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PREOPERATIVE EMBOLIZATION FOR SPINAL TUMORS USING GELATIN SPONGE PARTICLES WITH OR WITHOUT LIPIODOL

Tomoki Tozawa, Emika Inomata, Motoko Sasajima, Aoi Otaka, Masazumi Matsuda and Manabu Hashimoto

Department of Radiology, Akita University School of Medicine

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Abstract

Purpose : To present our methods of performing preoperative embolization for spinal tumors using gelatin sponge particles with or without lipiodol.

Materials and Methods : Twenty-one patients (median age, 70 years) with spinal tumors underwent preoperative embolization. We injected embolus through a microcatheter placed proximally in the segmental arteries supplying the tumors. Surgical decompression was performed within 24 hours after embolization. We recorded tumor vascularity (classified into mild or increased), embolic agents used, complications related to the embolization, and intraoperative blood loss.

Results : We successfully performed embolization with the particles for 63 of 69 (91%) segmental arteries supplying tumors. Complete embolization was achieved in 16 patients (76.2%). We injected lipiodol (median total dose, 1.5 ml) in 13 patients followed by gelatin sponge particles. Twelve of the 13 patients had increased tumor vascularity. Median blood loss was 532 ml in the 14 patients with increased vascularity of tumor and 238 ml in the 7 with mild vascularity. One patient experienced transient sensory disturbance after embolization.

Conclusion : This study revealed that efficacy of particle injection from the proximal portion of the segmental artery and feasibility of using lipiodol for embolization in hypervascular tumors.

Key words : Preoperative embolization, Spinal tumors

Introduction

Preoperative embolization for hypervascular spinal tumors has been recognized as effective for reducing intraoperative blood loss and facilitating surgery[1-4]. It may also be effective in non-hypervascular tumors[5-7]. However, the technical procedures and embolic agents used have varied among studies, so a definite consensus regarding for these issues has not yet been achieved[8-10].

Corresponding author : Tomoki Tozawa MD
Department of Radiology, Akita University School of Medicine, 1-1-1 Hondo, Akita City, Akita, Japan
Tel : +81-18-834-1111
Fax : +81-18-836-2623
E-mail : ttozawa@med.akita-u.ac.jp

We herein report our experience with preoperative embolization of spinal tumors injecting gelatin sponge with or without lipiodol through a catheter located in the proximal portion of the selected segmental artery.

Materials and Methods

Patients

We retrospectively reviewed the medical records and radiological reports from January 2009 to March 2020 at our institution concerning 22 consecutive patients who underwent preoperative embolization for spinal tumors followed by spinal surgery. This study was approved by the Institutional Review Bord of our hospital. The need of informed consent was waived in view of the retrospec-

tive nature of the study, but written informed consent was obtained from each patient before undergoing embolization.

Of these patients, we excluded one because the tumor involved the sacrum and iliac bone. This study therefore consisted of the remaining 21 patients. There were 11 men and 10 women (median age, 70 [range 46 to 90] years old). Of these, 20 patients had metastatic tumors. Most of the lesions were metastatic tumors of renal cell carcinoma ($n=7$) (Table 1). The primary symptoms at presentation were lower limb weakness in 12 patients, back pain in 8 and no symptom in 1.

Angiography and embolization

All procedures were performed under local anesthesia via a femoral sheath within 24 hours prior to surgery. We inserted a 4-F diagnostic catheter into the bilateral spinal segmental arteries at the tumor sites. In advance, we identified the segmental arteries running near or in the tumor on arterial phase computed tomography (CT) images. In most cases, we also inserted a catheter into the bilateral segmental arteries at one level above and below the involved levels. We obtained digital angiograms of the selected arteries and evaluated the presence of tumor blush and branches supplying the spinal cord. If a tumor stain was present and spinal arteries were not present, we advanced a microcatheter into the proximal portion of the selected arteries to obtain a secure catheter position. A lidocaine test was performed via a microcatheter in each artery. A dose lidocaine (10～20 mg) was given for each test. If neurologic changes did not occur, we attempted embolization.

Table 1. Patient and tumor characteristics ($n=21$)

Characteristic	n
Sex	
Man	11
Woman	10
Age (years) (median, range)	70 (46-90)
Tumor histology	
Metastatic	
Renal cell carcinoma	7
Thyroid cancer	2
Hepatocellular carcinoma	2
Lung cancer	3
Prostatic cancer	2
Malignant lymphoma	2
Breast cancer	1
Unknown (adenocarcinoma)	1
Primary	
sarcoma	1

Based on previous reports[9,11], we subjectively classified the degree of tumor vascularity on an angiogram into two groups : mild vascularity, showing a more prominent tumor stain than the normal vertebral body blush with a normal caliber of feeding arteries, and increased vascularity, showing intense tumor blush with early venous filling.

For embolization, we used gelatin sponge particles of 2 mm in size (Gelpart ; Nihon Kayaku, Tokyo, Japan) in all patients. Before use, one vial of particles was suspended in 20 ml nonionic contrast medium. In 6 of 21 patients, we crushed the particles into even smaller particles by pumping several times using a 3-way stopcock. We injected iodized oil (Lipiodol ; Guerbet, France) for the selected arteries in 13 patients before injecting gelatin sponge. The adaptation for the use of Lipiodol was left to the discretion of the operator, but it was mainly used for lesions judged to be increased vascularity based on an angiogram.

We did not perform super-selective catheterization of the feeders in any patients. We only infused embolic materials through the microcatheter positioned proximally in the selected segmental arteries until the flow ceased completely under fluorography.

Surgical procedure

Surgery was performed within 24 hours after embolization. In all patients, the lesions were decompressed posteriorly by laminectomy. Spinal fusion was performed with posterior instrumentation in 20 of 21 patients. Corpectomy was not performed in any patients. The intraoperative blood loss was estimated by the anesthesiologist and noted in the surgical report.

Statistical analysis

Data were expressed as the median (Range : min-max). Statistical analysis was performed using SPSS

software version 24.0 (IBM, Armonk, New York). Comparisons between two groups were done with Mann-Whitney U test. Differences were considered statistically significant at $P<0.05$.

Results

Angiography and embolization

On angiograms, 14 patients had increased tumor vascularity (Fig. 1), and 7 had mild vascularity (Table 2).

We successfully performed embolization for 63 of 69 (91%) segmental arteries supplying the tumors. Complete embolization was achieved in 16 of 21 patients

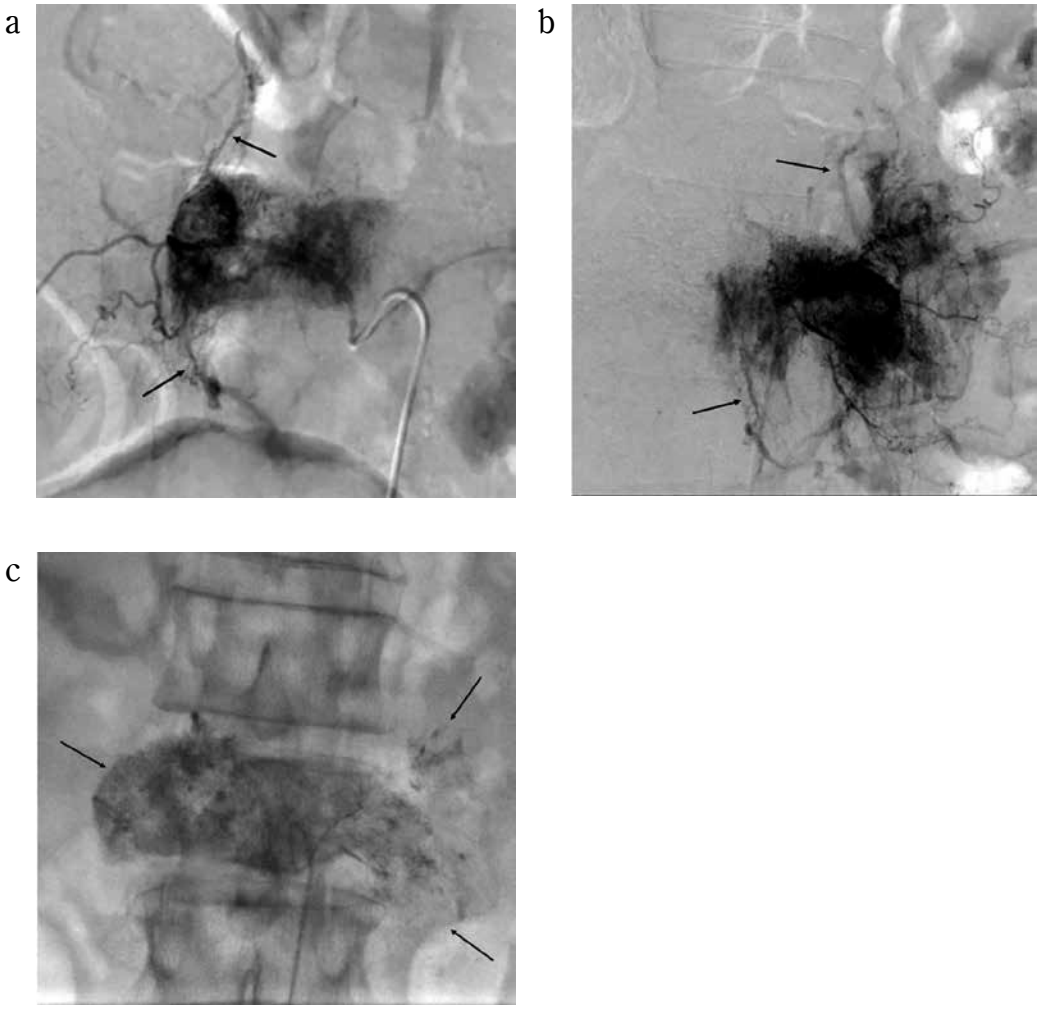

Fig. 1. Metastatic spinal tumor from renal cell carcinoma in a 70-year-old woman (case 3). Angiograms of the right (a) and left (b) 2nd lumbar arteries show a markedly increased tumor vascularity with early venous filling (arrows). We injected 1.5 ml of lipiodol into the right segmental artery through a microcatheter located in the proximal portion of the artery. We then injected gelatin sponge particles until the flow ceased completely. The same procedure was repeated at the left segmental artery, but the injected dose of lipiodol was 3 ml. A fluorogram (c) obtained after embolization showed lipiodol accumulation in the tumor (arrows).

Table 2. Details of results

Case/age (y)/sex	Vascularity	No. of embolized arteries/ No. of detected tumor feeders	Reason for incomplete embolization	Gelatine Sponge size (mm)	Lipiodol Total dose (ml)/ No. of infused arteries	Coil	Level of laminectomy	Blood loss (ml)	Operation time (min)
1/61/F	Increased	5/5		2	10.5 ml/4		Th 4–6	542	423
2/55/F	Increased	3/4	Spinal branch	2	6 ml/3		Th 5, 6	717	262
3/70/F	Increased	2/2		2	4.5 ml/2		L 2	457	296
4/78/F	Increased	4/4		2	4 ml/3		Th 12, L 1	1,250	356
5/90/M	Increased	6/6		Crush	3 ml/3	+	Th 6–8	522	274
6/51/F	Increased	2/2		Crush	1.5 ml/2		Th 11	410	183
7/76/F	Increased	3/3		Crush	1.5 ml/2		L 2	100	200
8/59/M	Increased	2/2		2	1.2 ml/1		Th 10	345	230
9/70/M	Increased	2/2		2	1 ml/1		Th 4	1,776	247
10/70/M	Increased	6/7	Spinal branch	Crush	1 ml/1		Th 6, 7	488	229
11/46/F	Increased	2/2		2	0.8 ml/1		L 3	143	127
12/82/M	Increased	2/2		Crush	0.8 ml/1		Th 2, 4	1,069	199
13/67/M	Increased	2/2		Crush			Th 2	910	224
14/59/M	Increased	2/2		2			Th 5, 6	1,003	265
15/74/M	Mild	2/2		2	1.9 ml/2		Th 9	147	302
16/74/M	Mild	6/6		2			Th 9, 12, L2	238	328
17/78/F	Mild	2/4	Spinal branch, unsuccessful	2		+	Th 10	444	335
18/67/M	Mild	2/2		2			Th 8	55	186
19/84/M	Mild	5/6	Unsuccessful	2		+	Th 5–7	219	251
20/80/F	Mild	1/2	Unsuccessful	2			Th 2	665	411
21/67/F	Mild	2/2		2			Th 4	246	182

Unsuccessful, inability to maintain catheterization. Crush, crushed gelatin sponge.

(76.2%). We did not perform embolization for the remaining 6 arteries in 5 patients due to the blood supply to the spinal cord in 3 arteries and an inability to maintain catheterization with a 4-F catheter in the other 3 arteries.

We injected lipiodol for 26 selected arteries in 13 patients followed by gelatin sponge particles. Twelve patients had increased tumor vascularity. A dose of 0.5–3 ml (median, 1.1 ml) of lipiodol was given for each artery under fluoroscopic guidance, and the total dose was 0.8–10.5 ml (median, 1.5 ml). Lipiodol accumulation in the tumors was observed on fluoroscopy in most sessions. In 8 of the 13 patients, we performed cone-beam CT after lipiodol injection to assess the lipiodol accumulation in and around the tumor. Cone-beam CT clearly depicted the extent of lipiodol accumulation from the selected arteries in all patients.

We performed coil embolization in three patients. We placed microcoils in two branches associated with large intratumoural arteriovenous (AV) shunting for flow control in one patient with increased tumor vascularity. We placed microcoils in the normal branches distal to the feeders to prevent non-target embolization for two arteries in one patient with mild tumor vascularity. In another patient with mild tumor vascularity, we occluded the normal branches of the adjacent five segmental arteries that were anastomosed with the segmental arteries supplying tumor.

One patient experienced transient right lower extremity sensory disturbance after embolization. We injected

lipiodol (total dose : 10.5 ml) into the patient, and the complication recovered completely within 2 weeks after embolization. The remaining 20 patients had no procedure-related complications.

Surgery

The median number of laminectomies was 1 (Table 3), and the numbers were similar between the increased and mild vascularity groups (1.5 vs. 1). The intraoperative blood loss ranged from 55 to 1,776 ml (median, 457 ml) and was greater in the increased vascularity group (median, 532 ml) than in the mild vascularity group (median, 238 ml) (Mann-Whitney U test, $P<0.05$). The operation time ranged from 127 to 423 minutes (median, 251 min) and was not significantly different between the groups (median, 239 min in the increased vascularity group vs. 302 min in the mild vascularity group : $p=0.41$). None of the patients had complications related to surgery.

Discussion

While the operative blood loss during spinal surgery may mainly depend on the operative procedures and the location and extent of tumors[9,12,13], preoperative spine tumor embolization has been recognized as a useful adjunctive procedure for ensuring this operation is performed safely. However, the embolization techniques and the embolic materials used have varied among reports, so these optimal parameters remain unclear. Several authors have suggested that medium sized particles (around 300 microns) may be suitable as embolic material[1,8-11,14] and that tumor feeders should be selectively catheterized with microcatheters, with the embolic materials injected directly into the feeders[1,6,9,11] ; if this is not feasible, normal branches distal to feeders can be embolized with microcoils to achieve flow redistribution[1,6,9,11].

However, our procedure is very simple : we simply advanced a microcatheter into the proximal portion of selected segmental arteries. We did not perform routine distal embolization with coils. The embolic agent used was mainly gelatin sponge (2 mm size). Previous studies have reported a mean intraoperative blood loss of 1,600 to 2,743 ml[1,6,9,11] in patients with increased tumor vascularity and 862 to 2,092 ml[6,7,9,15] in patients with mild tumor vascularity. The mean intraoperative blood loss in our study was 695 ml in the increased vascularity group and 287 ml in the mild vascularity group. We therefore believe that our results were within the acceptable range and demonstrated that complex maneuvers may not be needed when performing embolization to reduce intraoperative blood loss in most patients.

To our knowledge, there has been no report describing the use of lipiodol as an embolus in the preoperative embolization of spinal tumors. We speculate that most radiologists do not use lipiodol because it may carry a risk of migrating into the spinal branches passing through the tumor vessels. However, we used lipiodol as the embolic agent mainly in patients with hypervascular tumors to achieve embolization within the tumor vascular bed, thereby leading to decreased blood loss. On fluoroscopic observation, lipiodol droplets tended to flow into the tumor feeders and accumulated in the tumors. The use of lipiodol and the injected dose of lipiodol were left to the operator's decision, so optimal dose of lipiodol were unclear. However, lipiodol embolization seemed to be useful for monitoring the embolized area in patients with hypervascular tumors. In addition, cone beam CT per-

Table 3. Surgical results according to tumor vascularity

	All ($n=21$)	Increased vascularity group ($n=14$)	Mild vascuarity group ($n=7$)
Number of laminectomy	1 (1-3)	1.5 (1-3)	1 (1-3)
Intraoperative blood loss (ml)	457 (55-1,776)	532 (100-1,776)	238 (55-665)
Operation time (min)	251 (127-411)	239 (127-423)	302 (182-411)

Values are presented as median (range)

formed after lipiodol injection provided precise information on the embolized area. This approach may be useful for reducing the procedure time and avoiding unnecessary segmental artery embolization.

In the present study, one patient experienced transient right lower extremity sensory disturbance after embolization. John K. Houten *et al*. performed systematic literature analysis and reported that frequency of permanent neurologic deterioration secondary to embolization of metastatic spinal tumor causing spinal cord ischemia or infarction is 2% and transient or asymptomatic neurologic deterioration is 2%[16]. They also reported that frequency of permanent neurologic deterioration causing by tumoral swelling is 1% and transient or asymptomatic neurologic deterioration is 5%[16]. Our results showed equivalent frequency of the complication compared with the study.

Several limitations associated with the present study warrant mention. The main limitations were the single-center, retrospective design, and inclusion of only a small number of patients. Moreover, this is a study without a control group, so it is better to make it possible. Due to the lack of a control group and inhomogeneous dose of injected lipiodol, we were unable to determine whether or not embolization with lipiodol enhanced the embolization effect. However, we were able to safely embolize segmental arteries using lipiodol for hypervascular tumors in most patients.

Despite these limitations, this study nevertheless demonstrated the efficacy of 2-mm gelatin sponge injection via microcatheters proximally located in the segmental artery and the feasibility of using lipiodol for embolization in hypervascular tumors.

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