RESEARCH ARTICLE

THE EFFECTIVENESS AND THE FACTORS AFFECTING THE RESULT OF PREOPERATIVE TRANSARTERIAL EMBOLIZATION OF SPINAL TUMORS

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ARTICLE INFO	ABSTRACT
	Purpose: To evaluate the effectiveness of preoperative transarterial embolization of spinal tumors and the factors influencing subsequent surgical outcomes. **Materials and Methods:** We retrospectively reviewed the medical records of 22 patients who underwent preoperative embolization and surgery for a spinal malignancy from March 2005 to July 2014. Angiographic assessment of the main nutrient artery and bone tumor vascularity was performed, followed by tumor embolization using micro-coils, Gelfoam, or polyvinyl alcohol. Tumor staining was evaluated before the procedure was finished. **Results:** Embolization was successful in 20/22 (91%) patients and partially successful in 2/22 (9%). The average intraoperative blood loss was 2,658 mL among all patients. Intraoperative blood loss was lower in patients with successful embolization than in those with partial embolization although the difference was not statistically significant. Embolization using only microcoils resulted in more intraoperative blood loss than embolization with microcoils and Gelfoam, or microcoils and polyvinyl alcohol but the difference was not significant. Patients involving one vertebra showed less blood loss than those involving two vertebrae but this difference also was not statistically significant ($p > 0.05$). **Conclusions:** Although there was no statistically significant difference in the reduction of blood loss during surgery due to the embolic agent, degree of embolization, or the number of involved vertebrae, preoperative transarterial embolization of spine tumors is an effective method for reducing intraoperative blood loss in subsequent surgical resections.

INTRODUCTION

Primary and secondary spinal tumors frequently cause bone pain, unstable fractures, and neurological complications. In these cases, surgical resection is performed to alleviate pain and thereby improve the patient's quality of life. However, the procedures are often accompanied by heavy intraoperative bleeding which may result in insufficient resection of the lesion (Vetter *et al*., 1997; Shi, 1999 and Wirbel, 2005). Previous reports indicate that preoperative transarterial embolization of spinal tumors reduces blood loss during surgery, and this method is an effective means of extending resection of the lesion (Vetter *et al*., 1997; Hess *et al*., 1997; Sun *et al*., 1998; Roscoe *et al*., 1989; Berkefeld *et al*., 1999 and Gellad, 1990). In this study, we evaluate the effectiveness of preoperative transarterial embolization of spinal tumors and the factors influencing subsequent surgical outcomes.

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MATERIALS AND METHODS

Patients

We retrospectively reviewed the medical records of 22 patients, aged 37-82 years (mean 64.7 years; 12 male, 10 female), who underwent preoperative embolization and surgery for a spinal malignancy from March 2005 to July 2014. It was approved by the IRB Committee in Chonnam National University Hospital. All patients were diagnosed with a spinal tumor by computerized tomography or magnetic resonance imaging before treatment. The lesions were located in the thoracic spine (13 cases), lumbar spine (8 cases), and cervical spine (case). The cases included patients with primary tumors (multiple myeloma, 3; hemangioma, 1; bone necrosis, 1), and metastatic tumors arising from carcinomas (lung, 3; thyroid, 2; breast, 2; laryngeal, 1; renal cell, 5; prostate,1; hepatocellular, 1; colorectal,1) and malignant melanoma (1 case).

Embolization technique

All 22 patients underwent transarterial embolization two to three days before surgery. Preoperative embolization was performed by two experienced radiologists. A percutaneous right common femoral artery catheter was placed using 10% lidocaine for local anesthesia. Diagnostic angiography was then performed to assess the degree of bone tumor vascularity and identify the major artery feeding the tumor. A microcatheter (Microferret, Cook Group, Inc., Bloomington, IN, USA; Renegade Boston Scientific, Corp., Marlborough, MA, USA; or Progreat, Terumo Medical Corp, Somerset, NJ, USA) was used to cannulate the nutritive artery superselectively. Embolization was performed using Gelfoam (Pfizer, New York, NY, US) and polyvinyl alcohol (Boston Scientific Corp. Marlborough, MA, USA), or microcoils (Tornado, Cook Group, Inc; Nester, Cook Group; or Liquid, (Boston Scientific Corp. Marlborough, MA, USA). Gelfoam and polyvinyl alcohol (250 - 500 μ) were used when the distal branch of the feeding artery was cannulated, and microcoils were used when the proximal branch was cannulated. Embolization was continued until the tumor staining decreased to ≤ 70% of the staining present before embolization. Following completion of the procedure, angiography was performed to evaluate the decrease in tumor staining.

Surgery

All patients underwent surgery two to three days following tumor embolization, and all procedures were performed by a single orthopedic surgeon. In each case, the goal of surgery was complete tumor resection. The operative reports were reviewed, and intraoperative blood loss was recorded.

Statistical Analysis

The pre- and post-embolisation angiographic findings were compared, and embolization > 70% was defined as successful. Partial embolization was defined as < 70%. Statistical analysis was performed using PASW Statistics for Windows, Version 18.0 (SPSS Inc., Chicago, IL, USA). We compared the average operative blood loss in patients with successful and partial embolizations using a Mann-Whitney-Wilcoxon test. The same method was used to compare differences in operative blood loss due to the embolic agent and the number of vertebrae involved by tumor. A p-value less than 0.05 was defined as statistically significant.

RESULTS

The feeding arteries were observed as follows: intercostals, lumbar (8 cases), thyrocervical (1 case), thyroid (1 case), and bronchial (1 case). The Intraoperative blood loss in all cases ranged from 1,500 ml - 5,000 ml (average, 2,733 ml). Embolization was successful in 20/22 patients (91%) (Figure 1), and partial in 2/22 patients (9%) (Figure 2). One patient with a partial embolization was not completely embolized because the main feeding artery was the anterior spinal artery (artery of Adamkiewicz). The other incompletely embolized tumor was fed by several small side branches of both inferior thyroidal arteries making superselective catheterization technically difficult. The mean intraoperative blood loss in patients with successful embolization was 2,450 ± 587 ml compared to 3,700 ± 1,838 ml in patients with partial embolization. However, this difference was not statistically significant (p > 0.05). Embolic materials were Gelfoam (6 cases), microcoils (4 cases), microcoils and Gelfoam (10 cases), and microcoils and PVA (2 cases).


| A | B | C |
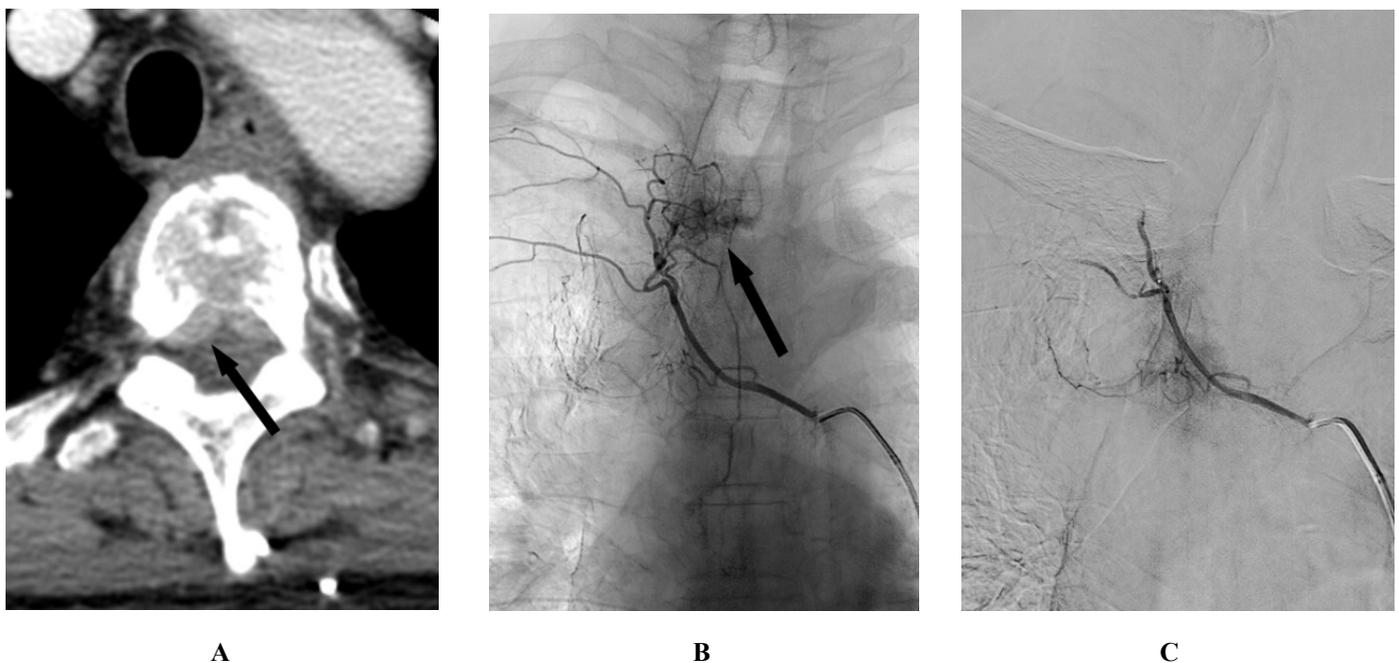
Fig 1. A 59-year old man with vertebral metastasis from lung cancer with partially successful embolization.
A. Axial CT scan shows tumor involving the L2 vertebral body and both pedicles with pathologic fracture and extraosseous mass formation.
B. Selective angiogram of the left L2 lumbar artery before embolization shows hypervascular tumor staining.
C. Selective angiogram of the left L2 lumbar artery after embolization with gelatin sponge and liquid microcoil shows devascularization with marked reduction of the tumor staining
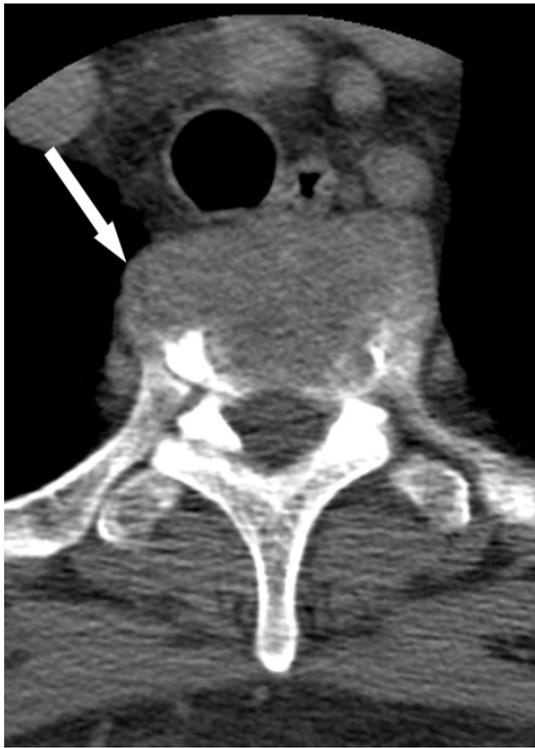
Fig 2.A 61-year old man with successful embolization of multiple myeloma.
A. Axial CT scan shows multiple myeloma involving the T11 vertebral body, right pedicle and transverse process with extension to the neural and vertebral foramen
B. Selective angiogram of the right T11 intercostal artery before embolization shows hypervascular tumor staining.
C. Selective angiogram of the right T11 intercostal artery after embolization with microcoils shows occlusion of the right T11 intercostal artery with complete disappearance of the tumor staining

The intraoperative blood loss was 2,000 - 5,000 ml (average, 2,640 ml) when using Gelfoam; 2,550 - 5,000 ml (average, 3,500 ml) using microcoils alone; 2,000 - 5,000 ml (average, 2,340 ml) using microcoils and Gelfoam; and 2,000 - 2,500 ml (average, 2,750 ml) using microcoils and polyvinyl alcohol. However, these differences were not statistically significant (p > 0.05). Single vertebra was involved in twenty cases, and two vertebrae in two cases. Average blood loss in single-vertebra disease was 5,564 ml, compared with 2,250 ml in cases involving two vertebrae. This difference was not statistically significant (p > 0.05). There were no complications related to the procedure during or after surgery in any patient.

DISCUSSION

Since its introduction by Feldman in 1975 (Feldman, 1975), the selective embolization of bone tumors has become a widely accepted interventional procedure. Indications for this procedure vary from therapeutic to palliative, and it is used to reduce intraoperative blood loss and for the relief of pain caused by bone tumors (Wirbel et al., 2005; Boruban et al., 2007). Preoperative embolization of bone tumors offers a safe and effective way to lower mortality by reducing blood loss during surgery (Barton, 1996). Previous studies reported that blood loss in patients who underwent preoperative embolization prior to spine tumor surgery ranged from 1,900 to 2,400 ml while in patients who did not receive preoperative embolization blood loss was 9,500-15,000 ml (Roscoe, 1989; Gellad *et al.*, 1990 and Sundaresan, 1990). Hess, *et al*. (Hess, 1998) reported that patients undergoing preoperative embolization had a lower average blood loss during surgery than patients who did not (2,000 ml vs. 3,800 ml, respectively). Manke, *et al.* (Kickuth, 2008) also reported a significant difference in blood loss between patients who received preoperative embolization and those who did not (1,500 ml vs. 5,000 ml, respectively). In our study population, the average intraoperative blood loss among the patients was 2,658 ml. All of the surgical procedures had been performed by the same specialized orthopedic surgeon. During the same period, the same surgeon performed two spinal tumor resections without preoperative embolization, and in these patients, the average blood loss was 4,550 ml.

The difference in intraoperative blood loss between the study patients and the two patients who did not undergo preoperative tumor embolization is statistically significant (p = 0.04) although the number of patients included is small. Sun (Sun, 1998), *et al.* reported a significantly higher blood loss during surgery in patients with partial embolization compared with patients with complete embolization and recommended more than 70% tumor embolization before surgery. On the other hand, Kickuth (Kickuth, 2008), reported that there was no significant difference in the amount of intraoperative blood loss between patients who underwent complete tumor embolization versus partial embolization. In our study, we defined partial and successful preoperative embolization as less than 70% and 70% or more, respectively. The average blood loss during surgery with successful embolization was 2,450 ml which was less than the average of 3,700 ml seen with partial embolization. However, there was no statistically significant difference in blood loss related to the extent of tumor embolization (p > 0.05). Several reports had described the embolic agents used for embolization prior to spinal tumor resection. According to Berkefeld *et al.* (Berkefeld, 1999), microcoils were not effective for preoperative embolization due to early recanalization. In our study, 12 patients who underwent embolization with microcoils were treated surgically within 2-3 days of the embolization procedure, and recanalization was not observed.

Further, with the exception of six patients who received a superselective distal embolization using Gelfoam, we used only microcoils for proximal embolization, or microcoils and Gelfoam or polyvinyl alcohol for distal embolization. Intraoperative blood loss averaged 2,900 ml when embolizing with microcoils and 2,500 ml when using microcoils and Gelfoam or polyvinyl alcohol. The difference was not statistically significant (p > 0.05). Guzman (Guzman, 2005) reported that there was no correlation between the degree of blood loss during surgery and angiographic tumor staining before embolization. We found no report comparing the amount of blood lost based on the number of vertebrae involved by disease. In our study, blood loss in the 20 patients with disease involving one vertebra averaged 2,500 ml. This was slightly less than the average blood loss in the two patients with two vertebrae involved (2,880 ml) although the difference was not statistically significant (p > 0.05). Limitations of this study include: 1) the number of patients is small, 2) there is an unequal number of patients with a partial embolization versus a successful embolization, 3) this study does not include a comparison of cases performed without embolization with cases performed after embolization. 4) our institution's medical records did not reliably record surgical blood loss in those cases performed prior to the period when preoperative embolization of spinal tumors became the routine practice.

In conclusion, preoperative embolization of spine tumors to reduce blood loss during surgical resection is a safe and effective method.

Ethical Approval

All authors hereby declare that all experiments have been examined and approved by the IRB committee in Chonnam National University Hospital and have therefore been performed in accordance with the ethical standards had down in the 1964 Declaration of Helsinki.

Interest of conflict

Authors have declared that no competing interests exist.

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