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Clinical Article

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The Patterns of Intraosseous Venography before Percutaneous Vertebroplasty for Osteoporotic Compression Fractures

Objective : Bone cement leakage is a well-known potential complication of percutaneous vertebroplasty (PVP) in patients with osteoporotic compression fracture. Even though there has been a controversy in the efficacy of antecedent venography to prevent this complication, many authors have performed intraosseous venography before bone cement injection. The goal of this study was to classify the venous drainage patterns of spine before PVP, and compare their patterns at different vertebral levels.

Methods : The authors retrospectively reviewed 1,042 intraosseous venographic patterns in 321 patients with 574 osteoporotic compression fractures during six-year period in one institution. To classify venogram patterns, we selected simple lateral X-ray of spine taken immediately after injection of the contrast dye. We classified the venography patterns according to contrast leakage pattern and leakage direction as follows; trabecular (TR), trabecular anterior (TA), trabecular posterior (TP), trabecular anterior-posterior (TAP), trabecular lateral (TL), venous anterior(VA), venous posterior (VP), venous anterior-posterior (VAP), soft tissue (ST). Also, we compared venogram patterns according to different spinal levels.

Results : In overall, the most common pattern was TP type accounting for 37.4% (390/1042) of all intraosseous venograms. This is followed by TAP in 21.5%, TR 17.4%, TA 11.6%, TL 5.8%, ST 4.1%, VA 1.2%, VP 0.6%, and VAP 0.4% in descending order of frequency. According to the spinal level, TR and TAP types were most common in thoracic spine (T6-T10), TP type was most common in thoraco-lumbar spine (T11-L2), and TP and TAP types were most common in lumbo-sacral spine (L3-S1). Contrast dye leakage to soft tissue such as psoas muscle or disc were detected in 43 (4.1%) venograms. Direct venous drainage without staining of vertebral body was found in 23 (2.2%) venograms. The 8.3% of thoracic venogram showed direct venous drainage. Thoracic level showed a more tendency of direct venous drainage than other spine levels (p<0.01).

Conclusion : The authors propose a new classification system of intraosseous venography during PVP. The trabecular-posterior (TP) type is most common through all spine, and venous-filling (V) type was most frequent in thoracic spine. Further study would be necessary to elucidate the efficacy of this classification system to prevent bone cement leakage during PVP.

KEY WORDS : Percutaneous vertebroplasty · Bone cement leakage · Venography pattern · Osteoporosis · Compression fracture.

INTRODUCTION

The vertebral body is the tissue surrounded by many vessels including venous plexus that communicate directly with vena cava or vein[2]. Vertebral venous system consists of basivertebral vein, external vertebral venous plexus, and internal vertebral venous plexus and connect with brain, chest, abdomen and subcutaneous tissue due to its anatomical feature of valveless structure[12]. Due to this venous communications, polymethylmethacrylate (PMMA) leakage can cause serious complications such as nerve root compression or pulmonary embolism during PVP for treatment of vertebral compression fractures[3,4,14,17,18,23,25]. Even though there are still some controversies, it is reported that intraosseous venography estimates the route of bone cement leakage and helps in decreasing these serious complications. The object of this study was to classify the venogram patterns according to the types of leakage of contrast media and to verify the differences of venogram patterns according to various spine levels.

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MATERIALS AND METHODS

The authors retrospectively reviewed 1,042 intraosseous venography (thoracic spine 341, lumbar spine 687, sacrum 14) in 321 patients with 574 vertebral compression fractures between February 2000 and January 2006 at one institute. The 71 patients (22%) were male and 250 patients (78%) were female with a mean age of 69 years (range, 29-87 years). All patients were treated due to osteoporotic compression fractures.

The intraosseous venography was performed just before the PMMA injection and operating method is as below. All patients were placed in prone position with local anesthetic infiltration. The fluoroscopic C-arm unit was then used to confirm the pedicle image of fractured vertebrae. Through this image, we inserted 11G Jamshidi needle into the pedicle and connected syringe which contain contrast media to needle, and then digital subtraction venography was performed during injection of 2-3 ml of contrast dye. The amount of contrast dye was decided according to size of vertebral body; 2 ml in thoracic spine, 3 ml in thoraco-lumbar junction and lumbo-sacral spine. With a transpedicular approach, the needle tip was advanced to the junction of anterior and middle thirds of vertebral body. To classify venogram patterns, we selected simple lateral X-ray of spine taken immediately after injecting the contrast dye. We classified the venogram patterns into three types : trabecular-filling type, venous-filling type, and soft tissue type by contrast leakage pattern (Table 1). These three types were subdivided by leakage direction (Fig. 1). TR (trabecular) type is the case when contrast dye is localized inside the confines of the vertebral body, TA (trabecular-anterior) type is considered when contrast dye fills the vertebral body and leaks anteriorly in the vertebral body through the vein, TP (trabecular-posterior) type is classified

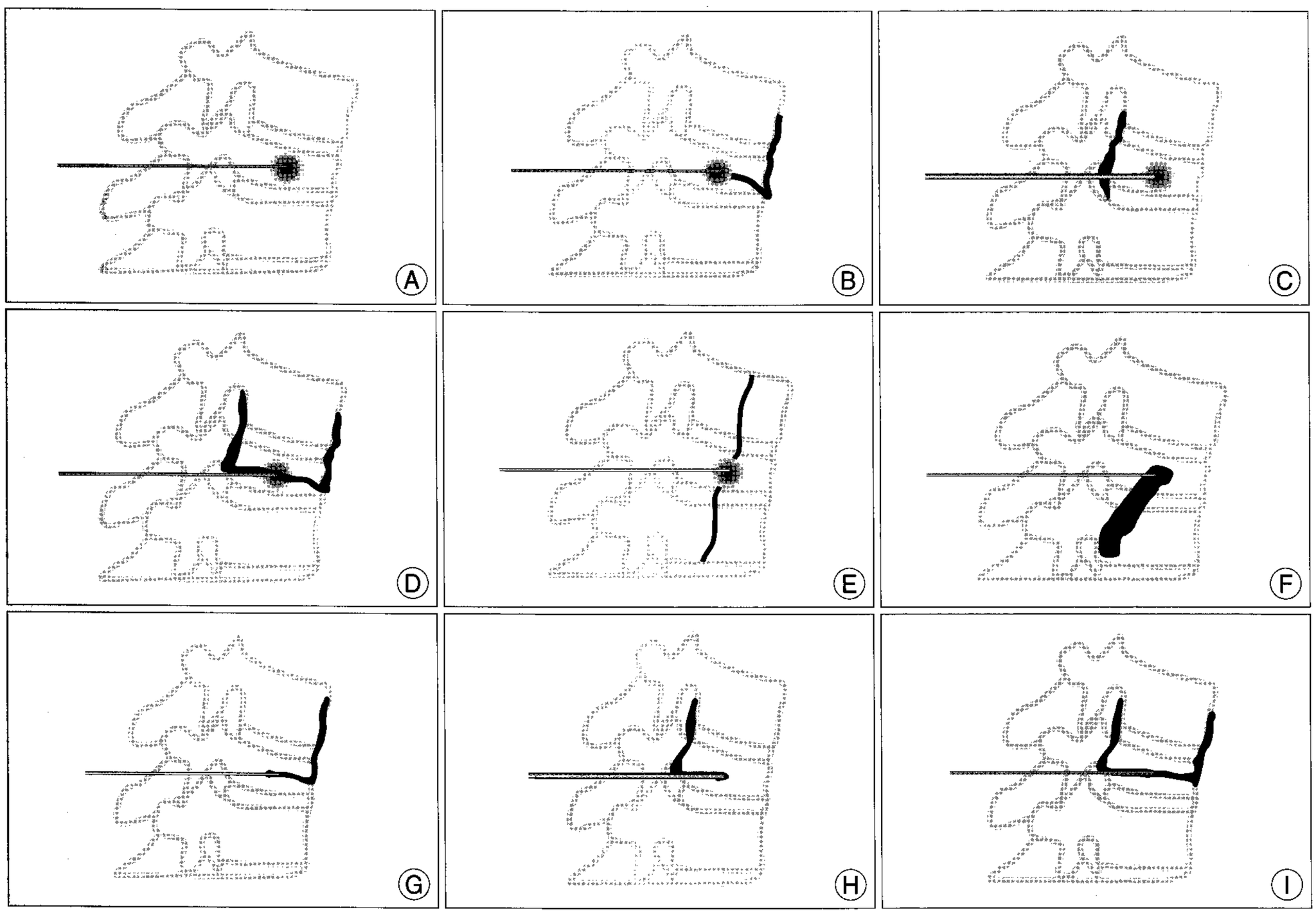

Fig. 1. Classification of intraosseous venography patterns. A : TR(trabecular) type when contrast dye is localized inside the vertebral body. B : TA (trabecular-anterior) type in which contrast dye is filling the vertebral body and leaks anteriorly through the vein. C : TP (trabecular-posterior) type when contrast dye fills the vertebral body and leaks posteriorly through the vein. D : TAP (trabecular-anterior posterior) type when contrast dye fills the vertebral body and leaks anteriorly and posteriorly concurrently through the vein. E : TL (trabecular-lateral) type in which contrast dye fills the vertebral body and leaks laterally through the vein. F : ST (soft tissue) type when contrast dye fills the vertebral body and leaks in soft tissue around the vertebral body. G : VA (venous-anterior) type is defined when contrast dye leaks anteriorly through the vein without filling vertebral body. H : VP (venous-posterior) type is classified when contrast dye leaks posteriorly through the vein without filling vertebral body. I : VAP (venous-anterior posterior) type when contrast dye leaks anteriorly and posteriorly concurrently without filling vertebral body.

when contrast dye fills the vertebral body and leak posteriorly in the vertebral body through the vein, TAP (trabecular-anterior posterior) type when contrast dye fills the vertebral body and simultaneously leaks anteriorly and posteriorly in the vertebral body through the vein, TL (trabecular-lateral) type when contrast dye fills the vertebral body and leaks laterally in the vertebral body through the vein. The ST (soft tissue) type is considered when contrast dye fills the vertebral body and leaks into soft tissue around the vertebral body. The VA (venous-anterior) type is the case when contrast dye leaks anteriorly in the vertebral body directly through the vein without filling vertebral body, VP (venous-posterior) type when contrast dye leaks directly posteriorly in the vertebral body without filling vertebral body, and VAP (venous-anterior posterior) type when contrast dye simultaneously leaks anteriorly and posteriorly in the vertebral body without filling vertebral body.

PMMA, about 3 cc in volume, was prepared with adequate viscosity and divided into three, each in 1 cc syringe. It was slowly injected by controlling the power of hand grip. The differences of venography pattern were then analyzed according to the level of vertebral body.

Statistical analysis was done using SPSS 11.0 stastistical package (SPSS Inc, Chicago, IL) and p-value of <0.05 was considered statistically significant.

Table 1. Classification of intraosseous venography patterns

Type		No. of cases (%)
Trabecular-filling type	Trabecular only (TR)	181 (17.4)
	Trabecular-anterior (TA)	121 (11.6)
	Trabecular-posterior (TP)	390 (37.4)
	Trabecular-anterior posterior (TAP)	224 (21.5)
	Trabecular-lateral (TL)	60 (5.8)
Venous-filling type	Venous-anterior (VA)	13 (1.2)
	Venous-posterior (VA)	6 (0.6)
	Venous-posterior posterior (VAP)	4 (0.4)
Others	Soft tissue (ST)	43 (4.1)
Total		1042 (100)

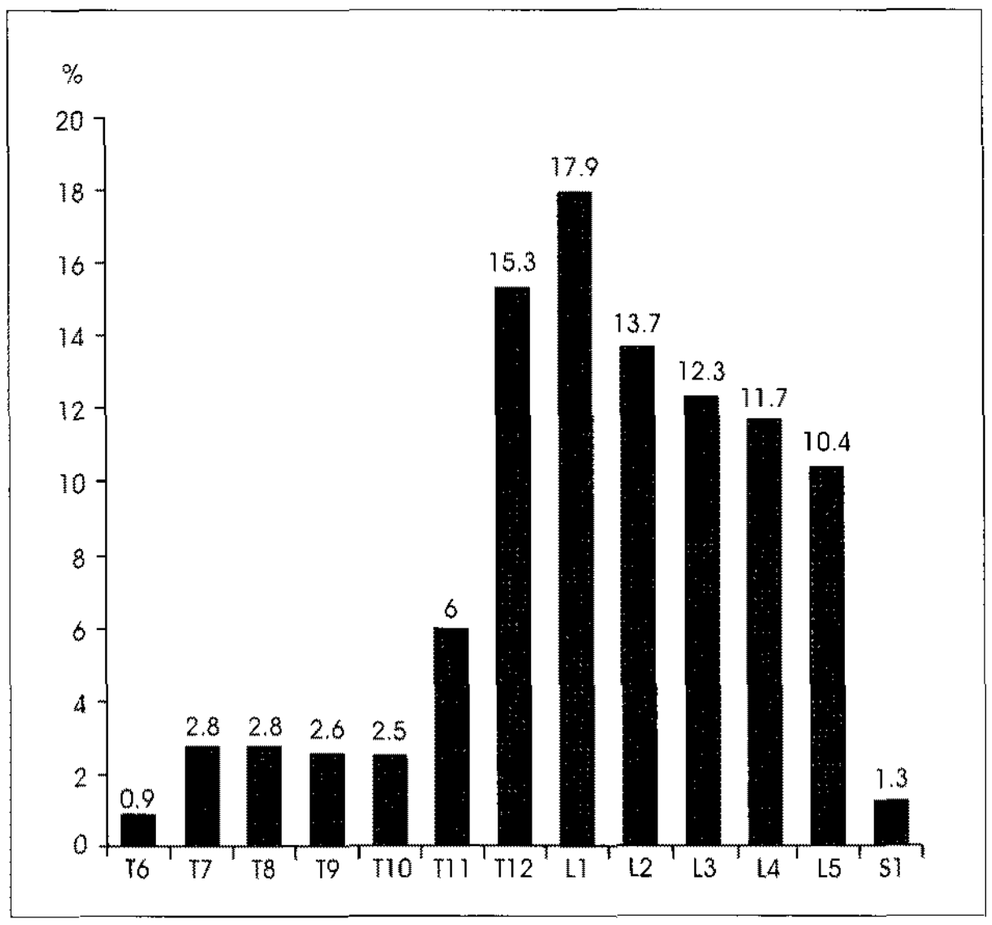

Fig. 2. Spinal distribution of venography level. The thoracolumbar level (T11-L2) is the most common site.

RESULTS

Venogram type

One thousand forty two venograms were performed in 574 osteoporotic compression fractures. Of these, there were 186 venograms (17.9%) in L1 vertebrae and 159 venograms (15.3%) in T12 vertebrae (Fig. 2).

TP type was the most common (37.4%) followed by TAP type (21.5%), TR type (17.4%), TA type (11.6%), TL type (5.8%), ST type (4.1%), VA type (1.2%), VP type (0.6%) and VAP type (0.4%) in descending order of frequency (Fig. 3, Table 1).

Venogram pattern according to spinal level

We classified the venogram pattern according to the various level of vertebral body where the venography was performed. We divided the spinal level as three groups; thoracic level (T6-T10), thoracolumbar level (T11-L2),

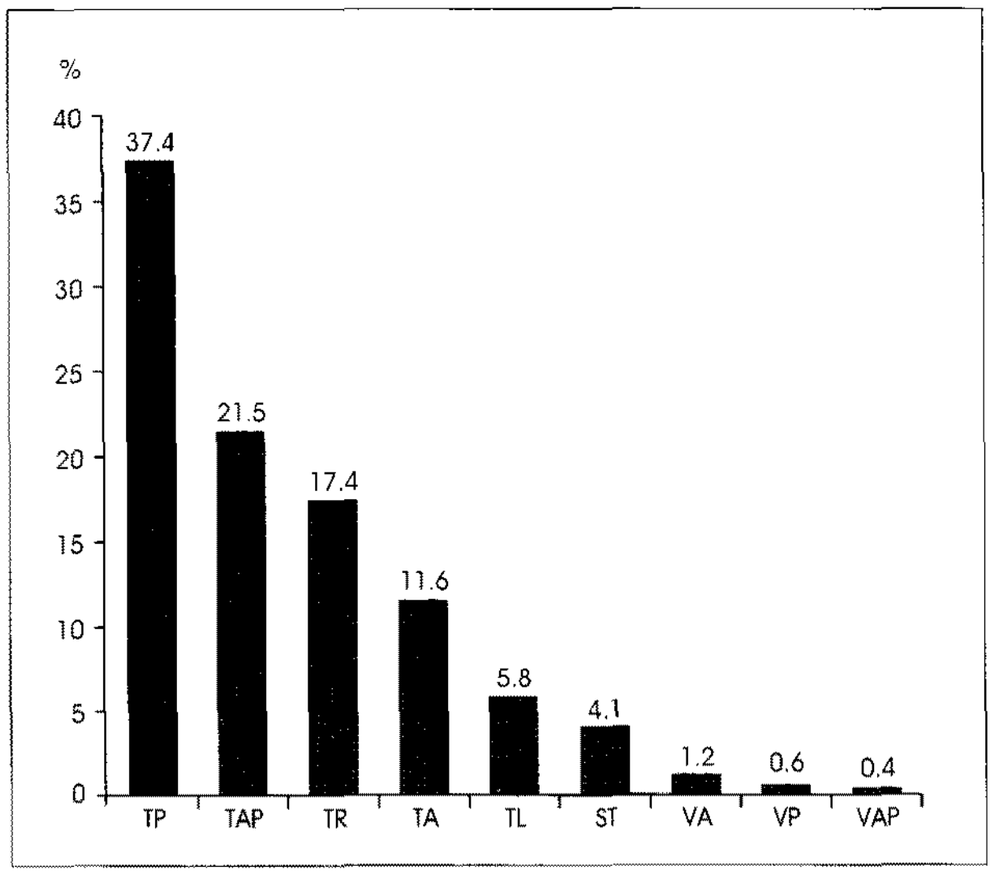

Fig. 3. Incidence of venography patterns. TP type is the most common and VAP type is the least. TP : trabecular-posterior, TAP : trabecular-anterior posterior, TR : trabecular, TA : trabecular-anterior, TL : trabecular-lateral, ST : soft tissue, VA : venous-anterior, VP : venous-posterior, VAP : venous-anterior posterior.

lumbosacral level (L3-S1). In thoracic level, TR type (26%) and TAP type (23%) were the most common (Table 2). In thoracolumbar level, TP type (47%) was the most common (Table 3). In lumbosacral spine, TP type (30%) and TAP type (28%) were the most common (Table 4). The dye leakage towards soft tissue around vertebrae, i.e. psoas muscle and disc was observed in 43 cases; among them, the leakage towards disc was observed in 17 cases (inferior disc 7, superior disc 10). Incidence of ST leakage was 5.3% in thoracolumbar level, 3.3% in thoracic level, 2.7% in lumbosacral level (Fig. 4). The venous-filling type that the contrast dye leak to vein directly without filling vertebral body was 23 cases in number, and it takes up 8.3% of thoracic level, 1.5% of thoracolumbar level, 1.3% of lumbosacral level (Fig. 5). The venous-filling type was frequent in thoracic level than other region, and it was statistically significant ($p<0.01$).

Table 2. Incidence of venography patterns in thoracic level

Type	%
TR	26
TAP	23
TA	18
TP	13
Others	20
Total	100

TR : trabecular, TAP : trabecular–anterior posterior, TA : trabecular–anterior, TP : trabecular–posterior

Table 3. Incidence of venography patterns in thoracolumbar level

Type	%
TP	47
TR	18
TAP	17
Others	18
Total	100

TP : trabecular–posterior, TR : trabecular, TAP : trabecular–anterior posterior

Table 4. Incidence of venography patterns in lumbosacral level

Type	%
TP	30
TAP	28
TA	20
TR	14
Others	8
Total	100

TP : trabecular–posterior, TAP : trabecular–anterior posterior, TA : trabecular–anterior, TR : trabecular

DISCUSSION

Vertebral body compression fracture is the most frequent complication of osteoporosis. PVP is highlighted in the minimal-invasive treatment for osteoporotic compression fracture of spine. It is known as a relatively safe treatment and is reported as good effect, but also is reported that there are many complications and harmful reactions[21]. Most of these complications are due to the leakage of bone cement[12].

Kim et al. reported that there are statistical significant relations between the PVP complication and the PMMA leakage[17]. They have reported serious complications such as the death due to pulmonary embolism, and intercostal neuralgia, back pain and abdominal pain. For avoiding these complications, it is important to prevent the PMMA leakage. Groen et al. emphasized the seriousness of PMMA leakage based on anatomical features of venous system of vertebrae[12]. The venous system of vertebrae consists of basivertebral vein, external vertebral venous plexus, and internal vertebral venous plexus, and this venous system is a valveless collateral circulation. Therefore, this venous system has clinical importance because it can directly connect to head, chest, abdomen and subcutaneous fat.

When performing PVP, increasing pressure of vertebral body during PMMA injection can cause the PMMA leakage through basivertebral vein, and it is reported up to 60%

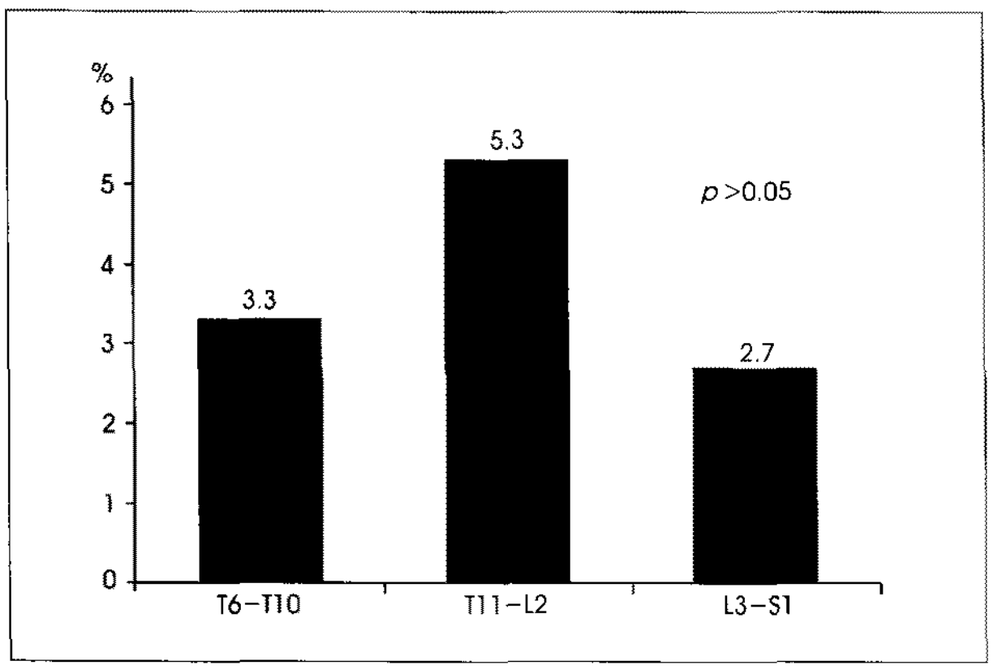

Fig. 4. Incidence of soft tissue-leakage type. The leakage to soft tissue around the vertebral body is most common in thoracolumbar level.

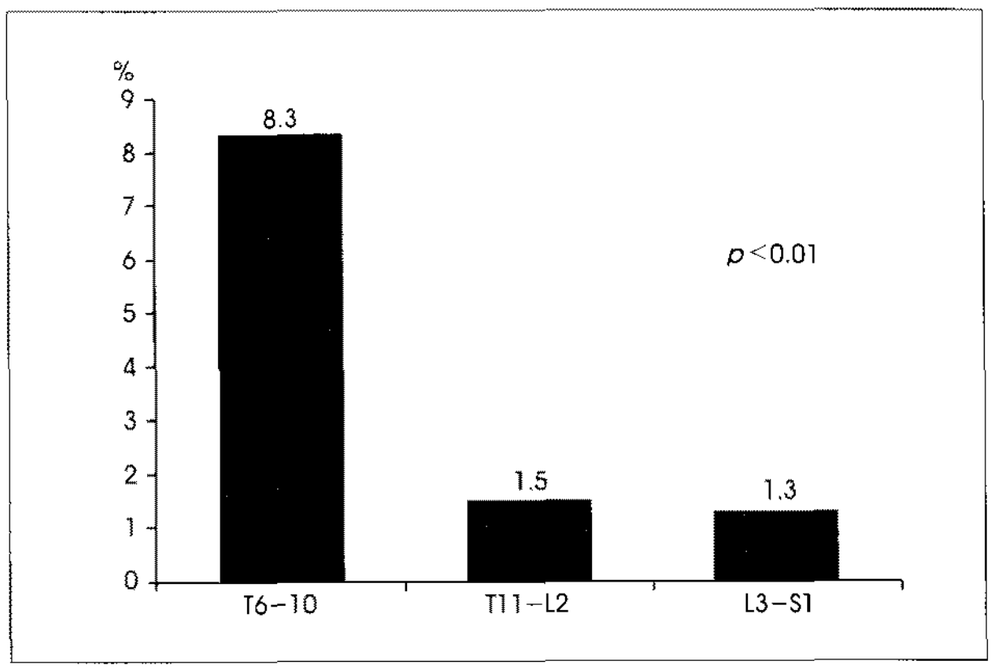

Fig. 5. Incidence of venous-filling type. The leakage directly through the vein without filling vertebral body is most common in thoracic level.

in clinical studies[12]. The valveless vertebral venous system is connected to the vena cava, so it's blood flow is determined by the pressure of vena cava. If the pressure of vena cava is high, the internal venous blood drain to heart through vertebral venous plexus without flowing through vena cava. Thus, the PMMA leakage in this situation can cause the complication of the cardio-pulmonary system[1,2,12]. The PMMA leakage during PVP, mainly occurs through intracortical fracture or vertebral venous system. According to the route of PMMA leakage, various complications can occur such as pulmonary embolism, cerebral embolism, nerve root compression, paraplegia, and spinal canal stenosis[3,4,6,8,13,14,16,18,23-26,28,29].

In an effort to decrease these kinds of complications, there are several reports to recommend the venography but, it is still debatable. It is reported that when needle tip is located in basivertebral vein, the PMMA leaks into spinal canal through this vein can occur[15,19]. Thus, if we know venography pattern in advance before PVP, it would be helpful to avoid these complications by controlling the needle tip during PVP. McGraw et al. reported that the venography is useful method because the coincidence rate was 83% between manifestation of PMMA leakage and pattern of the venography[22]. On the other hand, Vasconcelos et al. reported that there were no complications caused by PMMA leakage in 205 PVP cases without venography indicating that PMMA leakage can be avoidable without venography by exact inspection using C-arm fluoroscopy[27]. Other reports have emphasized that venography does not preclude the PMMA leakage exactly because of the difference of viscosity between contrast dye and bone cement[10,20,30]. Do et al. reported that there were no differences in incidence of PMMA leakage between two groups as one group performed by venography before PVP and the other did not perform by venography[8]. Even though they performed 1,500 PVP cases without venography, the complication due to the PMMA leakage could not be found[9]. Gaughen et al. compared the two groups (venography vs non-venography) on the clinical result and the degree of PMMA leakage, and found there were no specific differences between two groups[11]. The reason of less leakage of PMMA was that PVP was performed by skillful operator. The complication rate of PVP by skillful operator is reported below 2%[5,7,10,20]. The possibility of complication due to the PMMA leakage will be higher from unexperienced operator, therefore the venography would be helpful for beginners.

The venography patterns classified by authors would be useful to decrease the PVP complications. McGraw et al. classified the venography pattern as 6 types[22]. The 6 types are as follows : unilateral or bilateral vertebral body bone marrow blush, leakage through an endplate or cortical defect, direct venous filling, and stasis within the vertebral body. In case of leakage through the vein or cortical defect, the complication of PMMA leakage was prevented by changing the location of needle tip or controlling PMMA viscosity or controlling the speed of injection.

The author's classification of venography pattern is more detailed than the McGraw's method focusing on the direction of contrast leakage. The degree of clinical problem depend on direction of PMMA leakage. For example, in case of the anterior leakage through vertebral body, it provokes no clinical problem, but if the posterior leakage occurs into the spinal canal where spinal cord and nerve pass through, it can cause serious clinical problem. From this viewpoint, the venography pattern was classified based on the lateral image of simple spine X-ray taken immediately after shooting of the contrast dye (Fig. 1).

The limitation of this study is that author's classification of venography pattern was done by only lateral X-ray view using uniplane fluoroscopy. Getting a lateral view only provides an advantage of reducing PVP time for old persons, and also will predict to posterior leakage to spinal canal causing serious clinical problem. However, if the biplane fluoroscopy is available, both frontal and lateral venogram will be possible at once. In frontal X-ray view, bilateral marrow blush pattern can be easily detected and may predict to possible lateral leakage to paravertebral area. Further prospective study using both fronal and lateral venogram is planned.

In this study, venography pattern was divided into three types : trabecular-filling type, venous-filling type, and soft tissue type. And, each three type was subdivided according to the direction of contrast leakage. Trabecular-filling type is subdivided to TR type when contrast dye is located inside the confines of the vertebral body, and the TA, TP, TAP, TL types when contrast dye fills the vertebral body and leaks through the vein. Venous-filling type is subdivided into VA, VP, and VAP types when contrast dye leaks directly through the vein without filling the vertebral body. Soft tissue (ST) type is the case where contrast dye leaks through soft tissue around the vertebral body. Among them, TP type in which the contrast dye filling vertebral body and leaking posteriorly through venous channel is the most common type. If PMMA leaks through the vein directly, it can induce fatal complication such as pulmonary embolism. Therefore, if the patient showing venogram pattern of direct venous-filling type, it needs special caution during PVP. This

venous-filling type was most frequent in thoracic spine. PMMA leakage to posterior direction through basivertebral vein can occur if the pressure of the vertebral body increased due to PMMA injection during PVP[12]. The venous-filling type was more prevalent in thoracic spine because the size of the thoracic vertebral body is small, which may cause increased vertebral pressure easily during PMMA injection than other region of the vertebral body.

CONCLUSION

When the bone cement leaks during PVP, serious complications may occasionally occur. To decrease the complication due to PMMA leakage, the authors propose a new classification system of intraosseous venography according to the route and direction of contrast leakage. The trabecular-posterior (TP) type was the most common through all spine, and venous-filling (V) type was the most frequent in thoracic spine. Further study will be necessary to verify whether this classification of venography is helpful for preventing the PMMA leakage during PVP.

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