus is of little significance except in the anterior approach to the stellate ganglion. Its deviation may be straightened to a midline position by having the patient maximally extend his neck.

Relationship of the Stellate Ganglion to the Vertebral Column.—The sympathetic chain, at the level of the seventh cervical vertebra, lies at the base of its transverse process at its junction to the body (Figure 6, page 13 and Figure 9, page 19). The chain lies a little closer to the vertebral bodies in both the upper cervical and upper thoracic regions than it does at the level of the seventh cervical vertebra. The stellate ganglion itself usually extends from the lower border of the transverse process of the seventh cervical vertebra to the inferior edge of the transverse process of the first thoracic vertebra (Figure 6, page 13). The longus colli muscle lies between it and the transverse processes (Figure 9, page 19).

Relationship of the Stellate Ganglion to the Vagus and Recurrent Laryngeal Nerves.—The vagus nerve lies in the carotid sheath almost directly anterior to the sympathetic chain (Figure 9, page 19). The recurrent laryngeal nerve lies medial to the sympathetic chain and slightly anterior to it and may become involved during a block because of diffusion of the solution (Figure 6, page 13). The patient then may become hoarse. He may also have difficulty in swallowing fluid and food because of the non-closure of the laryngeal aditus.

The Relationship of the Stellate Ganglion to the Thyroid Gland (Figure 9, page 19).—The thyroid gland lies anterior and medial to the sympathetic chain, and at times the gland covers it. This relationship is unimportant

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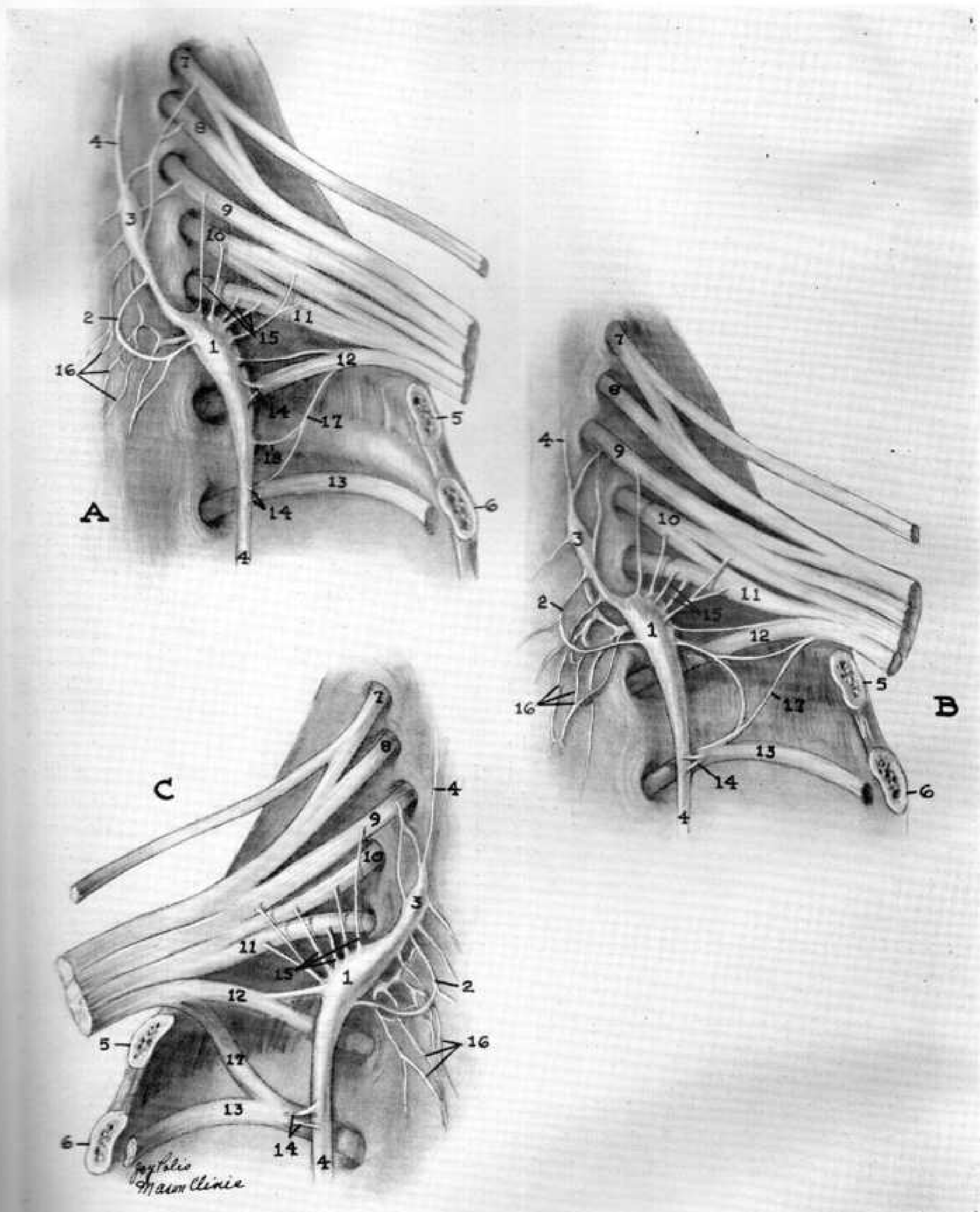

Figure 10. (After Kuntz.[11]) Variations in the sympathetic nerve distribution to the brachial plexus. 1. Stellate ganglion. 2. Ansa subclavia. 3. Middle cervical ganglion. 4. Sympathetic trunk. 5. First rib. 6. Second rib. 7. Fourth cervical nerve. 8. Fifth cervical nerve. 9. Sixth cervical nerve. 10. Seventh cervical nerve. 11. Eighth cervical nerve. 12. First thoracic nerve. 13. Second thoracic nerve. 14. Communicating rami. 15. Gray communicating rami. 16. Cardiac nerves. 17. Inconstant intrathoracic ramus from T_2 to T_1. 18. Sympathetic ramus joining ramus from T_2 to T_1.

when any approach but the anterior is employed. When using the anterior approach the gland must at times be punctured, but no sequelae have been noted in our series of cases.

ADDITIONAL INDIVIDUAL STUDIES OF THE CERVICO-THORACIC PORTION OF THE SYMPATHETIC NERVOUS SYSTEMS WITH VARIATIONS FROM THE CLASSICAL DESCRIPTION

Perlow and Vehe.[10]—They found the following in their dissections: (1) That the size of the stellate ganglion varied from 1 to 3 cm. in length and from 3 to 10 mm. in width. The dimensions of the stellate ganglia were bilaterally identical in 18 of the 24 cadavers. (2) Forty of the 48 dissections had inferior cervical ganglia which were continuous with the first thoracic ganglia. In the remaining eight dissections, they were separated but connected by a short cord. (3) In three instances there were two definite cords between the inferior cervical and the first thoracic ganglia. (4) The ganglion was found to lie anterior to the vertebral artery in 2 dissections, medial in 23, posterior in 2, medial and posterior in 5, and medial and anterior in 16 instances. (5) In all cases the cords connecting the stellate to the middle cervical ganglion were in close approximation to the vertebral vessels. (6) The eighth cervical and the first thoracic spinal nerves received gray rami from the stellate in all of the dissections. In three instances, the first thoracic nerve received additional gray rami direct from the second thoracic sympathetic ganglion.

Kuntz.[11]—During dissection of the sympathetic rami to the brachial plexus in 48 cadavers, Kuntz found that variations in the rami of the sympathetic nervous system to the brachial plexus, as well as the rami from the second intercostal nerve to the first intercostal nerve, are not infrequent (Figure 10, A, B, C, page 21. He stressed that sympathetic rami to the brachial plexus may arise as low as the second thoracic vertebra (Figure 10, A, B, C, page 21). Therefore, he drew the following conclusions: (1) Stellectomy or section of the gray rami connecting this ganglion with the brachial plexus is inadequate to insure complete sympathetic denervation of the blood vessels of the upper extremity. (2) Complete sympathetic denervation of the upper extremity requires removal of the stellate ganglion and of the upper portion of the thoracic sympathetic trunk to the level below the communicating rami of the second thoracic nerve. From this study, one would conclude that to effectively paralyze the sympathetic nerves to the upper extremity the blocking solution must diffuse as low as the second thoracic vertebra. X-ray studies show that this does occur (see Chapter 9, page 77).

Kirgis and Kuntz.[12]—Following Kuntz's [11] previous study, Kirgis and Kuntz [12] in reviewing anatomical data pointed out that not all the sympathetic fibers which join the nerves of the brachial plexus traverse the gray communicating rami arising from the cervicothoracic and middle cervical ganglia. They believed that intrathoracic rami from the second and third thoracic nerves which join the first and second thoracic nerves respectively, in all probability, carry sympathetic fibers (Figure 11, page 23). Thus, they conclude that to completely denervate the upper extremity, extirpation of the cervico-thoracic and lower sympathetic trunk ganglia, including the second and third thoracic, must be performed in a relatively high number of cases. This would mean that for a stellate ganglion block to paralyze all the sympathetic nerves to the upper extremity, the injected solution must diffuse caudad to at least the third thoracic vertebra. Roentgenologically, studies have shown that in a correctly executed stellate ganglion block this does occur (see Chapter 9, page 77).

Johnson and Moore.—The dissections of the cadavers in this series were performed by Dr. Robert J. Johnson of the University of Washington Medical School. Drawings of all dissections were made by Joy Polis, medical illustrator, and checked by the dissector to insure accuracy. Both the dissections and the

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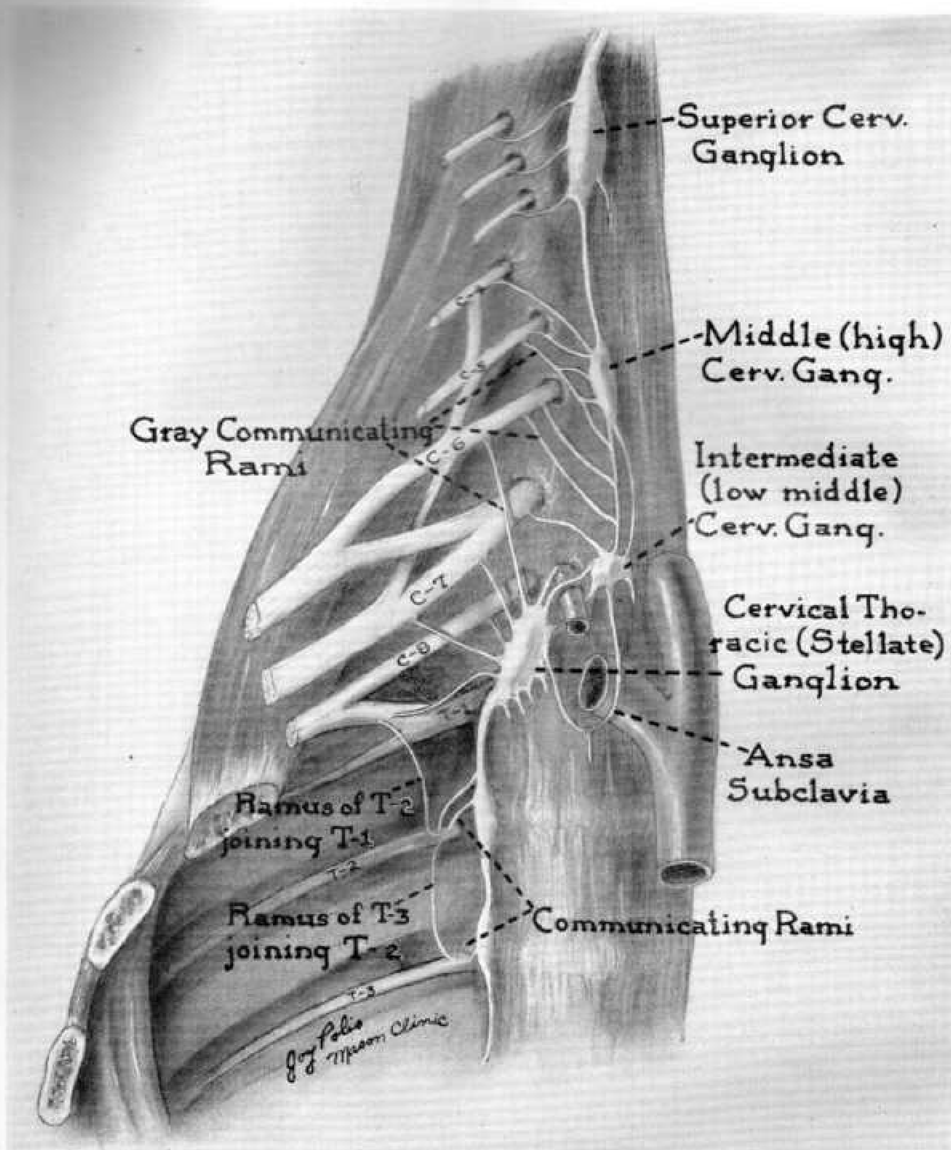

Figure 11. (After Kirgis and Kuntz.[12]) Variations in the sympathetic nerve distribution to the brachial plexus showing intrathoracic rami from second and third thoracic nerves.

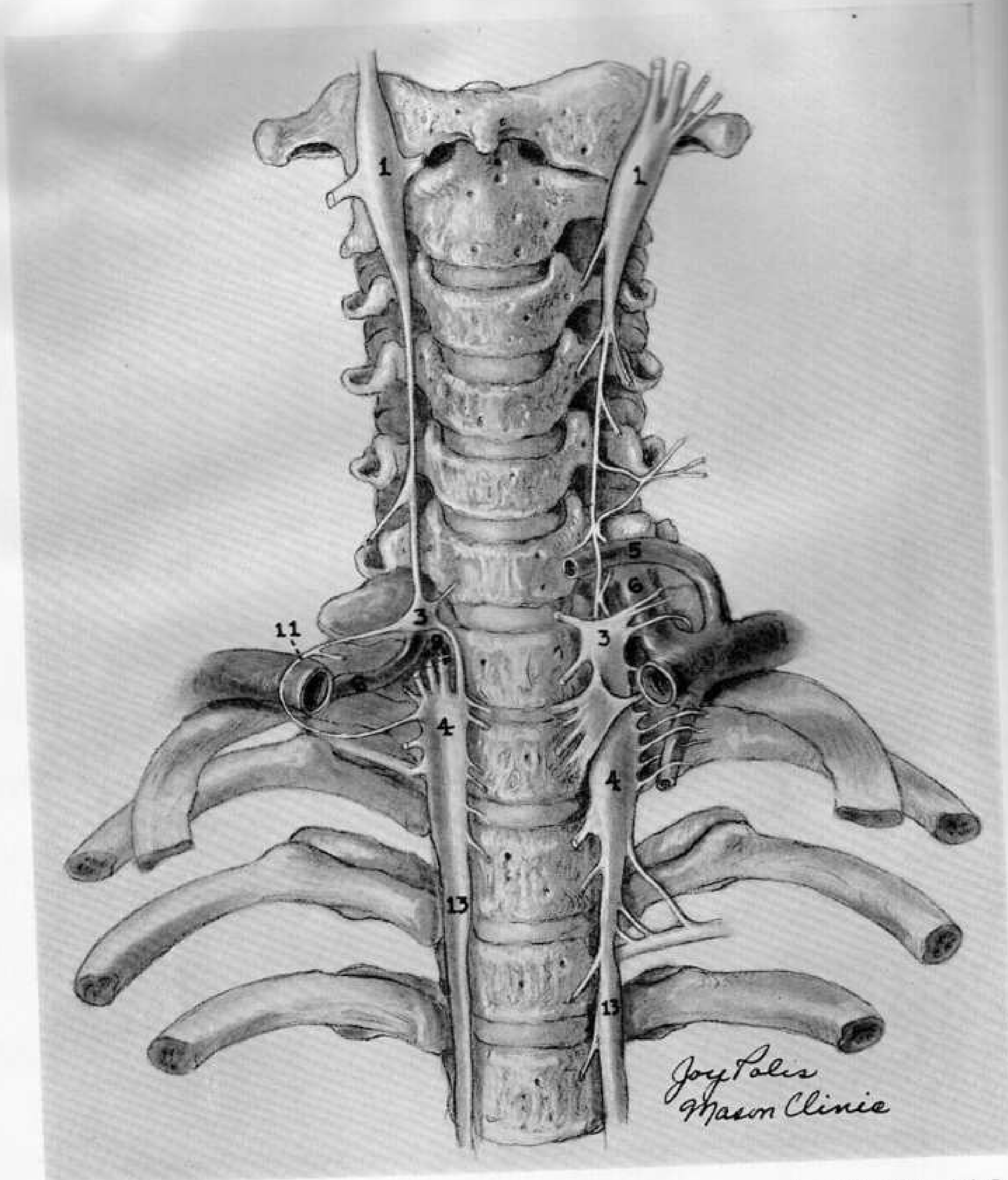

Figure 12. Anatomy of the cervico-thoracic portion of the sympathetic nervous system (life size). (1) Superior cervical ganglion. (3) Intermediate (or vertebral) ganglion. (4) Stellate ganglion. (5) Inferior thyroid artery. (6) Vertebral artery. (9) Nervus vertebralis. (11) Ansa subclavia. (13) Sympathetic chain caudad to first thoracic sympathetic ganglion.

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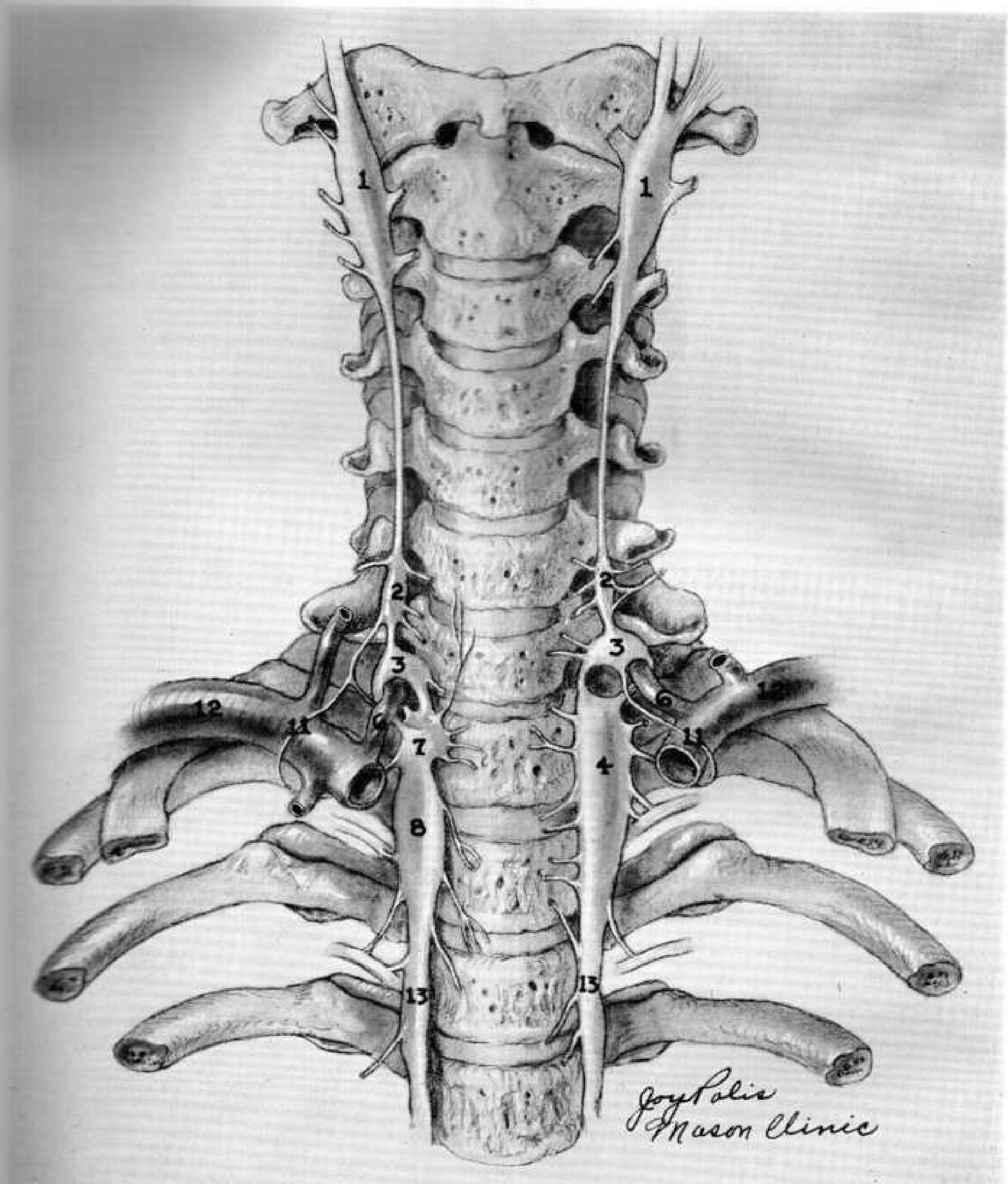

Figure 13. Anatomy of the cervico-thoracic portion of the sympathetic nervous system (life size). (1) Superior cervical ganglion. (2) Middle cervical ganglion. (3) Intermediate (or vertebral) ganglion. (4) Stellate ganglion. (6) Vertebral artery. (7) Inferior cervical ganglion. (8) First thoracic sympathetic ganglion. (11) Ansa subclavia. (12) Subclavian artery. (13) Sympathetic chain caudad to first thoracic sympathetic ganglion.

drawings were studied by the author. Illustrations 12 through 23 which appear herein were selected as representative of the anatomy of the cervico-thoracic portion of the sympathetic nervous system and its related structures as found in these dissections. For clarity, numbers rather than labels were chosen to identify the important anatomical structures in illustrations 12-23. The numbers used and the structures they signify are as follows:

1. Superior cervical ganglion.
2. Middle cervical ganglion.
3. Intermediate (or vertebral) ganglion.
4. Stellate ganglion.
5. Inferior thyroid artery.
6. Vertebral artery.
7. Inferior cervical ganglion.
8. First thoracic sympathetic ganglion.
9. Nervus vertebralis.
10. Kuntz's nerve.
11. Ansa subclavia.
12. Subclavian artery.
13. Second, third or fourth thoracic sympathetic ganglia. In illustrations 12-23, number 13 may be found on any of these three ganglia. It merely identifies the approximate position of the ganglia in the cervico-thoracic portion of the sympathetic chain. To accurately identify them, they should be compared with their respective thoracic vertebrae as well as the spinal nerves to which they supply gray rami communicantes.

When a number signifying a specific ganglion does not appear on these illustrations, it indicates that the ganglion assigned that particular number was *absent* in that cadaver. For example, in Figure 12, page 24, 2 is absent and this indicates the middle cervical ganglion could not be identified as a specific entity in the cadaver. It should be emphasized that the identification of the various ganglia was done on the cadaver rather than on the drawings.

The system used to identify the components of the cervico-thoracic portion of the sympathetic nervous system was not applied to the arteries depicted. In most instances, the vessels were included or identified only when they had a direct relationship to the cervico-thoracic sympathetic trunk. However, omission from an illustration does not mean that they were absent on the cadaver. For example, in Figure 12, page 24, the inferior thyroid artery on the right side, while present in the cadaver, was not depicted since its course was identical to the left inferior thyroid artery. Therefore, its depiction would serve no purpose except to clutter up the drawing. *It is emphasized that the main purpose of this study was to find the variations that occurred in the cervico-thoracic portion of the sympathetic nervous system—not those occurring in the other anatomical structures.*

The following brief description of the cervical and upper thoracic sympathetic trunk and of the findings in 37 body sides was written by Robert J. Johnson, M.D., Associate Professor of Human Anatomy at the University of Washington Medical School and contributed to the author for publication here. It is a portion of a more detailed study which is to be published by Dr. Johnson at a later date.

"The *Cervical Sympathetic Trunk* enters the neck from the superior thoracic aperture and ascends in front of the transverse processes of the cervical vertebrae to nearly reach the base of the skull. It terminates above in a ganglionic enlargement (superior cervical ganglion) lying anterior to the lateral mass of the first cervical vertebra and anterior to the transverse processes of the second and third cervical vertebrae (Figures 12-23). The cervical sympathetic trunk is usually described as possessing three ganglia distributed along its course. However, it would be more accurate to mention four ganglia as being present frequently enough to justify special names for them, and to ascribe a relatively typical locus for each of them. These ganglia are named, in sequence from above downwards, the superior cervical ganglion, the middle cervical ganglion, the intermediate cervical ganglion (the vertebral ganglion) and the inferior cervical ganglion (Figure 13, page 25, *Right side*). The inferior cervical gan-

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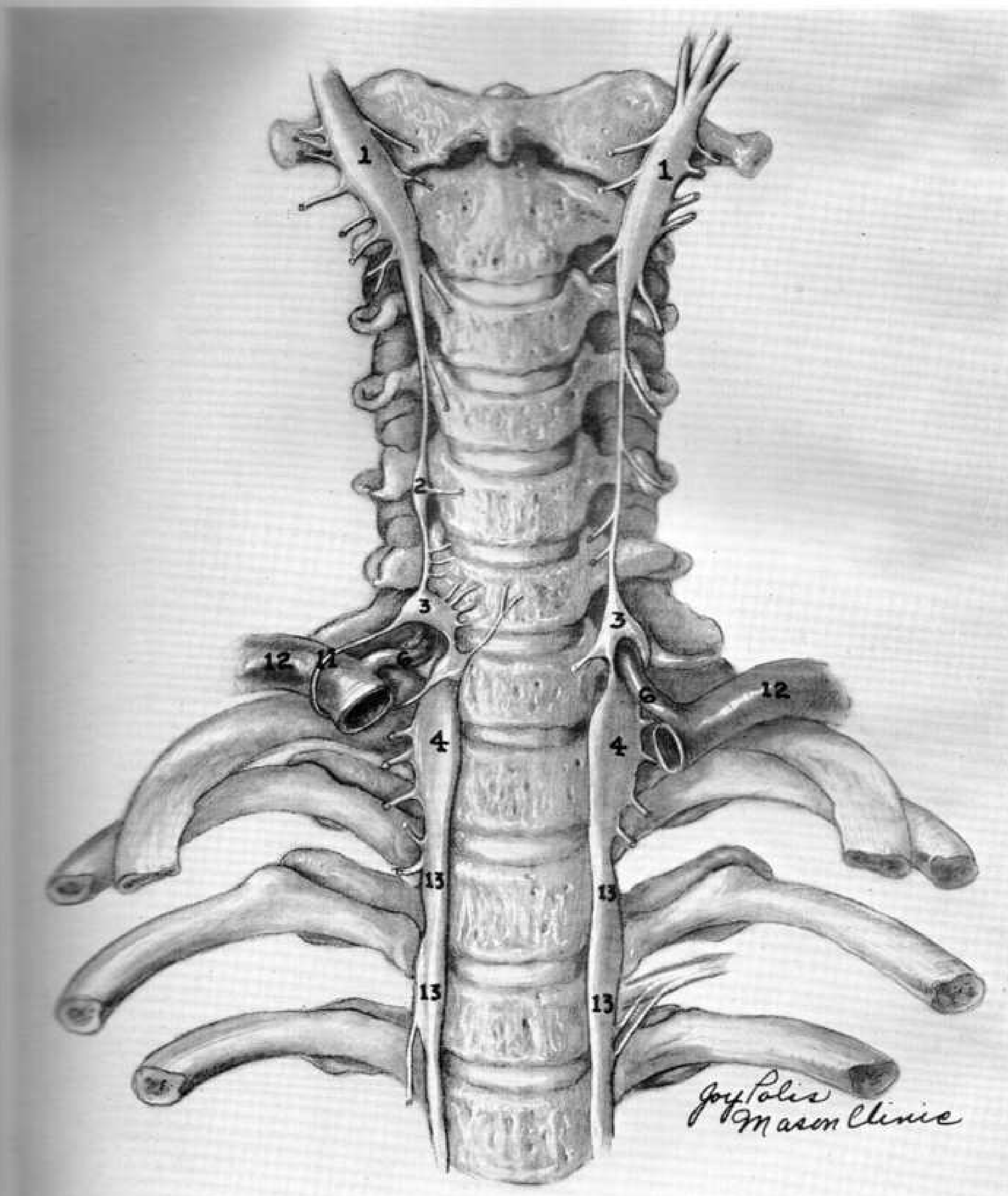

Figure 14. Anatomy of the cervico-thoracic portion of the sympathetic nervous system (life size). (1) Superior cervical ganglion. (2) Middle cervical ganglion. (3) Intermediate (or vertebral) ganglion. (4) Stellate ganglion. (6) Vertebral artery. (11) Ansa subclavia. (12) Subclavian artery. (13) Sympathetic chain caudad to first thoracic sympathetic ganglion.

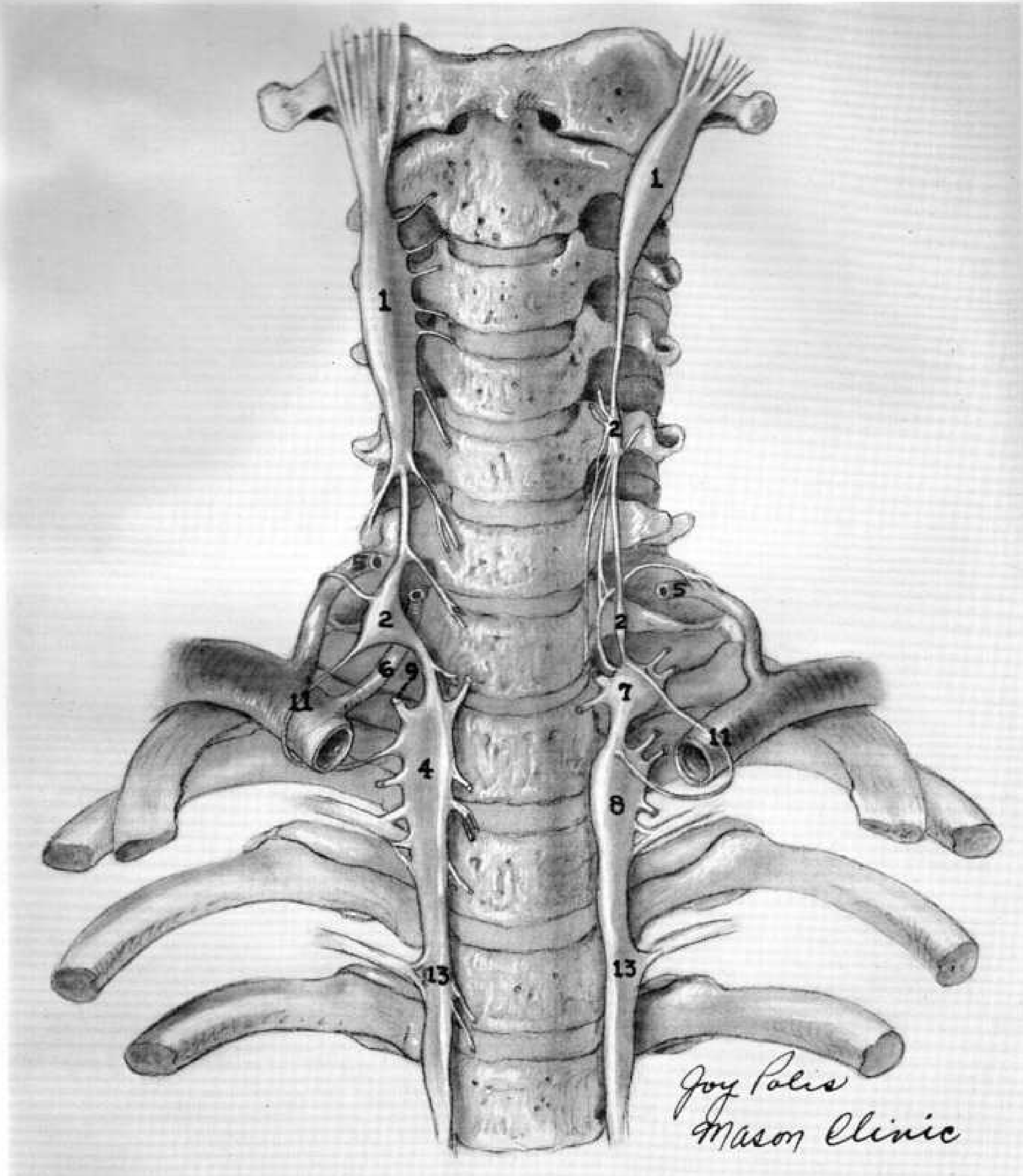

Figure 15. Anatomy of the cervico-thoracic portion of the sympathetic nervous system (life size). (1) Superior cervical ganglion. (2) Middle cervical ganglion. (4) Stellate ganglion. (5) Inferior thyroid artery. (6) Vertebral artery. (7) Inferior cervical ganglion. (8) First thoracic sympathetic ganglion. (9) Nervus vertebralis. (11) Ansa subclavia. (13) Sympathetic chain caudad to first thoracic sympathetic ganglion.

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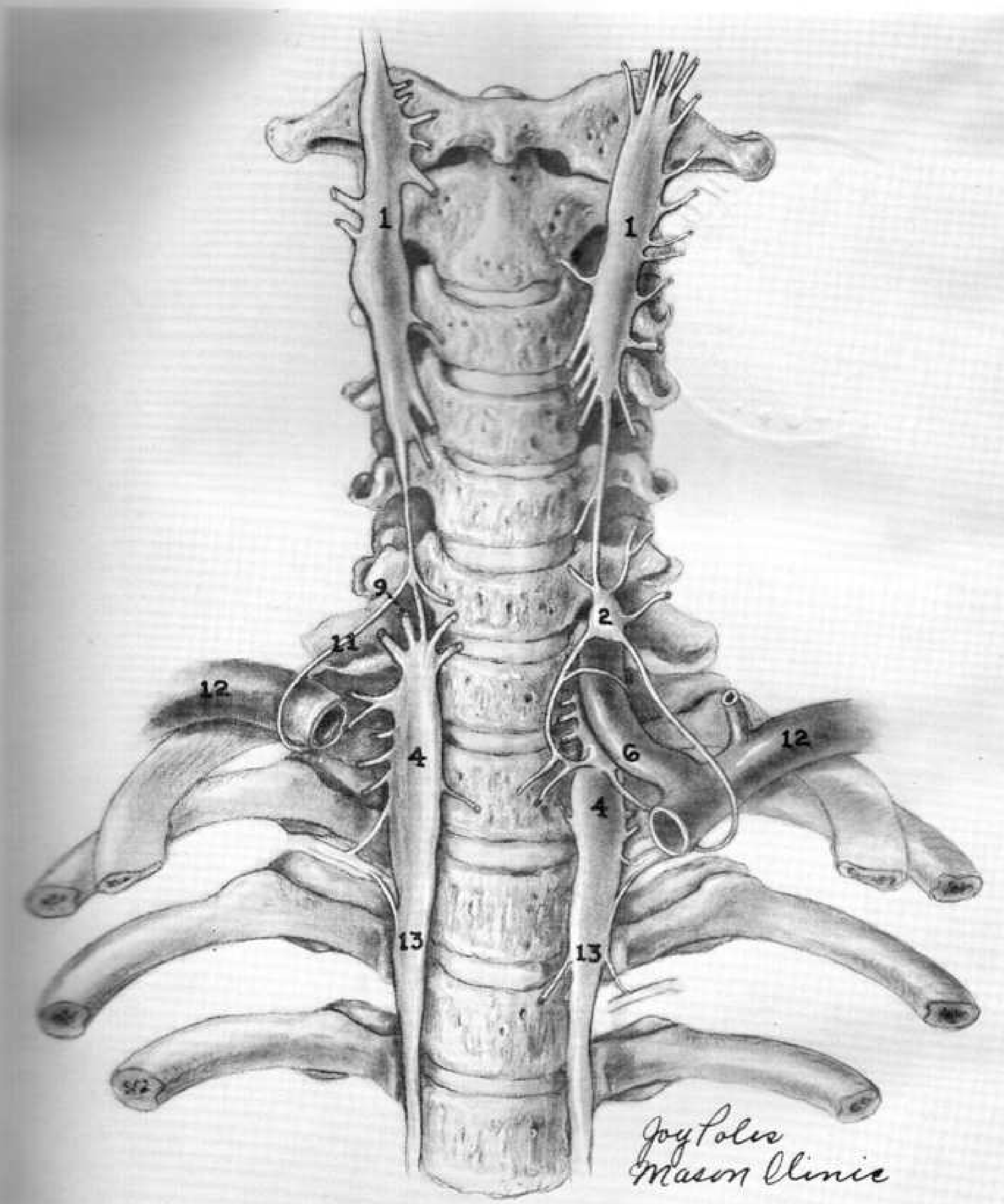

Figure 16. Anatomy of the cervico-thoracic portion of the sympathetic nervous system (life size). (1) Superior cervical ganglion. (2) Middle cervical ganglion. (4) Stellate ganglion. (6) Vertebral artery. (9) Nervus vertebralis. (11) Ansa subclavia. (12) Subclavian artery. (13) Sympathetic chain caudad to first thoracic sympathetic ganglion.

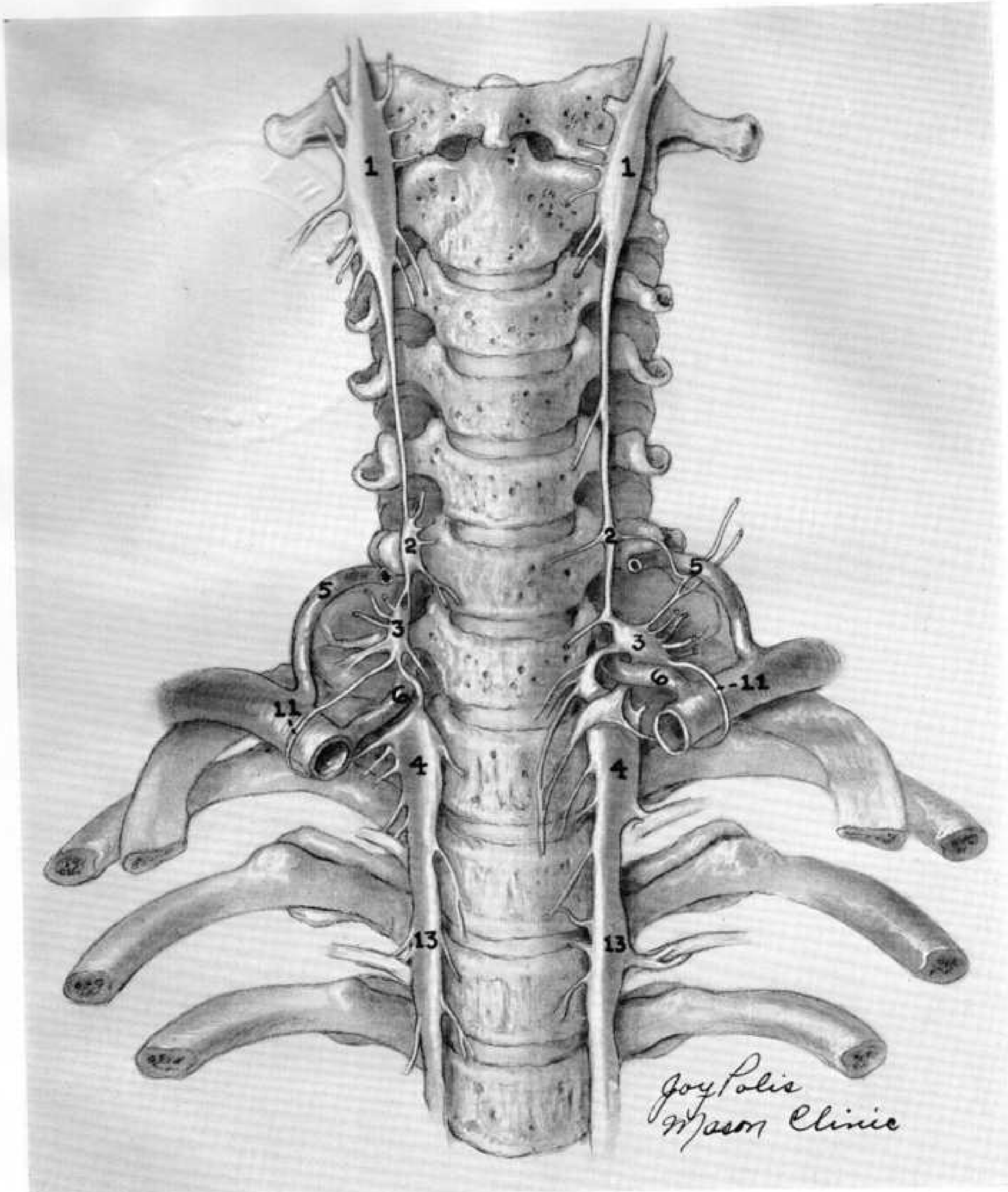

Figure 17. Anatomy of the cervico-thoracic portion of the sympathetic nervous system (life size). (1) Superior cervical ganglion. (2) Middle cervical ganglion. (3) Intermediate (or vertebral) ganglion. (4) Stellate ganglion. (5) Inferior thyroid artery. (6) Vertebral artery. (11) Ansa subclavia. (13) Sympathetic chain caudad to first thoracic sympathetic ganglion.

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glion is usually fused with the first thoracic ganglion to form a single larger ganglion which is named the stellate ganglion (Figure 13, page 25, *Left side*, and Figure 14, page 27). The stellate ganglia usually lie in front of the neck of the first rib. These cervical sympathetic ganglia give off gray rami communicantes to the several cervical spinal nerves. The ganglia do not, however, receive any white rami communicantes, for all entering preganglionic fibers gain access to the cervical sympathetic trunk by ascending up that trunk from thoracic levels.

"All of the named ganglia vary in size and exact location from specimen to specimen and hence their skeletal and soft tissue relationships are not to be pictured too rigidly. This variability in ganglionic size and location is to be explained by the embryogenesis of the sympathetic trunk and the migration of the postganglionic cell bodies toward their expected sites of accumulation as ganglionic enlargements. By advancing too far or not far enough, they produce unexpected ganglionic masses in positions other than the typical. These accessory ganglia may be large or small, but when large they tend to replace the expected next adjacent ganglion by a process of seemingly draining away the supply of postganglionic cell bodies. Or the expected ganglion may be broken up into two or more subdivisions, no one of which warrants the title originally used to designate the parent ganglion. Thus, by a process of excessive subdivision or excessive amalgamation in the embryo, the numbers of cervical ganglia may be modified and this results in the great variability found in the form of each individual sympathetic trunk.

"Despite this variability in the placement and size of the ganglia, the gray rami communicantes will, nonetheless, leave their individual ganglia and pass to their respective cervical spinal nerves, and thus the gray rami become the best clue as to which ganglion a particular enlargement on the sympathetic trunk actually corresponds. Microscopic clusters of postganglionic cells may occur at almost any site along the sympathetic trunk and over the course of the white and gray rami and even in the anterior roots of the spinal nerves. These aberrant cell clusters are also called intermediate ganglia and hence some confusion might occur with the large intermediate ganglion (of Jonnesco) on the sympathetic trunk between the middle and inferior cervical ganglia.[14] It is for this reason that Jonnesco's ganglion might better be called the vertebral ganglion because of its nearly constant relationship to the anterior surface of the vertebral artery.

"The following data is based upon the dissection of 37 body sides. All but one sympathetic trunk represent the paired trunks of 18 bodies. Since there was no significant contrast between the right and left sides in this series of specimens, no particular attempt is made to correlate the findings with a particular side.

"The *Superior Cervical Ganglion* is an elongated, fusiform structure, rather flattened from anterior to posterior, and lying in front of the transverse process of the 2nd and 3rd cervical vertebrae and commonly extending upward to lie in front of the lateral mass of the atlas (Figures 12-23). Reduction in its size will, of course, change these skeletal relationships (Figure 15, page 28). Average dimensions of this ganglion are 30 mm. long by 7 mm. in transverse width. It was present in each of the specimens studied and only occasionally deviates more than one vertebral body up or down from the expanse mentioned above. This ganglion is occasionally massive, being of perhaps twice the usual size, and of irregular contour (Figure 16, page 29). It usually sends branches to the last four cranial nerves and gray rami communicantes to the first three or four cervical nerves. The large internal carotid nerve ascends from the superior pole of the ganglion to accompany the internal carotid artery into the carotid canal of the temporal bone. The other vascular branches and the visceral branches arising from the superior ganglion will not be mentioned. Nor will the several vascular and visceral branches of the other cervical ganglia be discussed except to say that although they

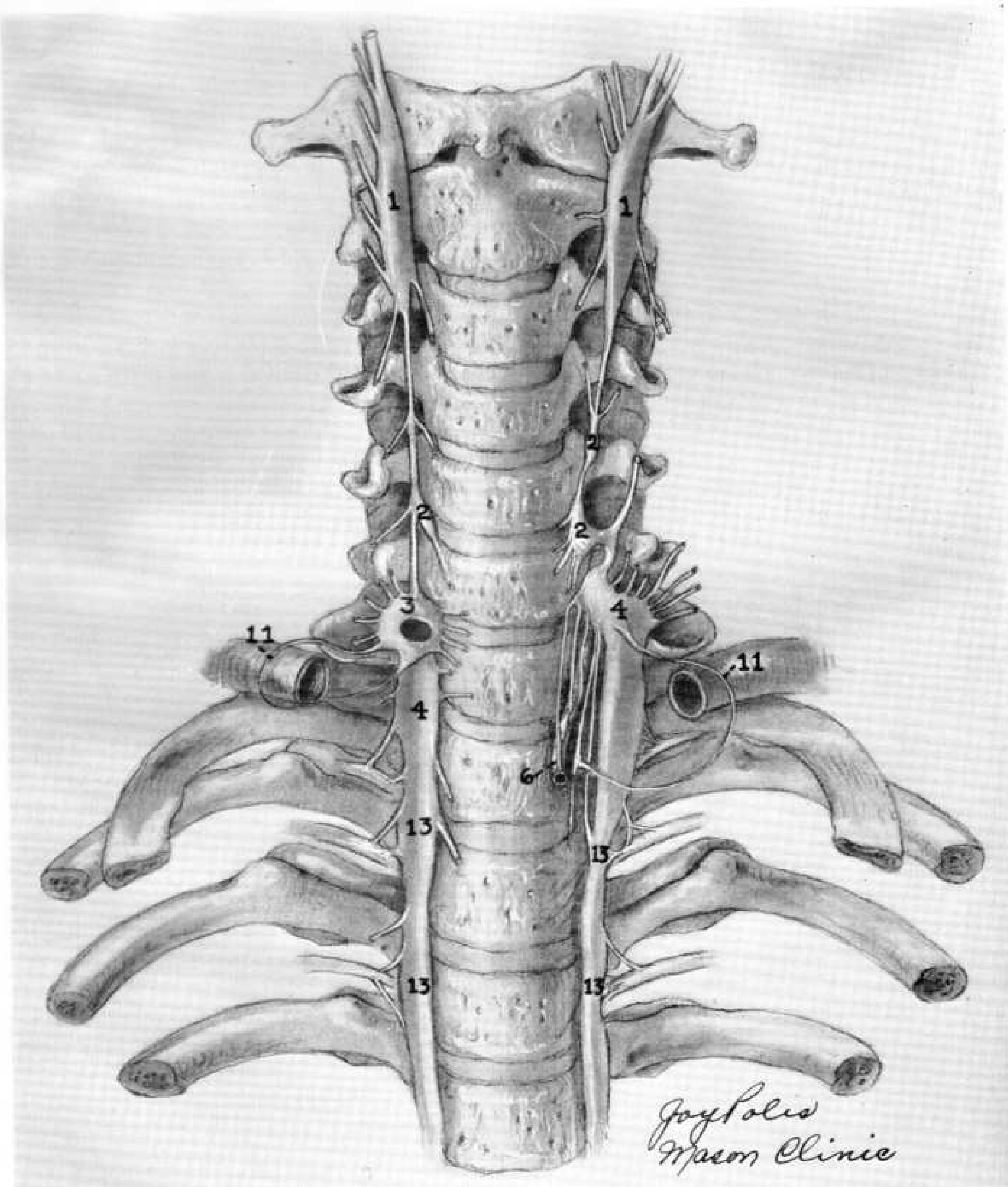

Figure 18. Anatomy of the cervico-thoracic portion of the sympathetic nervous system (life size). (1) Superior cervical ganglion. (2) Middle cervical ganglion. (3) Intermediate (or vertebral) ganglion. (4) Stellate ganglion. (6) Vertebral artery. (11) Ansa subclavia. (13) Sympathetic chain caudad to first thoracic sympathetic ganglion.

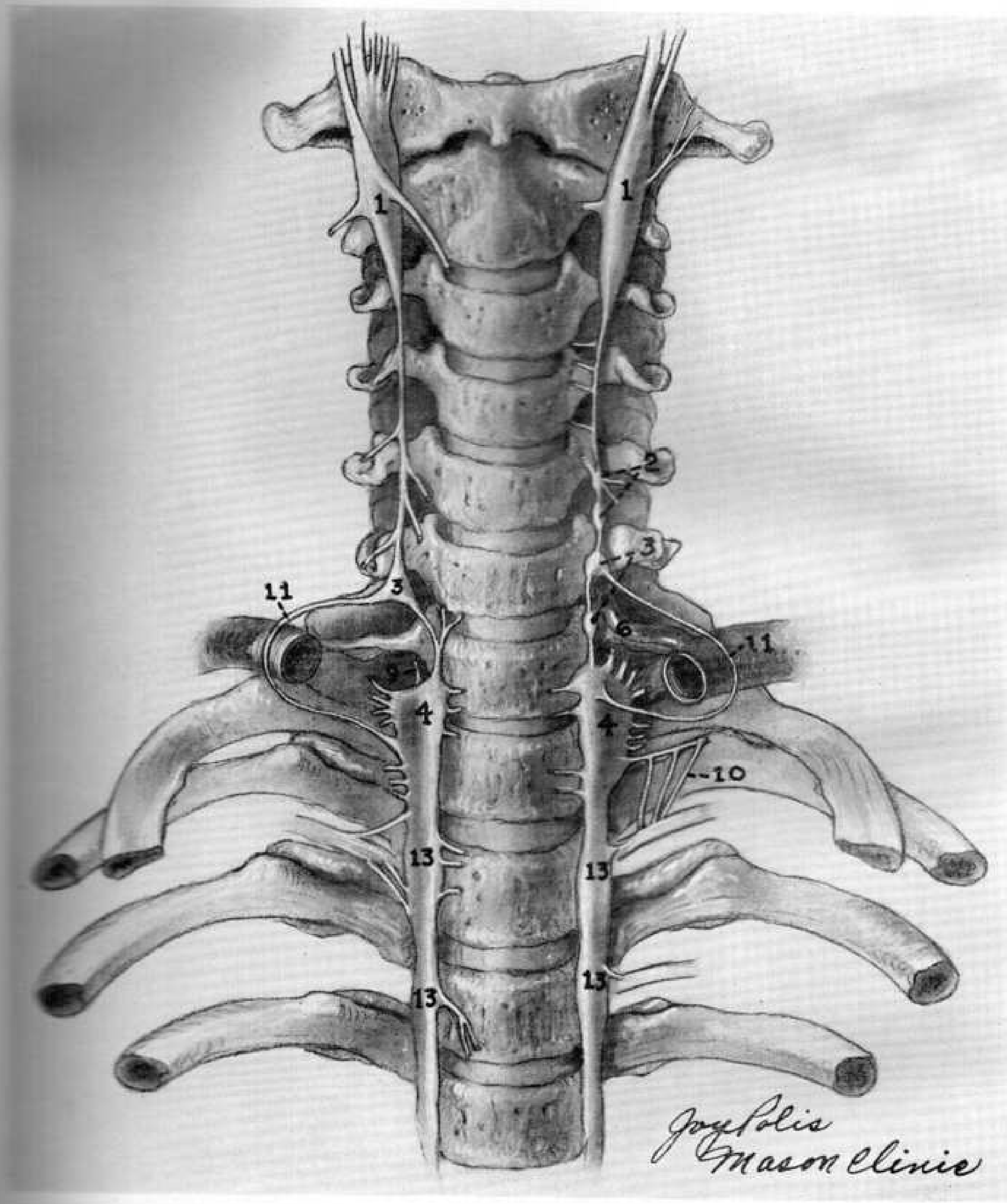

Figure 19. Anatomy of the cervico-thoracic portion of the sympathetic nervous system (life size). (1) Superior cervical ganglion. (2) Middle cervical ganglion. (3) Intermediate (or vertebral) ganglion. (4) Stellate ganglion. (6) Vertebral artery. (9) Nervus vertebralis. (10) Kuntz's nerve. (11) Ansa subclavia. (13) Sympathetic chain caudad to first thoracic sympathetic ganglion.

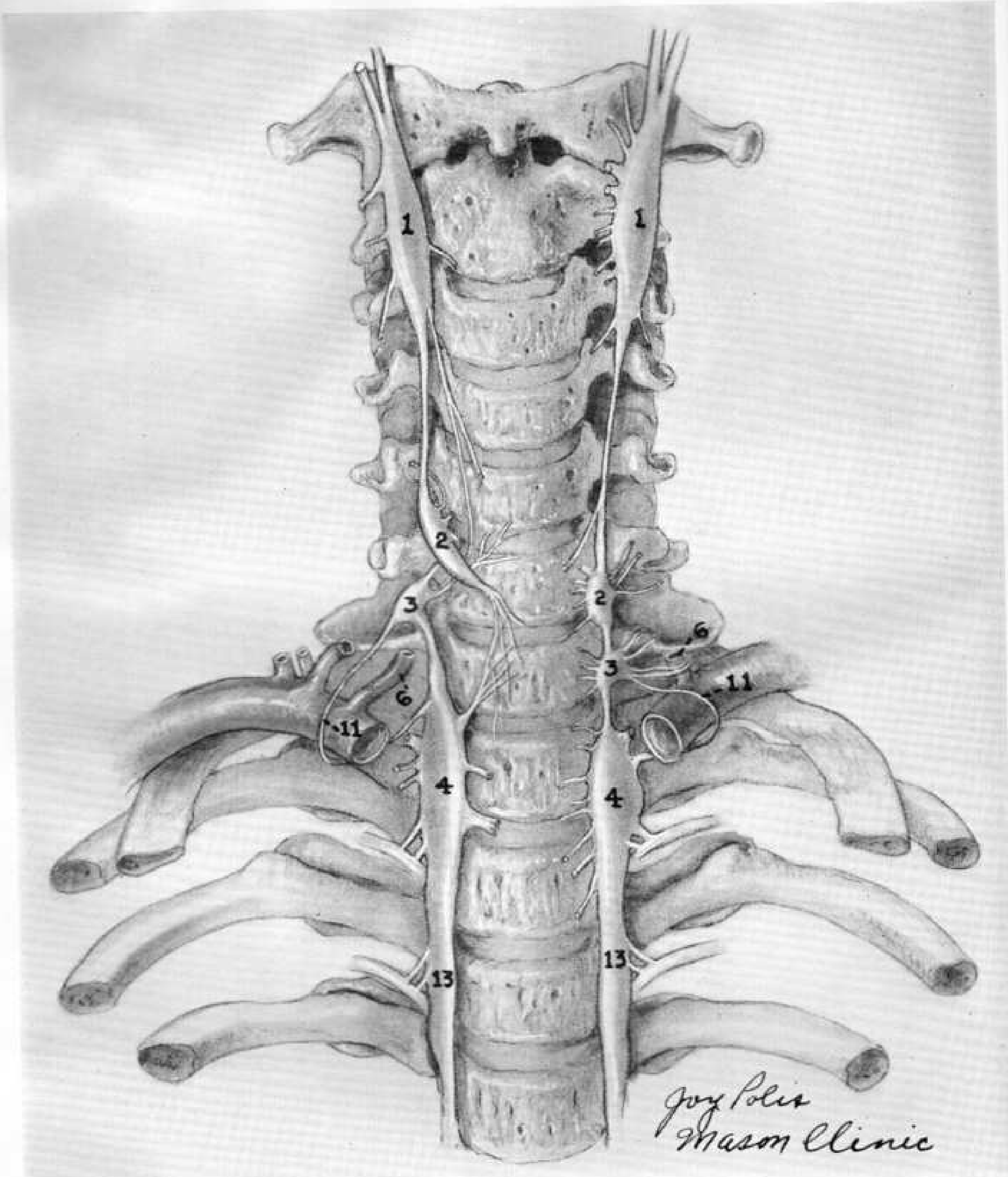

Figure 20. Anatomy of the cervico-thoracic portion of the sympathetic nervous system (life size). (1) Superior cervical ganglion. (2) Middle cervical ganglion. (3) Intermediate (or vertebral) ganglion. (4) Stellate ganglion. (6) Vertebral artery. (11) Ansa subclavia. (13) Sympathetic chain caudad to first thoracic sympathetic ganglion.

ystem (life size). (1) Su-
ebral) ganglion. (4) Stel-
ain caudad to first thoracic

typically arise from the ganglia they may also arise from the intervening trunk between ganglia.

The *Middle Cervical Ganglion* was the most variable of the cervical ganglia in this series of specimens (Figures 12-23). It usually sends its gray rami communicantes to the fifth and sixth cervical nerves. It was present as a single discrete and readily recognizable ganglion in the usually described position in only 16 trunks (43%) (Figure 17, page 30). It was present as a doubled structure in four more trunks, thus giving a total frequency of 54% (Figure 15, page 28, *Left side;* Figure 18, page 32, *Left side;* and Figure 19, page 33, *Left side*). In these latter instances one ganglion was present at the usual level of the sixth transverse process while the extra ganglion was above this at the level of the fifth transverse process. In three instances the two ganglia were scarcely more than a centimeter apart while in one they were 2.5 cm. apart (Figure 18, page 32, *Left side;* and Figure 15, page 33, *Left side*). This doubling occurred on the left side in each instance, but it is doubted if this has any significance when the number of cadavers in this study is considered. To include the higher of these two ganglia under the title of 'middle ganglion' is, of course, an arbitrary choice based upon its proximity and infrequency and upon the attachments of its rami communicantes.

This is usually the smallest of the ganglia and its average dimensions are 7 mm. long by 3 mm. wide. It varies in shape from fusiform to globular (Figure 20, page 34 and Figure 16, page 29). In the 36 paired sides it was found to be present on one side only in six bodies and to be bilaterally present in seven bodies. When unilaterally present, it was found twice on the right side and four times on the left (Figure 14, page 27, *Right side;* and Figure 21, page 36, *Left side*). It should be added here that the instances of doubled middle ganglia are considered as a single ganglion in the preceding two sentences.

The *Intermediate Cervical Ganglion (Vertebral Ganglion)* was named the 'ganglion intermediare' by Jonnesco [14] to indicate its position between the middle and the inferior cervical ganglion (Figures 12-23). The ninth edition of Cunningham's *Textbook of Anatomy*,[6] speaks of a low position of the middle cervical ganglion as being not infrequent, and that in this circumstance the ganglion usually lies upon the vertebral artery. This is, of course, a confusion of the intermediate ganglion with the middle cervical ganglion, and the reason for confusion probably rests upon the unappreciated fact that the middle cervical ganglion is very often absent while the intermediate ganglion is very rarely absent. The latter ganglion is usually described as an occasional finding and as being considered as a portion of the middle ganglion that has been displaced downwards or as a portion of the inferior ganglion that has been displaced upwards. Because of its frequency it should not be considered as either of these aberrant forms but as an independent ganglion deserving a special title as fully as does the inferior ganglion and perhaps more so than the middle ganglion.

"The intermediate ganglion lies directly in front of or in front and slightly medial to the vertebral artery just below the level of entrance of that artery into the foramen transversarium of the sixth cervical vertebra (Figure 22, page 37). It usually sends gray rami communicantes to the sixth and seventh cervical nerves. Its nearly constant topographic relationship to the vertebral artery justifies its title of 'vertebral ganglion' as Mitchell [15] has suggested. This is especially advisable in view of the widespread usage of the term 'intermediate ganglion' to indicate those aberrant postganglionic cell clusters so commonly found along the anterior roots of the thoracic spinal nerves and along the rami communicantes.

"The vertebral ganglion was found 30 times in the 37 sympathetic trunks. Its usual form is triangular with the apex above continuing upwards as the sympathetic trunk, while from the medial and lateral angles of its base, heavy trunks descend on either side of the vertebral artery to gain attachment to the inferior

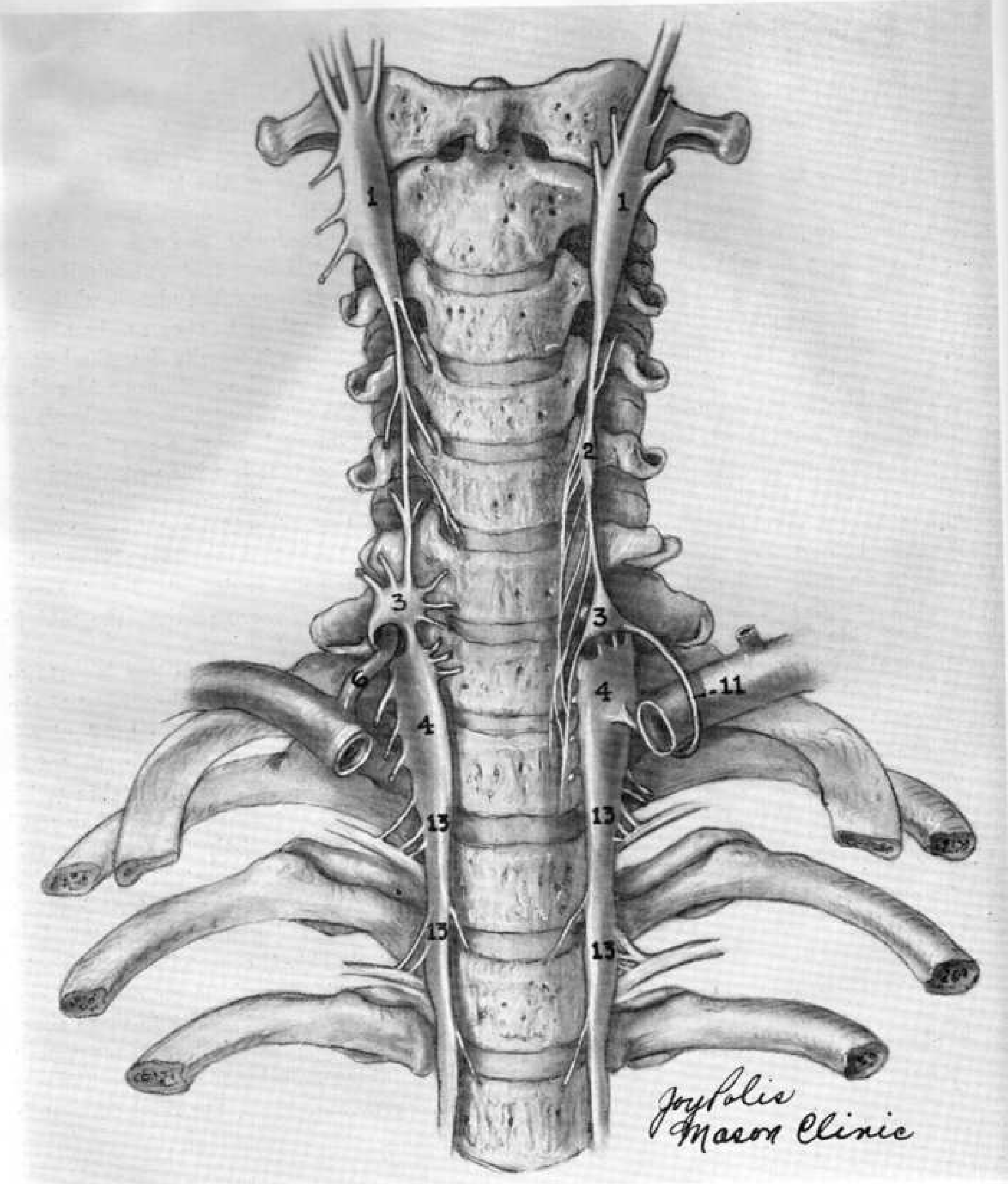

Figure 21. Anatomy of the cervico-thoracic portion of the sympathetic nervous system (life size). (1) Superior cervical ganglion. (2) Middle cervical ganglion. (3) Intermediate (or vertebral) ganglion. (4) Stellate ganglion. (6) Vertebral artery. (11) Ansa subclavia. (13) Sympathetic chain caudad to first thoracic sympathetic ganglion.

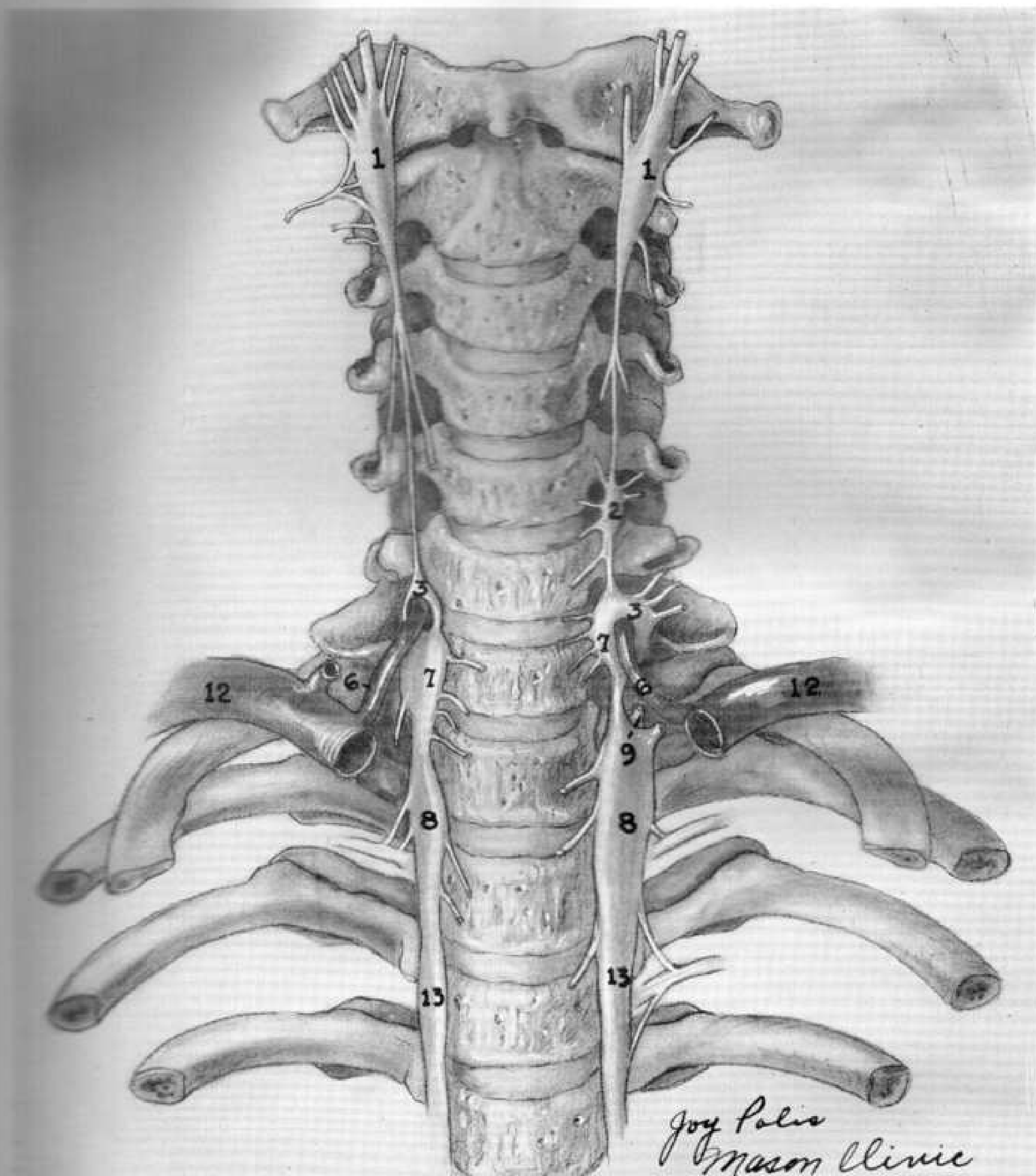

Figure 22. Anatomy of the cervico-thoracic portion of the sympathetic nervous system (life size). (1) Superior cervical ganglion. (2) Middle cervical ganglion. (3) Intermediate (or vertebral) ganglion. (6) Vertebral artery. (7) Inferior cervical ganglion. (8) First thoracic sympathic ganglion. (9) Nervus vertebralis. (12) Subclavian artery. (13) Sympathetic chain caudad to first thoracic sympathetic ganglion.

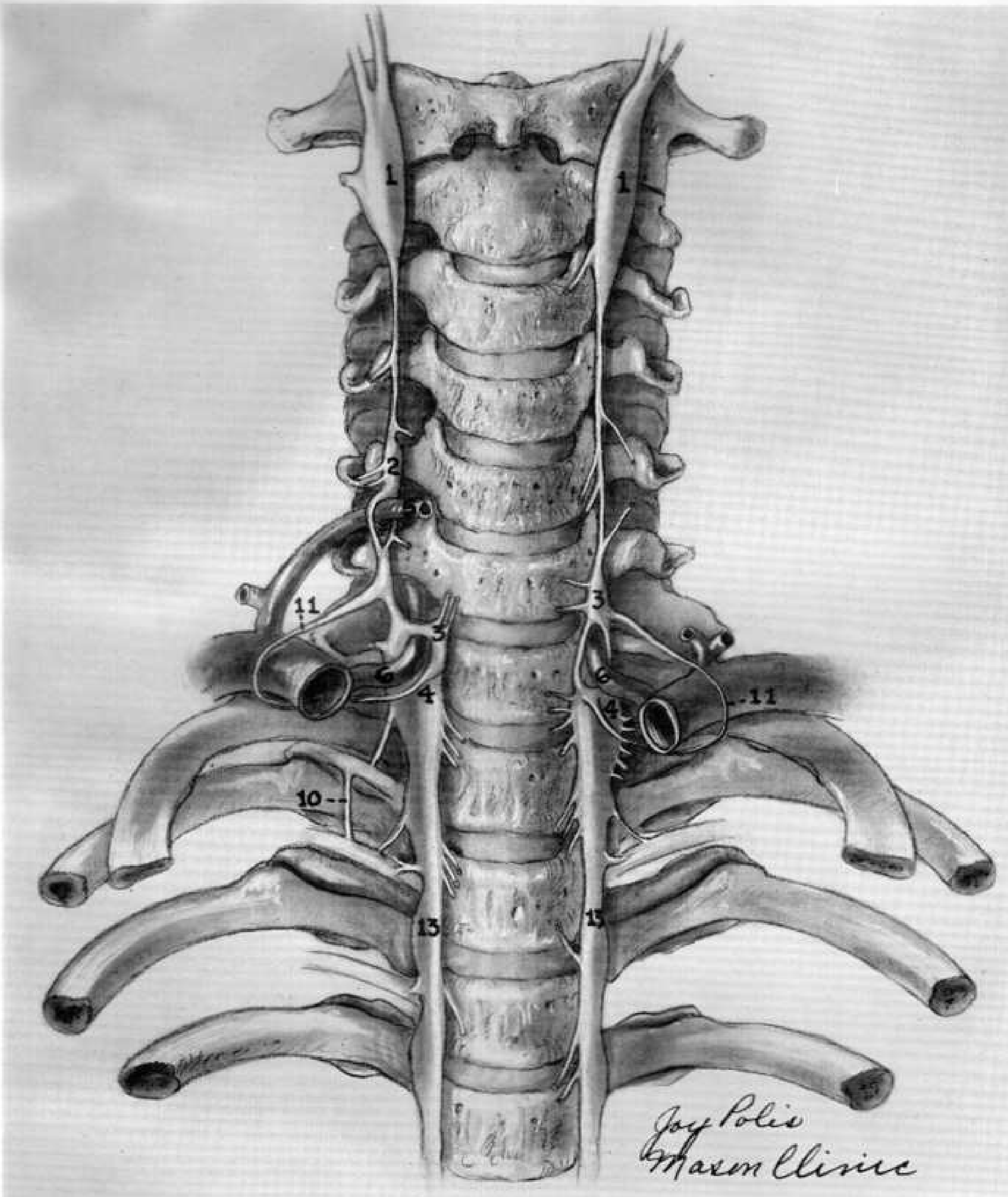

Figure 23. Anatomy of the cervico-thoracic portion of the sympathetic nervous system (life size). (1) Superior cervical ganglion. (2) Middle cervical ganglion. (3) Intermediate (or vertebral) ganglion. (4) Stellate ganglion. (5) Inferior thyroid artery. (6) Vertebral artery. (10) Kuntz's nerve. (11) Ansa subclavia. (13) Sympathetic chain caudad to thoracic sympathetic ganglion.

m (life size). (1) Su-
al) ganglion. (4) Stel-
. (11) Ansa subclavia.
on.

cervical ganglion (or stellate) which usually lies below this level and behind the root of the vertebral artery (Figure 13, page 25). Thus the sympathetic trunk is doubled from the vertebral to the inferior cervical or stellate ganglion. It might even be said to be tripled for the ansa subclavia descends from the vertebral ganglion, sweeps around the subclavian artery and recurves backward to reach the inferior cervical or stellate ganglion (Figure 13, page 25). A twig arises from the vertebral ganglion and ascends along the vertebral artery to enter into the plexus formed about that vessel. The vertebral ganglion was found in most instances to be 5 mm. long and 5 mm. in transverse width.

The *Inferior Cervical Ganglion and the First Thoracic Ganglion* are very commonly fused together to form one large and multipolar ganglion that is called the *Stellate Ganglion* (Figure 23, page 38). If the two ganglia are not fused together, there is no stellate ganglion (Figure 22, page 37). Notwithstanding this, it is common clinical parlance to call the inferior cervical and first thoracic ganglia the stellate ganglion under all circumstances. The inferior cervical ganglion sends gray rami communicantes to the seventh and eighth cervical nerves in most specimens while the first thoracic sends a gray ramus and receives a white ramus from the first thoracic nerve. The stellate ganglion, therefore, has rami communicantes connecting it with the seventh and eighth cervical and the first thoracic nerves in the typical specimen. The inferior cervical ganglion (or the upper portion of the stellate ganglion) lies in front of the neck of the first rib and may at times extend upward toward the transverse process of the seventh cervical vertebra (Figure 13, page 25; and Figure 23, page 38). It is then in front of the eighth cervical nerve. The first thoracic ganglion (or the lower portion of the stellate ganglion) lies in the interspace between the necks of the first and second ribs in front of the first thoracic nerve. It may descend downwards over the neck of the second rib. The second thoracic ganglion lies between the necks of the second and third ribs and is occasionally not clearly separable from the stellate ganglion. The stellate ganglion is often massive and varies considerably in shape, ranging from a fat oval to an elongated fusiform or lumpy spindle shape. It might be described as multipolar or star-shaped (hence the name stellate) because of the numerous branches arising from its periphery. The inferior cervical, or upper end of the stellate ganglion, gives rise to a rather husky branch (the nervus vertebralis) which ascends with the vertebral artery to enter the foramen transversarium of the sixth cervical vertebra. It, therefore, enters into the formation of the vertebral plexus to a minor degree, but chiefly the nervus vertebralis utilizes the foramina transversaria only as a route to reach the sixth or seventh cervical nerve which it joins. It is thus primarily a gray ramus communicans following this unusual route to its spinal nerve (Siwe [16]) (Figure 22, page 37).

"In this series of 37 sympathetic trunks, the inferior cervical ganglion existed as a discrete structure in six instances (Figure 22, page 37). All of the others were amalgamated with the first thoracic to form a stellate ganglion. It must be recognized that there is a measure of arbitrary judgment in the decision as to when a constriction between the upper and lower parts of a stellate ganglion has clearly separated them into their component parts. The average dimensions of the stellate ganglion are approximately 20 mm. in length and 7 mm. in the transverse width. When the inferior cervical ganglion was present, its usual measurement was 6 mm. in length and 7 mm. in transverse width.

"The *Second, Third and Fourth Thoracic Sympathetic Ganglia* lay upon the necks of the ribs or in the interval between the necks of the ribs. In five of the 37 body sides, a communication existed between the first and second intercostal nerves just lateral to the rami communicantes (Figure 19, page 33, *Left side;* and Figure 23, page 38, *Right side*). This is the aberrant route described by Kuntz [11] which permits postganglionic fibers from the second thoracic ganglion to reach the first thoracic nerve and yet bypass the first thoracic or stellate ganglion.

"The relationship of the cervico-thoracic sympathetic chain to the *lung* as well as the *fascial* planes were the same as previously described by Hovelacque (see pages 20 and 18, respectively)."

The above discussion and dissections show the close relationship of the *vertebral artery* to the stellate ganglion (Figures 12-23). Yet it is interesting to note that Patterson [17] found this artery did not furnish the blood supply to that structure. He discovered that the main blood supply to the ganglion came from the superior intercostal artery. Also, he noted that in most instances at least one accessory vessel from either the costo-cervical trunk, the thyro-cervical trunk, the deep cervical artery, or the first intercostal artery participated in supplying blood to the ganglion.

Conclusion.—Dissection and clinical studies following stellate ganglion block in which Diodrast solutions were injected and roentgen films made, have shown that irrespective of the approach to the stellate ganglion used, a block of the entire cervico-thoracic portion of the sympathetic nervous system results provided 12 to 15 cc. of the blocking agent is employed and the needle or needles correctly placed (Chapter 9, page 72). From the studies of Perlow and Vehe,[10] Kuntz,[11] Kirgis and Kuntz [12] and Johnson and Moore, it can be seen that while there are variations in the cervico-thoracic portion of the sympathetic nervous system, they occur in the area bathed by the blocking solution (see Chapter 9, page 77). Therefore, while the variations which occur in the anatomy of the cervico-thoracic sympathetic chain are of academic importance and interest, a correctly performed stellate ganglion block should produce a satisfactory block even when variations are present.

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CHAPTER 2

Physiology of the Cervico-thoracic Portion of the Sympathetic Nervous System

The rationale for the use of stellate ganglion (cervico-thoracic sympathetic) block for diagnosis and treatment of clinical entities of the upper extremities, head and neck and their contents, the upper chest wall, and the contents of the thoracic cage depends on the physiological function of the sympathetic nervous system in these areas. Therefore, a thorough understanding of these functions is essential.

Origin and Distribution of the Fibers of the Cervico-thoracic Portion of the Sympathetic Nervous System.—Langley,[1] Kuntz,[2, 3] Ranson,[4] and Gaskell[5] have shown that the efferent fibers of the upper cervical sympathetic ganglia pass through the stellate. They have shown also that the fibers forming the cervical portion of the sympathetic nervous system have their origin from the first through the fourth or fifth thoracic sympathetic ganglia and that direct fibers from the spinal nerves (white rami communicantes) in the cervical region do not exist. It is re-emphasized that when a stellate ganglion block is performed and the needle is correctly placed, a complete block of both the cervical sympathetic trunk and the upper thoracic sympathetic ganglia ensues regardless of the approach used (see Chapter 9, page 71). Therefore, when considering the physiology one must think about the cervical sympathetic ganglia and the upper thoracic sympathetic ganglia as a whole—not the stellate ganglion individually.

The physiological effects are almost entirely ipsilateral. Two exceptional cases of a contralateral effect without any ipsolateral effects have been cited by Arnulf.[6] One instance occurred following a block with a short-acting agent and the other followed a stellectomy. Both cases were characterized by a Horner's syndrome and an increase in temperature of the hemi-face and upper extremity on the side opposite the one on which the chemical and surgical stellectomy were performed. Blocking of the upper thoracic ganglia and the cervical sympathetic ganglia should not affect the somatic nerves unless there has been an overflow of the blocking solution or the needle has been misplaced. Tactile, thermal, and pressure sensations remain normal. Motor function should not be impaired. However, Leriche[7] has observed transient muscle weakness of the shoulder and arm in the occasional patient. This may be due to overflow to the brachial plexus.

The Method of Transmission of Impulse in the Sympathetic Nervous System.—This is usually referred to as "chemical transmission of nerve impulses," or "neuro-humoralism." According to the generally held theory, nerve impulses cause responses in muscles and glands by liberating chemical substances which act as the definitive exciting agent. Cannon,[8] Eccles,[9] and Bronk[10] believe that acetylcholine is liberated by the preganglionic impulse and its acetylated substance then stimulates the post ganglionic neurons which in turn discharge impulses. Thus an electro-chemical type of stimulation occurs.

Loewi,[11, 12] established the first real proof of the chemical mediation of peripheral nerve impulses by the release of specific chemical substances. He called this chemical substance "vagus substance (parasympathin)." At a later date acetylcholine was established as the parasympathetic chemical-stimulating substance by Feldberg and Krayer.[13] Sympathin, which consists of both an excitatory factor and an inhibitory factor, has been established as the sympathetic chemical susbtance by Cannon and his associates.[14, 15] It should be noted that, while sympathin closely resembles epinephrine (Adrenalin), it differs clinically and experimentally. When epinephrine (Adrenalin) is injected both the inhibitory and the excitatory factors act simultaneously. With sympathin either the excitatory or the inhibitory portion acts separately depending on the type of response the stimulation elicits. Sympathin E (Excitatory) is liberated in structures that are excited by sympathetic impulses, i.e., cardiac muscle, etc. Sympathin I (Inhibitory) is liberated in structures that are inhibited by sympathetic impulses, i.e., coronary vessels, etc.

The exceptions to this rule are the sweat glands and certain vascular beds, particularly those in the skin of the face. The nerves to these structures anatomically belong to the postganglionic sympathetic system, but their function is modified by parasympathetic drugs. Dale and Feldberg[16] have helped to clarify this problem by showing that vasodilatation and sweating are incited by nerve impulses which rely on acetylcholine and that these nerves are functionally analogous to parasympathetic postganglionic nerves. They are, therefore, cholinergic rather than adrenergic.

Functions of the Sympathetic Nervous System.—The three main physiological functions of the sympathetic nervous system may be classified as *vasomotor control*, *gland control*, i.e., sudoriferous, salivary and mucous, and *pain conduction*.

VASOMOTOR CONTROL

It is to alter control over vascular tone that the thoraco-cervical portion of the sympathetic system is most often blocked. The sympathetic nervous system's effect on the vascular bed is usually one of vasoconstriction. Therefore, when it is blocked (paralyzed) vasodilatation occurs providing pathological changes are not present in the vascular system, in the surrounding tissues (tumors, etc.) or in the nerves themselves. Vasodilatation caused by block of the thoraco-cervical trunk occurs in the head and neck, upper extremity, upper chest wall and viscera of the thoracic cage.

Brain.—Best and Taylor[17] state that it is now definitely established that vasoconstrictor impulses are conveyed to the brain by the sympathetic nervous system. Forbes and Wolff[18] observed the pial vessels in animals through a trephine hole covered with a glass plate, the space between the brain and the glass being filled with Ringer's solution. Stimulation of the sympathetic nerves resulted in observable constriction of the vessels while sectioning of the sympathetic nerves resulted in dilatation.

Volpitto and Risteen[19] observed the brain before and after unilateral stellate ganglion block in two human patients who had been trephined under local anesthesia. They noted the following: (1) Increase in the caliber of the pial vessels is limited to the blocked side. (2) Increase in the size of the vessels is immediate, and neither time nor additional injections of procaine causes further increase in their size. (3) Increase in the size of the dural and scalp vessels likewise occurs. (4) The increase in size of the vessels is the same in all parts of the ipsolateral brain.

Orbit.—The blood vessels of the sclera and conjunctiva increase markedly in size. The intraocular pressure usually parallels that of the cerebrospinal fluid and, upon infiltration of the stellate ganglion, intraocular pressure lowers, then in a few minutes it rises, thence stabilizes, only to fall at the end of one-half hour.[6] The latter effect is noted for the physiological duration of the drug used.

Face, Ears, Nose and Neck.—The facial skin becomes flushed and warm — signs of vasodilatation and increased circulation. Circulation of the external and middle ear is increased as evidenced by hyperthermia of the pinna and tympanic region. Vasodilatation of the nasal mucous membrane is marked, resulting in a feeling of stuffiness or complete obstruction.

The Mucous Membranes of the Pharynx.—Unilateral erythema and increase in size of the superficial blood vessels of the larynx and pharynx occur.

The Thyroid Gland.—Effect not known.

Upper Extremity.—The first signs of an effective block in the arms is usually dilatation of superficial veins. Within 15 to 30 minutes following the block, the arm shows a marked increase in temperature. If, during operations upon the upper extremity for vascular diseases or trauma, the artery goes into spasm and a stellate block is performed to relieve it, a lag period of 15 to 30 minutes usually elapses before the effects can be seen. This has been observed repeatedly by the author during surgical procedures.

The Heart.—Woollard,[20, 21] has shown that both sympathetic and parasympathetic fibers accompany the coronary vessels. But he feels statements as to the exact action of each upon the coronary vessels cannot be made with finality. According to Best and Taylor[17] in mammals most evidence indicates that the vagus (parasympathetic) is a vasoconstrictor while the sympathetics are vasodilatators. Several workers have reported an increased coronary flow as a result of stimulation of the stellate ganglion.[17] Anrep and Segall[22] and Anrep and Stacey[23] have shown the following in animals: (1) Coronary flow is increased considerably after vagal section, an observation indicating that these nerves exert a tonic vasoconstrictor influence. (2) Adrenalin causes an increase of 85% in the coronary outflow. (3) Upon vagal stimulation coronary circulation is diminished. (4) Vasoconstrictor fibers to the coronary blood vessels are present in the vagus, and vasodilatory fibers are found in the sympathetic nerve. Wiggers[24] showed that stimulation of the peripheral end of a cut vagus nerve in an atropinized dog reduced the flow from a coronary vein.

Leriche[7, 25] believes that stellate ganglion block results in vasodilatation of the coronaries and supports his arguments with the following points: (1) Stimulation of the stellate ganglion results in increased coronary pressure and carotid pressure (Leriche and Fontaine[26]). (2) The results of ligation of some branches of the coronary arteries are less severe after stellectomy (Cox, Lewiston and Roberts[27]). (3) Kymographic and histologic examinations of the ventricular wall show a dilatation of the capillaries following stellectomy (Monteiro, Rodrigues, Carvalho, and Pereira[28]). (4) In man, the good results obtained in angina pectoris with stellate block do not appear consistent with vasoconstriction. It should be noted that this last statement may not be a valid deduction in view of the fact that immediately after a block, angina patients may die of a coronary occlusion without pain. It may be that pain fibers accompanying the sympathetics are blocked and this explains the good results in spite of vasoconstriction. Flothow[29] agrees with Leriche, and in discussing clinical results in man states, "Regardless of what physiologists may have said in the past, the effect of interruption of vaso-motor fibers to the cardiac blood supply is vasodilating rather than vasoconstricting, at least in the presence of myocardial disease."

Feldberg and Krayer[13] have demonstrated acetylcholine in the coronary blood of animals during vagal stimulation. It might be expected that this substance would constrict the coronary arteries, thus reducing the blood flow. However, in mammals at least, acetylcholine dilates the coronaries.

Danielopolu[30, 31, 32] believes that sectioning of the stellate ganglion causes a vasoconstriction of the coronaries. He cautioned against the use of stellectomy in angina pectoris. He feels that stellectomy "hides" the pain by removing the pain carrying fibers but does not correct the underlying vascular insufficiency.

Katz and Jochim[33] believe that: (1) The vagi contain only cholinergic vasodilator fibers to the coronaries. (2) The sympathetics carry both dilator and constrictor fibers of the adrenergic type to the coronaries. (3) These fibers carry impulses from the central nervous system which exert a constant tonic effect regulating the caliber of the coronary vessels.

Since there are good arguments both for and against the sympathetic nervous system causing vasoconstriction of the coronary vessels, the statement of Best and Taylor [17] should be remembered. They state, "Perhaps the question of the sympathetic action upon the coronaries is really of no great practical importance since the response of the coronaries in dogs after sympathetic denervation is just as great as in normal dogs; nor is the dilator effect following stimulation of the stellate ganglion pronounced."

Lung.—The sympathetic nerves to the pulmonary vessels furnish the lung with both vasodilator and vasoconstrictor fibers. Bradford and Dean [34] demonstrated the vasoconstrictor fibers and Daly and Euler [35] the vasodilatory fibers. Both worked with dogs. The action of the sympathetics on the vessels of the lung is questionable, and Best and Taylor [17] make no definite statement concerning their actions. Francois-Franck [36] on the other hand believed that the sympathetics are vasoconstrictors.

GLAND CONTROL

Sweat Glands.—The cervico-thoracic portion of the sympathetic nervous system controls the sweat glands of the upper chest, upper limb, head and neck. Stimulation of the sympathetics results in sweating while blocking of the stellate ganglion results in anhidrosis. Best and Taylor [17] point out that while the sweat glands are under the control of the sympathetic nervous system, they are stimulated by pilocarpine and acetylcholine and inhibited by atropine. This can be nicely proved by executing a stellate block and then administering pilocarpine $\frac{1}{20}$ gr. (3 mg.) subcutaneously at 15-minute intervals until the patient begins to sweat. It will be noted that the side on which the block has been performed remains dry while the contralateral side sweats profusely.

Salivary Glands.—As with the sweat glands, block of the sympathetics inhibits salivation (secretion).

Bronchial Secretion.—Block of the stellate ganglion was shown by Dos Ghali [37] to stop secretion of the bronchial mucous glands in the same manner as it does with the sudoriferous glands.

PAIN CONDUCTION

The cervical sympathetics and upper thoracic sympathetics appear to mediate visceral cardiac pain sensations. Peripheral pain sensations are believed by some to be carried by the sympathetic system, but others challenge this view.

Cardiac Pain.—According to the findings of Stohr [38] and Katz and Jochim,[33] the afferent pain pathways from the heart have their sensory nerve endings in the adventitia of the coronary arteries and perhaps in the epicardium, endocardium and myocardium. Stimuli from these receptors are carried to the superficial and deep cardiac plexuses. Then they travel centripetally either through the direct thoracic cardiac sympathetic nerves to the upper four or five thoracic sympathetic ganglia or through the middle and superior cardiac sympathetic nerves to the middle and superior cervical sympathetic ganglia.[39, 40, 41, 42, 43, 44, 45] As pointed out previously, neither anatomists nor neurosurgeons have been able to demonstrate a direct connection from the spinal cord to the sympathetic trunk in the cervical region. Therefore, it may be assumed that impulses carried by the middle and superior cardiac nerves to the cervical portion of the sympathetic nervous system must pass down the sympathetic chain to the upper thoracic sympathetic ganglia thence to the spinal cord by the white rami communicantes.

It must be remembered that it is debatable as to whether or not pain stimuli are carried by the sympathetic nerves per se, or by visceral afferent sensory nerves that accompany the sympathetic nerves. Irrespective of which is the correct theory, cardiac pain travels centrad via the cervico-thoracic portion of the sympathetic nervous system.

Causalgic Pain in the Upper Extremity.—Leriche,[25] Foerster,[46] Reichert,[47] and Fay [48] believe that some of the sensory fibers supplying the peripheral parts of the body may reach the spinal cord by way of the sympathetic nervous system. A case of Slaughter's [49] tends to support this theory. Here the spinal cord was transected at the first lumbar vertebra, and there was severe pain in the leg which was relieved by bilateral lumbar and sacral sympathectomies. However, Burget and Livingston,[50] and Moore and Singleton [51] state definitely that pain impulses from blood vessels of the extremities as well as all other peripheral tissues are carried to the central nervous system by way of the posterior roots, and that pain is not carried from the *periphery* by the sympathetic nervous system. On the other hand, it is interesting to note that fibers which are stimulated by injection of irritants into the *visceral* arteries ascend either the major splanchnic nerves or the sympathetic chains to enter the spinal cord.[51] Livingston [52] in his book quotes Hinsey's personal communication which states, "There is no evidence, either clinical or experimental, which will stand critical analysis to support the view that pain impulses from the extremities reach the spinal cord by way of the sympathetic ganglia." In support of the theory that the sympathetic fibers do not carry pain from the periphery, Livingston [52] says, "It is not reasonable to ascribe the benefits conferred by sympathectomy in causalgic states to an interpretation of pain pathways."

MISCELLANEOUS

Effects on the Bronchi and Bronchioles.—Best and Taylor [17] concluded that stimulation of the sympathetic fibers causes dilatation of the bronchi and bronchioles while stimulation of the parasympathetic nerves causes constriction. Arnulf [6] states, "The sympathetic and pneumogastric (vagus) each contain at their level inhibitory and stimulatory filaments in variable proportions. It seems, however, that paralysis of the sympathetics relaxes the bronchial muscles, as is shown by its action in 'Crisis' of asthma." This would imply that the sympathetics cause constriction of the bronchioles. However, it should be pointed out that stellate ganglion blocks have precipitated asthmatic attacks.[53] This would support the theory that the sympathetics to the lung might be dilators.

Therefore, in conclusion, it must be pointed out that clinical experience with stellate ganglion block can be used to support the view that the sympathetics may be broncho-dilators in some instances and broncho-constrictors in others.

Effect on Heart Rate.—The sympathetics are credited with being cardiac accelerators.[17] Theoretically a block of the stellate ganglion should cause some slowing in the heart rate. However, in the *normal, healthy* patient this is not noted clinically unless both stellates are blocked at the same time, and even then a change in rate may not occur. White, Smithwick and Simeone [54] have shown that block of the cervico-thoracic portion of the sympathetic nervous system as a diagnostic procedure may temporarily correct paroxysmal auricular tachycardia and fibrillation. Numerous authors have reported successes following interruption of the cervico-thoracic sympathetics in cases with abnormal rhythms.[55, 56, 57, 58]

Trophic Changes.—These changes appear to be due to a direct vascular deficiency of the region involved. The chief characteristics are a shiny skin and absence of the normal skin configuration. Often, x-rays will reveal osteoporosis of the underlying bone. Such trophic changes are probably not directly due to loss of function of the stellate ganglion, per se, but to the vascular insufficiency often associated with dysfunction of the sympathetic nervous system.

CONCLUSION

As can be seen from the foregoing, the physiological action of the cervico-thoracic portion of the sympathetic nervous system is controversial. Because the experiences of my associates and I have been entirely clinical, references supporting both sides of the question have been cited without venturing an opinion.

Our clinical impressions gained at the

Mason Clinic will be cited in Part III entitled, "Clinical Indications and Uses of Stellate Ganglion Block," page 119.

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TABLE II

CONDITIONS IN WHICH BLOCK OF THE CERVICAL AND UPPER THORACIC PORTIONS OF THE SYMPATHETIC NERVOUS SYSTEM MAY BE OF VALUE

- I. CONDITIONS ASSOCIATED WITH VASCULAR DISTURBANCES
  - UPPER EXTREMITY AND UPPER CHEST WALL (T_1—T_4)
    1. Traumatic Vascular Occlusion
    2. Thrombophlebitis
    3. Postoperative Edema
    4. Raynaud's Disease
    5. Ischemic Paralysis (Volkmann's, etc.)
    6. Shoulder-hand Syndrome
    7. Idiopathic Neuralgias
    8. Causalgia
    9. Bursitis
    10. Herpes Zoster
    11. Cervical Rib
    12. Amputation Pain
    13. Phantom Sensations
    14. Frostbite
    15. Osteoporosis
    16. Non-union of Fractures
    17. X-ray Dermatitis
    18. Scleroderma
  - BRAIN
    1. Cerebral Accidents
    2. Spasm from Angiography
  - HEART
    1. Angina Pectoris
    2. Myocardial Infarcts
  - LUNG
    1. Embolism
    2. Acute Edema
    3. Hemoptysis
  - FACE
    1. Facial (Bell's) Palsy
    2. Herpes Zoster
    3. Neuralgias
    4. Occulsion of Retinal Artery
- II. INCREASED GLANDULAR SECRETIONS
  - HYPERHIDROSIS
  - BRONCHORRHEA
- III. BRONCHIOLAR SPASM (ASTHMA)
- IV. ABNORMAL CARDIAC RHYTHM

CHAPTER 13

Facts to Be Remembered When Contemplating Stellate Ganglion Therapy

As NOTED IN THE introduction, this block is relatively new in the field of therapy. Many of its uses have not been adequately explored, and the material which can be presented on many diseases is meager. On the other hand, information on its uses in some diseases is voluminous.

Often in diseases wherein stellate block has proven its value, it is tried only as a last resort when all other medical and surgical therapy has been exhausted. Such neglect of a valuable measure is to be condemned. When problems arise in which a stellate block or a series of stellate blocks is known to be of value, this procedure should be used immediately in conjunction with other acceptable medical and surgical therapy—not as a "last resort." The results should not be evaluated from the benefit derived from the first block. It is often necessary to perform a series of blocks, i.e., four to seven, before dramatic improvement occurs.

Theory for the Clinical Uses of Stellate Ganglion Block:—The block is believed to be effective in the treatment of diseases and syndromes discussed in this section because it breaks the "*vicious cycle*" of events which results in the pathogenesis of the problem in question. Livingston's [1] explanation of the "*vicious cycle*" and the results obtained from its interruption is excellent. Livingston [1] states in part: "An organic lesion at the periphery, involving sensory nerve filaments, may become a source of chronic irritation (Figure 65, page 123*). Afferent impulses from this 'trigger point' eventually create an abnormal state of activity in the internuncial neuron centers of the spinal cord gray matter (Figure 65, page 123*). The internuncial disturbance in turn is reflected in an abnormal motor response from both the lateral and anterior horn neurons of one or more segments of the cord (Figure 65, page 123*). The muscle spasm, vasomotor changes, and other effects which this central perturbation of function bring about in the peripheral tissues, may furnish new sources for pain and new reflexes. A vicious circle of activity is created. If the trigger point is removed early, the process may subside spontaneously. If the process is permitted to continue, it spreads to involve new areas, and tends to acquire a momentum that is increasingly difficult to displace. Perhaps in this stage, even a removal of the original irritant may not be sufficient to establish a cure. But if an important part of the circle of reflexes can be interrupted, the process may subside, and a normal physiologic status is again established. If again the pathologic patterns gain the ascendancy, the repeated breaking of the circle may result in a permanent cure.

"When I speak of 'breaking the vicious circle' I do not have in mind a simple chain which becomes functionless when one link is broken. The process that underlies the cases I have studied has a more dynamic character than this. The cases are rarely 'cured' by the

* Figure 65, page 123 inserted by author of this book.

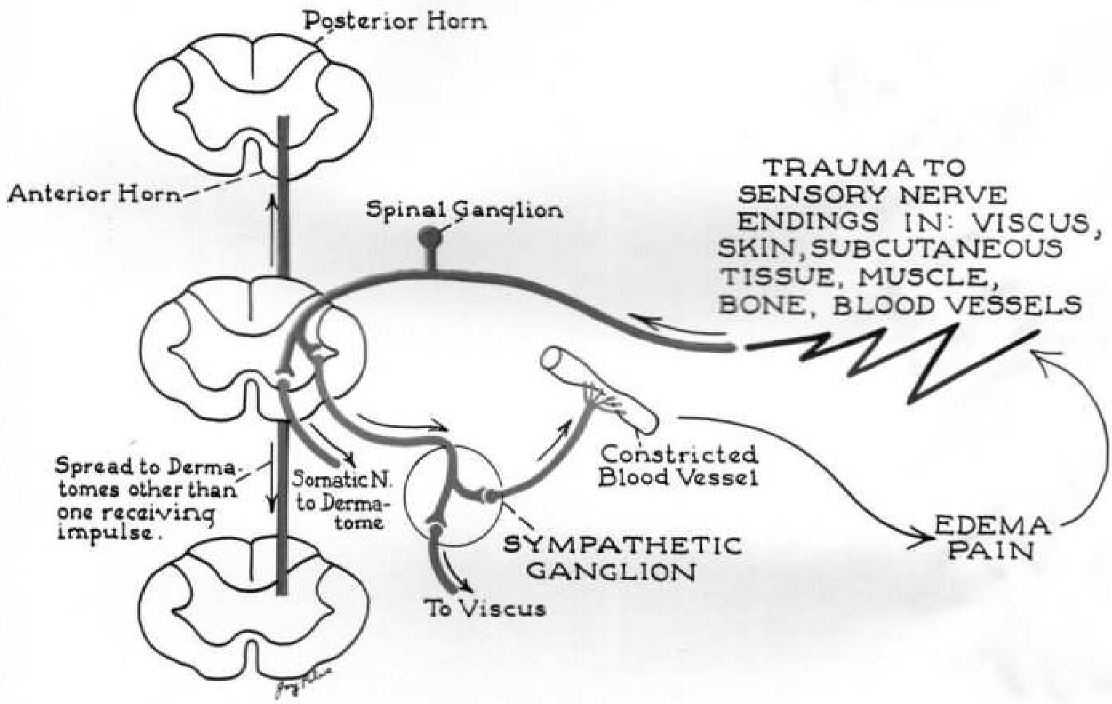

Figure 65. Schematic drawing of the "vicious cycle."

CHAPTER 36

Herpes Zoster (Shingles)

HERPES ZOSTER OF THE FACE and upper extremity is caused by an acute virus infection of nerve structures and is usually considered to be a ganglionitis.[1,2,3] Neuralgic pain or hyperesthesia in the region of distribution of the nerve often precedes the lesions which consist of vesicles resting on top of slightly elevated erythematous plaques. The vesicles are grouped in patches and lie along the course of the nerve or nerves affected. During the active stage of the disease, while the severity of the pain varies, it is usually more severe in the elderly patient. It is often severe enough to disturb sleep and may be unrelieved by ordinary sedation. Post-herpetic neuralgia—pain after the lesions are healed—may persist for many months and cause great discomfort.

INDICATIONS FOR STELLATE GANGLION BLOCK

Pathogenesis.—The essential lesion according to Head and Campbell[3] is an acute inflammatory process of the spinal or posterior root ganglion, that is, a ganglionitis. Because of the dramatic response to sympathetic nerve blockade, Findley and Patzer[4] concluded that vasospasm is an important factor in producing the signs and symptoms and they present the following tentative hypothesis as to the cause of the vasoconstriction: "Herpes zoster is caused by a filtrable virus closely related to that of chickenpox, although other agents (leukemia, tumor, abscess) are occasionally said to be responsible. In any event, the irritation process in the dorsal root ganglion leads to vesicle formation, either by peripheral migration of the virus itself, as seems likely, or by antidromic stimulation of the sensory nerve. At the same time, the cells in the corresponding intermediolateral cell column of the spinal cord are receiving an excessive number of normally directed impulses from the irritated ganglion, a circumstance which results in increased sympathetic vasoconstrictor tone and segmental arteriolar spasm. Local axon reflexes may play a minor role, but the essential point is that procaine infiltration of the sympathetic ganglion interrupts a vicious cycle of nerve impulses. Since it is highly unlikely that the results are due to simple blocking of afferent sensory impulses traversing the sympathetic ganglion on their path to the dorsal root, one must assume that the post-injection hyperemia, however transient, relieves pain by dilution of retained metabolites, and enhances dermal healing."

Clinical and Experimental Investigation.—Many physicians report immediate and marked relief of the acute symptoms of herpes zoster following stellate ganglion block.[4,5,6,7,8,9] In referring to four cases of herpes zoster treated by infiltration of the appropriate sympathetic ganglion, Findley and Patzer[4] state, "In each instance, relief from pain was instantaneous and permanent, and the lesion healed rapidly." Rosenak[7] found that, following procaine injections of the intervertebral ganglion and prevertebral sympathetic cord in 22 patients suffering with herpes zoster, the pain ceased and the vesicles dried in 24 to 48 hours in all but two cases. In paralysis of the radicular type associated with pain following

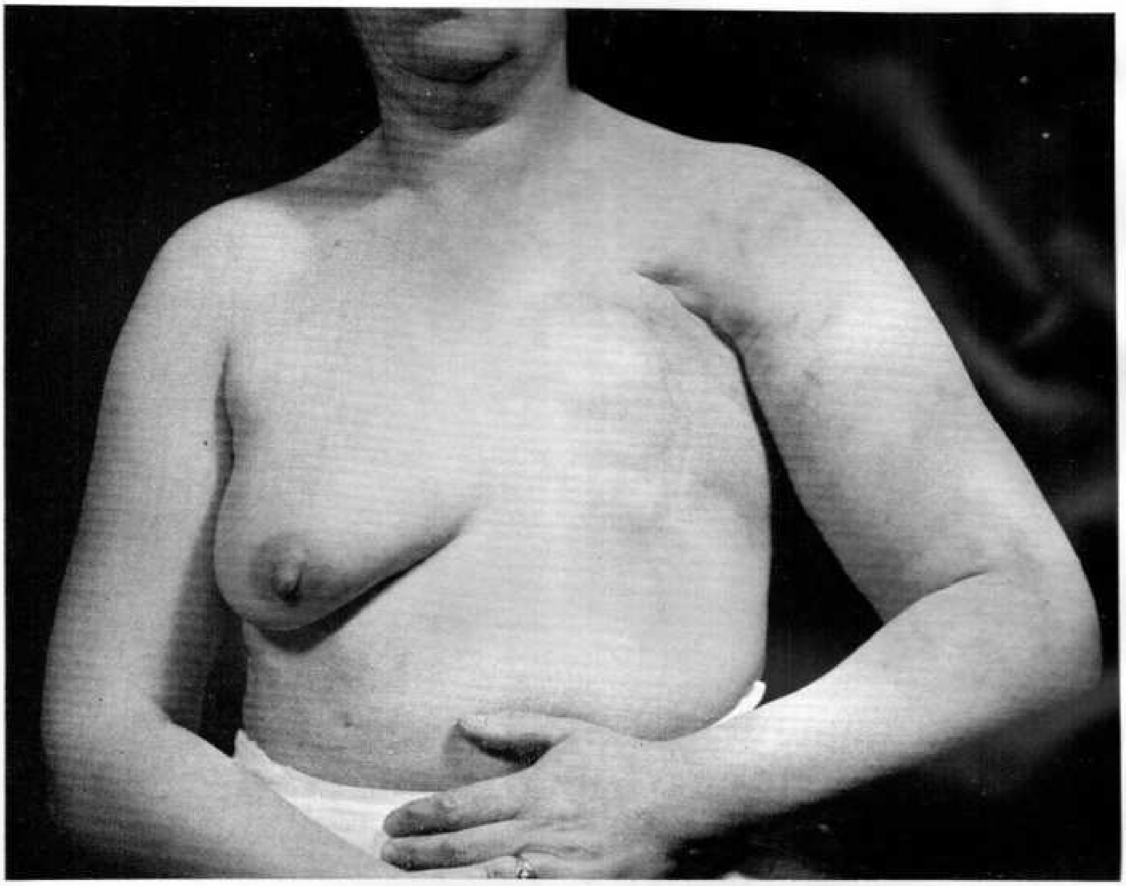

Figure 80. Early herpes zoster which occurred two months following a radical mastectomy for carcinoma. After five blocks on successive days, the painful areas had faded so that a photograph would have shown only normal skin texture. The distribution of the lesion of the upper chest wall, i.e., area under control of the upper four thoracic sympathetic ganglia is noteworthy.

herpes zoster, stellate ganglion block "remarkably" soothes the pain.[10]

Stellate ganglion block, in the author's opinion, should be tried as the first step in therapy of acute herpes zoster of the head, neck, upper chest and upper extremity. If it does not completely relieve the pain, then a somatic block of the dermatome involved should be done. I have treated three cases of acute herpes of the upper extremity and chest. One was treated as the red areas with vesicles started to appear and the results following the stellate ganglion block alone were miraculous (Figure 80, page 213). In this patient, after four blocks given in the period of a week, no evidence of the disease was apparent. In the other two cases the disease had been well established and the vesicles had been present for eight to ten days before hospitalization. In these cases the first three stellate ganglion blocks gave only partial relief and had to be accompanied by brachial blocks to completely eliminate pain (Figure 81, page 214). After these initial blocks, stellate ganglion block, per se, was effective in controlling the pain.

In seven cases of post-herpetic pain treated at the Mason Clinic, sympathetic or peripheral somatic blocks alleviated the pain only during the time of the physiologic action of the drug used. Intrathecal alcohol, root section, or in cases of herpes of the face, alcohol blocks of the terminal branches of the trigeminal

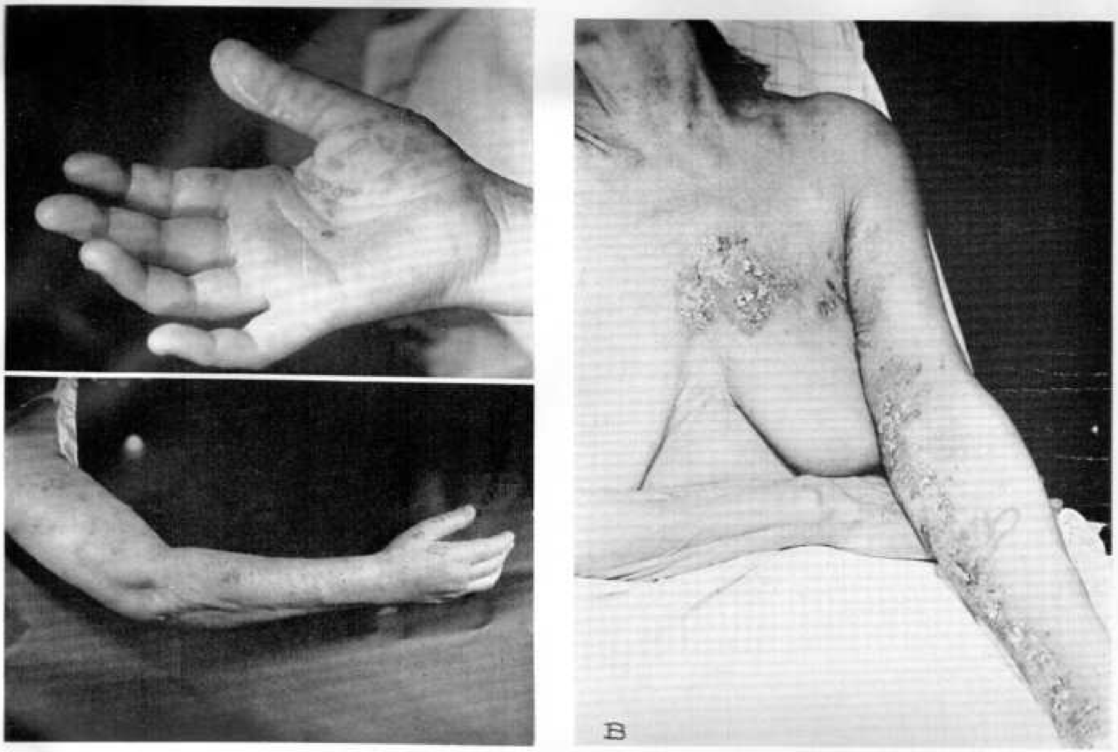

Figure 81. Herpes zoster of the brachial plexus.

nerve have been the effective definitive treatment used by us in alleviating this neuralgia (Figure 82, page 215). Arnulf [5] agrees that post-herpetic neuralgia does not yield to multiple sympathetic blocks.

USES OF STELLATE GANGLION BLOCK

Diagnostic.—None.

Therapeutic.—As stated previously, stellate ganglion block is most effective during the active phase of the disease and the earlier it is instituted the better the results. *Post-herpetic neuralgias respond poorly to sympathetic block.*

Stellate ganglion block should be done as soon as herpes zoster of the head, neck, upper chest wall or upper extremity is diagnosed. While one injection may give immediate relief lasting as long as 48 hours, for complete relief it usually is necessary to give one block daily for four or five days. If, after this time, pain persists or recurs, the block can be repeated at intervals necessary to give relief. A case of herpes zoster has been reported which received partial relief only, after the sixth block, and complete relief after the tenth block.[11] If the patient is receiving x-ray therapy, stellate blocks should be given at the same time rather than be withheld for use should roentgen therapy fail.

If an effective stellate block gives partial pain relief only, a somatic block of the correct dermatome, i.e., a brachial block for the arm, a block of one or more of the cervical nerves for the neck and back of the head, and a block of one of the branches of the trigeminal nerves for the face and forehead will usually give complete relief. We do the stellate ganglion block first and let one hour elapse to evaluate the pain relief before a somatic nerve block is executed.

When stellate ganglion block is used in the acute stage of herpes zoster, other medical therapy, i.e., analgesics, protamide, Aureomycin, Chloromycetin, Terramycin, x-ray therapy, and large doses of thiamin (B_1) and/or Rubramin (B_{12}) should not be omitted.

Figure 82. Post-herpetic lesions and pain over the distribution of the mandibular nerve. Stellate ganglion block gave no relief. Relief was obtained by an alcohol block of the mandibular nerve.

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They point out that in most instances stellate ganglion block will have a beneficial effect on post-traumatic reflex spasm but has no effect on chronic tetanus. Therefore, they use stellate ganglion block as a diagnostic procedure. They cite cases in which stellate ganglion block gave no relief and were thus diagnosed as tetanus. In these cases antitetanus therapy in the form of perineural and intramuscular injection of the serum brought about a cure.

Therapeutic: When convulsive seizures of the whole body occur, the extremity in which the tetanus bacilli are located may be amputated to eliminate further exotoxins gaining entrance to the body. However, the exotoxins left in the body may produce convulsions which may result in death if the patient receives extraneous stimuli.[71] Simon and Patey [71] believe that painful stumps often are the site of these stimuli which can bring on general tetanic reaction after a limb has been amputated. They believe the painful stump indirectly may be the cause of death in some of these cases because it is the trigger area which sets off the spasms. Simon and Patey [71] cite cases with generalized seizures which improved under medical therapy following amputation of the locally infected part. However, it was not unusual for them to have recurrences of the generalized tetanic seizures if pain in the stump, particularly of the causalgic type, developed. In these cases they found that the generalized tetanic convulsive seizure stopped without the resumption of serotherapy provided stellate ganglion block therapy eliminated the stump pain. Therefore, these authors felt that the pain from the stump presented a definite danger to the life of the patient and advocated stellate ganglion therapy in any case in which it could relieve the stump pain.

MIGRAINE HEADACHE

Indications for Stellate Ganglion Block.—*Pathogenesis:* The visual and cortical disturbances of migraine headaches have been shown to be associated with vasomotor changes in the cerebral vessels.[72, 73] From recent reports, the headache of migraine is caused by excessive pulsations and stretching of the walls of the dural and temporal arteries.[8, 73, 74]

Clinical and Experimental Investigation: Reports of relief from migraine following infiltration of the upper cervical sympathetic ganglion have been made by Orsoni.[75] Love and Adson,[76] Dandy,[77] and Craig,[78] have reported relief of cases of severe hemicrania following cervical or cervico-thoracic sympathectomies. However, the author has performed successful stellate ganglion blocks on two patients during migraine attacks and in no way improved their condition. White, Smithwick and Simeone [8] have studied patients with headaches from histamine, lumbar punctures and pneumoencephalographies, who have had unilateral denervations of the cervico-thoracic sympathetic nervous system by ganglionectomies and stellate blocks, and found no evidence of the reduction of pain on the denervated side. Regarding migraine, they write: "It can be stated the available evidence suggests that the autonomic nervous system is implicated in the abnormal pulsations of the cranial branches of the carotid artery which are so important in migrainous headache. But there is little evidence that these impulses ascend in the cervical sympathetic trunk nor to show that afferent impulses traverse this route."

Uses of Stellate Ganglion Block.—*Diagnostic:* If surgery of the sympathetic nervous system is to be performed for migraine, a diagnostic stellate ganglion block should be executed.[72]

Therapeutic: There is very little if any evidence at present that stellate ganglion block is of any use in aborting or relieving migraine headaches. However, if it is used to produce maximum dilatation of the blood vessels of the head and thereby reduces their pulsations and stretching, it should be used at the onset of the attack.

EPILEPSY

The possibility that stellate ganglion blocks may be of some help in preventing epileptic