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The application of interventional methods in control of blood loss during giant upper extremity tumor resection

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Abstract

Background The purposes of this retrospective study were to determine the efficacy of interventional methods in control of intraoperative blood losses and investigate the perioperative complications.

Methods The cases of 44 patients in whom a giant upper extremity tumor had been operated between 2008 and 2022 were analyzed retrospectively. Of these, 29 patients were treated with interventional methods (Group A) and 15 were treated without (Group B). Group A was further divided based on the intervention methodss: Group C (combination of balloon occlusion and transarterial embolization [TAE], $n=11$) and Group D (single TAE, $n=18$). Within Group D, patients were categorized based on the timing of TAE relative to surgery into Group E (TAE on the same day as surgery) and Group F (TAE performed days before surgery). We compared demographic features, blood loss, ICU admission rates, and use of vasopressors during surgery.

Results We collected clinical records from 44 patients diagnosed with a giant upper extremity tumor who underwent surgery. Group sizes were as follows: A (29), B (15), C (11), D (18), E (7), and F (11). Tumor volumes in the interventional and non-interventional groups were similar (704.19 ± 812.77 cm^3 vs. 1224.53 ± 1414.01 cm^3, $P=0.127$). Blood plasma transfusion was significantly higher in Group B compared to Group A (425.33 ± 476.20 ml vs. 155.90 ± 269.67 ml, $P=0.021$). Although overall blood loss did not significantly differ between Group A and Group B (467.93 ± 302.08 ml vs. 1150 ± 1424.15 ml, $P=0.087$), the rate of massive bleeding (defined as blood loss over 1000 ml) was lower in Group A (6.9% vs. 46.47%, $P=0.004$). The proportion of minors (patients aged less than 18) in Group C was significantly higher than in Group D (27.7% vs. 0.00%, $P=0.045$). The amount of RBC transfusion was also significantly higher in Group C compared to Group D (458.18 ± 292.22 ml vs. 164.44 ± 224.03 ml, $P=0.021$). No significant perioperative complications were observed.

Conclusions Interventional techniques have been shown to reduce both blood loss and the necessity for blood transfusions in patients with large upper extremity tumors. Furthermore, no significant perioperative complications have been observed.

Keywords Giant upper extremity tumor, Resection, Interventional methods, Anesthesia

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Background

Since the first reported cases in the 1970s, transarterial embolization (TAE) has gradually become an accepted treatment for primary and metastatic bone tumors. Preoperative embolization is known to effectively reduce intraoperative bleeding and minimize complications, particularly in tumors with a rich blood supply [1]. In lower extremity surgeries, especially for pelvic and sacral tumors, arterial embolization combined with abdominal aortic balloon occlusion has been widely adopted to reduce perioperative bleeding and related complications [2–4].

Similarly, when it comes to the giant upper extremity bone tumors, we might face the resembling problems, such as bleeding, limb preservation and rapid perioperative rehabilitation. Previous cases have been reported that preoperative arterial embolization is an effective neoadjuvant treatment for surgery for upper extremity bone tumors, especially for large tumors with joint involvement [5].For hypervascular bone tumors, TAE could be considered as preoperative measures to reduce the blood loss during the upper extremity tumor resection [6].

Additionally, subclavian artery balloon occlusion has been reported to reduce perioperative bleeding and complications in traumatic settings [7]. However, this technique carries potential risks, including subclavian artery stenosis, stroke, limb ischemia, and spinal cord ischemia. Some reports suggest that infraclavicular balloon placement may reduce the risk of perioperative stroke [8].

However, the impact of the interventional methods on the hemodynamics and the occurrence of perioperative complications for upper extremity tumor is still unclear. Our study aims to explore the effects of interventional methods on hemodynamic and perioperative complications during surgery for giant bone tumors of the upper extremity.

Materials and methods

The study protocol was approved by the Ethics Committee of Peking University People's Hospital (Approval No.2022PHB084-001).And the research adhered to the tenets of the Declaration of Helsinki.As shown in Fig. 1, we retrospectively analyzed the history data of 44 patients with retinoblastoma who were admitted to our hospital during 1st March 2008 and 1st March 2022 by searching our electronic medical record database using the key word "giant upper extremity tumor". The inclusion criteria were as follows: (1) giant upper extremity tumor ready

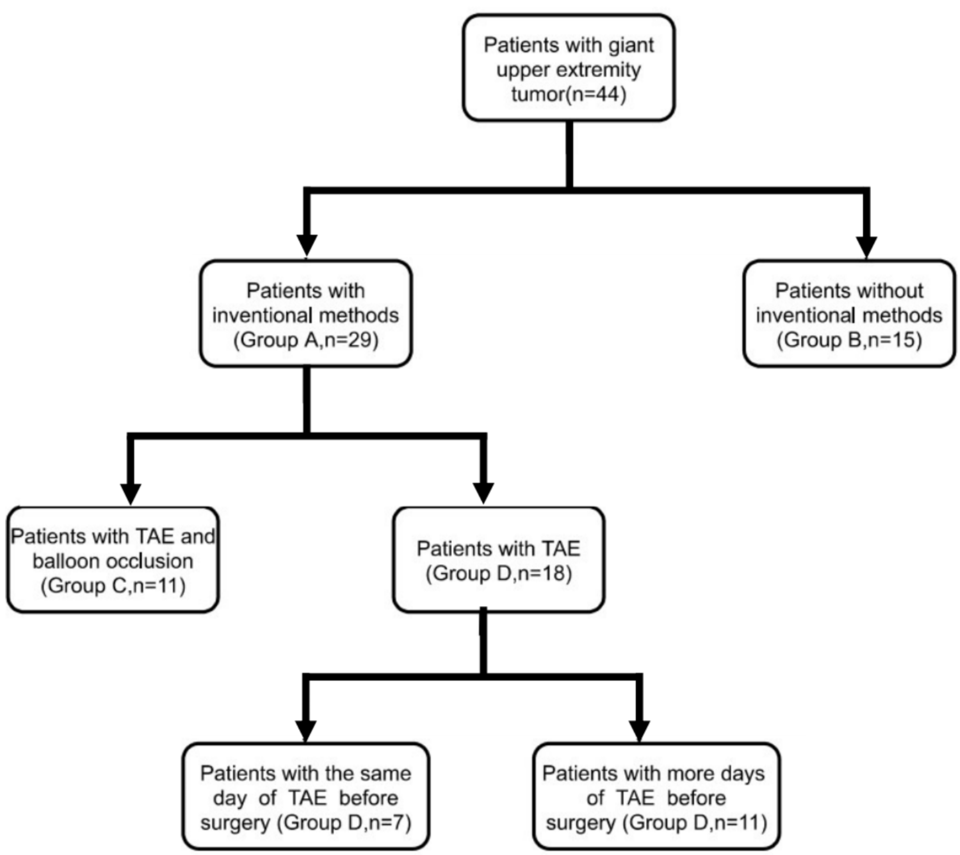

Fig. 1 Patient flow diagram for this analysis

for surgery(>10 cm in diameter) [9, 10]; (2) all the information related to the patients'features are available for analysis. The patients with missing clinical data and the cases without operation were excluded from our study. The demographic and clinical information were recorded from the electronic anesthetic documentation system. Based on the foregoing criteria, 44 patients were included into statistical analysis. According to the acceptance of interventional methods, the patients were divided into an interventional group (Group A; $n=29$) and an un-interventional group (Group B; $n=15$).The demographic data was collected including age, BMI (body mass index), American Society of Anesthesiologists (ASA) physical status, the size of the tumor(calculated by the maximum diameter of the tumor).

The procedure for the management of transarterial embolization (TAE) and subclavian artery balloon occlusion was as follows: On the day of surgery or some days prior, patients were transferred to the interventional operating room for TAE. After identifying the tumor with an abundant blood supply, gelfoam or microspring rings were applied to occlude the tumor's blood supply. On the day of surgery, the subclavian artery balloon was inserted under fluoroscopic guidance. Interventional physicians performed the procedure by inserting catheters via the femoral arteries under local anesthesia and placing the tips into the subclavian artery. The balloon was briefly inflated, and contrast was injected to confirm occlusion. After catheter placement, the patient was transferred to the operating room.

Based on the intervention methods, Group A was divided into Group C, receiving a combination of balloon occlusion and TAE ($n=11$), and Group D, receiving TAE only ($n=18$). Group D was further subdivided based on the timing of TAE, into Group E, where TAE was performed on the same day as surgery, and Group F, where TAE was performed more than one day before surgery. Clinical data collected included operation time, anesthesia time, estimated blood loss, transfusion requirements (red blood cells and plasma), vasopressor use, ICU admission, and postoperative hospital stay. Perioperative complications such as stroke, limb ischemia, and spinal function disturbances were also recorded, along with the timing of TAE and balloon occlusion.

Table 1 Demographic characteristics of patients with different kind of interventional methods

	Group C($n=11$)	Group D($N=18$)	*P*
Age(years old)	33.81 ± 20.47	57.89 ± 19.49	0.004*
Height(cm)	170.55 ± 8.25	163.33 ± 9.04	0.041*
Weight(kg)	63.18 ± 16.14	58.33 ± 12.14	0.365
BMI(kg/m2)	21.54 ± 3.91	22.39 ± 3.08	0.519
The tumor volume(cm3)	849.27 ± 990.69	615.53 ± 699.11	0.462
The operation time(min)	151.82 ± 54.14	144.17 ± 92.31	0.249
The anesthesia time(min)	183.64 ± 52.21	144.17 ± 92.31	0.805
Balloon occlusion time(min)	22.73 ± 34.67		
The blood loss(ml)	513.64 ± 357.14	440.00 ± 270.36	0.534
The transfusion of RBC(ml)	458.18 ± 292.22	164.44 ± 224.03	0.005*
The transfusion of blood plasma(ml)	216.36 ± 324.57	120.56 ± 232.64	0.363
The POD(days)	6.73 ± 2.28	10.94 ± 8.89	0.070
ASA classification			0.216
I	4	2	
II	7	15	
III	0	1	
Massive bleeding(percent)	1/11(9.09%)	1/17(5.88%)	1.000
The application of vasopressor(percent)	4/11(36.36%)	5/18(27.78%)	0.512
The admission of ICU(percent)	0/11(0)	2/18(11.11%)	0.512
The minors(patient's age less than 18)(percent)	3/11(27.27%)	0/18(0.00%)	0.045*

Statistical analysis

SPSS 21.0 statistical software was used for data description and analysis. The Shapiro-Wilk test was applied to the data from all the patients, revealing a normal distribution for variables. Continuous variables were expressed as mean ± standard deviation if they follow a normal distribution. The independent sample t test was employed for measurement data, and Chi-square or Fisher's exact tests were used for categorical data. A value of $P<0.05$ was considered significant.

Results

The utilization rate of interventional techniques was 65.91% (29/44) among patients diagnosed with giant upper extremity tumors. Among these interventional patients, 37.93% (11/29) underwent subclavian balloon occlusion, with an average balloon occlusion time of 22.73 min (as shown in Table 1). Based on the use of interventional methods, the patients were divided into two groups: an interventional group (Group A; $n=29$) and a non-interventional group (Group B; $n=15$). Group A was further subdivided into Group C, which included patients who received both balloon occlusion and TAE ($n=11$), and Group D, consisting of patients who underwent only TAE ($n=18$). Additionally, Group D was split into Group E, in which TAE was performed on the same day as surgery, and Group F, where TAE was performed several days before surgery (as illustrated in Fig. 1).

Perioperative hemodynamic control, clinical outcomes, and complications were closely monitored. The tumor volumes between the interventional group (Group A) and the non-interventional group (Group B) were comparable (704.19 ± 812.77 cm^3 vs. 1224.53 ± 1414.01 cm^3, $p=0.127$). However, the amount of blood plasma transfused in

Group B was significantly higher than in Group A (425.33±476.20 ml vs. 153.45±165.76 ml, p=0.021). While overall blood loss did not show a significant difference between Group A and Group B (467.93±302.08 ml vs. 1150±1424.15 ml, p=0.087), defining massive bleeding as blood loss exceeding 1000 ml revealed a significantly lower rate of massive bleeding in Group A compared to Group B (6.9% vs. 46.47%, p=0.004) (as shown in Table 2).

Group A was further divided based on the intervention methods into Group C, which received both balloon occlusion and TAE (n=11), and Group D, which underwent only TAE (n=18). The average balloon occlusion time was 22.73 min. Patients in Group C were significantly younger than those in Group D (33.81±20.47 vs. 57.89±19.49 years, p=0.004). Additionally, the proportion of minors (patients under 18 years old) was higher in Group C compared to Group D (27.7% vs. 0.00%, p=0.045). The volume of red blood cell (RBC) transfusion was also significantly greater in Group C than in Group D (458.18±292.22 ml vs. 164.44±224.03 ml, p=0.021). However, there was no significant difference in blood loss between the two groups (513.64±357.14 ml vs. 440.00±270.36 ml, p=0.534) (as shown in Table 1).

Based on the timing of pre-operative embolization, Group D was further divided into Group E (TAE performed on the same day as surgery) and Group F (TAE performed more than one day before surgery). The blood loss between these two groups did not show a significant difference (357.14±229.91 ml vs. 492.73±291.00 ml, p=0.314). Similarly, there was no significant difference in operation time between Group E and Group F (128.57±28.97 min vs. 154.09±117.06 min, p=0.583). Additionally, there were no significant differences in postoperative ICU admission or the use of vasopressors between the two groups (as shown in Table 3).

Table 2 Demographic characteristics of patients with giant upper extremity tumor

	Group A(n=29)	Group B(N=15)	P
Age(years old)	48.76±22.84	42.33±15.64	0.279
Height(cm)	166.07±9.31	167.60±7.24	0.582
Weight(kg)	60.17±13.72	65.20±11.16	0.228
BMI(kg/m2)	22.07±3.38	23.56±3.06	0.157
The tumor volume(cm3)	704.19±812.77	1224.53±1414.01	0.127
The operation time(min)	147.07±78.96	141.67±58.12	0.816
The anesthesia time(min)	177.07±78.84	171.00±58.29	0.794
The blood loss(ml)	467.93±302.08	1150±1424.15	0.087
The transfusion of RBC(ml)	275.86±286.37	466.67±532.74	0.128
The transfusion of blood plasma(ml)	155.90±269.67	425.33±476.20	0.021*
The POD(days)	9.35±7.36	10.47±7.36	0.641
ASA classification			0.441
I	6	2	
II	22	11	
III	1	2	
Massive bleeding(percent)	2/29(6.90%)	7/15(46.67%)	0.004*
The application of vasopressor(percent)	9/29(31.03%)	3/15(20.00%)	0.500
The admission of ICU(percent)	2/29(6.90%)	1/15(6.67%)	1.000

Table 3 Demographic characteristics of patients with different days of TAE

	Group E(n=7)	Group F(N=11)	P
Age(years old)	52.86±18.47	61.09±20.30	0.399
Height(cm)	165.29±8.40	162.09±9.61	0.482
Weight(kg)	59.71±11.29	57.45±13.10	0.712
BMI(kg/m2)	21.25±3.02	23.11±3.03	0.221
The tumor volume(cm3)	489.14±581.93	814.14±863.20	0.352
The operation time(min)	128.57±28.97	154.09±117.06	0.583
The anesthesia time(min)	158.57±28.97	182.27±117.72	0.612
The blood loss(ml)	357.14±229.91	492.73±291.00	0.314
The transfusion of RBC(ml)	291.43±234.91	83.64±183.70	0.052
The transfusion of blood plasma(ml)	161.43±276.43	94.55±210.35	0.583
The POD(days)	12.14±11.23	10.18±7.56	0.662
Massive bleeding(percent)	0/7(0)	1/11(9.09%)	1.000
The application of vasopressor(percent)	3/7(42.86%)	2/9(22.22%)	0.326
The admission of ICU(percent)	0/7(0)	2/11(18.18%)	0.497

None of the patients experienced subclavian artery stenosis, stroke, limb ischemia, or spinal cord ischemia during the study

Discussion

Interventional methods have been employed both for tumor therapy and perioperative management in surgical procedures. In cases of visceral tumors, such as hepatic and renal tumors, interventional techniques help reduce tumor size, minimize blood loss, preserve organ function, and are associated with minimal complications [11, 12]. Similarly, in bone tumors, these methods have proven feasible and safe, particularly for tumors with abundant vascular supply, as they significantly reduce intraoperative blood loss and facilitate tumor resection [13, 14]. While previous studies have explored the use of interventional techniques in upper extremity tumors, these reports were limited by very small sample sizes [15]. To our knowledge, this is the first comprehensive study evaluating blood loss control during the resection of giant upper extremity tumors using interventional methods.

One prior study highlighted the feasibility of preoperative and therapeutic embolization for bone and soft tissue tumors of the extremities. For instance, in a case of scapular Ewing sarcoma, blood loss was recorded at 1800 ml, with a devascularization rate of 70% [16]. In our study, we compared tumor volumes between groups and found no significant difference between the interventional and non-interventional groups (704.19±812.77 cm^3 vs. 1224.53±1414.01 cm^3, $p=0.127$). While overall blood loss between Group A (interventional) and Group B (non-interventional) was not significantly different (467.93±302.08 ml vs. 1150±1424.15 ml, $p=0.087$), the incidence of massive bleeding was significantly lower in Group A (6.9%) compared to Group B (46.47%, $p=0.004$). Additionally, plasma transfusion in Group B was significantly higher than in Group A (425.33±476.20 ml vs. 153.45±165.76 ml, $p=0.021$). These findings suggest that preoperative embolization of primary or metastatic bone tumors effectively reduces the risk of massive blood loss.

Transarterial embolization (TAE) can provide effective control of blood loss during surgery, but some challenges remain. For instance, TAE might not offer long-term devascularization of the tumor, as revascularization may occur over time. Furthermore, not all tumors can achieve complete occlusion through TAE [14]. To enhance blood control, additional interventional techniques such as subclavian artery balloon occlusion can be utilized. Subclavian balloons have been employed successfully in cases of subclavian artery avulsion following blunt trauma, offering effective control of hemorrhage and enabling open surgical repair [17]. Similarly, in a case of subclavian artery laceration following clavicle fracture, an endovascular balloon was used to control bleeding while clavicle fixation was completed [18].

In our study, Group A was divided into Group C (the combination of balloon occlusion and TAE, $n=11$) and Group D (TAE alone, $n=18$). Although there was no significant difference in blood loss between Group C and Group D (513.64±357.14 ml vs. 440.00±270.36 ml, $p=0.534$), RBC transfusion in Group C was significantly higher than in Group D (458.18±292.22 ml vs. 164.44±224.03 ml, $p=0.005$). This can be attributed to the higher proportion of minors (patients under 18 years old) in Group C (27.7% vs. 0%, $p=0.045$), who are more vulnerable to blood loss and ischemia, necessitating more aggressive transfusion management.

Endovascular balloon procedures may be associated with complications at various stages, including positioning, inflation, occlusion, deflation, and removal of the sheath [19]. To minimize these risks, it is crucial to reduce the occlusion time and limit the duration the balloon remains in the body. In our study, we did not observe any balloon-related complications, such as subclavian artery stenosis, stroke, limb ischemia, or spinal cord ischemia, in any of the patients. The balloons were inserted on the day of surgery, with an average occlusion time of 22.73 min, and the sheaths were immediately removed following surgery. Additionally, patients in the balloon occlusion group were significantly younger than those in the non-balloon group (33.81±20.47 vs. 57.89±19.49, $p=0.004$). Special caution should be exercised with elderly patients who may have preexisting vascular conditions, and effective communication with the anesthesia team is essential to ensure perioperative safety.

In cases of trauma, such as fractures, delayed hemorrhage can significantly increase perioperative mortality, while early embolization has been shown to improve patient outcomes [20, 21]. A shorter door-to-embolization time (DTE) has been associated with better clinical results in patients with complex pelvic fractures [22]. Similarly, for bone tumor patients, the timing of embolization prior to surgery has drawn considerable attention. A previous study on renal cell carcinoma bone metastases indicated that performing surgery within one day of TAE may reduce intraoperative blood loss [23]. The optimal time for embolization remains a subject of debate, with some researchers advocating for surgery as soon as possible to mitigate the risk of tumor revascularization [24–26].

In our study, Group D was divided based on the timing of TAE into Group E (TAE performed on the same day as surgery) and Group F (TAE performed more than one day before surgery). No significant difference in blood loss was observed between the two groups (357.14±229.91 ml vs. 492.73±291.00 ml, $p=0.314$). Similarly, operation times between Group E and Group F did not differ significantly (128.57±28.97 min vs. 154.09±117.06 min, $p=0.583$). Postoperative outcomes, including ICU admissions and vasopressor use, were also comparable between these groups.

In conclusion, for patients with giant upper extremity tumors, both TAE (Transarterial Embolization) and intraoperative balloon occlusion are potential intervention options. However, for elderly patients with pre-existing vascular issues, the use of endovascular balloon insertion should be approached with caution. For patients at high risk of revascularization, such as those with renal cell carcinoma bone metastases, it is advisable to perform surgery within one day after TAE. For other types of upper extremity tumors, the timing of TAE does not necessarily need to align closely with the surgical opportunity.

Limitations

The main limitation of our study is its retrospective characteristics. Because subjects were not randomly allocated, selection bias may exist. The number of cases is also small in our study, and this study could not be adequately powered statistically. Potential biases in patient selection, along with the small sample size, may reduce the overall reliability and generalizability of the conclusions. And the medical intervention (such as the choice of patients to receive TAE or balloon occlusion) cannot be made on a blinded base. As a result, a large multicenter and randomized controlled study is needed to verify the findings.

Conclusion

Interventional techniques have been shown to reduce both blood loss and the necessity for blood transfusions in patients with large upper extremity tumors. Furthermore, no significant perioperative complications have been observed.

Abbreviations

TAE	Transarterial embolization
BMI	Body mass index
ASA	American Society of Anesthesiologists
ICU	Intensive care unit
POD	Postoperative day
RBC	Red blood cell
DTE	Doortoembolization time

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Author contributions

Study conception: HL and YF. Study design: All authors. Study conduct: FH. Data analysis: FH.Data interpretation: FH. Drafting of the manuscript: FH. All authors approved the final version of the manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Ethical approval has been confirmed from the Ethics Committee of Peking University People's Hospital. Informed consent to participate was obtained from all of the participants in the study (ref approval number: Approval No.2022PHB084-001).

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

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References

1. Pan P, Lee EW, Eghbalieh N, et al. <ArticleTitle Language="En">Ipsilateral transradial access in transarterial embolization of upper extremity bony metastases:[J]. J Vasc Access. 2019;20(2):202–8.
2. Mangar D, Shube S, Omar H, et al. Intravascular balloon to minimize blood loss during total hip replacement in a Jehovah's Witness[J]. J Clin Anesth. 2011;23(1):71–4.
3. Zhang L, Gong Q, Xiao H, et al. Control of blood loss during sacral surgery by aortic balloon occlusion.[J]. Anesthesia & Analgesia. 2007;105(3):700–3.
4. Tang X, Guo W, Yang R, et al. Use of Aortic Balloon Occlusion to Decrease Blood Loss During Sacral Tumor Resection[J]. J Bone Joint Surg Am Volume. 2010;92(8):1747.
5. Makoto Emori M, Kaya M, Sasaki T, Wada. Takehiko Yamaguchi and Toshihiko Yamashita. Pre-operative selective arterial embolization as a neoadjuvant therapy for proximal humerus giant cell tumor of bone: radiological and histological evaluation.[J]. Japanese Journal of Clinical Oncology. 2012;42(9):851–5.
6. Zaw T, Ni JC, Park JK, et al. Upper extremity tumor embolization using a transradial artery approach: technical note[J]. Radiol Case Rep. 2016;11(3):190–4.
7. Seike Y, Matsuda H, Inoue Y, et al. Balloon protection of the left subclavian artery in debranching thoracic endovascular aortic repair[J]. J Thorac Cardiovasc Surg. 2019;157:1336–45.
8. Mario D, Kevin M, Randall DM, et al. Narrative review on endovascular techniques for left subclavian artery revascularization during thoracic endovascular aortic repair and risk factors for postoperative stroke[J]. Interact Cardiovasc Thorac Surg. 2021;32:764–72.
9. Dong Z, Fang K, Sui C, Guo J, Dai B, Geng L, Yang J. The surgical outcomes and risk factors of giant hepatic haemangiomas: a single centre experience. BMC Surg. 2022;22(1):278. https://doi.org/10.1186/s12893-022-01721-w. PMID: 35843944; PMCID: PMC9290193.
10. Xie QS, Chen ZX, Zhao YJ, Gu H, Geng XP, Liu FB. Outcomes of surgery for giant hepatic hemangioma. BMC Surg. 2021;21(1):186. https://doi.org/10.1186/s12893-021-01185-4. PMID: 33832476; PMCID: PMC8033692.
11. Safety. and efficacy of transarterial embolization of hepatocellular adenomas[J]. Br J Surg. 2019;106(10).
12. Murray TE, Doyle F, Lee M. Transarterial Embolization of Angiomyolipoma: A Systematic Review[J]. J Urol. 2015;194(3):635–9.
13. Radeleff B, Eiers M, Lopez-Benitez R, et al. Transarterial embolization of primary and secondary tumors of the skeletal system[J]. Eur J Radiol. 2006;58(1):68–75.
14. Facchini G, Parmeggiani A, Peta G et al. The role of percutaneous transarterial embolization in the management of spinal bone tumors: a literature review[J]. Eur Spine J 2021:1–13.
15. Sakurai K. Hashizume, Preoperative transarterial embolization using gelatin sponge for hypervascular bone and soft tissue tumors in the pelvis or extremities[J]. Acta Radiol. 2016.
16. Ibrahim WH, Safran ZA, Hasan H et al. Preoperative and therapeutic embolization of extremities of bone and soft tissue tumors[J].Angiology. 2013;64(2) 151–6.
17. Elkbuli A, Shaikh S, Mckenney M, et al. Subclavian artery avulsion following blunt trauma: A case report and literature review[J]. Int J Surg case Rep. 2019;61:157.
18. Arnold S, Gilroy D, Laws P, et al. Subclavian artery laceration following clavicle fracture, successfully treated with a combined endovascular and open surgical approach[J]. Case Rep. 2021;14(7):e241382.
19. Ribeiro J, Feng C, Nguyen A, et al. The complications associated with Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA)[J]. World J Emerg Surg. 2018;13(1):20.
20. Matsushima K, Piccinini A, Schellenberg M, Cheng V, Heindel P, Strumwasser A, et al. Effect of door-to-angioembolization time on mortality in pelvic fracture: every hour of delay counts. J Trauma Acute Care Surg. 2018;84(5):685–92.
21. Balogh Z, Caldwell E, Heetveld M, D'Amours S, Schlaphof G, Harris I, et al. Institutional practice guidelines on management of pelvic fracture-related hemodynamic instability: do they make a diference? J Trauma. 2005;58(4):778–82.
22. Kim H, Chang HJ, Kim JH et al. Relationship between door-to-embolization time and clinical outcomes after transarterial embolization in trauma patients with complex pelvic fracture[J]. Eur J Trauma Emerg Surg. 2021(5).
23. Celebioglu EC, Bilgic S, Merter A, et al. Scheduling surgery after transarterial embolization: does timing make any difference to intraoperative blood loss for renal cell carcinoma bone metastases?[J]. Diagn Interv Radiol. 2021;27:740–5.
24. Gottfried ON, Schloesser PE, Schmidt MH, et al. Embolization of metastatic spinal tumors. Neurosurg Clin N Am. 2004;15:391.

25. Truumees E. Dodwad SN,Kazmierczak CD.Preoperative embolization in the treatment of spinal metastasis. J Am Acad Orthop Surg. 2010;18:449–53.
26. Kato S, Hozumi T, Takaki Y, et al. Optimal schedule of preoperative embolization for spinal metastasis surgery.[J]. Spine. 2013;38(22):1964–9.

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