# Efficacy of Thoracic Sympathetic Ganglion Block and Prediction of Complications: Clinical Evaluation of the Anterior Paratracheal and Posterior Paravertebral Approaches in 234 Patients

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In the 10 years from 1980 to 1989, a total of 234 patients underwent 557 thoracic sympathetic ganglion blocks. The block was performed by the anterior paratracheal approach in 129 cases and by the posterior paravertebral approach in 428 cases. The procedures for using these two approaches are presented here. The efficacy of thoracic sympathetic ganglion blockade was evaluated as follows; marked efficacy was defined by the complete control of sweating in the palms, moderate efficacy was defined by a decrease in palmar sweating which persisted for at least one week, and minor efficacy was defined by a decrease in sweating followed by recurrence of hyperhidrosis within one week with maintenance of palmar warmth. In addition, the results were retrospectively reviewed in relation to the age and sex of the patients, the technique used, the laterality of the block, the disease treated, the doses of local anesthetic and neurolytic agents, and the number of blocks. The posterior approach was significantly more successful than the anterior approach, and the treatment of both T2 and T3 by the posterior approach was significantly more effective than the treatment of either nerve alone by the same approach ($P < 0.01$). The efficacy rate was significantly lower for hyperhidrosis than for the other diseaces ($P < 0.01$). Complete cessation of hyperhidrosis was signigicantly less common in the over-60 age group ($P < 0.01$). Regarding the dose of neurolytic, the complete cessation of hyperhidrosis was achieved significantly more frequently with doses of 2.5 ml or higher than with lower doses ($P < 0.01$) when both T2 and T3 were treated by the posterior approach. A dose-dependent response if hyperhidrosis was noted at dose levels higher than 2.5 ml. Thoracic sympathetic ganglion blockade was only occasionally associatid with complications, and no serious complications were observed. Before injecting the neurolytic agent, a mixture of contrast medium and local anesthetic was injected to determine the three-dimensional distribution of the contrast and to assess the scope of the analgesia produced by the local anesthetic. Significant complications could thus be avoided. (Key words: thoracic sympathetic ganglion block, technique, anterior approach, posterior approach, compartment block)

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Sympathetic nerve block is commonly performed for the treatmet of pain, peripheral circulatory disturbance, and hyperhidrosis in both inpatients and and outpatients. Blockade of

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the sympathetic nerves increases blood flow, raises the skin temperature, controls sweating, and relieves pains, and these effects can be prolonged by the use of a neurolytic agent.

The first sympathetic nerve block was performed in 1922 by Läewen[1], who injected novocaine by the paravertebral approach for the diagnosis of abdominal visceral pain. Subsequently, Pal[2] and Brunn and Mandl[3] used thoracic sympathetic ganglion block with novocaine for the relief of cardiac pain. There followed many reports on the injection of neurolytic agents to relieve pain in patients with angina pectoris[4–13]. Some isolated reports have also described the procedures, indications, and outcome of thoracic sympathetic ganglion block[9,10,13,14]. However, the number of subjects of those studies was small, and no detailed evaluations of this procedure have been made.

The author has performed upper thoracic sympathetic ganglion block (TSGB) by the anterior paratracheal approach or the posterior paravertebral approach on 557 occasions over a 10-year period. Through this experience, the author has developed techniques which can be used by even inexperienced clinician and which avoid the potential complications of sympathetic ganglion block. A detailed investigation into the efficacy of TSGB was also performed using various indices.

## Subjects

This study was conducted in patients admitted to the Kanto Teishin Hospital who underwent TSGB if this was the best treatment indicated or else after other treatments had been unsuccessful. Informed consent was obtained from each patient before the procedure was performed.

A total of 557 TSGB were performed on 234 patients in past 10 years from 1980 through 1989. The patients ranged in age from 14 to 88 years (57.5 ± 17.9 years, mean ± SD), and there were 117 males and 117 females (290 and 267 blocks, respectively). The disorders treated by TSGB included herpes zoster in 82 patients, hyperhidrosis in 46 patients, peripheral vascular disease (PVD) in 45 patients, reflex sympathetic dystrophy (RSD) in 31 patients, and other diseases in 30 patients (table 1). TSGB was performed on the right side on 251 occasions and on the left side in 306 occasions.

## Procedures for sympathetic ganglion blockade

1. *Anterior paratracheal approach*[15]

This approach is used to block the 2nd and 3rd thoracic sympathetic gangla via the supraclavicular paratracheal route. The patient's position for this technique is the same as that for a stellate ganglion block. A 22 G (8 cm) needle is inserted according to either the "inside" or the "outside" method. With the inside method, the carotid artery and the sternocleidomastoid muscle are pushed laterally in the same manner as when performing a stellate ganglion block, while these structures are pushed medially in the "outside" method. The locations of the 7th cervical and 1st thoracic vertebrae are confirmed by fluoroscopy, the carotid artery and sternocleidomastoid muscle are palpated separately with the left index and middle fingers to define the insertion site beside the 1st thoracic vertebra, and the needle is inserted at an angle of 60–80 degrees against the plane of the fluoroscope base. The needle is then advanced under fluoroscopic guidance along the inferodorsal outer border of the spine until its tip reaches the costal aspect of the 2nd thoracic vertebra, and the tip is then fixed as a site estimated to lieinside the radial ligament of the rib head. Then, an X-ray film is taken with the patient in the swim-

**Table 1.** Efficacy of TSGB via the anterior and posterior approaches

| | | Total | Marked efficacy | Moderate efficacy | Slight efficacy | No change | Aggra-vation | |
|---|---|---|---|---|---|---|---|---|
| All procedures: injection of both a local anesthetic and a neurolytic agent | Anterior approach | 129 | 36 | 12 | 28 | 53 | 0 | $P < 0.01$ |
| | Posterior approach | 428 | 139 | 71 | 112 | 101 | 5 | |
| Peripheral circulatory disturbance (45 patients) | Anterior approach | 65 | 22 | 4 | 10 | 29 | 0 | $P < 0.01$ |
| | Posterior approach | 81 | 46 | 12 | 11 | 10 | 2 | |
| Herpes zoster (82 patients) | Anterior approach | 27 | 2 | 5 | 9 | 11 | 0 | $P < 0.05$ |
| | Posterior approach | 98 | 13 | 30 | 39 | 16 | 0 | |
| Hyperhidrosis (46 patients) | Anterior apptoach | 23 | 8 | 1 | 4 | 10 | 0 | N.S |
| | Posterior approach | 147 | 63 | 12 | 18 | 53 | 1 | |
| Hyperhidrosis procedures for injection of only a neurolytic agent | Anterior approach | 21 | 8 | 1 | 4 | 8 | 0 | $P < 0.01$ |
| | Posterior approach (both T2 and T3) | 88 | 52 | 8 | 9 | 18 | 1 | |
| RSD (31 patients) | Anterior approach | 9 | 3 | 1 | 3 | 2 | 0 | N.S |
| | Posterior approach | 57 | 11 | 8 | 25 | 11 | 2 | |
| others (30 patients) | Anterior approach | 5 | 1 | 1 | 2 | 1 | 0 | N.S |
| | Posterior approach | 45 | 6 | 9 | 19 | 11 | 0 | |

Comparison of the anterior and posterior approach showed that the posterior approach was significantly more effective ($P < 0.01$).

For the total hyperhidrosis group, there was no significant difference of efficacy between the anterior and posterior approaches, but when neurolytic was injected at both T2 and T3, the posterior approach showed a significantly higher efficacy.

N.S: no significant difference

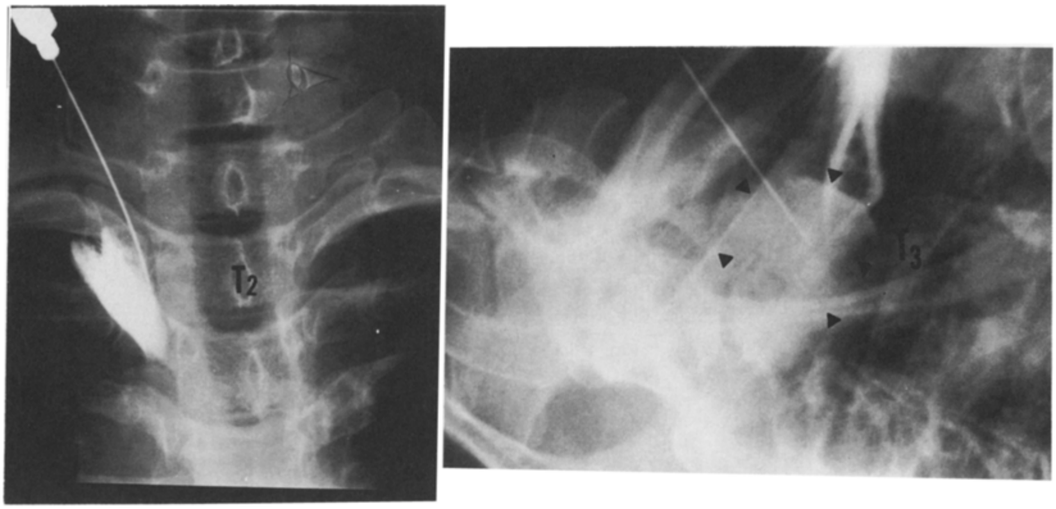


**Fig. 1.** A-P and lateral X-ray films of TSGB by the anterior approach.
The A-P X-ray film shows the distribution of contrast meduim from the lateral vertebral border to the end of the transverse process of the 2nd rib.
The lateral X-ray film shows that the contrast medium is retained in front of the posterior mediastinum and distributed in the area over the dorsal vertebral border.

mer's position to confirm the depth of needle insertion. The depth of insertion varied from 5 to 8 cm (6.4 ± 0.7 cm) in this series. After the needle tip has been confirmed to lie close to the dorsal border of the vertebral body, 3 ml of a mixture of contrast medium (60% sodium iotalamate, 2.4 ml) and 10% lidocaine (0.6 ml) are injected. After injection of the contrast medium, biphasic X-ray films are taken and the images are assessed three-dimensionally (fig. 1). Following confirmation of a favorable image pattern, the effect of the bleckade, and the absence of any complications, a neurolytic agent (99.5% alcohol or 5% phenol water) is injected 20 min after injection of the local anesthetic. In this study, the effect of blockade with the local anesthetic was assessed using a decrease in palmar sweating, a rise in skin temperature, and pain relief as the indices. Complications such as Horner's syndrome, hoarseness, and loss of sensation were carefully checked for after the local anesthetic was injected, and whether or not a neurolytic agent should be used was determined at 20 min after injection of the mixture of contrast and anesthetic. The doses of local anesthetic and neurolytic were 0.5–5 ml (2.6 ± 0.8 ml) and 0.5–3.5 ml (2.4 ± 0.6 ml) respectively. TSGB was performed by this anterior paratracheal approach on 129 occasions; a neurolytic agent was used in 95 of procedures and only a local anesthetic was used in 34.

2. *Posterior paravertebral approach*[15,16]

In principle, 22 G, 10 cm needles were inserted at 2 sites, and it was thus possible to block all the thoracic ganglia from the 1st to the 12th. During the study period, the position of the patient for performance of the block was initially the lateral position, but this was changed to the oblique (semiprone) position and later to the prone position (which is used currently). In most cases, we adopted the prone position and placed a pillow

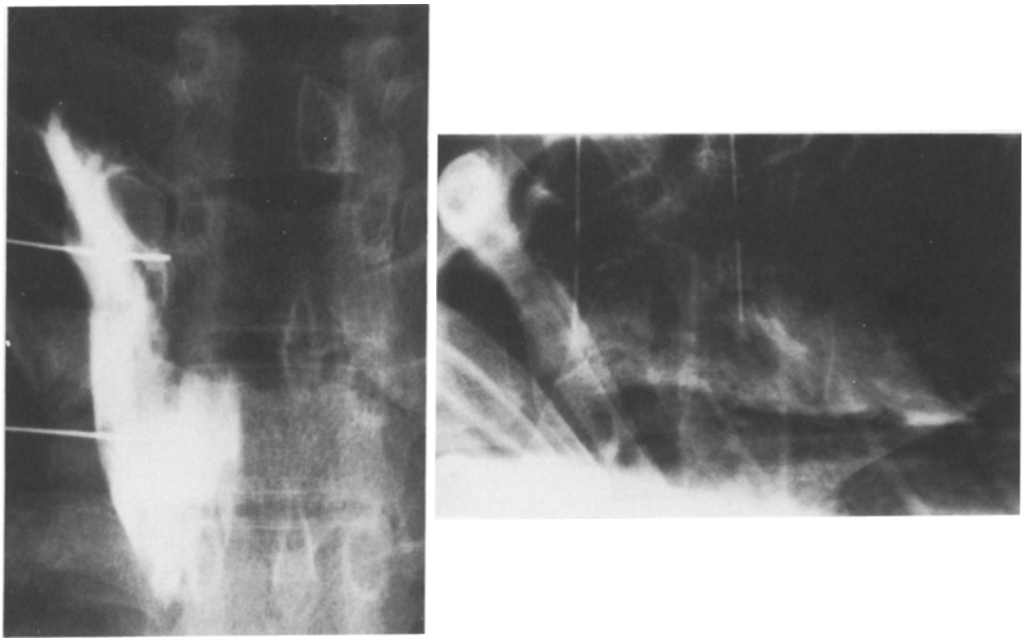

**Fig. 2.** These are a A-P and a lateral X-ray films of T2 and T3, showing that the contrast medium has spread from the lateral margin of the vertebral body to beyond the midpoint of the costal processes and to the posterior margins of the lateral surface of the 2nd and 3rd thoracic vertebra.

The contrast medium does not extend to the anterior surface of the vertebral body, showing that there is little outflow into the posterior mediastinum and mostly remains close to the vertebral body, and there is little outflow into the posterior mediastinum.

between the fluoroscope base and the anterior chest. An overhead X-ray tube with a variable incidence angle was used for fluoroscopy, and X-ray films were taken in both the anterior and lateral views to confirm the localization of the needle tip. When a lateral X-ray film was taken during blockade of the upper thoracic nerves, patients were placed in the swimmer's position if necessary. The point of insertion was an intercostal site about 4 cm lateral to the spinous process. The actual depth from the surface to the spinous process measured 3.5–6.0 cm (4.6 ± 0.6 cm) at the T2-3 intercostal space, and 3.5–6.3 cm (4.4 ± 0.6 cm) at the T3-4 intercostal space. The planned depth of insertion corresponded to one third of the vertebral body depth, which was calculated from measurements made on lateral X-ray films of the thoracic vertebrae taken previously. Needles were inserted exactly to the calculated depth under fluoroscopic guidance. When the proximal end of the needle came into contant with the perivertebral body, lateral images of the thoracic vertebra were taken to confirm the depth of insertion. Then, the needle was inserted under the lateral ligament and advanced to the intended zone corresponding to one third of the distance from the posterior border of the vertebral body. The actual depth of insertion was 5–8 cm (7.4 ± 0.8 cm) at the T2 space and 5.3–10.0 cm (7.3 ± 0.8 cm) at the T3 space.

When the needle had reached the target site, 3 ml of a mixture of contrast medium (60% sodium iotalamate,

**Table 2.** Efficacy of the application of a neurolytic agent at both T2 and T3 or at one of these levels (posterior approach)

| | | | Total | Marked efficacy | Moderate efficacy | Slight efficacy | No change | Aggravation |
|---|---|---|---|---|---|---|---|---|
| Procedures for injection of only a neurolytic agent | Posterior approach | (both T2 and T3) | 237 | 113 | 43 | 55 | 23 | 3 |
| | | (either T2 or T3) | 145 | 32 | 25 | 54 | 33 | 1 |

$P < 0.01$

2.4 ml) and 10% lidocaine (0.6 ml) were injected and the distribution of the contrast medium was monitored three-dimensionally (fig. 2). If the contrast medium entered a blood vessel, it was repidly cleared, while other characteristic patterns were seen if it entered the intercostal nerve or the extradural space. The dose of local anesthetic or neurolytic agent to be used was determined in the same manner as for the anterior paratracheal approach. The doses of local anesthetic and neurolytic used at the T2 level were 1–5 ml (2.4 ± 0.7 ml) and 1.0–3.5 ml (2.3 ± 0.6 ml) respectively, while the respective dose used at the T3 level were 1–5 ml (2.4 ± 0.6 ml) and 1–4 ml (2.4 ± 0.6 ml). This posterior paravertebral approach was adopted for 428 procedures, and in 237 of them a neurolytic agent (mostly 99.5% alcohol or phenol water) was injected at both T2 and T3. A neurolytic agent was injected at either of these levels in 145 procedures, and only a local anesthetic was used in the other 46.

## Methods

The efficacy of TSGB for the T2 and T3 dermatomes was evaluated on the basis of the control of sweating. Complete control of sweating was defined as "marked efficacy", a decrease in sweating which persisted for one week of longer as "moderate efficacy", a decrease in sweating followed by the recurrence of hyperhidrosis within one week despite maintenance of palmar warmth as "slight efficacy", unchanged sweating as "no change", and the worsening of symptoms or the development of complications as "aggravation".

The effects of TSGB were also retrospectively evaluated in relation to the approach used, age, sex, the laterality of the block, the number of repetitions, the doses of blocking agents, and the diseases treated. Complications occurring following the procedure were also investigated. The Wilcoxon t-test was used to test for differences between two groups, and one-way analysis of variance and Scheffe's multiple comparison were used to test for differences among 3 or more groups. $P$ values less than 0.05 were considered statistically significant.

## Results

When the anterior approach was compared with the posterior approach, the posterior approach was found to be significantly more successful (table 1). For the posterior approach, there was a significant difference of efficacy between the patients in whom a neurolytic agent was applied at both the T2 and T3 levels and those in whom it was applied at only one of these levels ($P < 0.01$) (table 2).

When efficacy was assessed in relation to age, there were no significant differences noted among the various age groups, except for patients aged over 60 years "marked efficacy" was

**Table 3.** Efficacy of TSGB classified by age (anterior approach + posterior approach)

| | Total | Marked efficacy | Moderate efficacy | Slight efficacy | No change | Aggravation |
|---|---|---|---|---|---|---|
| 10~19 | 65 | 24 | 6 | 15 | 20 | 0 |
| 20~29 | 108 | 46 | 8 | 18 | 34 | 2 |
| 30~39 | 86 | 31 | 11 | 18 | 25 | 1 |
| 40~49 | 65 | 19 | 12 | 21 | 13 | 0 |
| 50~59 | 79 | 26 | 12 | 21 | 19 | 1 |
| 60~69 | 81 | 20 | 13 | 23 | 24 | 1 |
| Over 70 | 73 | 9 | 21 | 24 | 19 | 0 |

N.S.

| | Marked efficacy | Moderate efficacy and worse | Total |
|---|---|---|---|
| All procedures | | | |
| 10–59 | 146 | 257 | 403 |
| Over 60 | 29 | 125 | 154 |
| | | | P<0.01 |
| Posterior aproach | | | |
| 10–59 | 118 | 195 | 313 |
| Over 60 | 21 | 94 | 115 |
| | | | P<0.01 |

$P < 0.01$

There was no significant differences of efficacy among the age groups, except that the complete control of sweating was attained at a signigicantly lower rate in patients over 60 years old.

**Table 4.** Efficacy of TSGB after various numbers of repetitions (anterior approach + posterior approach)

| | Total | Marked efficacy | Moderate efficacy | Slight efficacy | No change | Aggravation |
|---|---|---|---|---|---|---|
| 1 block | 234 | 67 | 41 | 67 | 58 | 1 |
| 2 blocks | 140 | 44 | 24 | 36 | 35 | 1 |
| 3 blocks | 66 | 20 | 4 | 19 | 21 | 2 |
| 4 blocks | 43 | 13 | 9 | 5 | 15 | 1 |
| 5 blocks | 24 | 12 | 2 | 4 | 6 | 0 |
| > 6 blocks | 50 | 19 | 3 | 9 | 19 | 0 |

N.S.

There were no significant differences of efficacy between the various groups.

significantly less common (table 3). Sex and the laterality of the nerve block had no significant effect on the outcome. In addition, the number of repetitions of blockade had no significant effect on the response (table 4,5).

Among the patients who underwent thoracic block using a neurolytic agent at T2 and T3 via the posteiror approach, a significant difference in the

**Table 5.** Efficacy of TSGB with various doses of neurolytic agent and various numbers of repetitions (posterior approach)

Neurolytic agent at a dose of 2.5 ml or more

| | Total | Marked efficacy | Moderate efficacy | Slight efficacy | No change | Aggravation | N.S. |
|---|---|---|---|---|---|---|---|
| 1 block | 47 | 23 | 9 | 12 | 3 | 0 | |
| 2 blocks | 29 | 17 | 4 | 5 | 2 | 1 | |
| > 3 blocks | 20 | 12 | 3 | 2 | 2 | 1 | |

Neurolytic agent at a dose of less than 2.5 ml

| | Total | Marked efficacy | Moderate efficacy + Slight efficacy + No change + Aggravation | N.S. |
|---|---|---|---|---|
| 1 block | 46 | 14 | 32 | |
| 2 blocks | 29 | 9 | 20 | |
| > 3 blocks | 20 | 11 | 9 | |

There was no significant difference of efficacy between the various groups at the different dose levels.

**Table 6.** Effect of TSGB using various doses of the neurolytic agent (posterior approach)

| | Total | Marked efficacy | Moderate efficacy + Slight efficacy + No change + Aggravation | |
|---|---|---|---|---|
| All procedures | | | | |
| Both T2 and T3, | | | | |
| 2.5 ml or more | 96 | 52 | 44 | $P < 0.01$ |
| less than 2.5 ml | 103 | 36 | 67 | |

| | Total | Marked efficacy | Moderate efficacy | Slight efficacy | No change | Aggravation | |
|---|---|---|---|---|---|---|---|
| procedures for hyperhidrosis | | | | | | | |
| Both T2 and T3, | | | | | | | |
| 2.5 ml or more | 45 | 36 | 2 | 1 | 6 | 0 | $P < 0.01$ |
| less than 2.5 ml | 30 | 7 | 6 | 6 | 10 | 1 | |

When a neurolytic agent was applied at both T2 and T3 at a dose of 2.5 ml or higher by the posterior approach, the number of cases of marked efficacy (complete resolution of hyperhidrosis) was significantly greater than those of lesser efficacy. Marked efficacy against hyperhidrosis was attained at significantly higher rate at doses of 2.5 ml or higher.

effect on hyperhidrosis was noted between those given 2.5 ml or more of neurolytic and those given under 2.5 ml. The difference between these dose groups was significant for all grades of efficacy (table 6).

The success of TSGB was significantly lower for treating hyperhidrosis than for other diseases, including herpes zoster, PVD, RSD, and others ($P < 0.01$) (table 7).

Complications following the injection of neurolytic agents included neuritis in 23 cases, Horner's syndrome in 14 cases, pneumothorax in 3 cases (the patient was in the lateral position

**Table 7.** Efficacy of TSGB in hyperhidrosis and other diseases (posterior approach)

| | Total | Marked efficacy | Moderate efficacy | Slight efficacy | No change | Aggravation |
|---|---|---|---|---|---|---|
| Hyperhidrosis | 147 | 63 | 12 | 18 | 53 | 1 |
| Other diseases | 281 | 76 | 59 | 94 | 48 | 4 |

$P < 0.01$

**Table 8.** Complications following the injection of a neurolytic agent

| | Anterior approach | Posterior (T2, 3) approach | Total |
|---|---|---|---|
| Neuritis | 4 | 19 | 23 |
| Horner's syndrome | 6 | 8 | 14 |
| Pheumothorax | 0 | 3 | 3 |
| Extradural injection | 0 | 1 | 1 |
| Autonomic imbalance | 0 | 1 | 1 |
| Total | 10 | 32 | 42 |

N.S.

The incidence of complications following the injection of a neurolytic agent showed no significant difference between the anterior and posterior approaches.

in 2 cases and in the prone position in 1 case), autonomic imbalance in 1 case, and entry of the neurolytic agent into the extradural space in 1 case. Thus, there were 42 episodes of complications noted in the 557 procedures using a neurolytic agent (7.5%) (table 8). Patients with sensory loss and persistent pain were defined as having neuritis. Neuritis persisted for 2 or more months in 2 cases and subsided within 2 months in the remaining 21 cases. Horner's syndrome was cured within 2 months in most cases, but currently persists after a year in 1 patient. For the detection of pneumothorax, auscultation of breath sounds was performed after nerve blockade, and a chest X-ray film was taken in patients with unilaterally reduced breath sounds. Pneumothorax was treated by intermittent suctioning of the intrathoracic air. Pneumothorax occurred in the patient treated in the prone position because this patient rose up during needle insertion. The one case of autonomic imbalance occurred in a female patient with hyperhidrosis who developed stiff shoulders, dizziness, light-headedness, headache, and dysmenorrhea after sympathetic ganglion blockade. These symptoms subsided with the recurrence of her hyperhidrosis.

Nerve blocking agents were injected only when the correct position of the needle tip was confirmed by fluoroscopy, and the injection of agents was stopped if the patient developed any adverse reaction during the procedure. The patient's response to injection of the mixture of local anesthetic and contrast medium was carefully examined to determine the appropriateness of the subsequent use of a neurolytic agent and to adjust the dose. The planned regimen for TSGB was thereby modified in 241 procedures.

**Table 9.** Effect of TSGB performed with lower doses of the neurolytic agent or only with local anesthetic due to the predicted risk of complications (anterior approach + posterior approach)

| | Total | Marked efficacy | Moderate efficacy | Slight efficacy | No change | Aggravation |
|---|---|---|---|---|---|---|
| procedures treated with regular doses of the neurolytic agent | 318 | 146 | 52 | 78 | 35 | 5 |
| procedures treated with reduced doses of the neurolytic agent or only with local anesthetic | 241 | 29 | 31 | 62 | 119 | 0 |

$P < 0.01$

**Table 10.** Incidence of complications from TSGB classified by the number of repetitions

| | Total | Neuritis | Horner's syndrome | Pneumothorax | Extradural injection | Autonomic imbalance |
|---|---|---|---|---|---|---|
| Once | 20 | 10 | 8 | 2 | 0 | 0 |
| Twice | 10 | 8 | 2 | 0 | 0 | 0 |
| 3 times | 6 | 3 | 2 | 1 | 1 | 0 |
| 4 times | 3 | 2 | 0 | 0 | 0 | 1 |
| 5 times or more | 2 | 0 | 2 | 0 | 0 | 0 |
| Total | 42 | 23 | 14 | 3 | 1 | 1 |

There was no significant difference in the incidence of complications between the various repetition groups.

Blockade was suspended due to the development of discomfort/nausea in 4 procedures and due to hypotension in 2 procedures (all blocks were via the posterior approach). After injection of the mixture of local anesthetic and contrast medium, the entry of contrast into a blood vessel was noted in 85 cases (anterior approach: 15; posterior approach: 70), nerve puncture was noted in 20 procedures (anterior; 1; posterior: 19), hemorrhage in 14 procedures (anterior: 4; posterior: 8), entry of contrast into the extradural space in 7 procedures (all posterior), and vertebral body puncture in 1 procedures (posterior). A neurolytic agent was not used when complications could be predicted. After the injection of local anesthetic, Horner's syndrome was noted in 6 procedures (3 each for the anterior and posterior approaches) and hoarseness in 4 procedures (all posterior), after which reduced doses of the neurolytic agent were used. In other 95 procedures (anterior approach: 8; posterior approach: 87), lower doses of neurolytic were used because the fluoroscopic images were not clear enough. In the patients not treated with a neurolytic agent or treated with reduced doses, the efficacy rate of TSGB was significantly lower than that for the whole series (table 9). The number of repetitions of blockade did not significantly modify the incidence of complications such as neuritis or Horner's syndrome (table 10).

## Discussion

TSGB can be performed by either surgical treatment, sympathectomy[17–21], or chemical nerve blockade. Although sympathectomy can be more effective, it is quite invasive and is associated with a high incidence of postoperative complications which are more likely to be serious[22–27]. It is also a one-off procedure on the other hand, alcohol blockade of the thoracic sympathetic ganglia can be repeated a number of times if it is carefully performed, and thus can achieve an adequate level of efficacy. These technique for TSGB uses 99.5% ethanol and can be safely performed even by inexperienced clinicians[28,29].

There have been a number of reports concerning the procedure of TSGB[30–41]. The published methods vary considerably regarding the patient's position during the procedure, the distance between the needle insertion site and the spinous process, the use of contrast medium prior to the injection of a neurolytic agent, the type and dose of the neurolytic used, and the provision of fluoroscopy. Furthermore, the number of patients treated was limited in the previous reports, and no detailed evaluations were made into the outcome of the procedure.

In addition, the variables altering the efficacy of TSGB have not been assessed in detail in any of the previous reports. In this study, the effects of TSGB via the posterior or anterior approach were compared and the effects of age and sex, the laterality of the block, the disease treated, the doses of anesthetic and neutolytic, and the number of repetitions were all assessed. An attempt was also made to predict the occurrence of complications from the response to the injection of local anesthetic and contrast.

1) *Efficacy*

When the anterior and posterior approaches were compared, the posterior approach was found to be significantly more effective. This may be explained as follows: The anterior approach allows only one needle to be inserted, while the posterior approach allows two needles to be inserted at the same time and both the T2 and T3 levels can be blocked by this approach. Accordingly, the success rate was much higher with the posterior approach. Among patients treated with a neurolytic via the posterior approach, there was also a significant difference in efficacy between those in whom both T2 and T3 were blocked and those in whom only one level was blocked. Therefore, it appears that TSGB is more successful when it is performed at two sites.

When the success rates were compared among the 6 disease groups treated, the rate was significantly lower in the hyperhidrosis group. Hyperhidrosis involves the development of excessive, uncomfortable sweating of the palms, soles, and axillae, and is thought to be caused by hypersensitivity of the sweat-regulatory center. However, no anatomical or functional abnormalities of the sweat glands or the associated sympathetic nervous system have ever been detected in patients with hyperhidrosis. It is generally noted that thermal sweating affects the trunk while mental sweating affects the palms, axillae, and soles, so the sweating seen in hyperhidosis appears to represent mental sweating which is controlled independently from the thermoregulatory center. According to Allen et al.[42], mental stress produces, the general stimulation of sweating even in normal individuals, and such sweating is marked at the palms, soles, and axillae because the sweat glands have a high density in these regions. This suggests that the sympathetic nervous system may by constantly stimulated in patients with hyperhidrosis, so that their sweating cannot be effectively controlled unless the sympathetic system is completely blocked.

When the effectiveness of TSGB was compared among the different age groups, "marked efficacy" (complete control of sweating) was less commonly achieved in patients over 60 years old and the difference was significant. For TSGB, the needle is first inserted into the anterior longitudinal ligament and then nerve blocking agents are injected around this ligament. However, osteoporosis is common in individuals over 60 years old[43], and both thoracic spondylosis and ossification of the anterior ligament also increase with age[44]. In patients with spondylosis, it becomes difficult to insert the needle into the optimum site or to retain the injected nerve blocking agent in the target area posterior to the vertebral body and around the ligament, because a gap between the perivertebral body and the ligament or splits in the ligament itself are apt to be produced by aging. In addition, vertebral body puncture is more likely to occur during insertion of the needle. This lower efficacy rate can be adequately explained by the compartment concept discussed in my previous report on the X-ray findings and efficacy of TSGB in 44 patients (131 procedures)[28,29]. It was found that TSGB is likely to be successful when an anteroposterior X-ray film of the thoracic vertebrae shows the contrast medium in a region surrounding the rid tubercle beyond the midpoint of the transverse process, and when the lateral X-ray film shows contrast medium lying in a compartment dorsal to the center of the vertebra. If the neurolytic agent is retained in this compartment outlined by the contrast medium for a reasonable length of time, the block will be successful. Also, when the needle tip is located within the ligament in the area corresponding to the posterior third of the perivertebral body, the injected contrast medium is likely to be retained in the target compartment without leaking into the posterior mediastinum. However, when patients have osteoporosis or thoracic spondylosis, little of the nerve blocking agent is retained in the intended compartment, and thus complete control of sweating can rarely by attained in patients over 60 years old. This compartment concept differs from that regarding the optimal needle position for radiofrequency thermocoagulation of upper thoracic sympathetic ganglia which was suggested by Yazebski et al[40]. The author considers that, even if the needle tip is not located at the sympathetic ganglion, blockade can still be effective if contrast medium remains within the compartment containing the sympathetic nerves.

This study showed no significant difference in effectiveness between the initial TSGB and repeat blocks, indicating that nerve block can be performed repeatedly with no loss of effect. On the other hand, surgical treatment like thoracic sympathectomy, or thoracic sympathetic thermocoagulation using a thoracoscope as reported by Kux[45] and Weale[46], can be carried out only once. These techniques may thus be considered disadvantageous when the possibility of recurrence is taken into consideration, although they can produce a longer duration of response.

In patients injected with a neurolytic agent at both T2 and T3 by the posterior approach, a significant difference in the complete control of sweating was found between the group given 2.5 ml or more of neurolytic and that given under 2.5 ml. A dose-dependent response of hyperhidrosis was also noted for neurolytic doses of 2.5 ml or higher. This may have occurred because the target site for treatment was formed on the basis of our compartment concept. It was therefore suggested that not only the dose of neurolytic but also the retention time of the agent in the target compartment are important determinants of the outcome of treatment. For the treatment of hyperhidrosis, it may by necessary to use higher doses of neurolytic agents, as indicated by the significantly lower efficacy rate of doses below 2.5 ml. However, in the treatment of peripheral circulatory disturbance or pain, good relief of symptoms may be obtained even if sweating persists.

2) *Complications*

White[9] performed paravertebral alcohol injection in 63 patients (85 episodes) and reported the following complications: pleuritic pain in 4 patients, severe pleuritic pain in 1, pneumonia in 1, and pneumothorax in 2. Alcohol neuritis occurred in almost all his patients and was persistent in about 10% of them.

Levy and Moor[12] performed paravertebral alcohol injection in 45 patients, and reported painful alcohol neuritis in 38, severe pain in 3, small pleural effusions in 5, and pleuritic pain in 1. Pneumothorax was not observed in this series.

Raj[32] performed his method reported that pneumothorax occurred in 4% of his patients. Dodelinder[35] performed his procedure under CT guidance in 12 patients, and reported Horner's syndrome in 3, upper extremity pain persisting for 4 months in 1, and pneumothorax in 1. Wilkinson[36] performed percutaneous radiofrequency upper thoracic sympathectomy in 27 patients, and reported pneumothorax in 2, medial bronchial neuralgia in 3, and Horner's syndrome in 1. Molitch and associates[47], reported the serious complication of Brown-Séquard paralysis in 1 patient.

At our institution, TSGB has been performed by even inexperienced clinicians, and despite this no serious complications attributable to TSGB have been observed.

All complications subsided after several days to several months (table 8). Pneumothorax was noted in 3 patients; 2 of them (12.5%) were placed in the lateral position for blockade via the posterior approach, and the other one (0.25%) was in the prone position for the posterior approach. The patient in the prone position rose up during manipulation of the needle, and this is considered to have been responsible for the occurrence of pneumothorax.

The anterior approach was introduced during this series as and alternative method for TSGB. The posterior approach was first used on patients in the lateral position, but the patient's position was unstable it made the technique more difficult. In addition, pneumothorax occurred occasionally with the posterior approach, while the anterior approach caused no cases of pneumothorax in our series. However, the anterior approach led to Horner's syndrome in 6 procedures. This higher incidence of Horner's syndrome with the anterior approach may be explained by the neurolytic agent running along the needle to the longus colli muscle and reaching the stellate ganglion. Neuritis was observed more frequently with the posterior approach, and this may be because of neurolytic agent ran along the needle to reach the posterior interior intercostal nerve.

There was no nausea or hypotension with the anterior approach, emphasising that one advantage of this method is that patients can relax in this stable position during the operation.

However, a comparison of the efficacy between the anterior and posterior approaches showed that the posterior approach was significantly more effective, and this is the approach currently used in most cases. Interestingly, Yamagami and Kitaguchi[48] have reported that radiofrequency thermocoagulation blockade of the thoracic sympathetic ganglia via the anterior approach may be inferior to alcohol block in the duration of effect, but has no risk of complications and therefore can be performed without hospitalization.

3) *Prediction and prevention of complications*

After the injection of a mixture of local anesthetic and contrast medium, potential complications following the application of the neurolytic agent could be predicted for 24.5% of the total numbar of injections (241/985 episodes; 35/129 for the anterior approach (27.1%), and 206/856 for the posterior approach (24.1%). These 241 procedure accounted for 43.3% of the total number of the TSGB performed. These findings indicate that adherence to this method can help to prevent the complications related to nerve blocks.

## Conclusions

1) TSGB performed via the posterior approach was significantly more successful than that via the anterior approach.

2) When using the posterior approach, blockade of both T2 and T3 was significantly more effective than blockade of only one of these levels. It was also proved that TSGB can be repeated and shows no significant difference in effectiveness with repetition. Therefore, repeated blockade may be successful even in patients who do not respond to the initial attempt.

3) TSGB showed a lower success rate in the treatment of hyperhidrosis compared with other diseases.

4) In patients over 60 years old, TSGB showed a significantly lower success rate for the complete control of sweating.

5) With the posterior approach, neurolytic doses of 2.5 ml or higher injected at both at T2 and T3 produced a significantly higher success rate for the complete control of sweating than doses under 2.5 ml. At dose of 2.5 ml or higher, the neurolytic agent showed a dose-dependent effect on the complete control of sweating.

In the treatment of hyperhidrosis, neurolytic agents given at 2.5 ml or higher doses produced the complete control of sweating more frequently.

6) To avoid the complications of TSGB, the distribution of the contrast medium should be monitored three-dimensionally and the response to the injection of local anesthetic should be examined. Theses findings can be utilized for the prediction of potential complications and for adjustment of the dose of neurolytic to be used.

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