Outcome of embolised vascular metastatic renal cell tumours causing spinal cord compression

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Abstract

Purpose To present the results of the surgical management of metastatic renal cell tumours of the spine with cord compression who underwent pre-operative embolisation.

Methods We conducted a retrospective cohort study of all embolised vascular metastatic renal cell tumours of the spine that underwent urgent surgical intervention over a 7-year period (2005–2011). All medical notes, images and angiography/embolisation details were studied. We recorded the timing (immediate vs. delayed) and grade of embolisation and compared this to the estimated blood loss (EBL); extent of metastatic spinal cord compression (using the Tomita score and Bilsky scores) was also compared to EBL. Finally, neurological (Frankel grade), surgical outcome and complications were reviewed in all patients.

Results During the study period, we operated on 25 emergency patients with metastatic renal cell carcinoma causing spinal cord compression who had received pre-operative embolisation (mean age 59.6 (24–78) years; 8 females, 17 males). All but one of our patients had hypervascularisation/arterio-venous fistulae on angiography. We were able to achieve greater than 90 % embolisation in the majority (17/25, 68 %). The estimated blood loss was 1,696 (400–5,000) ml; mean operating time was 276 (90–690) min and an average of 2.3 (0–7) units of whole blood was transfused. Nine patients had a posterior

only decompression/stabilisation, nine patients had a posterior decompression $\pm$ cement augmentation, six had combined anterior/posterior procedures and one had anterior corpectomy/reconstruction alone. There was no statistical difference in the EBL between immediate versus delayed surgery after embolisation or the grade of embolisation. Immediate surgery after embolisation and interestingly less complete embolisation showed a trend towards less EBL. The extent of the tumour as graded by the Bilsky score correlated with increased EBL ($p = 0.042$). No complications occurred during the embolisation procedure. The surgical complication rate was 32 % (8/25) including two major complications (septicaemia (1) and metal work failure (2)) and five minor complications. Postoperatively, 52 % (13/25) had no change in neurological status, 36 % (9/25) improved by at least one Frankel grade and 12 % (3/25) had neurological deterioration by one Frankel grade. The average survival following surgery was 14.1 (0.5–72) months.

Conclusion Blood loss (mean 1,696 ml) and complications (32 %) remain a concern in the operative treatment of vascular metastatic spinal cord compression. Most patients remained the same neurologically or improved by at least 1 grade (22/25, 88 %). Paradoxically, greater embolisation showed a trend to more blood loss which could be due to more extensive surgery in this group, a rebound ‘reperfusion’ phenomena or even the presence of arterio-venous fistulae. Interestingly, we also found that the extent of the tumour, as graded by the Bilsky score, correlated with increased blood loss suggesting that more extensive cord compression by metastases could lead to more blood loss intra-operatively.

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Introduction

Skeletal system metastases are the third most common metastases, behind those of the pulmonary and hepatic systems [1]. Within the skeletal system, the spinal column is the most common site of metastases. It is expected that symptomatic metastatic spinal disease will become more prevalent as survival rates for many common cancers improve. The primary treatment modalities for metastatic spinal tumours are surgery and radiotherapy. The goals are mostly palliative and include neurological preservation or improvement, mechanical spinal stability, and local tumour control [2, 3].

Certain tumours such as renal cell carcinomas (RCC) are known to be hypervascular. Pre-operative embolisation of such hypervascular tumours aims to reduce intra-operative blood loss and improves the surgeon's ability to decompress the spinal cord and maximize tumour resection [4–12]. Other potential benefits include reducing mass effect, arresting tumour growth, alleviating pain, and shortening hospital stays [3, 13].

The aim of the study was to review the outcome of metastatic RCC causing cord compression that underwent pre-operative embolisation and urgent surgery. In addition, the timing of pre-operative embolisation and surgery as well as grade of embolisation with regards to blood loss was noted carefully. Furthermore, we attempted to correlate the extent of metastatic spinal cord compression with the intra-operative blood loss.

Methods

During the study period (2005–2011), 295 patients with metastatic spinal tumours underwent surgery at our academic tertiary institute. In 25 of these patients, pre-operative tumour embolisation for metastatic RCC was performed. Angiography and embolisation were performed by experienced interventional neuroradiologists using standard trans-arterial endovascular techniques.

Diagnostic spinal angiography was performed with a 4- or 5-French catheter, with the aim of identifying the supply to the tumour and spinal cord. The number of major and minor vascular pedicles feeding the tumour was noted. The presence of shared tumour and cord supply at the same inter-costal level was regarded as a contra-indication to embolisation (or reason for limited embolisation) in this study.

Embolisation was performed using the diagnostic catheter as a guide and advancing a microcatheter along the inter-costal artery, either selecting a high-flow corporeal branch or embolising from a proximal position. The microvasculature was occluded with PVA particles

(ranging from 150 to 900 micron size) and high-flow shunts were occluded with 25–50 % NBCA tissue glue. The proximal inter-costal artery was usually occluded with platinum coils.

The estimated percentage embolisation was subjective based on the visual appearance of the tumour circulation following embolisation i.e. an estimate of the extent of tumour blush visible after treatment. The grading scale used in this study was similar to that used by others, including the very experienced unit in Memorial Sloan-Kettering, New York [7, 13].

A retrospective analysis of a prospectively maintained database of these patients was carried out. We excluded patients who were treated solely by radiotherapy, patients having a cement augmentation procedure without decompression and patients who had undergone previous surgery for spinal metastasis.

Magnetic resonance imaging (MRI) was used to grade the extent of metastases using the Bilsky [14] and Tomita [15] scores. The revised Tokuhashi [16] prognostic score was used to predict survival. Intra-operative blood loss was estimated by the anaesthetist and scrub nurse by measuring suction loss and swab weight and packed red blood cells were transfused to maintain the haemoglobin greater than 8 mg/dl. This study was deemed exempt from ethics approval as per our institutional guidelines on service evaluation.

Statistical analysis

Statistical analysis was performed using SPSS 17.0 version software (Statistical Package for Social Sciences, SPSS Inc.). Student's *t* test was used to analyse the statistical significance. *P* values less than or equal to 0.05 were considered significant. A Pearson correlation coefficient was computed to assess the relationship between the amount of estimated blood loss (EBL) and the extent of metastases (as given by the Tomita and Bilsky scores).

Results

The mean age of patients was 59.6 years (range 24–78 years) with 8 females and 17 males. The sites for metastatic spinal cord compression were cervical spine (2), thoracic spine (21) and lumbar-sacral spine (2). Seventeen patients presented with pain and neurological deficit, whilst six had pain only and two patients presented with neurological deficit only. The onset of symptoms is very subjective and reliant on patients' capacity for recall. Of the 19 patients with neurological deficit, 13 had a progressive neurological deficit and were operated on at a mean of 26 (1–60 days) from the onset of symptoms.

Neurological status at presentation, evaluated on the basis of Frankel grade was Frankel C (6), Frankel D (13) and Frankel E (6). The mean estimated blood loss in all patients was 1,696 (400–5,000) ml; mean operating time was 276 (90–690) min and an average of 2.3 (0–7) units of whole blood was transfused. Nine patients had a posterior only decompression/stabilisation, nine patients had a posterior decompression $\pm$ cement augmentation, six had combined anterior/posterior procedures and one had anterior corpectomy/reconstruction alone.

When we compared the blood loss in the total number of patients having a posterior approach ($n = 18$; mean 1,666 ml), with the six patients who had a combined approach (1,983 ml), then there was a tendency for the latter approach to be associated with more blood loss ($p = 0.18$).

Angiography and embolisation details

The grading of angiographic appearance and numbers are shown in Table 1. The anterior spinal artery was visualised in 17 patients, not visualised in 4 patients and no comments were noted in further 4 patients. Posterior spinal arteries were visualised in 8 patients, not visualised in 6 patients and no comments were noted in 11 patients. All but one case showed hypervascularisation or the presence of arterio-venous fistulae (24/25, 96 %). The extent of embolisation was graded subjectively, based on a visual compilation of multi-level angiographic runs, estimating the degree of elimination of tumour blush following embolisation (Table 2). ‘Near-total’ (greater than 90 %) embolisation was achieved in 17/25 (68 %); three patients had ‘sub-total’ (51–90 %) embolisation; five patients had partial (less than 50 %) embolisation including two patients who were not embolised due to the presence of shared

tumour and cord supply. There were no complications during the embolisation procedure.

Timing of surgery after embolisation

Ten patients were operated immediately after the embolisation procedure was performed (i.e. under the same anaesthetic); 11 patients were operated within 24 h of embolisation and 4 patients between 24 and 48 h after embolisation. Results comparing the immediate (under the same anaesthetic) surgery group versus delayed surgery (within 24 h or 24–48 h) groups are shown in Table 3. Immediate surgery after embolisation ($n = 10$) was associated with slightly less blood loss and marginally greater operating time when compared to those operated in the delayed fashion ($n = 15$). These differences were not statistically significant. In addition, there was no difference in survival period between groups.

Extent of embolisation

Tumours in which greater than 90 % embolisation (near-total) was achieved ($n = 17$; Table 4) and those where all the major vascular pedicles were embolised ($n = 15$; Table 5), had a little higher blood loss, but with shorter operating time and marginally better survival. However, there were again no statistically significant differences in these outcome results.

Grading of metastatic spinal cord compression versus blood loss

The Pearson correlation coefficient was computed to assess the relationship between the EBL with Tomita and Bilsky scores. There was a positive correlation between the EBL and the Bilsky score ($r = 0.437$, $p = 0.042$) but not for the Tomita score ($r = 0.219$, $p = 0.327$). This would suggest that there was a (weak) correlation between the extent of spinal metastases, as given by the Bilsky score and blood loss.

Outcome and survival

Postoperatively, 52 % (13/25) had no change in neurological status, 36 % (9/25) showed improvement in neurological status by at least one Frankel grade and 12 % (3/25) had neurological deterioration by one Frankel grade. The complication rate was 32 % (8/25) including three major and five minor complications as below (Table 6).

The average survival following surgery was 14.1 (0.5–72) months. In our series, the revised Tokuhashi score did not appear to correlate with survival (Pearson correlation; $p = 0.329$).

Table 1 Grading of angiographic appearance for all patients

Grade	Angiography details	No. of patients
0	Normal vascularisation	0
I	Homogenous blush (normal feeding arteries)	1
II	Hypervascularisation (dilated feeding arteries)	14
III	Arterio-venous fistula	10

Table 2 Estimated extent of embolisation in all patients

Extent of embolisation	No. of patients
90–100 % (near-total)	17
51–90 % (sub-total)	3
Less than 50 % (partial)	5

Table 3 Timing of Surgery after Embolisation

	Immediate (<i>n</i> = 10)	Delayed (<24 h = 11; 24–48 h = 4) (<i>n</i> = 15)	<i>p</i> value
EBL (ml)	1500 (400–4,000)	1,794 (400–5,000)	0.49
Operating time (min)	293 (150–690)	265 (90–600)	0.44
Transfusion (units)	2.1 (0–7)	2.4 (0–7)	0.77
Operative procedure	7: Posterior decompression 2: Decompression/stabilisation 1: Anterior corpectomy only 2: Anterior–posterior approach	2: Posterior decompression 7: Posterior decompression/stabilisation 4: Combined anterior/posterior	
Survival (months)	13.83 (0.5–36)	16.2 (0.5–67)	0.97

Table 4 Grades of embolisation and outcome

	More than 90 % embolisation (<i>n</i> = 17)	Less than 90 % embolisation (<i>n</i> = 8)	<i>p</i> value
Blood loss (ml)	1,780 (400–4,000)	1,581 (400–5,000)	0.71
Operating time (min)	243 (90–360)	275 (150–600)	0.21
Transfusion (units)	2.5 (0–7)	2.1 (0–7)	0.86
Operative procedure	13: Posterior decompression/stabilisation 3: Combined anterior/posterior 1: Anterior only	4: Posterior decompression/stabilisation 3: Combined anterior/posterior 1: Anterior only	
Survival (months)	16.2 (0.5–72)	11.8 (0.5–36)	0.16

Table 5 Comparisons of patients with all major vascular pedicles embolised versus fewer embolised pedicles

	All major vascular pedicles embolised (<i>n</i> = 15)	Fewer embolised pedicles (<i>n</i> = 10)	<i>p</i> value
Blood loss (ml)	1,740 (400–4,000)	1,487 (400–5,000)	0.60
Operating time (min)	266	289	0.88
Transfusion (units)	2.2	2.4	0.94
Operative procedure	7: posterior decompression/stabilisation 4: Posterior decompression+/cement 4: Combined anterior/posterior	2: Posterior decompression/stabilisation 5: Decompression+/cement 2: Combined anterior/posterior 1: Anterior only	
Survival (months)	15.8 (0.5–72)	11.5 (0.5–36)	0.19

Table 6 Complications in all patients

Major	
Metal work failure	2
Septicaemia	1
Minor	
Respiratory complications	3
Urinary retention	2

Discussion

Our study shows that blood loss (mean 1,696 ml) and complications (32 %) remain a concern in the urgent operative treatment of vascular metastatic renal cell tumours spinal

cord compression. Paradoxically, greater embolisation showed a trend to more blood loss. We speculate that advanced knowledge of the fact that more complete embolisation was obtained in some patients had given us greater surgical confidence of more aggressive surgery with regards to tumour resection and had resulted in greater amount of blood loss. Other explanations include venous bleeding, a rebound ‘reperfusion’ phenomena or even the presence of arterio-venous fistulae, which were present in almost half of all patients. Interestingly, we also found that the extent of the tumour, as graded by the Bilsky score correlated with increased blood loss suggesting that more extensive cord compression by metastases led to more blood loss.

Use of pre-operative selective embolisation to reduce blood loss during surgery for spinal metastatic tumour is a well established procedure and described as a relatively

safe and effective means to control intra-operative blood loss and improve the resectability of the tumour. Pre-operative embolisation reduces tumour vascularity, allowing more complete resection and a lower morbidity rate in patients with hypervascular tumours. The authors of previous reports have shown efficacy for renal and non-renal spinal metastases such as melanoma, sarcoma, thyroid, breast, prostate, hepatic carcinoma, and neuroendocrine tumours such as paragangliomas [6–13].

Nevertheless, the amount of blood loss is variable [13, 17–20]. The procedure is associated with minimal morbidity when performed by experienced interventional radiologists. The extent, to which arterial feeding or regional segmental vessels and tumour blush as well as subsequent intra-operative blood loss are eliminated, has been used to grade the success of embolisation.

For effective vascular control, it is generally recommended to perform the surgery as early as possible after embolisation [10]. Although embolisation can still be effective if surgery is performed within 48 h [10], early surgery lowers the likelihood of recanalisation and modifications in the blood supply of the tumour. In our study, we found that there was only a “trend” towards less blood loss in patients who were operated immediately after embolisation when compared to those who underwent surgery in a delayed manner. Most of our patients had their surgery for metastases in thoracic spine (21), and it is not really possible to compare this with the small number at other sites—cervical (2) and lumbar (2). However, Prabhu et al. [13], in their series of 51 patients, found thoracic (2,300 ml) and lumbosacral tumours (3,700 ml) to be associated with significantly more blood loss than those of the cervical region (1,500 ml; $p = 0.015$).

This same study found blood loss of 2,400 ml for anterior approaches, 3,100 ml for anterior–posterior approaches, and 850 ml for posterolateral approaches. Although there was a trend towards the less blood loss with the latter approach, this difference was not statistically significant [13]. In our series, we also found less blood loss with the posterior approach ($n = 18$, mean 1,666 ml), when compared to the combined approach ($n = 6$, mean 1,983 ml; $p = 0.18$).

Neurological complications occur in approximately 2 % of patients following spinal angiography and local or systemic complications in 4–10 % [17, 18]. Complications include transient or permanent quadriplegia or quadriparesis as well as aortic dissections in up to 8.5 % of patients [19, 20]. In our series, there were no local or systemic complications following embolisation.

Jackson et al. [18] also found no statistically significant decrease in intra-operative blood loss, but did state that embolisation facilitated the resection of RCC metastases. King et al. [21] also found no statistically significant difference in blood loss between embolised and unembolised tumours, but they discontinued surgery in three patients in

whom embolisation had not been performed because of uncontrollable haemorrhage. The findings of several other authors substantiate the effectiveness of pre-operative embolisation in decreasing intra-operative blood loss to a mean of 1–3 l comparable with our results [2, 4–6, 8, 9, 13, 18–22]. An interesting study from the Czech Republic [23] found greater blood loss in the embolised group ($n = 8$, EBL mean 4,750 ml) versus the non-embolised group ($n = 7$, EBL mean 1,786 ml). They also suggested that metastasis size, extent of tumour and technical complexity of surgery may have an important effect on the amount of blood loss.

Limitations of our study include the lack of a control group, the estimation of effectiveness of embolisation based on reduced EBL comparing ‘near-total’ with ‘sub-total or partial’ embolisation within the cohort and the small number of patients in each embolisation category. There are several confounding variables that may explain why the population with ‘complete’ embolisation had equivalent blood loss to the population with incomplete embolisation. These include extent of surgery in patients with large(r) tumours and limited surgery in patients with incomplete embolisation.

It is possible that we did not find a statistically significant difference between the various embolisation grades simply because there were not enough patients. Given the aim of the embolisation procedure to reduce blood loss, and the nature of surgery, it is possibly not ethical or practical to conduct a randomised control study for such interventions.

Higher blood loss with a greater degree of metastatic spinal cord compression as given by the Bilsky score is certainly an interesting finding in our series. This would reaffirm our opinion and agree with Rehak et al. [23] in that the evaluation of the benefits of pre-operative embolisation on the basis of blood loss alone is not an adequate method and other variables such as tumour extent (as well complexity of surgery amongst others) must be considered. In this series, near-total embolisation showed a trend to faster operations and longer survival. To explore this further, we would recommend the study of embolisation and the other aforementioned variables in a prospective multi-centre setting, rather than continuing to focus on estimated blood loss alone which is a potentially flawed surrogate marker for effectiveness of embolisation.

Conflict of interest None.

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