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ORIGINAL ARTICLE

Efficacy and Safety of Preoperative Embolisation of Bone Tumours: A Tertiary Centre Experience

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ABSTRACT

Introduction: *Preoperative embolisation of bone tumours minimises risk of major intraoperative haemorrhage. Technical success is defined as obliteration of tumour vascularity by ≥70% on post-embolisation angiography. We retrospectively reviewed the technical success, efficacy, and safety of preoperative embolisation of bone tumours in our centre.*

Methods: *Nineteen patients underwent preoperative embolisation of bone tumours from December 2010 to July 2022. Subsequent surgery was performed 1 day post-embolisation. Patient demographics, tumour histology and location, presence of pathological fracture or spinal cord compression, primary embolic agent used, technical success, intraprocedural blood loss, need for blood transfusion, and major complications related to embolisation or subsequent surgery were assessed.*

Results: *Most of the bone tumours were metastases (n = 14) with the majority being hypervascular metastases from renal cell carcinoma or thyroid cancer. The primary bone tumours (n = 5) included vertebral haemangioma (n = 2), plasmacytoma (n = 2), and chordoma (n = 1). Pathological fractures were present in 11 patients. Among the 11 tumours in the spine, eight of them were complicated by spinal cord compression before embolisation. Particles were used as the main embolisation agent in all cases, with 89% technical success. There were no major embolisation-related complications. In patients after successful embolisation, the estimated intraprocedural blood loss ranged from 20 to 3,000 mL.*

Conclusion: *Preoperative embolisation of bone tumours is safe and feasible with high technical success.*

Key Words: *Bone neoplasms; Hemangioma; Radiology, interventional; Spinal cord compression*

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Data Availability: All data generated or analysed during the present study are available from the corresponding author on reasonable request.

Ethics Approval: This research was approved by the Kowloon Central / Kowloon East Cluster Research Ethics Committee of Hospital Authority, Hong Kong (Ref No.: KC/KE-23-0038/ER-4). The requirement for informed patient consent was waived by the Committee due to the retrospective nature of the research.

中文摘要

骨腫瘤術前栓塞的有效性和安全性：一個三級醫療中心的經驗

尹芳盈、錢永恩、黎國忠、陳文光

引言：骨腫瘤術前栓塞盡量減少了術中大出血的風險。技術成功的定義是栓塞後血管攝影中腫瘤血管消失≥70%。我們對本中心骨腫瘤術前栓塞的技術成功率、有效性和安全性進行回顧性分析。

方法：2010年12月至2022年7月期間，19例患者接受了術前骨腫瘤栓塞治療，他們於栓塞後1天進行手術。我們分析了患者基本數據、腫瘤組織學和位置、是否存在病理性骨折或脊髓壓迫、使用的主要栓塞劑、技術成功率、術中失血、輸血需求以及與栓塞或後續手術相關的主要併發症。

結果：大多數骨腫瘤是轉移瘤（n = 14），其中大多數是腎細胞癌或甲狀腺癌的富血管轉移瘤。原發性骨腫瘤（n = 5）包括椎體血管瘤（n = 2）、漿細胞瘤（n = 2）和脊索瘤（n = 1）。11名患者存在病理性骨折。11個脊椎腫瘤中，有8個在栓塞前併發脊髓受壓。所有病例均使用以顆粒為主的栓塞劑，技術成功率為89%。沒有嚴重的栓塞相關併發症個案。栓塞成功的患者的預計術中失血量為20至3,000 mL。

結論：骨腫瘤術前栓塞是安全且可行的，技術成功率亦高。

INTRODUCTION

The management of bone tumours is complex and requires a multidisciplinary approach. In general, the best line of treatment is surgical resection. Bone tumours with impending or completed pathological fractures require early surgical intervention to prevent or stabilise the fractures. Nevertheless, surgery may be technically difficult due to large or hypervascular tumours, difficult anatomical locations, or close proximity to adjacent vital structures such as the spine. In these scenarios, arterial embolisation plays a pivotal role as a preoperative methodology to achieve devascularisation of the tumour, thus minimising intraoperative bleeding and complications. In this study, we aimed to evaluate the technical success, efficacy, and safety of preoperative embolisation of bone tumours in our tertiary musculoskeletal tumour centre.

METHODS

This retrospective study evaluated 19 patients who underwent preoperative embolisation of bone tumours followed by surgery at our centre from December 2010 to July 2022. Patient demographics, tumour histology and location, presence of pathological fractures or spinal cord compression, and choice of primary embolic agent were recorded. The technical success of embolisation, defined as reduction of tumour arterial blush by ≥70% on postoperative angiography,[1,2] as shown in our case (Figure 1), was assessed. In cases of no definite tumoural staining identified on preoperative angiography, which was seen in one of our patients, technical success could not be reliably evaluated. Clinical notes as well as operative and anaesthetic records were reviewed for major surgical complications, intraoperative blood loss, and requirements for transfusion. Categorical data are presented as percentages, while numerical data are presented as medians with ranges.

Techniques

Case selection for preoperative embolisation requires a multidisciplinary team discussion. Factors to consider include tumour histology, location, size and vascularity, and the risk of significant intraprocedural haemorrhage.[2] Tumour histology is confirmed by image-guided core needle biopsy. The location, size, and vascularity of the tumour are assessed on imaging. Preprocedural review of imaging, in particular computed tomography angiography, is important for identifying blood supply and drainage, tumour extension into adjacent structures, and proximity to vital structures potentially sharing the arterial supply. Before the embolisation procedure, the results of laboratory tests including clotting profile, platelet count, haemoglobin level, and creatinine values are reviewed. Abnormal coagulation should be corrected since many of the embolic agents require a functioning intrinsic clotting mechanism.

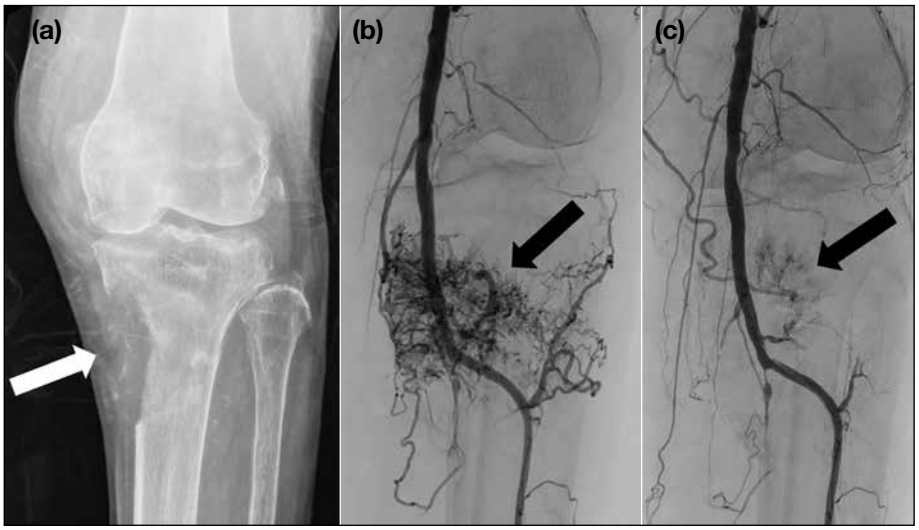

Figure 1. (a) Bone metastasis from renal cell carcinoma in the left proximal tibia manifests as a large expansile lytic bone lesion (arrow) on radiograph. (b) It shows significant hypervascularity (arrow) on angiogram with supply from multiple genicular arteries and the anterior recurrent tibial artery. (c) Post-embolisation angiogram confirms technical success of the procedure with minimal residual tumoral vascularity (arrow).

All patients in our centre had surgery performed 1 day following the embolisation. In view of potential revascularisation with a prolonged interval between embolisation and surgery, the timing of embolisation should be as close as possible to that of the operation, ideally within 3 days after embolisation.[2] The procedure was performed by radiologists with 8 to 26 years of experience in vascular interventional radiology. The embolisation procedure was done under local anaesthesia in the angiography suite. Vascular access was obtained via femoral arterial puncture. A 5-Fr or 6-Fr vascular sheath and a 4-Fr or 5-Fr pre-shaped catheter were used. A pre-embolisation angiogram was obtained to assess the degree of tumour vascularity, identify the major supplying arteries, and confirm the safety of embolisation. For instance, careful attention must be paid to ensure there is no opacification of a spinal pial artery such as the artery of Adamkiewicz. If embolisation was not contraindicated for any of these reasons, a microcatheter was introduced coaxially through the catheter to achieve superselective catheterisation of tumour feeding arteries and reduce the chance of non-target embolisation. Micron-sized solid embolic particles were primarily used in all cases. They lodged in the tumour vessels proximal to or at capillary level, thus occluding vessels within the tumour to achieve distal tumour microvasculature penetration. The particles were suspended in non-ionic contrast medium to enable visualisation during the angiographic procedure. The choice of particle diameter was determined by vessel size and desired distal embolisation. Injection of embolic agents must be performed under fluoroscopic guidance to guard against reflux into non-target vessels. All embolisation procedures were performed under continuous fluoroscopic guidance. Multiple angiograms were acquired to evaluate the degree of vessel occlusion. The endpoint of the procedure was reached when all the major tumour-supplying vessels were occluded with near-complete obliteration of tumour blush. Finally, a post-embolisation angiogram was performed to assess the technical success of embolisation, which was defined as catheterisation of the major tumour feeding arteries with reduction of the tumour blood supply by ≥70%.[1,2]

Table. Demographics, clinical, and pathological characteristics of patients (n = 19).* †

Age, y	
<50	3 (16%)
50-59	6 (32%)
60-69	7 (37%)
≥70	3 (16%)
Sex	
Female	10 (53%)
Male	9 (47%)
Tumour histology	
Metastasis from renal cell carcinoma	6 (32%)
Metastasis from thyroid carcinoma	5 (26%)
Metastasis from pleomorphic liposarcoma	1 (5%)
Metastasis from solitary fibrous tumour	1 (5%)
Metastasis from paraganglioma	1 (5%)
Vertebral haemangioma	2 (11%)
Plasmacytoma	2 (11%)
Chordoma	1 (5%)
Tumour location	
Spine	11 (58%)
Pelvis	2 (11%)
Extremities	6 (32%)
Pathological fractures	11 (58%)
Spinal cord compression‡	8 (73%)

* Data are shown as No. (%).
† Because of rounding, not all percentages total 100.
‡ Calculated based on total No. of patients with tumours involving the vertebrae (n = 11).

RESULTS

There were 10 female and nine male patients who underwent preoperative embolisation during the study period (Table). Patient age ranged between 22 and 77 years and the median age was 61 years. The majority of the tumours were bone metastases (n = 14, 74%) and most of them were either metastases from renal cell carcinoma (n = 6, 32%) or thyroid carcinoma (n = 5, 26%). The rest of the bone tumours (n = 5, 26%) included vertebral haemangioma (n = 2, 11%), plasmacytoma (n = 2, 11%), and chordoma (n = 1, 5%). More than half (n = 11, 58%) of the tumours were located within multiple vertebrae. The rest were located in the extremities (n = 6, 32%) or the pelvis (n = 2, 11%). Pathological fractures were present in 58% of the patients (n = 11). Among the 11 vertebral tumours, cord compression was seen in eight (73%) of them.

Technical success was achieved in 16 out of 18 (89%) patients and selected case examples are shown in Figures 2 to 4. Only partial embolisation could be performed in two patients due to the proximity of the tumour feeding arteries to the spinal artery in one patient and the occurrence of chest pain during the procedure in another patient. Technical success could not be reliably evaluated in one patient since no definite tumour staining was evident on pre-embolisation angiogram for comparison. The primary embolic agents used included trisacryl gelatin microspheres (Embosphere; Merit Medical, Warrington [PA], US) [n = 8], polyvinyl alcohol (PVA) particles (Contour; Boston Scientific, Marlborough [MA], US) [n = 7], and PVA hydrogel microspheres (Bead Block; Terumo Medical, Tokyo, Japan) [n = 4].

There was no mortality related to embolisation. Minor complications in the form of post-embolisation syndrome and pain from ischaemic necrosis of tumours occurred in six patients (32%) and these were treated with analgesics and fluid. In patients with embolisation

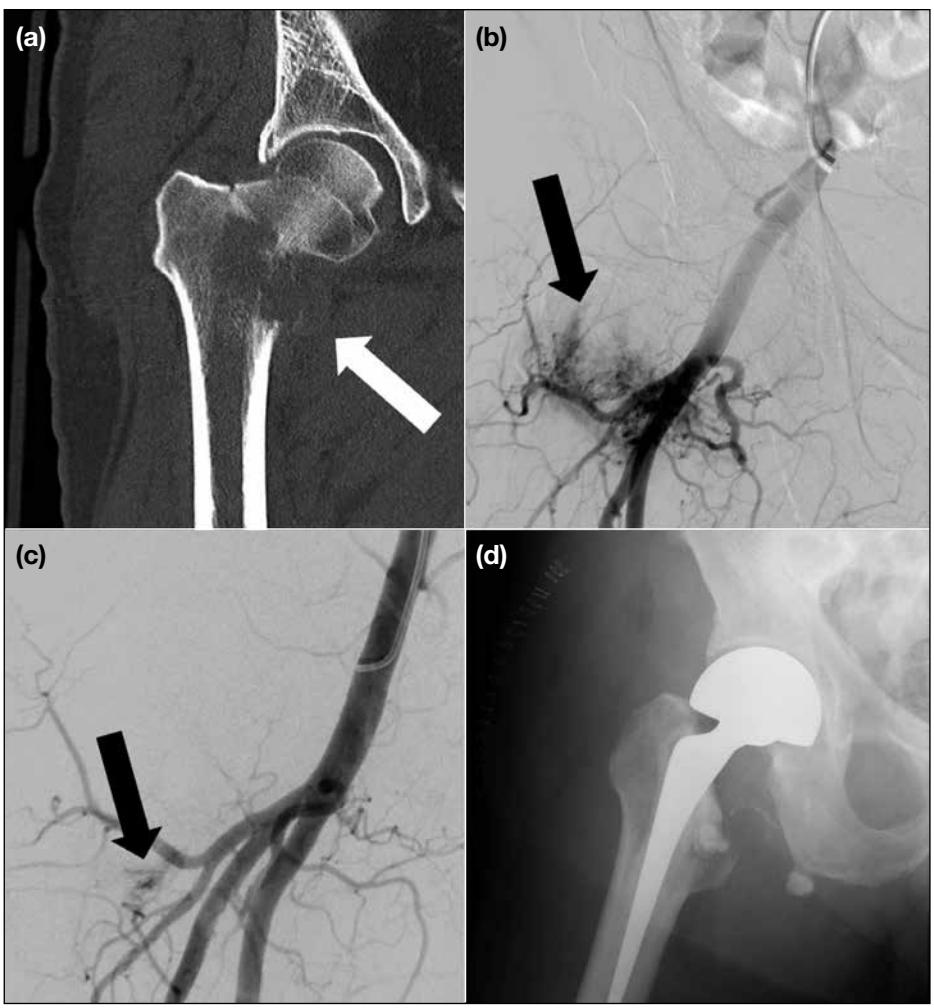

Figure 2. (a) Preoperative embolisation performed for bone metastasis from renal cell carcinoma at the right femoral intertrochanteric region (arrow) with pathological fracture. (b) Angiogram of the right femoral artery shows the hypervascular tumour (arrow) supplied by branches of lateral and medial circumflex femoral arteries. (c) Post-embolisation angiogram demonstrates >90% reduction in tumour vascularity (arrow), suggestive of technical success. (d) The patient underwent bipolar hip arthroplasty on the subsequent day with intraoperative blood loss of around 100 mL.

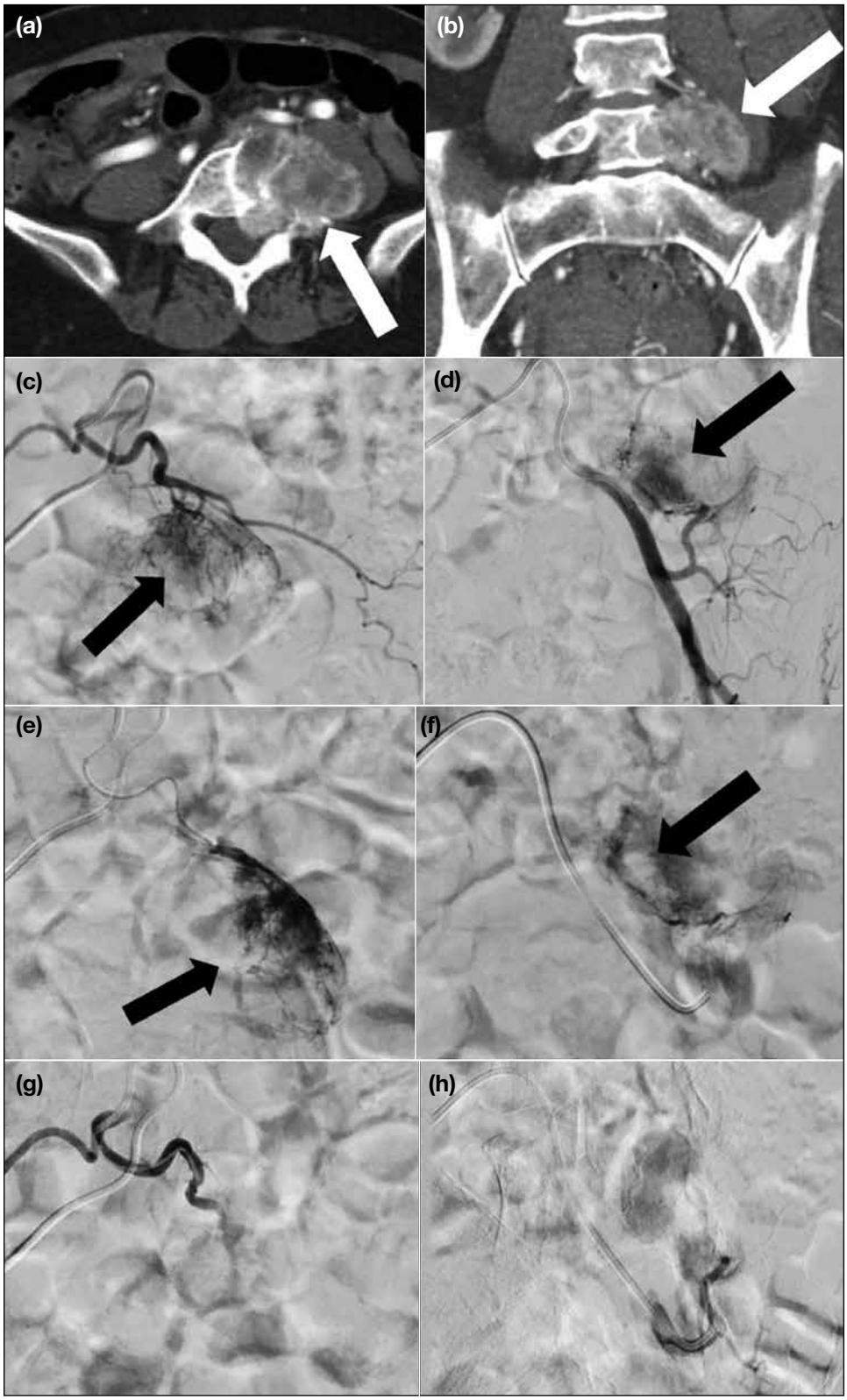

Figure 3. Histologically proven spinal metastasis from solitary fibrous tumour undergoing preoperative embolisation. Computed tomography shows the L5 spinal tumour (arrows) with intraspinal (a) and paraspinal (b) extension. Pre-embolisation angiograms confirm the hypervascular tumour (arrows) to be supplied by branches of the left fourth lumbar artery (c) and iliac branch of the left iliolumbar artery (d). Superselective pre-embolisation angiograms by microcatheters advanced into the branches of the left fourth lumbar artery (e) and the branches of the iliac branch of the left iliolumbar artery (f) reveal significant tumour blush (arrows). Post-embolisation angiograms of branches of the left fourth lumbar artery (g) and the iliac branch of the left iliolumbar artery (h) demonstrate absent tumour blush, suggestive of technical success.

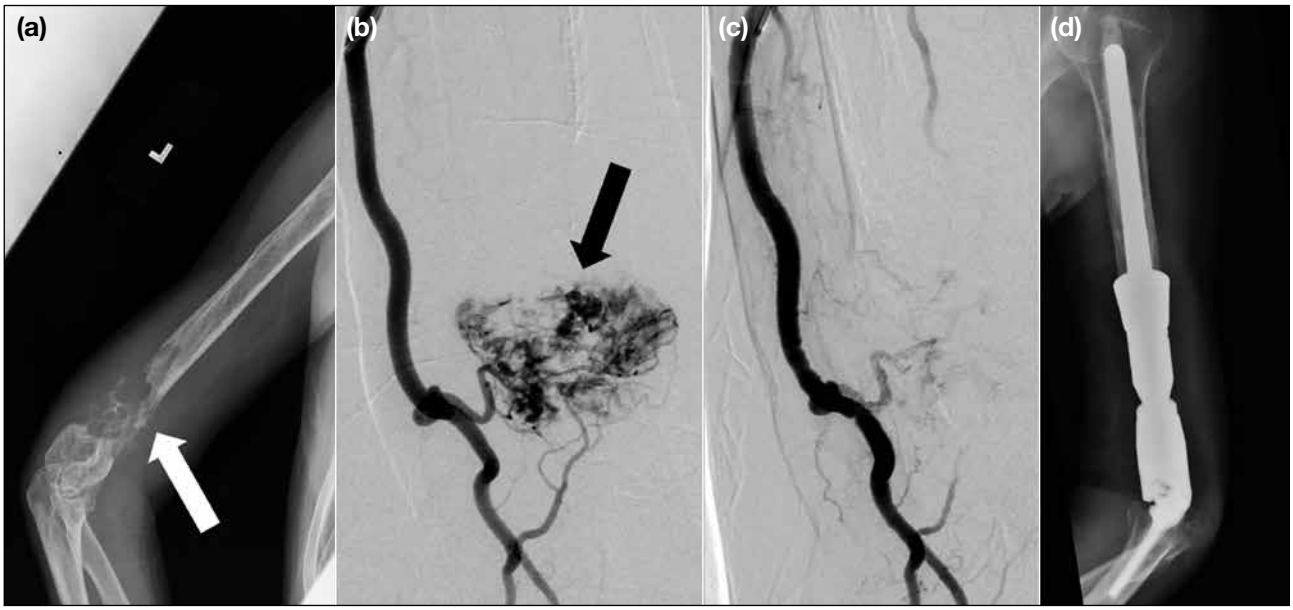

Figure 4. (a) Pathological fracture through a renal cell metastasis in the distal left humerus (arrow) is seen on the radiograph. (b) Brachial angiogram shows the hypervascular tumour (arrow) with arterial feeders from the brachial artery and radial recurrent artery. (c) Completion angiogram demonstrates successful devascularisation. (d) The patient underwent partial resection of the humerus and total elbow replacement with minimal blood loss.

of vertebral tumours, there were no procedure-related neurological deficits. The median of intraprocedural blood loss was 700 mL (range, 20-14,000). Two patients (11%) suffered major haemorrhages requiring massive intraprocedural blood transfusions. One of them had a spinal metastasis from renal cell carcinoma with supply from the bilateral T6 segmental arteries. However, successful embolisation was only achieved at the right T6 segmental artery because the spinal artery was seen in repeated angiograms of the left T6 segmental artery (Figure 5). To minimise the risk of spinal cord infarction, the procedure was abandoned after only light embolisation of the left T6 segmental artery and the target of technical success could not be achieved. The patient had significant intraprocedural blood loss requiring massive transfusion and the transfused blood volume was around 3 L. Postoperatively, there was diplegia of the lower limbs, suggestive of spinal cord injury. Another patient had sacral chordoma with no definite tumour staining on preoperative angiography. As a result, technical success of the embolisation procedure could not be reliably evaluated. Embolisation was performed pre-emptively in view of the possibility of massive intraoperative bleeding. Unfortunately, major intraprocedural haemorrhage was still encountered, necessitating massive transfusion with transfused blood volume of around 4 L.

DISCUSSION

Successful embolisation of bone tumours may potentially decrease intraoperative blood loss and improve visualisation of the surgical field, thus minimising risks of major complications and enabling safer and more complete resection. It is particularly beneficial when there is a high risk of intraoperative bleeding, spinal involvement with cord or neural encroachment or in technically difficult locations with expected prolonged surgery,[3] such as hypervascular spinal and pelvic bone metastases. In our case series, the median estimated intraprocedural blood loss was 700 mL, which was lower than that reported in other studies.[4,5]

Apart from its role as an adjuvant therapy to surgery, embolisation may also be performed as a palliative treatment for symptomatic relief of bone metastases. It may be done as a standalone treatment or combined with ablation or cementoplasty.[6] It has been used successfully to achieve neurological improvement in patients with hypervascular vertebral metastases causing acute spinal cord compression[7] and symptomatic relief in patients with painful bone metastases from renal cell carcinoma.[8] There have been studies supporting embolisation as a primary treatment for benign bone tumours such as aneurysmal bone cysts and giant cell tumours.[9-11] It is particularly beneficial in tumours located in the spine

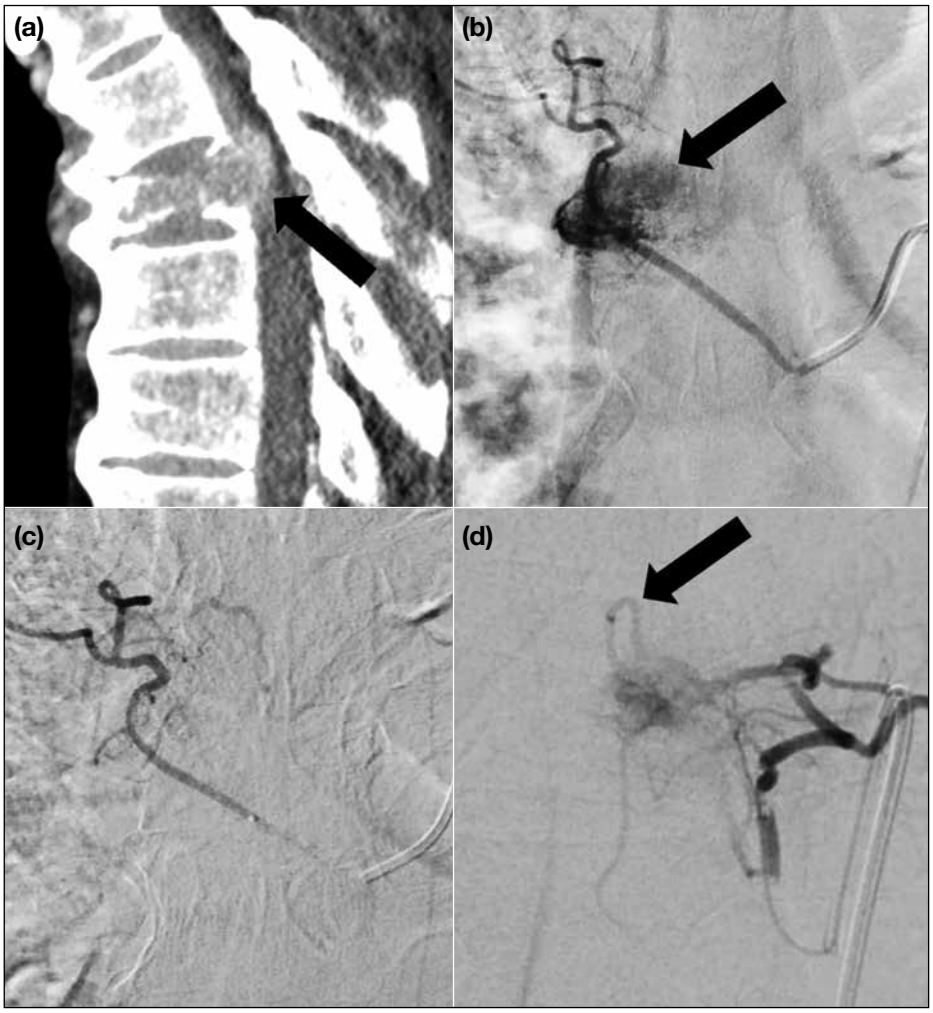

Figure 5. (a) Sagittal view of computed tomography of the thoracic spine reveals a T6 bone metastasis from renal cell carcinoma with extension into the spinal canal (arrow). (b) Superselective catheterisation of the right T6 segmental artery shows significant tumour staining (arrow) and non-visualisation of the spinal artery. (c) Post-embolisation angiogram of the right T6 segmental artery shows absent tumour blush. (d) The spinal artery (arrow) was visualised on repeated angiogram of the left T6 segmental artery after initial light embolisation, therefore no further embolisation was performed.

or pelvis, where surgery and radiation are associated with high rates of morbidity and recurrence. Serial embolisation of these tumours is usually performed until there is symptomatic relief or near complete resolution of tumour vascularity.[10] Radiological response can also be assessed and it manifests as reduction in tumour vascularity and increase in ossification. In patients with vertebral haemangiomas complicated with spinal cord compression or spinal pain, surgery or radiotherapy has been the traditional treatment of choice. However, surgery alone is associated with risk of significant bleeding from these highly vascular tumours. Preoperative embolisation has been shown to be a useful adjunctive therapy to minimise bleeding risk.[12,13]

Particulate materials, namely PVA particles and microspheres, are primarily used for embolisation. PVA is water-soluble synthetic polymer made from polyvinyl acetate through partial or full hydrolysis to remove the acetate groups, with size ranging from 50 to 1000 μm. It has the ability to penetrate and occlude the tumour blood supply. It is compressible after drying and will expand to up to 15 times its compressed size after rehydration.[14] Most interventional radiologists have extensive experience in using it and it is relatively easy to deliver. It is safe without any long-term side-effects. The conventional preparation (Contour PVA) has irregular outlines and therefore occludes vessels larger than its diameter due to aggregation of particles. Some newer preparations, e.g., Bead Block PVA hydrogel microspheres, are engineered PVA particles with relatively uniform size. Their microporous nature also enables them to be compressible and facilitates delivery through small catheters. Embosphere microspheres are trisacryl gelatin microspheres with size ranging from 40 to 1200 μm. Their compressibility allows smooth passage through microcatheter with a diameter smaller than its size. They are more uniform in size than PVA

and their sizes do not change in liquids. They also have less tendency to clump after injection. The choice of the primary particulate embolic agent is mainly determined by the operator's experience and preference. There is currently little published literature comparing the efficacy of different embolic materials in preoperative embolisation of bone tumours. A study performed to assess the intraprocedural blood loss post-embolisation showed no clinically significant difference between trisacryl gelatin microspheres and PVA particles.[15] Liquid embolic agents may induce more tumour necrosis than particles and be beneficial when definitive treatment is aimed. Nonetheless, they are technically more difficult to handle and their use requires an experienced operator. They are also associated with a higher risk of non-target embolisation and non-target necrosis compared with particles.[6] As a general rule, if embolisation is performed as preoperative or palliative treatment, liquid agents have little advantage over particulate agents.

Complications of embolisation of bone tumours include arterial dissection, pain due to ischaemic necrosis of tumour, non-target embolisation, infection, haemorrhage, and post-embolisation syndrome.[8,16] Post-embolisation syndrome is a common but usually self-limiting side-effect. Patients present with symptoms such as pain, fever, and malaise, which could be treated with analgesics and fluid. Non-target embolisation is another potential complication. Aside from the use of microcatheters to reduce its risk, coils may be employed to embolise and protect the non-target vessels more proximally, which could not be navigated beyond to get close to the tumour feeding vessels.[7]

Limitations

There were limitations in our study. First, it was retrospective in nature and a non-embolisation group was not available for comparison. With reference to other studies from the literature, it still offered a reasonable view of preoperative embolisation as a potentially helpful procedure in the management of bone tumours. Another limitation was the heterogeneous study population with different tumour pathologies and surgeries performed, but this reflected the diversity of primary and metastatic bone tumours that could be considered for preoperative embolisation. Ideally, a prospective randomised controlled trial with a larger study population would be optimal for determining the exact value of preoperative embolisation compared with non-embolisation. Other factors that could affect intraprocedural blood loss, including patient factors, and the surgery performed, should also be taken into account.

CONCLUSION

Preoperative embolisation is safe, technically feasible, and potentially useful in the treatment of bone tumours, although a high risk of intraoperative bleeding should be taken into consideration.

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