

Orthopedic Oncology: Complex Adult and Pediatric Cases

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Learning Objectives

- To gain knowledge of the general indications and surgical approaches of the most complex procedures utilized for treatment of soft tissue and bone tumors
- To understand the unique precautions and restrictions required following these complicated orthopedic procedures
- To identify safe and appropriate rehabilitation interventions and strategies when working with this patient population
- To better understand the need of physical therapy along the continuum of care for these patients immediately post-op, during their cancer care, and beyond

ORTHOPEDIC INTERVENTION FOR TUMOR INVOLVEMENT

Indications for Surgical Intervention

- Primary sarcomas
- Other primary cancers
- Metastatic bone disease
- Benign bone and soft tissue tumors

Primary Sarcomas^{1,2}

- | | |
|--|--|
| <ul style="list-style-type: none"> • Primary bone sarcomas: cancer which originates in the bone tissue itself <ul style="list-style-type: none"> – Osteosarcoma – Chondrosarcoma – Ewing sarcoma | <ul style="list-style-type: none"> • Primary soft tissue sarcomas: cancer which originates within soft tissues of the body <ul style="list-style-type: none"> – Pleomorphic sarcoma – Leiomyosarcoma – Liposarcoma |
|--|--|

Other Primary Cancers^{1,2}

- Multiple myeloma
 - Originates in plasma cells in bone marrow found within bone
- Non-Hodgkin lymphoma
 - Generally develops in lymph nodes
 - Can originate in lymphocytes in bone marrow found within bone
- Tumors can cause bone destruction
- However, NOT considered primary bone cancer

Metastatic Bone Disease^{1,2}

- Cancer cells that break off from a primary tumor and spread to the bone via the bloodstream or lymph vessels
- More common than primary bone cancers in adults
- Risk factors – variable
 - Primary cancer
 - Size of existing tumor/s, grade of cancer, extent of metastases

Benign Tumors¹

Benign bone tumors

- Osteoid osteoma
- Osteoblastoma
- Osteochondroma
- Enchondroma
- Chondromyxoid fibroma
- Fibrous dysplasia

Benign soft tissue tumors

- Lipoma
- Leiomyoma
- Fibroma
- Neurofibroma
- Hemangioma

SURGICAL CONSIDERATIONS

Role of Orthopedic Surgery¹

- Surgical intervention dependent on
 - Type of cancer
 - Bone/bones affected
 - Strength of bone/bones
 - Existing treatments
 - Symptoms
 - General health
- Role of orthopedic oncologist
 - Remove cancer in bones and/or muscles
 - Rebuild the resulting defects in a functionally acceptable manner

Goals of Surgery³

- Curative
 - Main goal = remove ALL cancer
 - Remove tumor + normal surrounding tissue → clear margins
 - Cancer cells left behind = positive margins
 - Positive margins may need additional treatment
- Palliative
 - Relieve symptoms
 - Improve function
 - Quality of life
 - Not expected to cure primary disease

Surgical Interventions

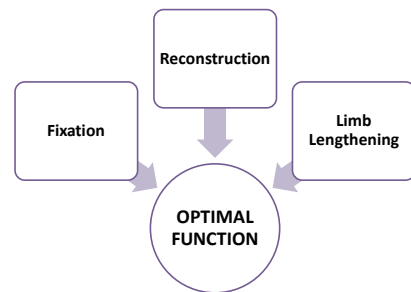
- Complex decision making process
 - Limb salvage vs amputation
 - Reconstruction options
 - Limb lengthening procedures
 - Surgical management of metastatic disease

LIMB SALVAGE VS AMPUTATION

Limb Salvage vs Amputation^{1,2,3}

- Limb-salvage surgery (limb-sparing surgery) – achieving a successful wide excision while maintaining limb
 - May or may not require bone grafts, surgical fixation/stabilization (cement, intramedullary nails, screws, or rods), or soft tissue reconstruction
- Amputation – successful wide excision requires the partial or complete removal of a limb

Limb Salvage



Amputation^{1,3}

- Indications
 - Neglected tumor
 - Widespread or recurrent disease
 - Fracture
 - Considerable remaining growth in a young child
 - Superior function vs limb salvage procedure

Amputation³

Advantages	Disadvantages
<ul style="list-style-type: none"> • Complete removal of tumor • ↓ local recurrence rate • Additional surgery often not needed • Advances in prosthetics • Management of cancer sequelae 	<ul style="list-style-type: none"> • Phantom sensation/pain • ↓ proprioception • Painful neuromas in residual limb • Cosmesis • Psychosocial aspects

Limb Salvage vs Amputation: The Pelvis^{1,3}

- Complex anatomy
 - Pelvic tumors difficult to remove completely with surgery alone
 - Often require chemotherapy and/or radiation
 - Pelvic reconstruction complicated and technically difficult
 - ↑ post-operative complications
- Limb salvage: internal hemipelvectomy
- Amputation: external hemipelvectomy

Internal Hemipelvectomy^{1,3}

- Limb-sparing surgery for tumors of the pelvis and its surrounding structures (also known as internal hemi-pelvic resection)
- Resection
 - Part or all of the unilateral pelvis
 - Proximal femur
 - Surrounding tissue if necessary
- Preservation
 - Neurovascular bundle
 - Lower extremity

Internal Hemipelvectomy

- Post-op considerations
 - WB status – WBAT, PWB, FFWB (foot-flat weight bearing)
 - Activity as tolerated
 - Leg length discrepancy
- Rehab implications and plan of care (POC)
 - ROM/therapeutic exercise
 - Bed mobility
 - Functional transfers
 - Balance
 - Gait training
 - ADL modifications
 - Adaptive equipment, assistive devices, DME
 - Orthotics

External Hemipelvectomy^{1,3}

- Highest level of lower extremity amputation for tumors in/around the hip and pelvis and surrounding structures
- Resection
 - Entire unilateral pelvis with disarticulation at SI joint and pubic symphysis
 - Entire lower extremity

External Hemipelvectomy

- Post-op considerations
 - WB status
 - NWB surgical site
 - WBAT through remaining extremities
 - Activity determined by wound closure
 - Pressure-relieving mattress
 - No prolonged sitting
 - Phantom sensation/pain
 - Psychosocial considerations
- Rehab implications and plan of care (POC)
 - ROM/therapeutic exercise
 - Bed mobility
 - Functional transfers
 - Cushioning for comfort and OOB tolerance
 - Balance
 - Gait training
 - ADL modifications
 - Adaptive equipment, assistive devices, DME
 - Prosthetics?

Literature Review

- Beck LA, et al. "Functional outcomes and quality of life after tumor-related hemipelvectomy."⁴
 - Descriptive retrospective cohort study
 - Compared functional outcomes and QOL of patients following internal vs external hemipelvectomies
 - Functional outcomes using the Barthel Index and QOL using the Linear Analog Self-Assessment tool (LASA)
 - Overall no significant difference in functional abilities between groups at 3 different time points
 - LASA subcategories showed no difference between groups, except in pain category

Literature Review

- Guo Y, et al. "Comparison of postoperative rehabilitation in cancer patients undergoing internal and external hemipelvectomy."⁵
 - Retrospective study comparing post-op rehabilitation, functional outcome, and pain management following internal vs external hemipelvectomy
 - Inpatient rehabilitation admission associated with older age, plastic surgery involvement, and post-op complications
 - Significant FIM increases from initial evaluation to discharge in both groups
 - Patients s/p external hemipelvectomy required ↑ pain medication and ↑ hospital LOS

Case Study

RECONSTRUCTION

Reconstruction⁶

- Developments in adjuvant therapies and microsurgical technique
 - Limb salvage procedures > amputation
 - Wide local excision + complex reconstruction + adjuvant therapies = first-line approach
 - Plastic surgery for reconstruction and to enhance wound healing

Reconstruction⁷

- Skin graft – transfer of skin from donor site to recipient site (without blood supply)
 - Split thickness skin graft (STSG)
 - Portion of donor site skin including epidermis and some underlying dermis
 - Full thickness skin graft (FTSG)
 - Entire layer of donor site skin

Reconstruction⁷

- Flap – transfer of skin, underlying tissue, and blood supply from donor site to recipient site
 - Includes skin, muscle, musculocutaneous, and osteocutaneous flaps
 - Pedicled flap – vascular supply remains connected anatomically throughout flap transfer
 - Free flap – vascular supply disconnected from axial blood supply during transfer, then reconnected micro-surgically to new artery or vein at recipient site

Reconstruction^{6,7}

- Potential graft/flap complications
 - Infection/abscess
 - Wound dehiscence
 - Seroma/hematoma
 - Failure
 - Necrosis due to vascular compromise

Reconstruction

- Post-op considerations
 - WB status, ROM and/or activity restrictions
 - Orthopedic team: bone integrity and stability
 - Plastic surgery team: graft/flap integrity and healing
 - More conservative precaution/restriction followed
 - Meticulous review of orders, frequent communication, thorough documentation
- Rehab implications and plan of care (POC)
 - ROM/therapeutic exercise
 - Bed mobility
 - Functional transfers
 - Balance
 - Gait training
 - ADL modifications
 - Adaptive equipment, assistive devices, DME
 - Orthotics

Literature Review

- Agrawal N, Wan D, Bryan E, et al. “Outcomes analysis of the role of plastic surgery in extremity sarcoma treatment.”⁶
 - Retrospective cohort analysis
 - Impact of well-integrated team performing complex, orthopedic reconstruction on outcomes of sarcoma resection
 - Amputation rate ↓’d significantly without ↑’d rate of positive margins
 - Post-op infection and wound dehiscence rates ↓’d

Case Study

LIMB LENGTHENING

Limb Lengthening⁸

- Indications
 - Potential limb length discrepancy (LLD)
 - Need for durable reconstruction
- Continued bone growth
- Common tumor location near bone physes
- Smaller skeletal size

Options for Lengthening

- Distraction osteogenesis (external fixation)
- Expandable prosthesis (internal lengthening)

External Fixation⁹

- Utilizes the process of distraction osteogenesis to provide reconstruction of bone defects following tumor resection
 - Two segments of bone slowly pulled apart allowing new bone to grow and fill in gap
- Allows for continued growth over time
- Prevents significant leg length discrepancy

External Fixation

- Components
 - Rings: structural frame
 - Rods: connect rings
 - Pins/screws: inserted into the bone
 - Clamps: connect rods to pins

External Fixation^{8,9}

- Indications
 - Optimal function
 - Prevention of significant LLD
 - Maintain potential for continued limb growth
 - Satisfactory cosmesis

External Fixation^{10,11}

- Procedure
 - Wide resection of tumor
 - Placement of external fixator
 - Corticotomy of proximal and distal metaphysis of bone defect
 - Distraction followed by consolidation period
 - Surgical adjustments as needed
 - Removal of external fixator once adequate consolidation is achieved

External Fixation¹⁰

- Possible complications
 - Pain
 - Pin site infection
 - ROM limitations
 - Fracture
 - Non-union
 - Neurovascular injury
 - Edema/cellulitis
 - Deep vein thrombosis (DVT)

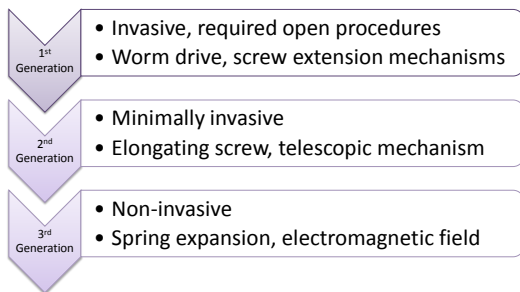
External Fixation

- Post op considerations
 - WB status
 - ROM restrictions/goals
 - CPM
 - Foot plates
 - Infection risk
 - Handling
 - Anxiety/fear
- Rehab implications and plan of care (POC)
 - ROM/therapeutic exercise
 - Bed mobility
 - Functional transfers
 - Balance
 - Gait training
 - ADL modifications
 - Adaptive equipment, assistive devices, DME
 - Orthotics/shoe lift

Expandable Prostheses¹²

- Option for internal reconstruction and lengthening during limb salvage procedures for continued growth
- Prevents significant leg length discrepancies
- Requires close follow up for periodic lengthening
- Prosthetic replacement may be necessary after maximal lengthening

History of Expandable Prostheses⁸



Expandable Prostheses^{12, 13, 14}

- **Minimally invasive**
 - Composed of exchangeable parts
 - Lengthening percutaneously via screwdriver
 - Requires periodic surgeries for lengthening
 - Pro: Allows for continued limb growth
 - Con: Surgery is indicated for each lengthening, associated possible surgical complications
- **Non-invasive**
 - Composed of energy loaded spring
 - Lengthening via exposure to external electromagnetic energy
 - Does not require surgery for lengthening
 - Pros: Less expensive, safer lengthening technique
 - Cons: Potential hardware failure

Expandable Prostheses^{12, 13, 14}

- Indications
 - Optimal function
 - Prevention of significant LLD
 - Maintain potential for continued limb growth
 - Satisfactory cosmesis

Expandable Prostheses^{13, 14}

- Procedure
 - Wide resection of tumor
 - Reconstruction with expandable prosthesis
 - Acute lengthening
 - Periodic lengthening

Expandable Prostheses^{13, 14}

- Possible complications
 - Infection
 - Neurovascular injury
 - Mechanical failure
 - Hardware loosening
 - Mechanical dysfunction of expansion mechanism
 - Joint stiffness
- Less likely to occur in less invasive types of expansion

Expandable Prostheses

- Post-op considerations
 - WB status
 - Partial weight bearing initially
 - Knee immobilizer (if applicable)
- Rehab implications and plan of care (POC)
 - ROM/therapeutic exercise
 - Bed mobility
 - Functional transfers
 - Balance
 - Gait training
 - ADL modifications
 - Adaptive equipment, assistive devices, DME
 - Orthotics

Literature Review

- Ness K, et al. "A comparison of function after limb salvage with non-invasive expandable or modular prostheses in children."¹⁵
 - Found equal number of revisions required
 - Similar functional results between the two types of lengthening prostheses

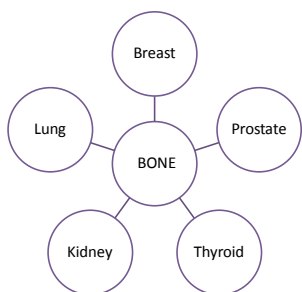
Case Study

SURGICAL MANAGEMENT OF METASTATIC DISEASE

Metastatic Disease¹⁶

- Cancer originates from primary site in the body and spreads elsewhere via the bloodstream or lymph vessels
 - Originates from primary site in the body and spreads to bone
 - Originates in bone and spreads elsewhere in the body
- Orthopedic surgery may be indicated to treat primary or metastatic disease

Metastatic Bone Disease¹⁷



Metastatic Bone Disease¹

- Most common locations of bone mets
 - Spine
 - Pelvis
 - Femur
 - Humerus
 - Ribs
 - Skull

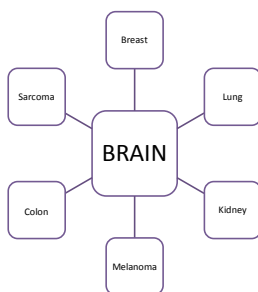
Spinal Procedures¹⁷

- Indications
 - Tumor resection
 - Relieve pressure
 - Provide stabilization
- Procedures
 - Spinal decompression
 - Spinal stabilization
 - Rods, screws, plates, cages
 - Kyphoplasty/vertebroplasty

Spinal Procedures

- Post-op considerations
 - Spinal precautions
 - No Bending (flexion/extension of spine)
 - No Lifting > 5-10lbs.
 - No Twisting of spine
 - Neurological function
 - Brace/collars
- Rehab implications and plan of care
 - ROM/therapeutic exercise
 - Bed mobility
 - Functional transfers
 - Balance
 - Gait training
 - ADL modifications
 - Adaptive equipment, assistive devices, DME

Brain Metastases¹⁸



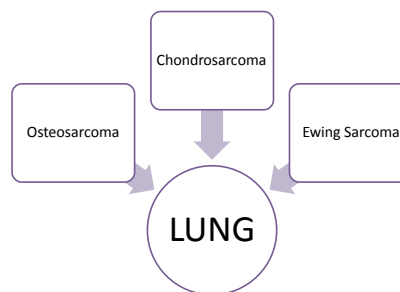
Craniotomy¹⁹

- Indications
 - Biopsy and/or resection of brain tumor
- Procedure
 - Bone flap provides access to brain for tumor removal

Craniotomy

- Post-op considerations
 - Craniotomy precautions
 - Maintain position of head above the heart
 - No lifting > 5-10lbs.
 - Avoid Valsalva maneuver
 - Monitor neurological exams closely
 - Re-assessment with each patient encounter
- Rehab implications and plan of care
 - ROM/therapeutic exercise
 - Bed mobility
 - Functional transfers
 - Balance
 - Gait training
 - ADL modifications
 - Adaptive equipment, assistive devices, DME

Lung Metastases^{20, 21, 22}



Thoracotomy^{23, 24}

- Indication
 - Metastatic lung nodules
- Procedure
 - Incision in chest wall between ribs to access pleural space
 - Excision of lung metastases
 - Chest tube placement for drainage

Thoracotomy

- Post-op considerations
 - Pulmonary hygiene
 - Recent orthopedic surgery
 - WB status
 - AD - new surgical incisions in chest wall
- Rehab implications and plan of care
 - ROM/therapeutic exercise
 - Bed mobility
 - Functional transfers
 - Balance
 - Gait training
 - ADL modifications
 - Adaptive equipment, assistive devices, DME
 - Chest PT

Literature Review

- Karplus, et al. "Should contralateral exploratory thoracotomy be advocated for children with osteosarcoma and early unilateral pulmonary metastases?"²⁵
 - Reviewed incidence of unilateral and bilateral pulmonary metastases along with recurrence rates
 - Found that exploratory thoracotomy did not improve survival rates

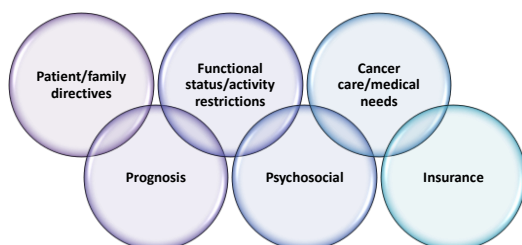
Case Study

CONTINUUM OF CARE

Continuum of Care

- Immediate post-op plan of care
- Rehab following hospital discharge
- Long-term rehab considerations

Immediate Post-op Plan of Care



Discharge Planning

- Once patients are medically stable, discharged to:
 - Acute rehabilitation
 - Sub-acute rehabilitation
 - Home
 - With services (RN, PT, OT)
 - Without services
 - Outpatient rehabilitation
- Skilled nursing facility
- Hospice

Rehab Following Hospital Discharge

- Oncology rehabilitation is rapidly growing, however still a small community
- These patients CAN and WILL be encountered in any setting! (These patients may come to you!)
 - Patients travel along rehab continuum of care



Rehab Following Hospital Discharge

- Need for increased knowledge!
 - Orthopedic restrictions and precautions
 - Basic medical and oncology history
 - Immediate treatment-related side effects
 - Surgery
 - Radiation
 - Chemotherapy
 - Current and future POC
- When in doubt... CLARIFY!
 - Surgical teams
 - Orthopedic team
 - Plastic surgery team
 - Medical oncology team
 - Acute care therapy team

Long-Term Rehab Considerations

- Advances in treatment → increased survivorship!
- Increased survivorship → NEED for rehabilitation services!
 - Progression of disease
 - Disease recurrence
 - Treatment side-effects
 - No evidence of disease (NED)
 - Co-morbidities
 - Secondary malignancy

Long-Term Rehab Considerations

- Surgery-specific impairments
 - Chronic pain
 - Muscle weakness/imbalance
 - Leg length discrepancy
- Additional treatment/surgical procedures
- Duration of rehabilitation
- Psychosocial factors

Rehabilitation Plan of Care³

- Individualized plan of care based on **BOTH** cancer care and rehabilitation needs
- Requires constant re-assessment, adaptability, and communication

Conclusion

- Patients with bone tumors often require orthopedic surgical interventions that may result in complex medical and rehabilitation needs.
- Therapists must be aware of and adhere to the unique precautions and restrictions required following these procedures.
- A multi-disciplinary and multi-factorial approach to rehabilitation plan of care is crucial.
- Well-informed rehabilitation professionals are vital in returning function and improving quality of life.

QUESTIONS?

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