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Vertebral Tumors – Diagnostic &Treatment Protocols

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Abstract

Vertebral bony tumors are notorious for their ability to mimic each other. With ever changing treatment protocols and newer adjuvant therapies introduced at regular intervals of time, we considered a small but concise update on management of these entities with our own diagnostic algorhythm, along with brief details on management, and a quick access table for radiological diagnosis. We hope that this effort, prepared with an extensive literature review supplemented with images and tables will assist in updating spine surgeons of all hues and thus assist in treating their patients.

Keywords: EA treatment; Rats with spinal cord injury; HIF-1α /VEGF signaling pathway; Blood oxygen microenvironment; Mechanism of nerve regeneration and recovery

Introduction

Vertebral Bony Tumors are well known to occur at different ages and affect all sections of the bony spinal column. Identification is usually radiological after the patient presents with symptoms that range from radicular pain and paresthesia (due to root compression), myelopathy (due to compression of the cord), or instability pain (due to weakening of the load bearing apparatus). Often presentation is a combination of these three overlapping syndromes, and thus diagnosis becomes confusing [1].

Despite many attempts at simplifying this conundrum, considerable differences persist. We present our own diagnostic algorhythm along with some essential tumor features that assist in the diagnosis of these tumors.

As radiology is vital to the diagnosis, and eventual management, we present a simplified table with accounts for different modalities as well as their features in distinguishing tumors from one another. Treatment is always as per the WBB System propounded for bony tumor resection. We also present a brief overview of surgical and adjuvant modalitiesinvolved in eventual management [2-6].

Diagnostic Analysis

The diagnostic protocol envisioned by us involves a 3-step process.

- Demographic assessment
- Clinical analysis
- Radiological assessment

These three simple yet efficient steps are essential to the accurate diagnosis of the problem.

Step 1: Demographic assessment

Vertebral tumors are almost exclusive to certain ages, and sexes. That itself gives an important clue to the nature of the lesion. Natural history and progression of the disease, as in all tumors, helps to differentiate benign from 'aggressive' tumors [7].

Here we are careful to use the term 'aggressive' over malignant as many tumors such as Giant cell tumors and certain tumor-like conditions mimic malignant behavior even though they're histopathologically considered benign or locally aggressive, (a favored term indicating aggressive local behavior devoid of distal metastasis) [8].

Figure 1 shows the demographic stratification of bony vertebral tumors where although some overlap exists, an idea regarding the nature of the disease can be obtained.

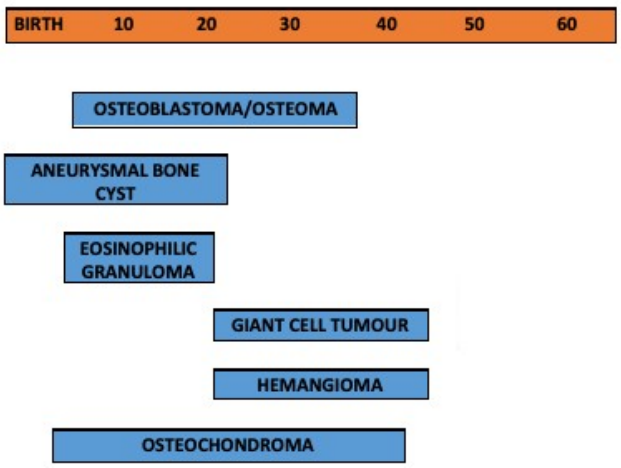

Figure 1.Demographic analysis: The commonest age of occurrences for common benign vertebral bony tumors is shown above.

Step 2: Clinical analysis

As in all medical conditions, a good history to elucidate progression and presenting complaints as well as a focused clinical examination to detect

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important signs assist in determining the extent, seriousness and treatability of the disease [9].

Figure 2 demonstrates a simple protocol wherein 3 standard symptoms are assessed in detail;

1. Pain: The first symptom perceptible is usually pain. Pain here takes on many forms thereby presenting a clue to the nature of the pathology.

a.Radicular pain caused by nerve root compression leads to a electric shock like painmoving from spine to limb (or trunk)

b.Instability pain is usually position related and worsens on assuming the offending position or changing position.

2. Neurological deficits: Neurological signs are subtle but an indication of compromise of the central canal and/or neural foramen resulting in a peculiar series of symptoms that assist not just in detection of the nature of the pathology, but also its approximate spinal level thereby helping formulate management strategies. Neurological signs can either be:

a.Lower motor neuron (LMN) indicating involvement of the nerve root and thereby signaling compression either peripheral to the central canal or involving the caudaequina. Symptoms and signs can vary from simple paresthesia and focal anesthesia to motor loss (e.g. foot drop).

i. Caudaequina compression will sometimes involve bladder symptoms which when detected may lead to a diagnosis of caudaequina syndrome which may require urgent imaging and decompression.

b. Upper motor neuron (UMN) involvement which implies compression onto the cord (myelopathy).

3. Other uncommon and subtle symptoms suggest either bony deformity due to erosion of the bone, or stiffness due to paravertebral muscle spasm indicating wither a paravertebral collection, or muscle infiltration which implies an advanced disease

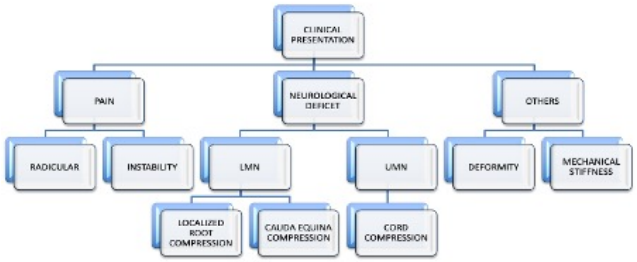

Figure 2. Clinical assessment: A flow chart demonstrating the different clinical presentations and their appropriate signs and inferences. Abbreviations used: LMN _ Lower motor neuron, UMN – Upper motor neuron.

Step 3: Radiological assessment

The definitive diagnosis of the lesion once a demographic and clinical picture emerge lead to the domain of the radiologist, where through a series of modalities certain identifying features lead to the diagnosis of the lesion.

Apart from diagnosis, extent, location and effects of the disease are also seen which are vital in planning surgery and determine whether adjuvant therapy can aid in treatment [10-13].

Table 1 describes in detail the radiological features of common vertebral tumors as seen by MRI, CT and other specific modalities. The table is self-explanatory and describes diagnosis fairly easily. Further analysis is decided by looking into:

Location: Cervical tumors allow easy anterior access which is vitals in body lesions. Dorsal (Thoracic) lesions imply a low tolerance to cord and neurological compression, the presence of ribs articulating at the transverse process and difficult anterior approaches.

Lumbar and sacral tumors indicate conus and/or caudaequina compression with its associated problems. Hence location is pivotal to management of the lesion.

Extent: This can be assessed in 2 planes.

1. Axially, it implies either

a. Anterior (involving the body),

b. Posterior (Involving the posterior elements) or

c. Both.

Axial extent features prominently in the Weinstein Borini, Bigniani System (WBB), where the vertebra in its axial plane is considered as the face of a clock. Based on the extend of involvement surgery is planned [14].

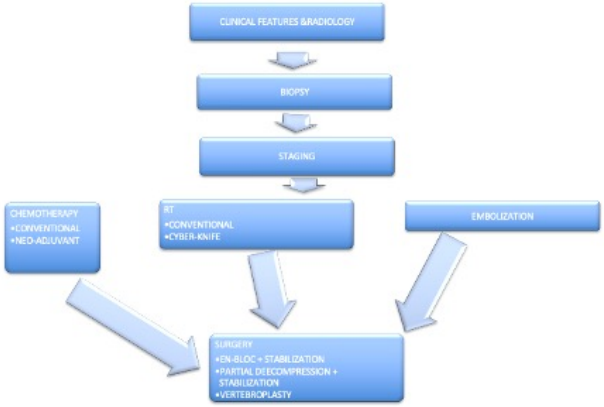

Figure 3. Treatment protocol: The diagram illustrates the different modalities and the need for biopsy before proceeding with adjuvant management.

Table 1. The radiological features of common vertebral tumors.

	MRI			CT	Others
	T1W	T2W	Contrast		

Chondroma	1) Intermediate to low signal intensity 2) Small foci of hyper intensity (intramuralhemorrhage or mucus pool)	High signal intensity	Heterogeneous enhancement with honeycomb appearance	1) Well circumscribed destructive lytic lesion 2) Expansilesoft tissue mass 3) Irregular intratumoral calcifications	**Bone scan:** Normal to decreased uptake
Chondrosarcoma	Low to intermediate intensity signal	Very high intensity	Heterogeneous moderate to intense contrast enhancement. (Septal and peripheral rim like enhancement seen)	1) Matrix calcification 2) Endosteal scalloping 3) Cortical Breach	**X-Ray:** 1) Lytic intralesional calcification 2) Endosteal scalloping 3) Moth eaten appearance in High Grade lesions 4) Periosteal reaction **Bone scan:** intense increased uptake
Osteoblastoma	Low to isointense	1) Iso to hypo intense 2) FLAIR phenomena also seen	FLAIR Phenomena: high signal surrounding the marrow and soft tissue due to oedema	1) Lytic lesion 2) Internal Matrix mineralization	**X-Ray:** 1) Expansile Lytic lesion with rim of reactive sclerosis 2) Internal Calcification **Bone scan:** Intense Uptake
Haemangioma	High intensity signal	High intensity signal	Significant enhancement	1) POLKADOT sign (Axial) 2) CORDUROY sign (Sagittal)	**X-Ray:** 1) CORDUROY sign
Aneurysmal Bone Cyst	Variable signal	Variable signal	Septations may enhance	Fluid levels with cortical breach	**X-Ray:** Expansileosteolytic lesion with sclerotic margins **Bone scan:** DOUGHNUT sign
Osteoid Osteoma	Variable signal	Variable signal	Variable signal	Focally lucent nidus with surrounding lucent bone	**Bone scan:** Double Density sign
Giant Cell Tumor	Low to intermediate signal	Heterogeneous high signal	Solid Components will enhance	1) Narrow zone of transition 2) Pathological fractures	**Bone scan:** Increased Uptake around periphery
Eosinophilic Granuloma	Low signal	Iso to hyper intense	Enhancement	Cortical erosion	**X-Ray:** Vertebra Plana **Bone Scan:** Variable Uptake
Enchondroma	Intermediate to low intensity signal	High intensity	Variable enhancement	Homogenous lesion with or without calcification	**X-Ray:** round to oval well circumscribed osteolytic lesion.
Ewing's Sarcoma	Intermediate to low intensity signal	Heterogeneously high signal	Prominent enhancement	1) Permeation 2) ONION SKIN appearance 3)sclerosis	**X-Ray:** 1) Permeation 2) Onion Skin appearance 3)sclerosis **Bone scan:** Increased Uptake

Multiple Myeloma	Diffuse abnormal marrow changes	Diffuse abnormal marrow changes	Diffuse abnormal marrow changes	1) Punched Out lesions with decreased mineralization	**X-Ray:** 1) Punched Out lesions with decreased mineralization **Bone scan:** variable **PET-CT:** focused uptake over site of lesion. Valuable for disseminated lesions

Additional features include:

- Prevertebral, intracanalicular or paravertebral collections
- Inflamed and enlarged Lymph nodes
- Number of lesions (together or with Skip levels)
- Muscle involvement
- Non vertebral lesions of similar nature (signifying metastasis)

1. Vascularity (both of the lesion as well as of the cord – a factor that will determine post-operative and Post RT recovery) An Angiogram can be done to add information in vascular lesions or in lesions drawing vascular supply from the cord and its supply system.

The putting together of these 3 steps gives not just a diagnosis, but a number of additional features required for decision making and treatment planning. Once the details are in, management can be discussed and proceeded onto. Most importantly, by staging the disease (Tomita's Staging for vertebral metastasis)(Table 2), prognosis can be explained to the patient thereby preparing them for the road ahead and ensuring good patient compliance. Figure 3 shows the coming together of diagnostic modalities to effect a diagnosis.

Table 2. Tomita staging system: Spread of tumor is divided into intracompartmental, extracompartmental, and multiple spread. The system is used primarily for metastasis of the spine.

Type	Description	Location
1	Vertebral Body	Intracompartmental
2	Extension to Pedicle	
3	Body & Lamina Extension	
4	Epidural extension	Extracompartmental
5	Paravertebral Extension	
6	Involving adjacent vertebrae	
7	Multi-Level Disease	Both

The definitive diagnosis of course is made by histopathological analysis of a biopsy sample. This maybe obtained either by resection, debulking or by a minimally invasive trans-cutaneous method depending upon the suitability of various factors [15].

Factors influencing treatment

Suitability for surgery: This is decided by assessing the:

- Karnofsky performance score to determine whether the patient will tolerate surgery or not.
- Nature of the disease
- Extent of the disease
- Additional factors enumerated above.
- Wish of the patient and relatives once fully informed about the disease and treatment options.

Stage of the disease

In advanced stages, palliation without surgery maybe the best option for the patient. Here we recommend a Metastatic work up complete with an FDG PET CT to rule out other involved levels as well as extra-spinous spread/ Origins. A tomita staging along with SINS staging for instability.

Surgical planning

This includes:

1. Histopathological and immunohistochemical analysis of a tissue biopsy:

This represents a simple and definitive method of confirming the diagnosis. Biopsies can be obtained by

- This is preferred as larger tissue samples can be obtained.
- Surgical percutaneous (Minimally Invasive)
- most commonly done with CT guidance. The yield of tumor tissue however is variable

2. Pre-Operative trans arterial Embolisation (TAE)

Although surgery is by far the definitive treatment of choice, complete excision is complex due to several factors such as

- Tumor bulk
- Vascularity
- Vicinity to vital structures
- Potentially inaccessible location of the lesion

Trans-Arterial Embolization (TAE) is an important modality that assists in these crucial circumstances. In some cases it may even become the primary modality for curative treatment. It reduces tumor vascularity thereby intra-operative blood loss and the need for blood transfusions. It also improves tumor definition by improving the planar segregation of the lesion [16].

Catheter angiography is performed prior to embolization to identify the feeding vessels of the tumor. The embolizing agents are then injected into these vessels blocking circulations these agents' maybe temporary or permanent depending upon the physical states.

- NBCA, absolute alcohol, ONYX, STDS,
- Polyvinyl alcohol, Embospheres, gelatin foams.
- These are reserved for larger vessel occlusion especially in the distal segment of the feeding vessels

Surgery must be performed within 3 days of embolization in order to avoid re-vascularization.Complications may include the dreaded post embolization syndrome (pain, malaise and fever).

1.Pre-operative chemotherapy

Chemotherapy is of 2 types

- Pre-op neoadjuvant chemotherapy

Pre-op Chemo-Embolization has been shown to increase the sensitivity of tumors to subsequent doses of chemotherapy thereby reducing the overall chemotherapy dosage and improving patient compliance and comfort.

- Conventional chemotherapy

Tumors such as Round cell tumors have excellent response to chemotherapy, particularly pre op neoadjuvant therapy.

2. Radiotherapy (RT)

This includes:

a. Conventional RT: This exists in various forms. These may include:

- External Beam RT
- Intensity Modulated RT
- Image guided RT
- Steriotactic Radiosurgery (for precise localization and minimizing side effects)
- Brachytherapy
- HDR Plaques
- HDR Catheters

b. Cyber-Knife

This provides a non-invasive option for spine malignancy patients who are unable to undergo surgery. This is superior to standard RT as spine tumors move with respiration thereby scattering the conventional RT dosage and efficacy. Cyber-knife is precise and minimizes damage to the sensitive spinal cord, pleura and viscera

1. Surgery

This is of 3 types:

a. Resection:

This is dependent on the Weinstein BorrianiBiagnini System (Figure 4) Here the Vertebra in the Axial Plane is divided into 12 zones as per the face of a clock. Resection is planned depending upon the segments involved. If the tumor is predominantly located onto the posterior elements, then a wide laminectomy is preferred. Involvement of half the vertebral body with ipsilateral pedicle and lamina will lead to a hemilaminectomy, and exclusive vertebral body lesions (with or without the involvement of other elements) would imply the requirement of a vertebrectomy [17,18].

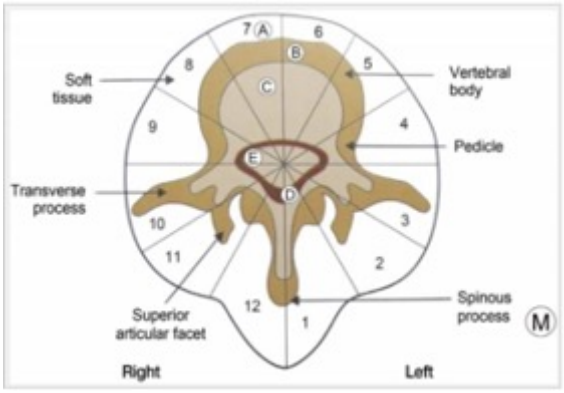

Figure 4. Weinstein BorrianiBiagnini System for Vertebral Tumors (WBB) depicting the axial image of a vertebral bone superimposed on the face of a clock.

Lesional surgery can either be intracapsular excision/ curettage (preferred for benign lesions) or en-bloc resections for malignant and aggressive lesions.

b. Stabilization:

This is decided by the Spinal Instability in Neoplasia Score (SINS), shown in Table 3, proposed by the spinal oncology study group in 2010. The score measures variables such as nature of the lesion, extent, location and degree of deformity (vertebral collapse) A score of 0-6 indicates a stable spine. A score of 7-12 is probably instable, and scores of 12 and above a definitely instable. Surgical stabilization is indicated for scores of 7 and above.

c. Palliation:

Surgery here is planned for 2 major aims:

- Here percutaneous CT guided biopsies or fluoroscopy guided transpedicular biopsy of the lesion maybe attempted with minimal anesthesia and hospitalization reducing the inconvenience to the patient and enable early start of palliative chemo-radiation.
- Vertebroplasty and kyphoplasty help relive compressive symptoms and pain leading to clinical improvement of the disease. Limited decompressive resections and laminectomies are also advocated to release pressure on the cord. Cord decompression due to collections or hematomas, either open or trans-cutaneous also help in reducing symptoms temporarily.

The summarized surgical approach is depicted in Figure 5. Benign lesions are surgically curetted. Metastases depending upon the stage are either managed with adjuvant therapy or surgery. Localized aggressive lesions are treated with an en-Bloc resection with appropriate stabilization as mentioned above.

Table 3. The sins score: SINS score for detecting instability in spinal neoplasms. A score of over 7 indicates a need for stabilization.

Component (Spinal Instability Neoplastic Score)	Score
Location	
Junctional (Occiput-C2, C7-D1, T11-L1, L5-S1)	3
Mobile spine (C3-C6), (L2-L4)	2
Semirigid (D3-D10)	1
Rigid (S2-S5)	0
Pain	
Yes	3
Occasional pain but not mechanical	1
Pain free	0
Bone lesion	
Lytic	2
Mixed (Lytic/ Blastic)	1
Blastic	0
Radiological spinal alignment	
Subluxation/ Translation present	4
De Novo Deformity (Kyphosis/ Scoliosis)	2
Normal alignment	0
Vertebral Body Collapse	
> 50% collapse	3
< 50% collapse	2
No collapse, but > 50% of the body involved in the lesion	1
None of the above	0

Postero-lateral involvement of spinal elements	
Bilateral	3
Unilateral	1
None of the above	0

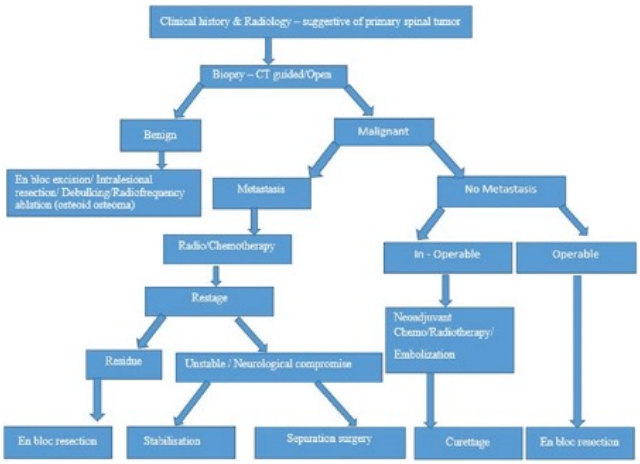

Figure 5. Management protocol: A flowchart depicting the management strategy for vertebral tumors both benign and aggressive. The table covers surgery and management only for the tumor. Stabilization is determined by the SINS score.

Conclusion

Although vertebral bony tumors are rare, they pose a significant challenge to surgeons and oncologists to effect good outcomes. A multispecialty team approach with appropriate use of our diagnostic and treatment protocol should ensure good outcomes for all patients.

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