Contrast Radiography and Effects of Thoracic Sympathetic Ganglion Block

—Anatomical Analysis—

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Thoracic sympathetic ganglion block is less effective than lumbar sympathetic ganglion block due to differences in the anatomical structure of these regions. Contrast radiographic findings and an analysis of the effects of lumbar sympathetic ganglion block have been reported, but there are few reports concerning thoracic sympathetic ganglion block. The relationship between contrast radiography findings and the effects of thoracic sympathetic ganglion block were studied in 131 block procedures which mainly had hyperhidrosis. (Key words: thoracic sympathetic ganglion block, contrast medium, neurolytics, thoracic sympathetic nerves, compartmental block)

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Sympathetic nerve block is an important technique for use in the pain clinic, and its indications are extensive for both inpatients and outpatients. Sympathetic nerve block can increase blood flow, elevate skin temperature, arrest perspiration, and produce analgesia without affecting the somatic nerves. The duration of action can be further prolonged by the concomitant use of neurolytics. The use of thoracic sympathetic ganglion block has been limited, because of technical difficulties due to the close proximity of the lungs and ribs to the insertion tract of the needle.

Furthermore, thoracic sympathetic ganglion block is less effective than lumbar sympathetic ganglion block due to the anatomical position of the sympathetic ganglia at each level. Concerning lumbar sympathetic ganglion block, a correlation has been reported between the contrast radiographic findings and its efficacy, but there are few reports available on thoracic sympathetic ganglion block[1,2]. We studied the relationship between contrast radiographic findings and the efficacy of thoracic sympathetic ganglion block in 44 patients (131 block procedures) who mainly had hyperhidrosis.

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Methods

This study was performed in patients hospitalized at the Kanto Teishin Hospital, and in all cases the block was performed with the patient's informed consent. Patients with hyperhidrosis were mainly selected for the study and arrest of perspiration was taken as indicating an effective block. In hyperhidrosis it is more difficult to obtain an effective thoracic sympathetic ganglion block than in other diseases, according to our experience, so it was considered appropriate to study these patients.

Patients

The 44 patients (131 block procedures) included 32 patients (109 procedures) with hyperhidrosis, 6 patients (14 procedures) with TAO, 6 patients (10 procedures) with Ray-

Table 1. Failure before injecting neurolytics

Cause of failure	No of vertebral levels attempted
Intravascular injection	20
Nerve root puncture	7
Poor position of needle tip	4
Decreased cutaneous sensation	1
Outflow of the contrast medium	
into the longus colli muscle	5
into the intercostal nerve	1
into the post mediastinum	1
Inflow into the epidural space	3

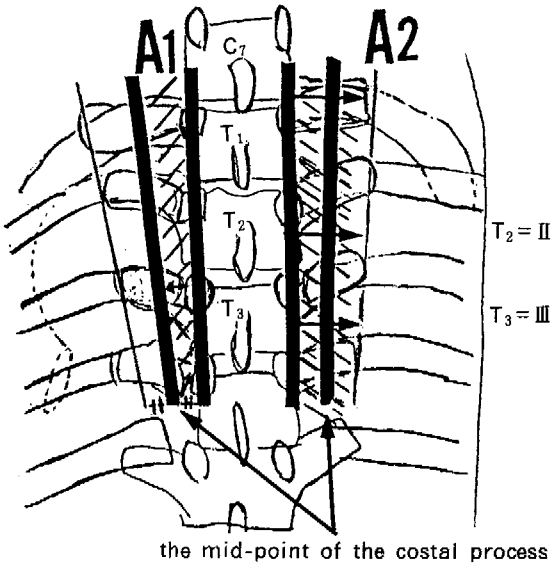

Fig. 1. Diagram of an anteroposterior (A) X-ray film of the thoracic vertebrae.

If contrast medium was present from the lateral margin of the thoracic vertebrae to the mid-point of the costal processes, it was designated as IIA1 or IIIA1, and if the contrast medium extended further laterally it was designated as IIA2 or IIIA2.

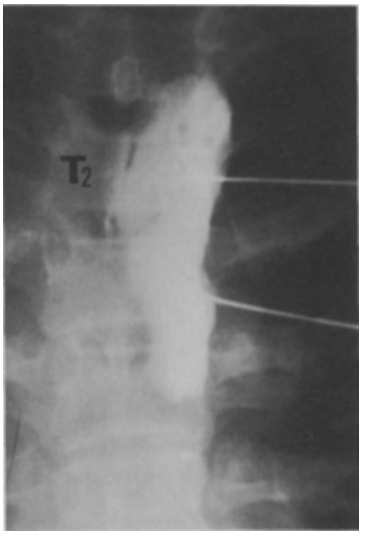

Fig. 2. This is a thoracic sympathetic ganglion block of the right 2nd and 3rd thoracic vertebrae. The contrast medium has not spread from the lateral margin of the thoracic vertebrae to the mid-point of the costal processes, so this is a type IIA1 and IIIA1 block, as explained is figure 1. The contrast medium extends to the mid-point of the anterior surface of the vertebral body, and it is considered that it has flowed into the posterior medastinum.

naud's syndrome. There were 27 males and 17 females and their ages ranged from 14–78 years (31.9 years on average).

The site of the block was on the right side in 71 procedures and on the left side in 60 procedures. Thoracic symathetic ganglion block was performed by a posterior paravertebral method in all cases[1,2]. The site was mainly the 2nd and 3rd thoracic vertebrae, and the needle was sometimes inserted into the 4th thoracic vertebrae. For thoracic sympathetic ganglion block in each procedure the needle was inserted in principle into 2 vertebral bodies, rarely into 3 vertebral bodies, and a total of 264 vertebral bodies were punctured. As a neurolytic, 99.5% alcohol

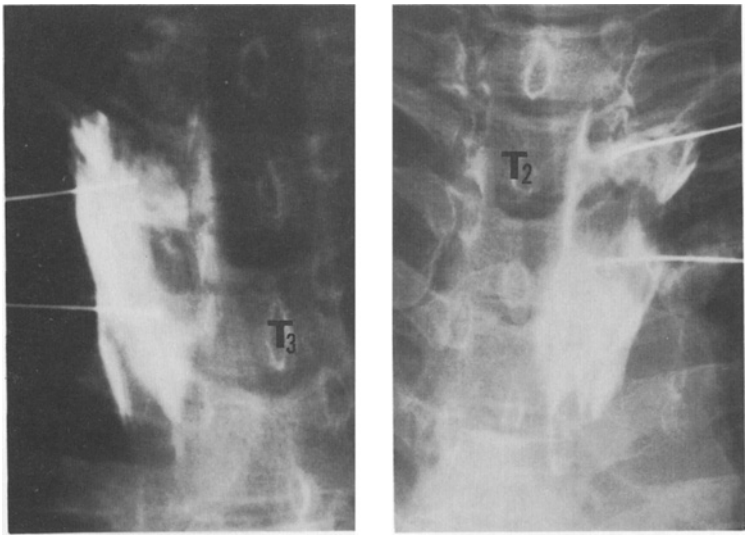

Fig. 3. These are A-P and lateral X-ray films of the 2nd and 3rd thoracic vertebra, showing that the contrast medium has spread from the lateral margin of the vertebral body to beyond the mid-point of the costal processes. This block is type IIA2 and IIIA2, as explained in figure 1. The contrast medium does not extend to the anterior surface of the vertebral body, showing that there is little outflow into the posterior medastinum.

was injected into 217 vertebral bodies, 10% phenolated water into 2 vertebral bodies, and 5% phenolated water into 2 vertebral bodies. The quantity of the alcohol injection was 1–3 ml (2.45 ml on an average). In 42 vertebral bodies no injection of the neurolytics was made because of various problems as listed in table 1. Thoracic sympathetic ganglion block, in which no neurolytics were injected at all in these procedures, was excluded from this study. As contrast medium, 3 ml of a mixture of 60% sodium iotalamate 2.4 ml and 10% lidocaine 0.6 ml was injected for each vertebrae, radiography was performed from 2 directions, anteroposterior and lateral, and the findings were evaluated 3-dimensionally.

Results

Contrast radiography was performed and anteroposterior and lateral X-ray films of the 2nd (II) and 3rd (III) thoracic vertebrae were assessed. In the anteroposterior (A) view, those cases where the contrast medium extended from the lateral margin of the thoracic vertebrae to the mid-point of the costal processes, were designated as IIA1, or IIIA1, and those in which it extended further laterally were designated as IIA2 and IIIA2 (figs. 1,2,3). In the lateral (L) X-ray film, the distance from the anterior margin of the vertebral body to the posterior margin was divided equally into 3 parts: those cases in which the contrast medium was present within the first 2/3 of the body from the anterior margin were designated as IIL1, or IIIL1, and those in which it extended further posteriorly were designated as IIL2 and IIIL2 (figs. 4,5,6). Cases where no neurolytics were injected were designated as II0 and III0.

The block was judged as effective if perspiration was arrested completely on the palm of the hand, when examined on the day after the block.

With regard to the comparison of contrast radiographic findings and the efficacy, IIA2L2 + IIIA2L2 (pattern 3) was 98.3% effective (effective: 58 block, ineffective: 1

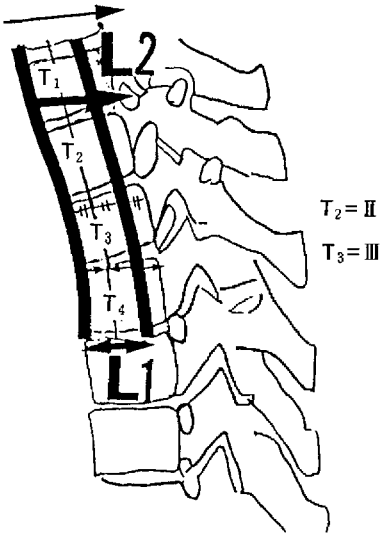

Fig. 4. Diagrams of X-ray films of the thoracic vertebrae.

In this diagram the distance from the anterior margin of the vertebrae to the posterior margin in the lateral (L) X-ray film is divided equally into 3 parts. If the contrast medium extends from the anterior margin across 2/3 of the vertebra, it is designated as IIL1 or IIIL1, while if it extends further backwards it is designated as IIL2 or IIIL2.

Fig. 5. This is a lateral film of a block of the 2nd and 3rd thoracic sympathetic ganglia.

The contrast medium extends from the anterior margin of the vertebral body to cover only about half of the bone so this is a IIL1 and IIIL1 block, as explained in figure 4. Contrast medium is abundant from the vertebral body to the posterior mediastinum. Furthermore, some contrast medium has flowed into the longus colli muscle.

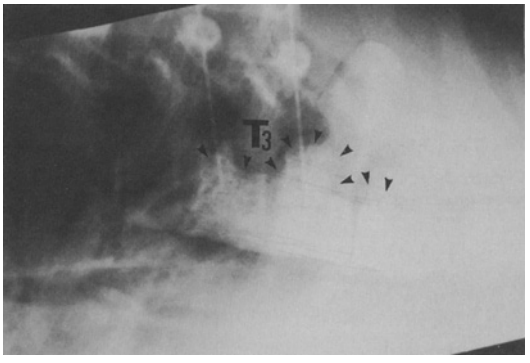

Fig. 6. The contrast medium has spread to the posterior margins of the lateral surface of the 2nd and 3rd thoracic vertebra, so the type of block is IIL2 and IIIL2, as explained in figure 4. The contrast medium remains mostly close to the vertebral body, and there is little outflow into the posterior mediastinum.

block). The sum of IIA2L2 + (III0, IIIA1L1, IIIA2L1, IIIA1L2) (pattern 2) and (II0, IIA1L1, IIA2L1, IIA1L2) + IIIA2L2 (pattern 2) was 77.1% effective (27 vs 8), and blocks showing other radiographic features (pattern 1) were all ineffective (38 out of 38 blocks, $P < 0.001$, table 2).

Discussion

It was White[3] who initially used contrast medium in the performance of a thoracic sympathetic ganglion block. He injected 0.25 ml of Lipiodol, a very small quantity. Katz[4] used a mixture of contrast medium and 6–10% phenolated water. Dondelinger[5] used a CT guide to inject 0.5 ml of contrast medium, and confirmed the extent of the block with CT. However, White and Dodelinger used smaller quantities of contrast medium than we used. In their studies, the quantity of neurolytic injected was 1–3 ml, which was more than the quantity of contrast medium, and it could be expected that the neurolytic might flow to unexpected sites. Further, since Katz used a mixture of neurolytic and contrast medium, there is a risk of complications after the injection and it is difficult to predict the possible side effects.

We injected a 3-ml volume comprising

Table 2. Comparison of Contrast Radiographic Findings and the Effects of Thoracic Sympathetic Ganglion Block at the 2nd and 3rd Thoracic Vertebrae

		Contrast radiographic appearance of the 3rd thoracic vertebra				
		III0 (pattern 1)	IIIA1L1	IIIA2L1	IIIA1L2	IIIA2L2 (pattern 2)
Contrast radiographic appearance of the 2nd thoracic vertebra	II0	0	−4	−4	−1	+8 −1
	IIA1L1	−1	−6	−3	−1	+1 −1
	IIA2L1	−4	−3	−9	−1	+3 −2
	IIA1L2	0	−1	0	0	+1
		(pattern 2)				(pattern 3)
	IIA2L2	+11 −2	+2 −1	+1 −1	0	+57 −1

Contrast radiographic findings	Efficacy of block (+)	Sum
pattern 1	0 (0%)	38
pattern 2	27 (77.1%)	35
pattern 3	57 (98.3%)	58
Sum	84	131

($P < 0.001$)

The 2nd thoracic vertebra is designated as II, and the 3rd thoracic vertebra as III. If the block is effective, it is designated as (+) and if not effective as (−).

In the anteroposterior (A) X-ray film, if the contrast medium extends from the lateral margin of the thoracic vertebrae to the mid-point of the costal processes, it is designated as A1, and if the contrast medium spreads further outward it is designated as A2.

In the lateral (L) X-ray film, the distance from the anterior margin of the vertebral body to the posterior margin is divided into 3 equal parts. If the contrast medium extends from the anterior margin to cover 2/3 of the vertebra, it is designated as L1, and if it extends further posteriorly it is designated as L2. No injection of a neurolytic was designated as II0 and III0. The presence or absence of an effect was investigated for each contrast radiographic pattern. Contrast radiographic findings of IIA2L2 + IIIA2L2 (pattern 3) were associated with 98.3% efficacy. The efficacy of the sum of the IIA2L2 + (III0, IIIA1L1, IIIA1L2) (pattern 2) and IIIA2L2 + (II0, IIA1L1, IIA2L1, IIA1L2) (pattern 2) types was 77.1%, and other contrast radiographic findings (pattern 1) were associated with no efficacy ($P < 0.001$).

60% sodium iotalamate (2.4 ml) and 10% lidocaine (0.6 ml) into each ganglion block needle under fluoroscopic control. By analyzing the extent of spread of the contrast medium and seeing the degree of effectiveness of the local anesthetic, we could estimate the effect and side effects of the block on the basis of our experience of 1,030 block procedures up to late 1989. However, no detailed analysis had been made of the correlation between the extent of the contrast medium and the effect of the block before this study.

A nerve block using a contrast medium is generally performed under radioscopy. The purpose of this nerve block using contrast medium is to make a diagnosis as well as to estimate the effects and side effects of the block by the extent of the contrast medium. As reported previously[2], nerve blocks that are confirmed with contrast medium can be divided into two types: the intra-myelin sheath block and the compartmental block, in which the effective nerve is blocked by retaining a drug solution in a certain section for a certain time. The nerve root block, in which contrast medium is used and which is important for diagnosis, is an intra-myelin sheath block. Thoracic sympathetic ganglion block, celiac plexus block, and lumbar sympathetic ganglion block, in which contrast medium is used to estimate the effects and side effects, are compartmental blocks.

In celiac plexus block and lumbar sympathetic ganglion block, as reported by Shiotani[6] and Yamamuro[7], analysis of the distribution of contrast medium and the effect of the block was made using the com-

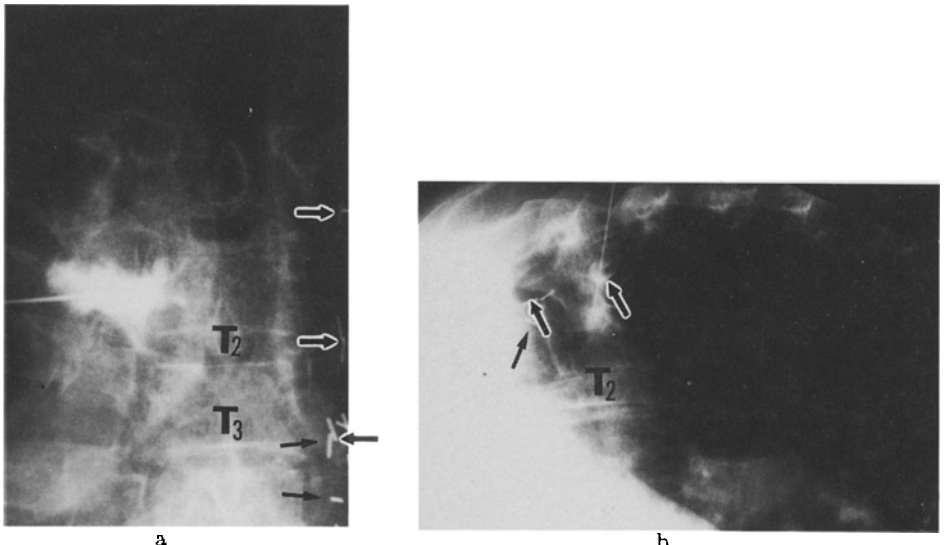

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Fig. 7.

a) A patient with vibration disturbance in whom right thoracic sympathetic ganglionectomy was performed.
The anteroposterior X-ray film shows the 2nd and 3rd thoracic vertebrae. The arrow indicates the site of the clip for ganglionectomy. At the left of the 2nd thoracic vertebra, a thoracic sympathetic ganglion block has also been performed. The contrast medium is spreading beyond the clip, and this block was effective.

b) This is a lateral X-ray film of the thoracic vertebrae. A clip placed at the time of right thoracic sympathetic ganglionectomy is shown. At the left of the 2nd thoracic vertebra, thoracic sympathetic ganglion block has been performed, and the contrast medium extends backwards from the clip.

partment concept.

We have previously reported on the techniques of thoracic sympathetic ganglion block[8], but there has not been any other detailed report on this subject. The distribution of the contrast medium and the effect of the block were studied in 131 blocks. These were mainly performed in hyperhidrosis patients[9,10] in whom it is especially difficult to obtain an effective sympathetic ganglion block in the upper thorax.

In these 131 blocks, the probability of a good effect was high if the contrast medium extended beyond the mid-point between the lateral margin of the vertebral body and the costal process in an anteroposterior X-ray film, and extended as far as the posterior margin of the vertebral body in a lateral film.

In a patient with vibration disturbance who underwent right thoracic sympathetomy and left thoracic sympathetic ganglion block, a comparison was made between the site of excision and the site of the block. When the position of the clip for thoracic sympathectomy on the right side and the position of the contrast medium when the effects were obtained, they nearly corresponded on the X-ray film (fig. 7). If the position of the thoracic sympathetic ganglion is between the clips, the position of the sympathetic nerves on the X-ray film of the thorcic vertebra is also at this site.

Anatomically, thoracic sympathetic ganglia are present on the anterior margin of the ligamentum capituli costae radiatum (fig. 8). Thoracic sympathetic ganglion block is not the significance of achieving by directly inserting a needle into the sympathetic ganglion, but is that of a chemical compartment block using a neurolytic. It intends to block not only the thoracic sympathetic

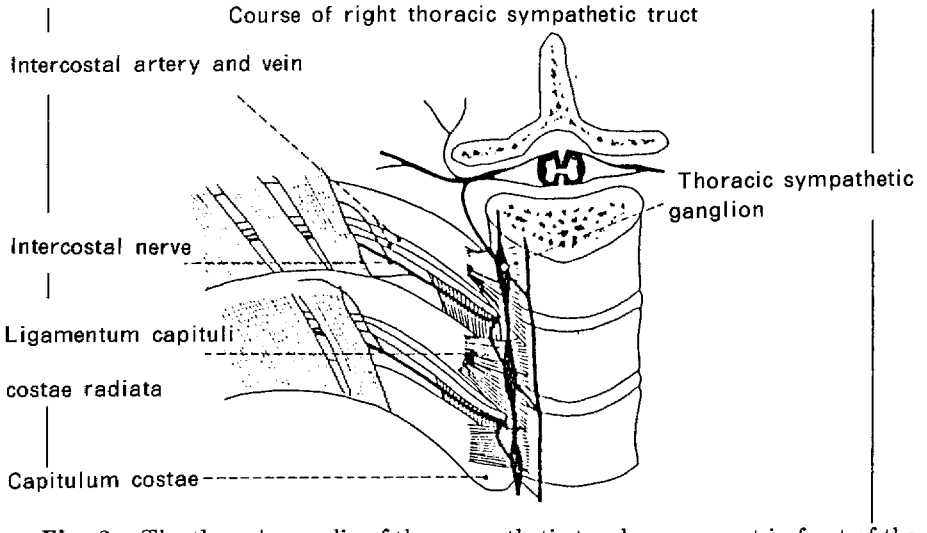

Fig. 8. The thoracic ganglia of the sympathetic trunk are present in front of the ligamentum capituli costae radiata which connects the anterior parts of the heads of the ribs, both vertebral bodies and the intervertebral disk. The ganglia above and below it are connected to each other by the ramus internodialis. Therefore, if the needle tip is placed close to the ligamentum capituli costae radiata, there is a high probability of efficacy.

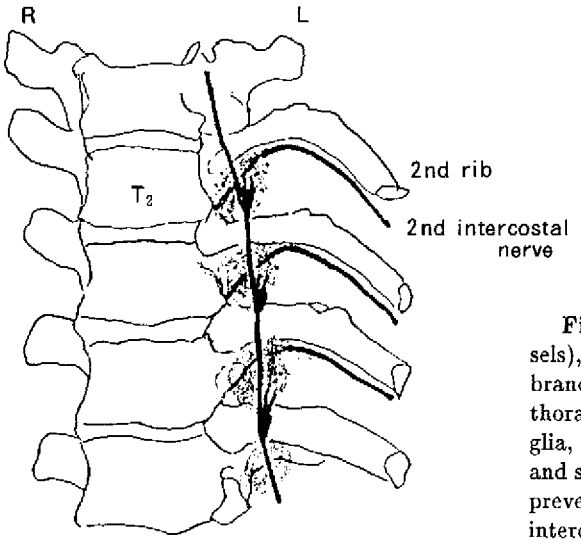

Fig. 9. Fat tissue, lymphatic glands (vessels), intercostal blood vessels, and their branches separate the intercostal nerves and the thoracic sympathetic nerves (sympathetic ganglia, rami internodiales, preganglionic fibers, and some of postganglionic fibers), and serve to prevent the neurolytic drug from reaching the intercostal nerve when it is injected.

ganglion itself, but also the thoracic sympathetic nerves, including the ganglion, white communicating branch and gray branch. If a neurolytic remains for a certain time in the compartment containing the sympathetic nerves, then they can be blocked chemically. If the compartment containing the sympathetic nerves of the 1st to the 12th thoracic vertebrae is considered three-dimensionally, it can be regarded as a flat, slender, tubular space which is open in the direction of the anterior thorax and extends cranially and caudally. The walls of this tubular compartment are constituted mainly by the following 3 elements. The border on the side of the lung is the costal pleura, and the inter-

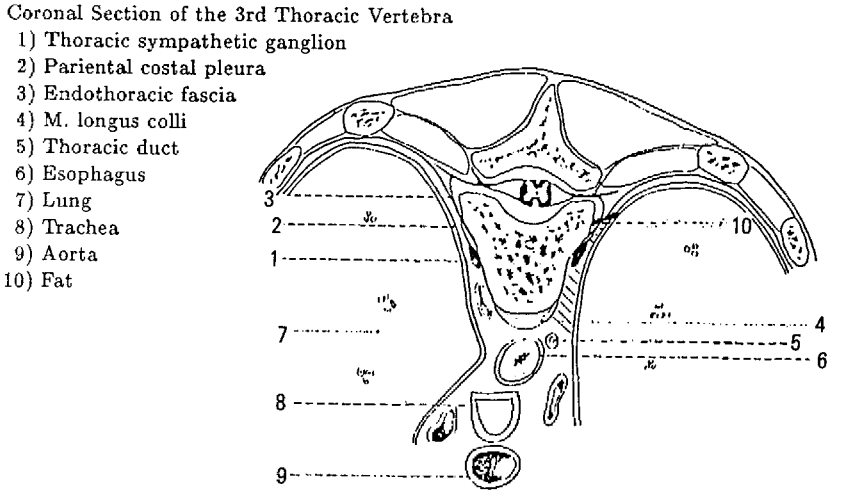

Fig. 10. The hatched region shows part of the compartment into which the contrast medium is injected. It is a flat, slender, tubular space, open to the anterior thorax, and extending both cranially and caudally. As shown in this figure, the contrast medium, and the thoracic sympathetic nerves are present in a compartment composed of the costal pleura, the lateral surface of the vertebral body, the longus colli muscle, fat, and lymphatic tissue, as shown in figure 9. If the contrast medium enters this compartment, it can be expected that a lasting effect will be obtained when a neurolytic drug is injected. However, there are only loose tissues connected to the posterior mediastinum, and there is nothing in particular to retain the contrast medium. For this reason, both the contrast medium and the neurolytic drug solution are likely to flow out into the posterior mediastinum.

costal nerves are mainly surrounded by fat, in addition to lymph glands (vessels), intercostal blood vessels, and their branches (fig. 9). The lateral surfaces of the vertebral bodies provide the other border of a compartment where the sympathetic nerves are present. The second wall, which contains fat, lymph glands (vessels), and intercostal blood vessels or their branches, plays a role in separating the sympathetic nerves and the intercostal nerves. However, according to the Atlas of Topographical and Applied Human Anatomy[12], this role is also played by the endothoracic fascia (fig. 10). The wall is not depicted clearly in other anatomy books. Further in the 1st – 3rd thoracic vertebral parts, the longus colli muscle also constitutes a part of the compartment. The posterior mediastinum and this compartment are separated by loose connective tissue, and an injected drug solution tends to flow out into the posterior mediastinum where the resistance is less. In cases where contrast medium flowed out in large quantities into the posterior mediastinum, the quantity of contrast medium remaining adjacent to the posterior part of the vertebral body was small, and it was difficult to determine the effect.

Similarly, when contrast medium flowed into the longus colli muscle, determining the effect tended to be difficult.

Another factor which plays a part in retaining contrast medium behind the vertebral body is the insertion of the needle tip into the ligamentum capituli costae radiata. By sinking the needle tip into the ligament, flow of the drug solution into the posterior mediastinum is prevented. It prevents the forward outflow of the drug solution, and serves to direct the solution back along the needle tract behind the vertebral body, and thus helps in retaining the solution in the compartment behind the vertebral body.

CT scans are presented of cases where the contrast medium showed an effective block or flowed into the longus colli muscle and posterior mediastinum and showed an ineffective block (fig. 11).

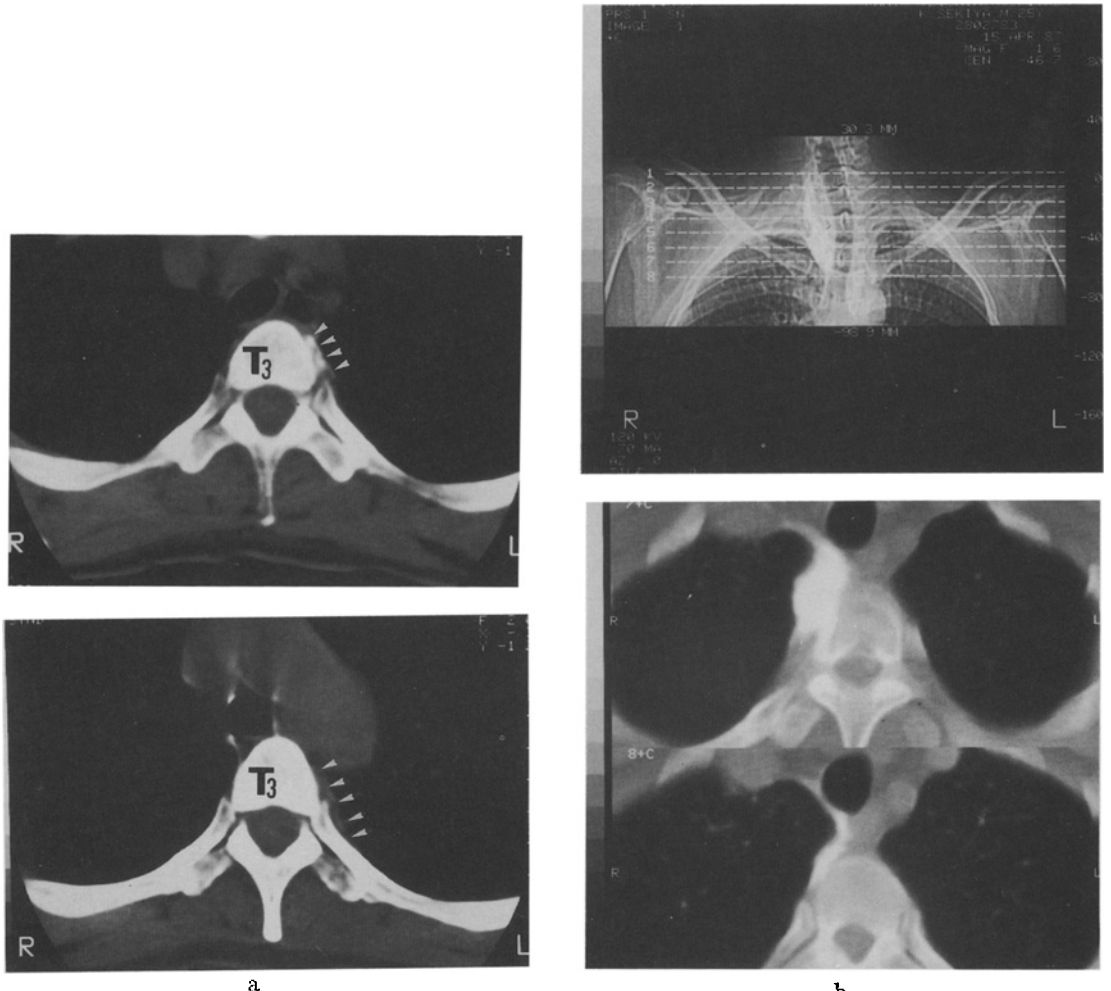

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Fig. 11.

a) CT appearance after Thoracic Sympathetic Ganglion Block at the 3rd Thoracic Vertebra. The contrast medium is present in the compartment shown in the schematic figure, and extends beyond the capitulum cotae. The outflow of contrast medium into the posterior mediastinum is only slight.

b) CT Appearance Following 2nd and 3rd Thoracic Sympathetic Ganglion Blocks. In A-P view of the thoracic vertebra, the contrast medium extends along the longus colli muscle. Also in the CT scan of the 2nd thoracic vertebra, the contrast medium is present in the longus colli muscle, and there is no contrast medium in the compartment.

Since the probability of a block being effective is very high when contrast medium is present in compartments IIA2L2 and IIIA2L2, it is considered that the thoracic sympathetic nerves are present in this compartment.

Furthermore, unless contrast radiography of the 2nd and 3rd thoracic vertebrae shows IIA2L2 + IIIA2L2, the probability of an effective block is low.

As for the neurolytic dose, considering that this thoracic sympathetic ganglion block is a compartmental block, the probability of an effect is high if a large dose is injected. However, from the view-point of causing complications a high dose can be

a problem, and 3 ml is appropriate in our experience. We observe the extent of the contrast medium spread as well as the effects or side effects of the local anesthetic, and then decide whether or not to use a neurolytic or a local anesthetic only, or else adjust the neurolytic dose to between 0.5 and 3 ml.

In our investigation of 131 thoracic sympathetic ganglion blocks (hyperhidrosis in 32 cases, TAO in six cases, Raynaud's syndrome in six cases), an effect was shown when the contrast medium spread beyond the midpoint from the lateral margin of the vertebral body to the costal process in the anteroposterior view, and to the posterior margin of the vertebral body in the lateral view.

An effective block involves not only the thoracic sympathetic ganglia, but also the thoracic sympathetic nerves, including the preganglionic and postganglionic fibers. These sympathetic nerves are present in a compartment consisting of the costal pleura, endothoracic fascia, fat, lymphatic glands (vessels), and intercostal blood vessels or their branches, as well as the lateral surface of the vertebral body, the vertebral ligaments, and the longus colli muscle. If this compartment is filled with the injected drug solution, the block will be effective.

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