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Frequent Epidural Infusion of Injectate Occurs in Bilateral Experimental C6 SGB Using Cadavers

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ABSTRACT **It is well known that epidural infusion of injectate in association with a C6 paratracheal stellate ganglion block (SGB) leads to negative and/or positive side effects for the patient. However, this associated infusion has not been demonstrated experimentally using cadavers. We found that, in postmortem-fixed cadavers, epidural infusion occurred much more frequently in cases of bilateral SGB than in unilateral SGB. The frequency in the bilateral case (36.1%) was far beyond the two times of the unilateral one (7.7%). The injectate (latex resin, 10 ml for one side) was delivered from the prevertebral deposit into the epidural space by way of the spaces around the C8 and/or T1 spinal nerve roots. Thus, the latex spread around and/or in the brachial plexus usually combined with the epidural infusion. We speculate that the amount of injectate spreading into the prevertebral space in the bilateral injection (total 20 ml) was beyond the hypothetical tentative capacity and that the excess amount made the addional, perineural spread. The present results suggests that, in clinical cases, the frequency of epidural infusion depends on the amount of injectate even in the routine unilateral SGB. However, the cadaveric study did not indicate how much amount is the excess for the living patient.**

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Key words : Stellate ganglion block, Epidural space, Cadaver dissection, Prevertebral space

1 Introduction

Stellate ganglion block (SGB) is a nerve block managed most frequently in our pain clinic for face, head and/or upper extremity discomforts. Our established technique is anterior paratracheal approach at the 6th cervical vertebral level (C6 SGB). But just at the C6 injection site, there exist only cervical sympathetic trunk. The spread route of the injectate during C6 SGB has been studied in experiments on cadavers[1-4], as well as by computerized tomography (CT)[5-7], ultrasound[8] or magnetic resonance imaging (MRI) in living patients or volunteers[9,10]. The former investigators using cadavers noted the retropharyngeal space as the spread route of injectate. Whereas, notably, the latter investigators, who studied in living patients or volunteers, described that the injectate diffuses into the tight space under the cover of the prevertebral fascia, which is occupied by the longus colli.

In those research situations, recently, we demonstrated that, using postmortem-fixed or fresh cadavers, spread of injectate during C6 SGB traveled along the interlaminal prevertebral space (PVILS, Fig. 1)[11]. This potential fascial space corresponds to a classical concept, i.e., the "danger space" for the deep infection such as Ludwig's angina[12-17]. It occupies between the anterior and posterior laminae of the prevertebral fascia. Thus, the PVILS lies immediately in front of the longus colli muscle and it forms a single space extending across the midline. However, in our previous study[11], SGB injectate (i.e., latex resin) often made leakage from the injection point into the retropharyngeal space and/or the lateral phar-

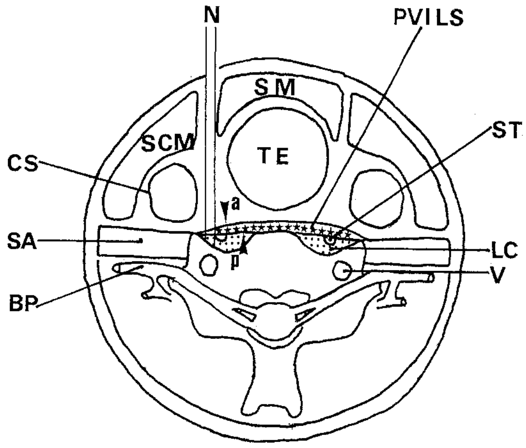

Fig. 1 Fascial arrangement at the C6 cervical level. Cross-section of the cervical region. The top of the figure corresponds to the ventral aspect. The puncture needle (N) for SGB attaches the anterior tubercle of C6. The prevertebral fascia comprises the anterior lamina (arrowhead with "a") and the posterior lamina (arrowhead with "p"). The PVILS (labeled by stars), i.e., the interfascial space between the two laminae, is located in front of the longus colli muscle (dotted area, LC). The cervical sympathetic trunk (ST) is located immediately dorsal to the posterior lamina. The anterior lamina separates the retropharyngeal space (a space behind the trachea and esophagus (TE)) from the PVILS (see also Fig. 4). The carotid sheath (CS), enclosing the large cervical vessels, is located in the lateral pharyngeal space. The scalenus anterior muscle (SA) separated the PVILS from the brachial plexus (BP). SCM, sternocleidomastoideus muscle; SM, strap muscles; V, vertebral artery.

yngeal space (a space around the carotid sheath). Moreover, the leakage increased much more in 20 ml unilateral injection than in 10 ml cases possibly due to decreased capacity of the PVILS by the postmortem fixation (unpublished data). In fixed cadavers, the PVILS seemed not to be able to accept 20ml of latex at a time without severe leakage. Actually, our previous report[11] suggested that the capacity of the PVILS in postmortem-fixed cadavers is smaller than that in the fresh cadavers. Therefore, even 20 ml in amount of injectate seems to be acceptable for C6 SGB for patients although this amount is not usual in our clinic.

Evans et al.[1] suggested that a larger dose of injectate in a lumber sympathetic block leads to an "additional" spread of the injectate into the epidural space. According to them, an epidural infusion of injectate is often associated not only with a lumber sympathetic block but also with a SGB. We simply speculated that the incidence of the additional spread depends on the amount of injectate, i.e., larger amount leads higher frequency. However, in our model of C6 SGB using cadavers, excess dose is not received into the correct route (i.e., the PVILS) but it causes severe leakage (see above). Then, for the present cadaveric study, we hypothesized that the bilateral injections (10 ml for each side) corresponds to the unilateral injection of 20 ml , because the PVILS is a single, continuous space extending across the midline (see above) and because the spread of injectate across the midline was observed more frequently in fixed cadavers than in fresh cadavers[11].

Using our cadaveric model of C6 SGB, consequently, the aim of this study was to clarify the hypothetical relationship between the amount of injectate and the frequency of epidural infusion. For this purpose, we conducted to compare the bilateral injections of total 20 ml of injectates and the unilateral injection of 10 ml. We believed that the latex injected bilaterally would join together in the PVILS, that could result in the almost same effect as expected in the unilateral injection of large dose in the living state. Therefore, the authors appreciate very much if the readers would translate the word "unilateral" (or "bilateral") into "10 ml" (or "20 ml") amount of injectate in this article.

2 Materials and Methods

A total of 88 cadavers (43 males and 45 females) that had been donated to Sapporo Medical University or Tohoku University School of Medicine for the purpose of medical education and research were used in the present study. The subjects were 55-97 years old when they died. The cadavers had been treated by fixation with 7-

10 L of 10% v/v formaldehyde solution injected via the femoral artery without drainage of the blood from the venous side and had been laid in a supine position for several months before the study.

The injectate used was a solution of latex (Neoplen 601-A, DuPont Dow elastomers, Tokyo, Japan). Immediately before use, it was diluted with water so that its viscosity was almost the same as that of a local anesthetic solution.

To ensure that the injection technique was standardized throughout the study, all experimental SGBs were performed by the first author (M. H.), who is an experienced anesthesiologist. The injections were performed unilaterally (52 cadavers) or bilaterally (36 cadavers) using the anterior paratracheal approach at the C6 level. In this approach, the needle is placed just medial to the anterior tubercle of C6 transverse process and it is kept on the tubercle during the injection[18]. Care is taken not to scratch the bones with the tip of the needle, nor to move the tip downward,nor to pull the needle away from the tubercle (Fig. 1).

After a 10-cm square of skin covering the C6 anterior tubercle had been removed so that the deep cervical structures could be easily identified by finger palpation, 10 ml of latex solution was injected unilaterally through a 19-gauge needle over a period of about 10 sec. When conducted bilaterally, the injection on the contralateral side was followed immediately after the former. After allowing for complete polymerization of the latex (over a period of more than 2-3 days), minute dissection was performed to reveal its distribution.

3 Results

In most cases, the latex spread into the PVILS (Table 1) : in 86.5% (45/52) of the cadavers in the case of a unilateral injection (Fig. 2A) and in 100% (36/36) of the cadavers in case of a bilateral one (Fig. 2B). In these cases in which the latex spread into the PVILS, there was also a spread of the latex to the stellate ganglion in 91.9% (41/45) of the cadavers when injected unilaterally and in 94.4% (34/36) of the cadavers when injected bilaterally. In the latter cases, the left side was involved more frequently (29 left sides vs. 23 right sides).

The bilaterally-injected latex reached the thoracic level in front of or under the level of the T1 vertebra in 94.4% (34/36) of the cadavers, and in 10 of these 34 cases, the latex reached the T4 level. Moreover, in these 34 cases, the latex extended onto the inner surface of the upper thor-

Table 1 *Frequency of latex spread at various sites*

	Unilateral injection		Bilateral injection		
Site of latex spread	No	%	No	(left, right, both)	%
PVILS	45	86.5	36		100
Stellate ganglion	41	78.8	34	(11, 5, 18)	94.4
Epidural space	4	7.7	13	(4, 3, 6)	36.1
Brachial plexus	14	26.9	8	(2, 3, 3)	22.2
Vertebral artery[2]	37	71.2	32	(12, 13, 7)	88.8
Post. Thoracic wall[3]	38	73.1	34	(11, 5, 18)	94.4
Total	52		36		

1. In 13 of the total 36 specimens, latex spread into the epidural space. Latex was found around the spinal nerve root on the left and right sides in 10 and 9 specimens, respectively. However, in 6 of the 13 specimens, both sides were involved. Thus, in 7 (left, 4; right, 3) specimens, the spread of latex along the nerve root was restricted to one side.
2. Prevertebral portion of the vertebral artery
3. Inner surface of the posterior thoracic wall at the T1 level

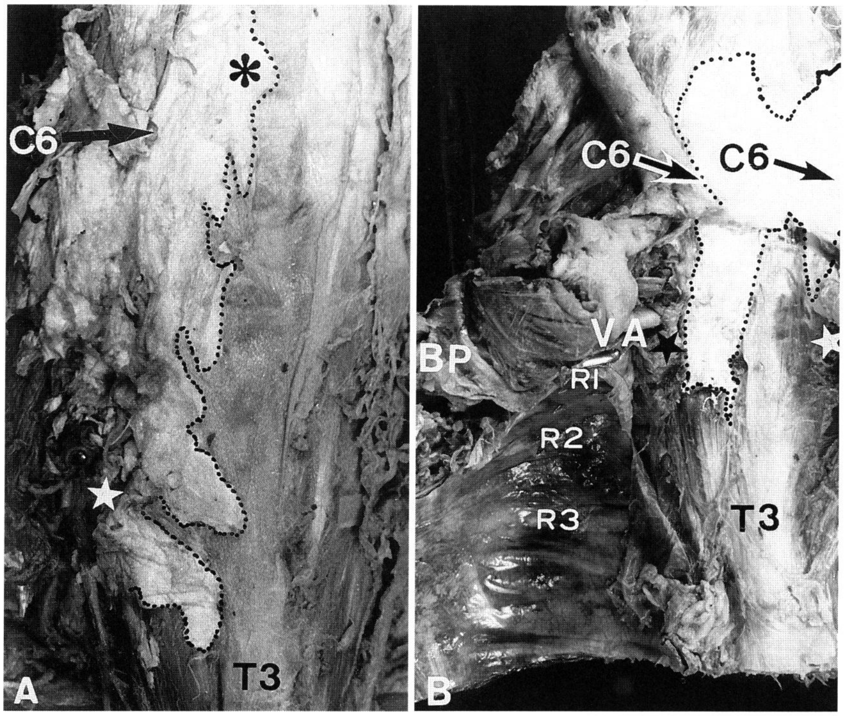

Fig. 2 Latex spread into PVILS
Ventral views after removal of viscera and large vessels. Unilateral (A) and bilateral (B) injections. Injection point (C6 in the right side) is indicated by arrows with " C6 ". A, Latex has extended slightly into the left side (asterisk) in the cervical region but is restricted in the right side of the thoracic region. The left border of latex spread is indicated by a dotted line. Latex has reached the stellate ganglion (star). B. Latex spreds (encircled by dotted lines) injected from both sides have fused with each other in the PVILS in front of the C5-T2 vertebrae. The stellate ganglion (stars) is covered by latex in the left side. BP, upper nerve roots of the brachial plexus ; R1, 2, 3, first, second and third ribs ; VA, prevertebral portion of the vertebral artery.

acic wall, i.e., the space between the endothoracic fascia and the intercostal muscles at the T1 level. The latex also reached the thoracic level in 38 of the 52 (73.1%) cadavers that were injected unilaterally, but the lowest level was T2. The unilaterally injected latex spread across the midline in 11.5% (6/52) of the cadavers, while the bilaterally injected latex spread over almost the entire ventral aspect of the vertebral column.

Consequently, the latex, if injected unilaterally (i.e., 10 ml amount), occupied smaller part of the PVILS or remained its residual capacity, while the bilaterally-injected latex (i.e., 20 ml of amount) occupied larger part of the PVILS or it corresponded to almost full capacity of the PVILS.

As well as spreading into the PVILS and extending to the stellate ganglion, the latex also spread into other spaces in many cases (Table 1) : the epidural space including a space around the spinal nerve root (Fig. 3) ; a space in and/or around the nerve sheath of the brachial plexus (Fig. 3) ; a space around the vascular sheath of the subclavian and/or the prevertebral portion of the vertebral artery ; and a space between the thoracic wall muscles and the endothoracic fascia at the cost-vertebral region. Epidural spread of the latex was seen much more frequently in bilaterally injected cases (36.1%, 13/36) than in unilaterally injected cases (7.7%, 4/52). The epidural spread was consistently associated not only with the PVILS spread but also with a patchy or belt-like deposit of latex around the spinal nerve root(s) at the C8 and/or T1 levels

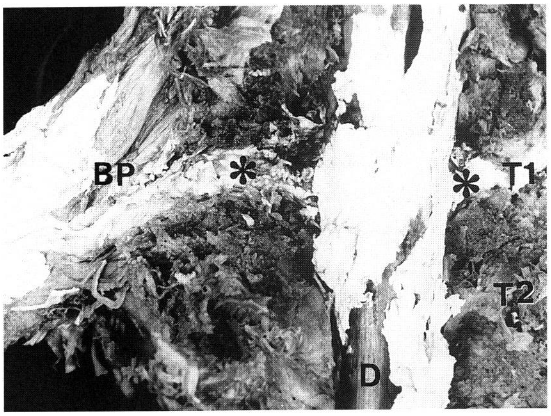

Fig. 3 Epidural spread of latex
Dorsal view of a bilateral injection case after complete removal of the vertebral laminae. The epidural latex has extended from the C5 level to the T4 level. Note the latex around the T1 nerve roots (asterisk) in both sides. A slight protrusion of latex spread along the T2 root is not communicated with the major spread site. Note also the latex spread around the dorsal aspect of the brachial plexus (BP) in the left side (right-hand side). Spinal dural sac (D) containing the spinal cord.

(Fig. 3). Notably, other nerve roots were never involved. There was no apparent laterality of the nerve root(s) involved (10 left sides vs. 9 right sides). The spread around the nerve root was found in 19 of the 72 sides (26.4%) in the bilaterally-injected cases, while in 7.7% of the unilaterally-injected cases. Spread of latex in and/or around the brachial plexus and/or around the prevertebral portion of the vertebral artery was also often seen in combination with epidural spread. When the latex spread around or into the brachial plexus, the posterior fasciculus and/or the inferior trunk were frequently involved.

The incidence of epidural infusion in the bilateral injections was more than 4.7 times than in the unilateral case. Moreover, the bilateral injection resulted in more than 3 times cases of spread around the nerve root if compared with the unilateral inlection. Conclusively, the 20 ml amount of latex caused epidural infusion much more frequently than the hypothetical increase of incidence (i.e., 2.0 times) estimated by the unilateral injection of 10 ml (see also Introduction).

4 Discussion

The present results confirmed our previous reports[11], i.e., spread of injectate during C6 SGB follows the PVILS. The present results also demonstrated that the bilateral injection of latex leads to spread around the nerve root and epidural infusion much more frequently than the unilateral injection. If an accidental scratch of the nerve sheath or epidural infusion actually occurred incidentally, the frequency of those additional spreads could be estimated as almost 2-times higher in the bilateral injection than the unilateral injection. Therefore, we considered that the much more difference in the present study indicates another factor rather than the incidental fascial damage.

Then, what happened actually in the bilaterally injected cases? We speculate a tentative, relatively high pressure in the PVILS caused the epidural spread of latex via the intervertebral canals just above and below the T1 vertebra. At the level, the PVILS is located very close to the perinural space (Fig. 4). Moreover, McCabes and Low[19] and Bernard and Hill[20] suggested the fascial continuation between the prevertebral fascia and perineural sheath around the spinal nerve root. Although the PVILS is located across the midline, spread latex was observed contralaterally in only 11.5% of the unilaterally injected cases. This finding also suggests the enough residual capacity in the unilateral case. On the other hand, two streams of latex were fused in the PVILS when injected bilaterally. A bilateral injection for SGB is not performed actually for patients. However, we speculated that even a unilateral injection would sometimes cause a similar situation in patients because of the individuality in the tentative capacity of the space (i.e., the lesser capacity). Alternatively, in patients, deep respiration may cause rapid fluctuation in the tentative capacity of the PVILS. It is likely that the bottom of the capacity results in additional spread such as epidural infusion. However, strangely enough, the frequency of spread of latex around

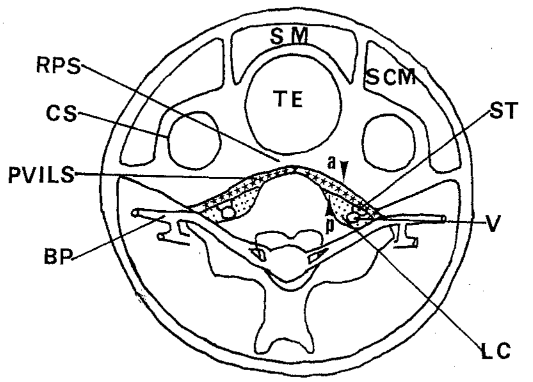

Fig. 4 Fascial arrangement at the C7 cervical level. Cross-section of the cervical region. The top of the figure corresponds to the ventral aspect. Note that the anterior tubercle and scalenus anterior muscle are absent between the PVILS (labeled by stars) and brachial plexus (BP) (see also Fig. 1). RPS, retropharyngeal space. Other abbreviations are same as in Fig. 1.

or into the brachial plexus was not related to the type of injection. We speculated that the latex spread onto the posterior thoracic wall and/or around the prevertebral portion of the vertebral artery increased in amount too much to deliver to the plexus in the bilateral cases. Nevertheless, overall, we believe that the incidence of epidural infusion depends not only on the amount of injectate but also capacity of the fascial space.

Although it is likely that epidural infusion in association with SGB is more common than usual expectations, most cases might not show clinical evidence of this. In patients, SGB injectate seems to spread gradually into the PVILS with a partial leakage into the lateral pharyngeal or retropharyngeal space[12]. The PVILS is usuallly thought to be closed tightly at its lateral margins. However, the present results suggest that, even in patients, the PVILS is likely to open to a perinural space. Moreover, we believe that the frequency of epidural infusion depends on the amount of injectate even in the routine unilateral SGB for patients. However, the cadaveric study never indicated how much amount is the excess for the patient because of the difference between cadavers and living state[12] and because of possible great individualism in the PVILS capacity. The 20 ml dose, conducted in the present study, is likely to much smaller than the capacity of the PVILS in the living state. Finally, according to our clinical experiences, we speculate that some abnormal conditions of the arrangement and/or mechanical quality of the fasciae, such as those possibly caused by traffic accident or infection, stimulate leakage or additional spread along the nerve root to make symptomatic epidural infusion.

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Refereces

1. Evans J, Dobben GD, Gay GR. Peridural effusion of drugs following sympathetic blockade. JAMA 1967, 200 : 573-578.
2. Moore DC. Anatomy of the cervical and upper thoracic portions of the sympathetic nervous system. In : Moore DC. Stellate ganglion block. Springfield, Thomas books, 1954, 10-47.
3. Moore DC. The Use of X-ray and radiopaque materials. In : Moore DC. Stellate ganglion block. Springfield, Thomas books, 1954, 65-79.
4. Moore DC. Tehiniques used by the Author. In : Moore DC. Stellate ganglion block. Springfield, Thomas books, 1954, 83-95.
5. Erickson SJ, Hogan QH. CT-guided injection of the stellate ganglion description of technique and efficacy of sympathetic blockade. Radiology 1993, 188 : 707-709.
6. Christie JM, Martinez CR. Computerized axial tomography to define the distribution of solution after stellate ganglion nerve block. J Clin Anesth 1995, 7 : 306-311.
7. Yamamuro M, Eba Y, Kaneko T, et al. Stellate ganglion block at the sixth cervical vertebra (2) A study of technique. Pein Kurinikku (J Pain Clin) 1991, 12 : 507-512 (in Japanese).
8. Kapral S, Krafft P, Gosch M, Fleischmann D, Weinstabl C. Ultrasound imaging stellate ganglion block : Direct visualization of puncture site and local anesthetic spread : a pilot study. Reg Anesth 1995, 20 : 323-328.
9. Guntamukkala M, Hardy PAJ. Spread of in-

jectate after stellate ganglion block in man: an anatomical study. Br J Anesth 1991, 66: 643-644.
10. Hogan QH, Erickson SJ, Haddox JD, Abram SE. The spread of solutions during stellate ganglion block. Reg Anesth 1992, 17: 78-83.
11. Honma M, Murakami G, Sato TJ, Namiki A. Spread of injectate during C6 stellate ganglion block and fascial arrangement in the prevertebral region: an experimental study using donated cadavers. Reg Anesth Pain Med 2000, 25: 573-583.
12. Smith JE. Retropharyngeal absecess with reference to abnormally large percentage of adult cases. Ann Otol 1940, 49: 490-500.
13. Van der Bremppt X, Derue G, Severin F, Colin L, Gilbeau JP, Heller F. Ludwig's angina and mediastinitis due to Streptococcus milleri: usefulness of computed tomography. Eur Respir J 1990, 3: 728-731.
14. Nguyen VD, Potter JL, Hersh-Shick MR. Ludwig's angina: an uncommon and potentially lethal neck infection. AJNR 1992, 13: 215-219.
15. Beasley DJ, Amedee RG. Deep neck space infections. J La State Med Soc 1995, 147: 181-184.
16. Hollinshead WH. Fascia and fascial spaces of the head and neck. In: Hollinshead WH. The Head and Neck, 3rd ed. Philadelphia, Lippincott (Harper & Row), 1982, 269-289 (Anatomy for surgeons, Vol. 1).
17. Coller FA, Yglesias L. The relation of the spread of infection to fascial planes in the neck and thorax. Surgery 1937, 1: 323-337.
18. Eba Y. Stellate ganglion block at the level of six cervical vertebra. Pein Kurinikku (J Pain Clin) 1991, 12: 329-338 (in Japanese).
19. McCabes JS, Low FN. Subarachnoid angled: an area of transition in peripheral nerve. Anat Rec 1969, 164: 15-34.
20. Bernard CM, Hill HF. The spinal nerve root sleeve is not a preferred route for redistribution of drugs from the epidural space to the spinal cord. Anesthesiology 1991, 75: 827-832.

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解剖体において両側性の星状神経節ブロックは頻繁に硬膜外腔への薬液浸潤を起こす

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星状神経節ブロックに伴う薬液の硬膜外腔流入は，比較的まれな副作用とされているが，症状を伴わない例を含めれば実は予想外に高頻度の可能性がある．しかしその原因や薬液浸潤路について詳細な報告はない．解剖体を用いた模擬星状神経節ブロックにおいて，我々はC6旁気管前アプローチに従い，一側に付きラテックス樹脂を10 ml注入した．ラテックスは椎前葉間隙(Prevertebral interlaminal space)に主に分布し，さらに第8及び第1脊髄神経根に沿って硬膜外腔に到達していた．椎前葉間隙は左右共通であり，そこに入るラテックス量は両側注入で20 ml，一側注入では10 mlである．我々は，両側注入が一側注入に比較して，はるかに頻繁に硬膜外腔へのラテックス流出を起こす事に注目した(両側の36.1%，13/36，右のみ4，左のみ3，両側6；一側注入は7.7%，4/52)．仮にこの頻度が穿刺回数に比例するなら，両側注入における硬膜外腔流入は一側注入の約2倍の頻度になるはずである．両側注入の場合，筋膜隙の許容量を超えるラテックスが短時間に入るため，椎前葉から一続きと言われる脊髄神経鞘を介して，硬膜外腔に薬液の漏出が起こると考えた．この結果は，硬膜外腔への薬液流出の頻度が，生体においても薬液量に比例して高まることを示唆している．しかし，本研究における10 ml・20 mlという数値は，生体における許容量とその個人差を示すものではない．