Pre-operative Embolization for Bone Tumors; Single Center Experience

Walailak Chaiyasoot, M.D., Thana Pongpanumaspaisan, M.D., Trongtum Tongdee, M.D., Somrach Thamtorawat, M.D., Satit Rojwatcharapibarn, M.D.

Department of Radiology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.

ABSTRACT

Objective: The purpose of this study was to report our experience with 35 patients, presenting with primary or secondary bone tumors, who underwent pre-operative transarterial embolization in our institution.

Methods: Pre-operative transarterial embolizations between 2009 and 2013 were retrospectively reviewed in 35 patients (20 men and 15 women), with a mean age of 49.29 years, range 15-79 years. Medical records were reviewed to obtained patient's data, histological diagnosis, anatomical site, post embolization complication, interval between embolization and surgery, operative procedure and operation time. Estimated blood losses (EBL) were obtained from operative notes or anesthetic notes.

Results: Thirty-five patients had a total of 43 procedures in 5 years period, in which five patients underwent twice and one patient underwent four pre-operative embolizations. All 43 pre-operative embolization procedures were technically successful and underwent surgery after embolization, with a mean of 2.7 days, range 0-15 days. No patient experienced embolization associated major complication. The mean estimated blood loss was 2,915 mL (range 20-14,000 mL).

Conclusion: Pre-operative transarterial embolization of both primary and secondary bone tumors was safe, effective and tended to reduce intra-operative blood loss particularly when superselective embolization was performed. Blood loss during surgery increased if the operation was not performed within 3 days after embolization due to re-canalization and angiogenesis.

Keywords: Preoperative transarterial embolization; bone tumors

Siriraj Med J 2016;68:332-338
E-journal: https://www.tci-thaijo.org/index.php/sirirajmedj
doi:10.14456/smj.2016.21

INTRODUCTION

The major surgery for large primary and secondary bone tumors has mean intra-operative blood loss of 6,000 mL, with up to 18,500 mL[1] which leads to large amounts of blood transfusion and its associated complications. However, in our institution, there has been no record of the mean amount of blood loss during each operative orthopedic surgery of bone tumor. This is because of lots of variation of tumor types, sizes and bony involvement by location of the tumors making them difficult to be estimated in each procedure. Feldman et al[2] first reported the use of pre-operative selective arterial embolization to decrease peri-operative bleeding in 1975. Several prior literatures revealed that embolization is an effective treatment to reduce blood loss. The purpose of this study was to report our experience in the patients with primary or secondary bone tumors, who underwent pre-operative transarterial embolization in our institution.

Correespondence to: Walailak Chaiyasoot
E-mail: wchaiyasoot@gmail.com
Received 10 May 2016
Revised 3 November 2016
Accepted 4 November 2016

MATERIALS AND METHODS

This retrospective study has been approved by the Institutional Review Board with the approval number Si 807/2557. Thirty-five patients who had been performed pre-operative embolization in our Interventional Radiology unit during 2009 to 2013 were reviewed. All patients had a proven pre-operative tissue diagnosis before embolization including renal cell carcinoma metastases (n=11), giant cell tumor (n=8), follicular or papillary thyroid carcinoma metastasis (n =4), chordoma (n=4), osteosarcoma (n=3), chondrosarcoma (n=2), malignant fibrous histiocytoma (n=1), malignant peripheral nerve sheath tumor metastasis (n=1), and breast cancer metastasis (n=1).

Diagnostic angiography was performed using a standard vascular angiography catheter (4-5F Cobra, 5F DAV, 5F Vertebral, 5F Simmon I), based on lesion location. A 2.7F microcatheter was usually superselectively catheterized into suitable feeding arteries to deliver effective embolization and to minimize damage to non-target tissue. Embolizations were performed with one or combination of Gelfoam, polyvinyl alcohol (PVA) particles sizes of 250-355, 355-500 microns and coils. The choice of embolic agent depends on the individual tumor vasculature including vessel caliber, presence of arteriovenous shunts, collateral supply to or from adjacent normal tissues the and the most important, operator experience. The embo-lization endpoint was deemed to be when all assessable major vessels supplying the tumor had been occluded and decreased tumor blush.

Medical records were reviewed to obtain the patient's data including sex, age, histological diagnosis, anatomical site, complications post embolization, the time interval between embolization and surgery, operative procedure and operation time. Estimated blood losses (EBL) were recorded from operative or anesthetic notes by means of measurement from the suction into drainage bottle and weighting total number of used gauzes to stop bleeding during the operative procedure.

Statistical analysis was performed by using basic descriptive statistics to determine mean, range and frequency.

RESULTS

There were totally 35 patients (20 men and 15 women), with a mean age of 49.29 years, range, 15-79 years who had 43 pre-operative embolization in a 5 year period. Five patients underwent two pre-operative embolizations and one patient underwent four pre-operative embolizations. All 43 pre-operative embolization procedures were technically successful and patients underwent surgery after embolization, with a mean of 2.7 days, range 0-15 days. None of the patients had embolization associated major complications.

The mean estimated blood loss was 2,915 mL (range 20-14,000 mL).

Patient demographics, histological diagnosis, anatomical site, embolic materials, interval between embolization and surgery, surgical procedure, operation time, and estimated blood loss were shown in Table 1.

Embolizations were performed with only Gelfoam in 29 procedures, only PVA in 8 procedures and a combination with PVA in 6 procedures.

Anatomical sites included 17 pelvises, 16 long bones and 2 scapulas.

About 60-80% obliteration of tumor vascularity was obtained which relied on feasible catheterization of arterial feeders noted on immediate post embolization angiogram.

DISCUSSION

All patients had pre-operative imaging evaluation for anatomical site, organ involvement, and identifiable arterial feeders for operative planning. Pre-operative transarterial embolization of bone tumors in our study mainly included renal cell carcinoma metastases (n=11), giant cell tumor (n=8) (Fig 1) and follicular or papillary thyroid carcinoma metastasis (n=4) which were hypervascular in nature. The rest of the tumors included chordoma (n=4), osteosarcoma (n=3), chondrosarcoma (n=2), malignant fibrous histiocytoma (n=1), malignant peripheral nerve sheath tumor metastasis (n=1) and breast cancer metastasis (n=1) which also showed hypervascularity on pre-operative imaging evaluation which were

TABLE 1. Patients demographic data.

Case	Age	Sex	Histological diagnosis	Anatomical site	Embolic materials	Interval (days)	Surgical procedures	Operation time (hrs)	EBL (mL)
1	38	M	Intramedullary osteosarcoma	Right hip	PVA (355-500)	6	Hemipelvectomy sacrectomy	13.5	11,000
2	60	M	Renal cell carcinoma metastasis	Left scapula	PVA (355-500) Gelfoam	1	Scapulectomy	6.5	3,900
3	32	F	Osteosarcoma	Right hip	Gelfoam	5	Hemipelvectomy sacrectomy	11	5,600
4	25	F	GCT	Right iliac bone	PVA (250-355) Gelfoam	4	Wide excision sacrectomy	9	14,000
5	58	F	Chondrosarcoma	Sacrum	Gelfoam	1	Hemipelvectomy	9	14,000
6	62	M	Thyroid carcinoma	Right humerus metastasis	Gelfoam	0	Wide excision	5	600
7	66	F	Thyroid carcinoma	Right humerus metastasis	Gelfoam	1	ORIF	2	1,850
8	44	M	Thyroid carcinoma metastasis	Left humerus	Gelfoam	2	Curettage	1.5	500
9	58	F	Chordoma	Sacrum Left iliac bone	Gelfoam PVA (355-500)	1 5	Wide excision, sacrectomy Debulking tumor	7 2.15	3,750 2,000
10	46	F	Chordoma	Sacrum	Gelfoam	1	Partial sacrectomy	4.5	2,200
11	66	M	Renal cell carcinoma metastasis	Right proximal ulnar	Gelfoam	3	Curettage	1.15	20
12	50	M	Chondrosarcoma	Pelvis	Gelfoam	1	Decompression	2.5	1,400
13	57	M	Renal cell carcinoma metastasis	Right proximal femur	Gelfoam	1	Curettage, hemiarthoplasty	2	350
14	60	M	Renal cell carcinoma metastasis	Both hips	Gelfoam	3	ORIF	3	2100
15	23	F	GCT	Right iliac bone	PVA (250-500) Gelfoam Gelfoam Gelfoam PVA (355-500) Gelfoam	 13 1 1 2	 Curettage Curettage Curettage Curettage	 8 1.5 1.5 2.5	 10,000 3,000 450 2,200
16	70	M	Renal cell carcinoma metastasis	Right proximal femur	Gelfoam	2	Hemiarthroplasty	3	1,000
17	50	M	Renal cell carcinoma metastasis	Left proximal femur	Gelfoam	0	Hemiarthroplasty	2.5	300
18	46	M	Chordoma	Sacrum	Gelfoam Gelfoam	0 0	Debridement Curettage	1 1.5	500 1,000
19	79	M	Renal cell carcinoma metastasis	Left distal femur	Gelfoam	1	ORIF	2	400
20	76	F	Renal cell carcinoma metastasis	Right proximal humerus	PVA (250-355) Gelfoam	6	ORIF with curettage	1	400

Case	Age	Sex	Histological diagnosis	Anatomical site	Embolic materials	Interval (days)	Surgical procedures	Operation time (hrs)	EBL (mL)
21	18	F	Malignant fibrous histiocytoma	Left femoral head	Gelfoam	1	Hemipelvectomy	3	900
22	69	F	Renal cell carcinoma metastasis	Left humeral neck	Gelfoam	1	ORIF	1	20
23	15	M	Osteosarcoma	Right proximal humerus	Gelfoam	1	Forequarter amputation	2	800
24	68	M	Thyroid carcinoma metastasis	Left SI joint	Gelfoam	0	Tumor removal	0.5	1,300
25	24	F	GCT	Left SI joint	Gelfoam	0	Curettage	1	500
26	56	F	Chordoma	Sacrum	PVA (355-500)	5	Total sacrectomy	6	4,000
27	37	F	GCT	Sacrum	Gelfoam	0	Curettage	2.5	1,800
					Gelfoam	1	Curettage	2.5	3,500
28	36	F	GCT	Sacrum	Gelfoam	1	Curettage	3	2,500
					Gelfoam	1	Curettage	2	2,500
29	66	M	Renal cell carcinoma metastasis	Left scapula	PVA (250-500)	5	Total scapulectomy	3	600
30	19	M	MPNST	Pelvis	Gelfoam	1	Hemipelvectomy	4.5	4,000
31	62	M	Renal cell carcinoma metastasis	Right proximal humerus	PVA (355-500)	4	Wide resection	4	400
32	31	M	GCT	Right proximal humerus	PVA (355-500)	5	Curettage	1.5	3,500
33	46	F	Metastatic breast cancer	Right proximal humerus	PVA (150-250)	4	Hemiarthroplasty	1.5	1,000
34	56	M	GCT	Left proximal femur	Gelfoam	4	Tumor debulking	2	10,000
					PVA (355-500) coils	15	Tumor debulking	1.5	1,500
35	19	M	GCT	Sacrum	PVA (355-500) Gelfoam	7	Curettage	1.5	4,000

Abbreviations: GCT = giant cell tumor, MPNST = malignant peripheral nerve sheath tumor, PVA = Polyvinyl alcohol, Interval = the time between embolization and surgery

suitable for delivering embolic materials due to high blood flow to the tumors.

Lackman et al[3] had reported good outcome of using embolization for pelvic giant-cell tumors as an alternative to surgery, by downsizing and slowing the growth of tumors. In contrast, Wang-Peng et al in 1990 had reported their results of 87 patients who underwent wide surgical resection which carries significant uncontrollable blood loss, morbidity and mortality during surgery. Simpson et al[4] described 12 patients who underwent partial resection of large sacral lesions. One died from massive hemorrhage and six suffered wound complications. Our procedures were requested by the orthopedic surgeons, who trust the benefit of pre-operative transarterial embolization before tumor resection which would be easier and more safe as compared to the surgery alone. In our study, there was no embolization associated major complication or mortality, which was in concordance with the prior studies.

Several studies had reported their results with pre-operative transarterial embolization, for both primary and secondary bone tumors.

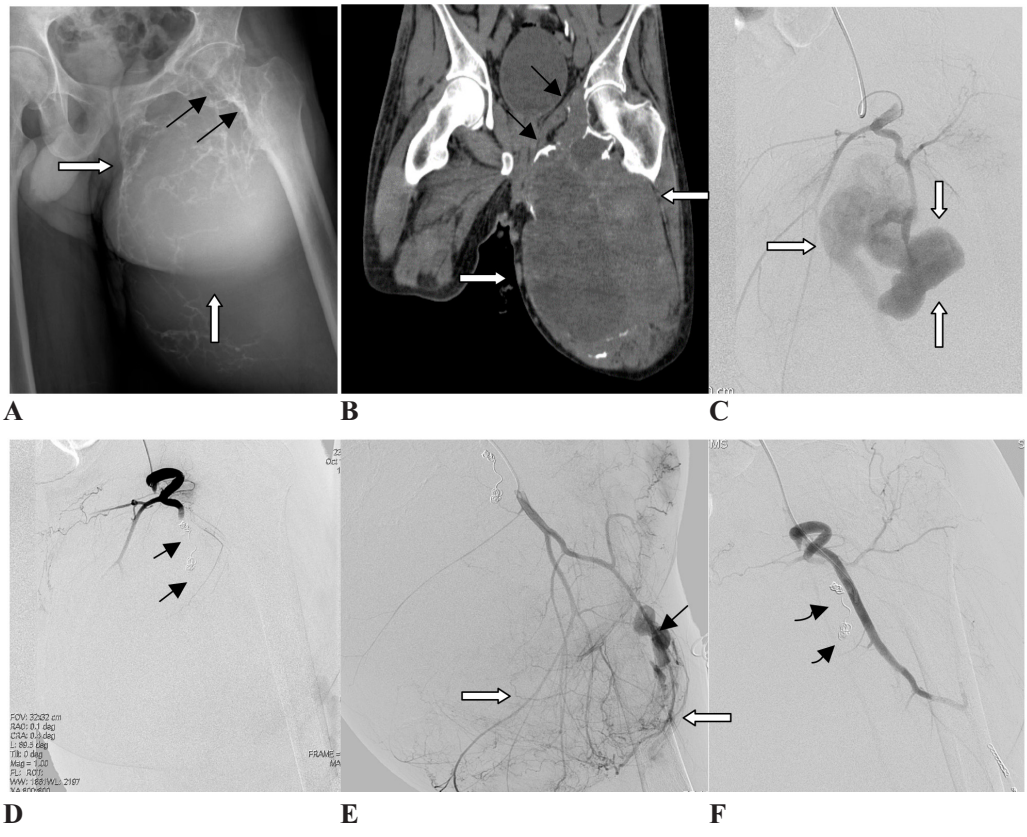

Fig 1. A 56-year-old male had history of a large mass at left hip for 4 years with progressive pain, biopsy resulted giant cell tumor.

A.-B. Plain film and coronal CT of left femur showed a large soft tissue mass at medial left thigh (white arrows) with bony destruction of head and neck of left femur, acetabulum and left inferior pubic ramus (black arrows).

C.-D. Selective left deep femoral circumflex arteriogram showed large aneurysmal dilatation (white arrows), multiple coil embolization and Gelfoam were done (arrows).

E.-F. Selective another branches of left deep femoral arteriogram showed hypervascularity and neovascularization (white arrows) with aneurysm (black arrow) post successful pushable coils (curve arrows) and Gelfoam embolization.

The mean intra-operative EBL ranged from 391 to 1,500 mL.[5-8] Massive blood loss is arbitrarily defined as the loss of one blood volume within a 24 hour period,[9] while normal adult blood volume being approximately 7% of ideal body weight in adults. In our study, the mean intra-operative EBL was 2,914 mL (range 20-14,000 mL) which was higher compared with those prior study results. At the cutoff value of intra-operative blood loss at 4,000 mL or more in our study representing massive intra-operative blood loss, there were nine patients who had EBL which ranged from 4,000-14,000 mL, including giant cell tumor (GCT) (n=4), osteosarcoma (n=2), chordoma (n=1), chondrosarcoma (n=1) and malignant peripheral nerve sheath tumor (MPNST) (n=1). In this group, six of nine patients (66%) had tumor involving pelvis and underwent hemipelvectomy and/or sacrectomy, so they developed massive intra-operative blood loss post embolization (Fig 2). We concluded that the patients who will have major surgery including hemipelvectomy and/or sacrectomy should have complete embolization due to high risk of massive intra-operative blood loss.

Complete pre-operative transarterial embolization should be accomplished in order to get significant reduction of intra-operative blood loss. The basic principle of transarterial embolizaton is the occlusion of most of the capillary tumor bed.

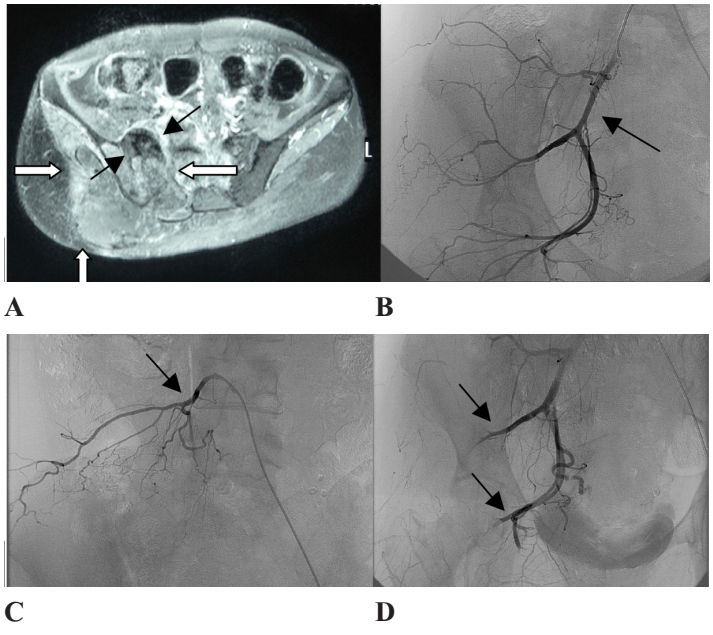

Fig 2. A 32 year-old female with pelvic osteosarcoma

A. MRI pelvis showed bony destruction at right iliac bone and sacrum associated with enhancing soft tissue mass (white arrows) which encased right external and internal iliac arteries (black arrows).

B.-C. Selective angiogram of right internal iliac and right 4th lumbar arteries which were the tumor feeders (arrows).

D. Post embolization angiogram showed about 80% devascularization (arrows). However, patient still had about 5,600 mL intra-operative blood loss during right hemipelvectomy.

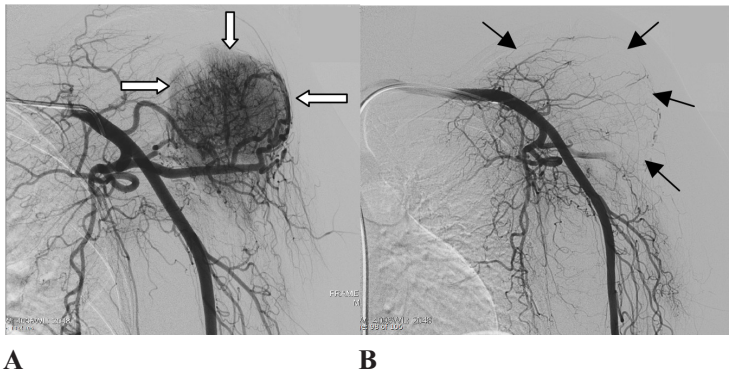

Fig 3. A 44-year-old male with history of metastatic thyroid cancer at left proximal humerus.

A. Angiogram of left subclavian artery revealed a hypervascularized and neovascularized mass with tumor staining at left proximal humerus (white arrows) feeding by anterior and posterior circumflex humeral arteries.

B. After superselective Gelfoam embolization into both arterial feeders, angiogram showed markedly decreased tumor vascularity (black arrows). He underwent curettage with cement augmentation at left proximal humerus with EBL only about 500 ml.

The occlusion of only the major tumor feeding arteries is ineffective, because of numerous collaterals in hypervascular bone tumors. Interventional radiologists must seek and occlude every arterial feeder as much as possible for total obliteration of the tumor vessels because the amount of blood loss and blood transfusion during surgery highly depends on the tumor devascularization.[7] Sun S, et al[8] had reported that the best results were achieved when more than 70% of the tumor stain was obliterated. In our study, about 60-80% obliteration of tumor staining was obtained which relied on feasible catheterization of arterial feeders. However, there were nine patients who still had

massive intra-operative blood loss possibly due to major operation.

Also note that seven of fourteen patients (50%) who had transarterial embolization ≥4 days before surgery developed massive intra-operative blood loss. One of two who patients performed surgery more than 7 days after embolization, had massive intra-operative blood loss, even if we used a combination of Gelfoam and PVA particles which is a permanent embolic material for embolization. This was similar to Barton et al[1] who reported that intra-operative blood loss increased if surgery was not performed within 3 days of embolization, blood loss was 500-1,500 mL if before 4 days, compared to 1,500-2,800 mL at 4-14 days post embolization, due to re-canalization and angiogenesis. Nine of our patients who experienced massive intra-operative blood loss had used Gelfoam alone in 4, PVA alone in 2 and combination of Gelfoam and PVA for embolization in 3 patients.

Superselective catheterization using a coaxial system (microcatheter inside the large catheter) is also important to improve effectiveness of the embolization. Our study showed that only two of twenty patients (8.7%) with superselective embolizations (Fig 3), suffered from massive intra-operative blood loss. On the other hand, seven of twenty-three pre-operative non-superselective embolizations (30%) had massive intra-operative blood loss. Furthermore, advantages of using a coaxial system include the ability to deliver embolic agent farther from the parent vessel, reducing the risk of non-target embolisation, and easier for cannulation of the small tumoral vessels which are difficult to cannulate with the larger diagnostic catheter, preventing arterial spasm and vessel occlusion.[10]

Limitations of this study were small size of population and very high variety of data, including different size, type and location of the tumors, embolic materials, different operative procedures, and accuracy of estimated intra-operative blood loss in operation record which affected reliability of data and statistical significance. Randomized controlled studies of tumor embolization are not available, because of the logistic and ethical problems. However, our orthopedic surgeons trust the benefit of pre-operative transarterial embolization before tumor resection which would help them more easy and more safety to control the intra-operative blood loss as compared to surgery alone.

CONCLUSION

Pre-operative transarterial embolization of both primary and secondary bone tumors was safe and tended to reduce intra-operative blood loss, especially bone tumors involving pelvis which are high risk for massive intra-operative blood loss if hemipelvectomy and/or sacrectomy will be performed. Superselective catheterization has an important role to improve the effectiveness of tumor devascularization. Intra-operative blood loss increased if surgery was not performed within 3 days after embolization.

REFERENCES

1. Barton PP, Waneck RE, Karnel FJ, Ritschl P, Kramer J, Lechner GL. Embolization of bone metastases. J Vasc Interv Radiol 1996;7(1):81-88.
2. Feldman F, Caserella WJ, Dick HM, Hollander BA. Selective intraarterial embolization of bone tumors: a useful adjunct in the management of selected lesions. Am J Roentgenol Radium Ther Nucl Med 1975;123:130-39.
3. Lackman RD, Khoury LD, Esmail A, Donthineni-Rao R. The treatment of sacral giant-cell tumors by serial arterial embolization. J Bone Joint Surg Br 2002;84:873-77.
4. Simpson AH, Porter A, Davis A, Griffin A, McLeod RS, Bell RS. Cephalad sacral resection with a combined extended ilioinguinal and posterior approach. J Bone Joint Surg Am 1995;77-A:405-11.
5. Salai M, Garniek A, Rubinstein Z, Segal A, Morag B. Preoperative angiography and embolization of large pelvic tumors. J Surg Oncol 1999;70(1):41-44.
6. Chatziioannou AN, Johnson ME, Pneumaticos SG, Lawrence DD, Carrasco CH. Preoperative embolization of bone metastases from renal cell carcinoma. Eur Radiol 2000;10(4):593-96.
7. Shi HB, Suh DC, Lee HK, Lim SM, Kim DH, Choi CG, et al. Preoperative transarterial embolization of spinal tumor: embolization techniques and results. AJNR Am J Neuroradiol 1999;20(10):2009-15.
8. Sun S, Lang EV. Bone metastases from renal cell carcinoma: preoperative embolization. J Vasc Interv Radiol 1998; 9:263-69.
9. Harvey GK, Mollison PL, Anstee DJ. Mollison's blood transfusion in clinical medicine. 11th ed. Blackwell Publishing; 2005.p. 35.
10. Gupta P, Gamanagatti S. Preoperative transarterial embolization in bone tumors. World J Radiol 2012;4(5):186-92.