Perioperative Management of Patients Undergoing Orthopaedic Oncological Surgeries

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KEY POINTS

- Perioperative management of patients undergoing orthopaedic oncological surgeries requires a multidisciplinary collaboration and a tailored approach.
- Goals of patient management include preoperative evaluation and optimisation, adequate analgesia, and prevention of surgical complications followed by early postoperative rehabilitation.
- Regional anaesthesia techniques can be applied solely or in combination with general anaesthesia for various orthopaedic oncological surgeries.
- Multimodal analgesia is an essential part of orthopaedic oncological surgeries.

INTRODUCTION

Orthopaedic oncological surgeries present a unique set of challenges for both surgeons and anaesthesiologists due to the complexity of the procedures, the specific needs of cancer patients, and the potential for perioperative complications. The goal of perioperative care is to ensure optimal outcomes by focusing on preoperative evaluation and preparation, intraoperative management, and postoperative monitoring and pain control. This tutorial aims to provide a comprehensive overview of the epidemiology and classification of bone tumours, types of surgeries, preoperative optimisation, selection of an appropriate plan of anaesthesia technique, multimodal analgesia, and rehabilitation.

EPIDEMIOLOGY

In 2023, the incidence of newly diagnosed cases of primary bone tumours in the United States was 3970 (2160 in males and 1810 in females). In the same year, primary bone cancers accounted for 2140 deaths, including adults and children. Primary bone tumours are rare and account for less than 1% of all cancers. Bone metastases from other cancers are much more common.[1] Chondrosarcomas are the most common primary bone tumours in adults, followed by osteosarcomas, chordomas, and Ewing sarcomas, whereas osteosarcomas and Ewing sarcomas are common in children and adolescents.

BONE TUMOUR CLASSIFICATION AND TYPES OF SURGERIES

Primary bone tumours can be benign or malignant, as mentioned previously, but bone metastases from other primary cancers are much more common. The World Health Organisation classification of tumours[2] is based on the histopathology and molecular biology of the cells. Table 1 specifies the types of bone tumours that are generally encountered.

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TAKE ONLINE TEST

Tissue of Origin	Benign	Malignant
Bone	Osteoma Osteoid osteoma Osteoblastoma	Osteosarcoma
Cartilage	Chondroma Osteochondroma Chondroblastoma	Chondrosarcoma
Fibrous	Fibroma	Fibrosarcoma
Giant cells	Benign osteoclastoma	Malignant osteoclastoma
Marrow		Myeloma Ewing sarcoma

Table 1. Common Type of Bone Tumours

Surgical resection with or without reconstruction is one of the modalities of treating bone tumours. The type and extent of surgery depends on the location, classification, staging, locoregional and distant spread of the tumour, availability of other modalities of treatment, patient physical condition, and rehabilitation strategies. Orthopaedic oncological surgeries range from simple excision to radical resections with major reconstructions; therefore, the perioperative management should be individualised in each case. Table 2 lists the common oncological surgeries performed.[3]

PREOPERATIVE EVALUATION AND PREPARATION

Close collaboration among surgeons, oncologists, transfusion medicine, anaesthesiologists, pain physicians, and physiotherapists is needed for optimal surgery outcome. Apart from patient-related factors like age and comorbidities, specific factors such as adverse effects of prior chemotherapy or radiotherapy should be thoroughly addressed. Preoperative anaemia can be due to nutritional deficiency, chronic inflammatory conditions, and chemotherapy. Once nutritional deficiencies have been treated or ruled out, preoperative erythrocyte-stimulating agents are preferred for building haemoglobin but carry the risk of increased thrombosis. Erythrocyte-stimulating factors should not be administered without iron supplementation. Preoperative target haemoglobin depends on age, comorbidities, end-organ dysfunction, and nature of surgery.[4] Adequate blood product availability and cross-matching should be ensured before major surgeries. Preoperative embolization should be considered in patients with highly vascular tumours to decrease intraoperative blood loss.

Chemotherapy regimens can have unfavourable effects on various organ systems (Table 3). The adverse effects of these agents should be investigated and addressed before planned surgeries.[5–7] Myelosuppression is a common consequence of almost all chemotherapy regimens. Cardiotoxicity due to anthracycline administration can cause systolic dysfunction, and preoperative echocardiography is recommended in these patients.[8]

Location of Tumour		Surgery
Appendicular skeleton	Upper limb	• Above and below elbow amputation • Shoulder disarticulation • Proximal humerus resection with bone and soft tissue reconstruction • Bone curettage and grafting • Total scapula resection with muscle flap reconstruction
	Lower limb	• Above and below knee amputation • Proximal/distal femur resection with reconstruction • Long stem arthroplasties and cemented nailing • Proximal/distal tibial resection with reconstruction • Bone curettage and grafting
Axial skeleton	Spine	• Tumour excision and decompression
	Pelvis	• Hemipelvectomy • Sacrectomy • Radical excision of bone tumour with visceral resection and lymph node dissection
	Hip	• Hemiarthroplasty • Hip disarticulation

Table 2. Types of Surgery According to the Location of the Bone Tumour

Chemotherapeutic Agents	Adverse Effects	Anaesthetic Consideration
Anthracycline antibiotics		
Doxorubicin Daunorubicin	Acute/chronic cardiac toxicity-ST/T changes, bundle branch block, pericarditis, myocardial dysfunction, QT prolongation, dysrhythmias, pericardial effusion	Preoperative echocardiography should be considered (especially in older individuals and in those with existing cardiac disease) Serum electrolyte monitoring Exaggerated myocardial depression with anaesthetic agents
Platinum Analogues		
Cisplatin Carboplatin	Neurotoxicity, peripheral neuropathy, nephrotoxicity, renal loss of electrolytes (K, Mg), ototoxicity, hepatotoxicity	Consider neuropathy during regional anaesthesia Electrolyte monitoring Liver/renal function monitoring Preoperative neurological assessment
Taxanes		
Paclitaxel Docetaxel	Peripheral neuropathy Autonomic neuropathy Cardiac toxicity Bradyarrhythmia/tachyarrhythmia	Preoperative neurological assessment Consider neuropathy during regional anaesthesia Electrolyte monitoring
Antimetabolites		
Methotrexate	↓ excretion with NSAIDS and acute renal failure Mucositis Reversible encephalopathy Interstitial pneumonitis Hepatic and lung fibrosis	Monitor lung and liver function Leucovorin administration Avoid NSAIDs
Alkylating agents		
Cyclophosphamide Ifosfamide	Hepatotoxicity, haemorrhagic cystitis, encephalopathy, subclinical renal impairment, pseudocholinesterase inhibition by cyclophosphamide	Monitor liver and renal function Ensure adequate hydration and diuresis Serum electrolyte monitoring Succinylcholine's duration of action can be prolonged

Table 3. Common Chemotherapeutic Agents Used Perioperatively in Bone Cancers and Their Adverse Effects. NSAIDS, nonsteroidal anti-inflammatory drugs

Radiotherapy can be administered for the treatment of primary tumours or symptomatic relief of bone fracture as a palliative measure. The adverse effects of radiotherapy depend on the site of radiation. Chest wall radiation can cause parenchymal fibrosis, pulmonary vasculature occlusive disease, and increased capillary permeability, resulting in pulmonary oedema after surgery under general anaesthesia.[9] Mediastinal irradiation can cause cardiotoxicity especially when combined with anthracyclines.[7] These patients can present with dry cough and dyspnoea on rest and need further evaluation by pulmonary function tests.[10] Differential diagnoses include infection, chemotherapy/radiotherapy-induced lung disease, pulmonary embolism, and lung metastasis.

Patients presenting preoperatively with chronic pain may be taking opioid and nonopioid analgesics and antidepressants. These patients may be opioid tolerant and can require an escalated dose of pain medications intra- and postoperatively. Regional techniques should be considered if applicable. Adverse effects and possible interactions between these medications and anaesthesia drugs should therefore be taken into consideration in the perioperative period.

INTRAOPERATIVE CONSIDERATIONS

There is wide variability in the type of orthopaedic oncological surgeries, including positioning, duration, blood loss, types of resection, cementation, reconstruction, and the severity of postoperative pain. Close communication with the surgeons is essential for selecting a proper anaesthesia technique.

Positioning

Patient positioning can vary depending on the tumour's location and surgeon accessibility. Anatomical positioning is preferred with all pressure points padded to prevent compression injuries, and extremes in positioning are avoided to prevent stretch

injuries to nerves. In addition, patients with bone tumours may have additional concerns due to associated pathological fractures, bone metastasis, and pain. Extreme precautions should be taken to prevent new fractures.

Patients in the supine position should have their arm abducted less than 90° and their forearm supinated to prevent brachial plexus injury. Patients placed in the lateral decubitus position should have their head and neck in a neutral position with proper padding of the eyes and ears. An axillary roll should be placed on the dependent side to prevent compression on the neurovascular bundle. The dependent upper extremity should be monitored for the adequacy of perfusion.

The prone position carries additional risk of patient injuries. The neck should be maintained in a neutral position during and after positioning. Eyes should be taped, and a prone pillow should be used to avoid pressure on the eyes. Postoperative visual loss is a risk in the prone position especially if the surgery is prolonged and associated with blood loss and hypotension. Abdominal compression can limit diaphragmatic excursion and thus limit ventilation. It can also cause aortocaval compression and compromise circulation. In the prone position, the arms should be kept flexed beside the patient in a neutral position ("superman position") or adducted adjacent to the patient's body. Continuous vigilance is advised during the intraoperative period to avoid any inadvertent excessive pressure or stretch injury to the brachial plexus.[11]

Monitoring

American Society of Anesthesiology standard monitoring includes electrocardiogram, noninvasive blood pressure, end-tidal carbon dioxide, temperature, and pulse oximetry. Additional monitoring depends on the type of surgery and patients' clinical conditions. Invasive arterial blood pressure and urine output monitoring are indicated in patients at risk of hemodynamic instability due to preoperative organ dysfunction or if undergoing major oncological surgeries associated with increased blood loss. Patient intravascular volume status can be monitored by dynamic fluid indices like pulse pressure variation or systolic pressure variation in addition to other hemodynamic parameters. Transoesophageal echocardiography can be used in surgeries with extreme hemodynamic fluctuations if the expertise and equipment are available. Blood gas analysis is used to detect acid-base changes during the intraoperative period and monitor haemoglobin, lactate, electrolytes, and glucose. Point-of-care testing like thromboelastography can be used to guide blood product transfusions in cases with massive haemorrhage. Neurophysiological monitoring (somatosensory evoked potential and motor evoked potential) are used to assess the functional integrity of the spinal cord during surgery to prevent any potential insult especially if there was already a deficit.[12]

Management of Intraoperative Haemorrhage

Bone tumours can be highly vascular. Patient blood management includes anaemia optimization, ensuring adequate blood product availability, large-bore intravenous access, use of antifibrinolytics and point-of-care coagulation test-guided transfusions.[13] Bone metastasis from thyroid and renal cell carcinomas can develop neovascularisation, thus increasing the risk of bleeding during resection. Pelvic bone metastasis often requires preoperative embolization to decrease intraoperative blood loss.

The evidence of blood conservation strategies to minimise adverse effects in major orthopaedic oncological surgeries is still lacking. Preoperative autologous donations are rarely possible due to causing anaemia. Moreover, autologous as well as allogeneic transfusions can have immunomodulatory effects and do not offer any survival benefit.[14] Intraoperative cell salvage in oncological surgeries carries a theoretical risk of tumour cell dissemination by transfusion and is traditionally not used in oncological surgeries. However, leucocyte depletion filters, which remove malignant cells, have been used in prostatectomies and cystectomies with no adverse effect on the survival of the patients.[15]

Data for the use of antifibrinolytics in orthopaedic cancer surgeries are derived from their use in other oncological surgeries. Antifibrinolytics stabilise the preformed clot and do not initiate new clot formation. These agents have not been associated with an increased risk of thrombosis in already hypercoagulable oncological patients.[16] Tranexamic acid and epsilon-aminocaproic acid are 2 options available in orthopaedic oncological surgeries. The dosing of tranexamic acid is usually 10 mg/kg, followed by an infusion of 1 mg/kg/h (maximum dose of 50mg/kg). The use of tranexamic acid is contraindicated in patients with hypersensitivity to the drug, acquired defective colour vision, and active intravascular clotting such as disseminated intravascular coagulation.[17]

Anaesthesia Techniques

Primary bone tumours and bone metastases can arise anywhere in the body. Both general and regional anaesthesia alone or in combination can be used according to the patient's medical condition, surgical access, and location of the tumour.

Upper Extremity Tumours

Upper extremity tumour surgeries vary from simple bone excisions to major resections, followed by reconstructions with tissue flaps or partial/total amputations of the limb. An interscalene, supraclavicular, infraclavicular, or axillary block can be performed as the sole intraoperative anaesthetic and for postoperative analgesia depending on the location of the tumour. Postoperatively, analgesia can be continued by placing a nerve catheter to infuse local anaesthetic. The surgeons can also place a

perineural, subfascial, or subcutaneous catheter before closure. Regional anaesthesia can often be combined with general anaesthesia in patients when the procedure is prolonged, involving large blood loss with uncomfortable positioning for surgical access.[3]

Lower Extremity Tumours

Similar to upper extremity tumours, lower extremity tumour resections can be performed under neuraxial or regional anaesthesia alone or in combination with general anaesthesia depending on the patient's condition. The advantages of neuraxial anaesthesia are multiple for oncological surgeries of the lower limb. They can be used as the sole method of surgical anaesthesia and postoperative analgesia. Epidural analgesia is considered to be superior to intravenous patient-controlled analgesia.[18] They provide an advantage for postoperative pain control in opioid-tolerant patients and those who developed opioid-related adverse effects.

Neuraxial anaesthesia can be challenging due to multiple bone metastasis, associated pain, concurrent anticoagulation, and difficult positioning. Sympathectomy in addition to blood loss can cause precipitous hypotension intraoperatively. Lower limb nerve blocks are an alternative that can provide analgesia in patients unsuitable for neuraxial blockade.

Primary tumours or pathological fractures of the femur due to metastasis often require extensive surgeries like an arthroplasty or hemiarthroplasty often with placement of long-stem prosthesis. Patients with metastatic bone disease are at an increased risk of cement implantation syndrome compared with those undergoing a standard hip replacement. Multiple aetiologies have been proposed to explain the increased susceptibility in this group of patients. Factors such as poor preoperative physical condition, prior chemotherapy and radiotherapy, anaemia, dehydration, and bone modification by the tumour may play a role.[3] Surgical factors include increased amount of cement use for the fixation of long stem prosthesis. The pathophysiology includes a reaction to methylmethacrylate monomer in the cement and/or embolization during the cementation process, which then leads to complement activation and histamine release.[19] Hypoxia, hypotension, and altered mentation are hallmark clinical features of bone cement implantation syndrome. The treatment is mostly supportive and may include endotracheal intubation to maintain adequate oxygenation and fluid boluses and inotropic agents to manage hypotension.

Spine and Pelvic Tumours

Management of patients undergoing spinal and pelvic tumour surgery is often complicated by massive bleeding. Preoperative tumour embolization, haemoglobin optimisation, securing good intravenous access, invasive arterial monitoring, and ensuring the availability of blood products are essential parts of the perioperative plan.

Spinal tumour surgeries involve vertebrectomy at a single level or multiple levels. Depending on the tumour location, positioning during surgery might have to change from supine/lateral to prone. Often, neurophysiological monitoring (somatosensory evoked potential, motor evoked potential, and electromyogram) is used intraoperatively.[12] Therefore, total intravenous anaesthesia without the use of muscle relaxants is required in these cases. Depth of anaesthesia monitoring should be used, and there should be constant communication between surgeons, anaesthesiologists, and electrophysiologists.

Sacrectomy is a radical surgery that involves partial or en bloc removal of the sacrum with dissection and ligation of the neurovascular bundles. It may include partial or complete removal of visceral organs like the urinary bladder, large bowel, ureters, cervix, and uterus. An anterior or posterior myocutaneous rotational flap is used for wound closure. Apart from the intraoperative concerns for major orthopaedic oncological surgeries mentioned above, these surgeries are complicated by prolonged duration, alteration between prone and supine positions, and visceral organ resections.[20,21]

Epidural analgesia is the preferred form of analgesia for pelvic surgeries[22] if there are no contraindications due to extensive resection and neurovascular dissection. However, if an epidural cannot be placed, a multimodal approach with intravenous patient-controlled analgesia is an alternative option.

POSTOPERATIVE MANAGEMENT AND REHABILITATION

Admission to high-dependency units should be based on the patient's comorbidities, type and duration of surgeries, blood transfusions, and anticipated pain.

Pain Management

Acute postoperative management can be very challenging in these cases due to several factors. Patients can be already opioid tolerant before surgery. Therefore, the extensive resection with neurovascular involvement makes these patients vulnerable to long-term neuropathic pain. Adequate acute pain control is essential to prevent chronic pain and establish early rehabilitation.

Multimodal analgesia plays a definitive role in the management of these patients. Neuraxial and regional anaesthesia should be considered if there are no contraindications and should be used in combination with simple analgesics, opioids, and adjuvants.[23] Many adjuvants with different levels of evidence have been used as opioid-sparing alternatives (Table 4).

Analgesic Drugs	Class/Mechanism	Dose	Important Consideration
Ketamine	NMDA antagonist	IV bolus 0.3–0.5 mg/kg Infusion 0.1–0.2 mg/kg/h	Can cause dysphoria and excessive salivation
Clonidine	α-2 agonist	PO 0.2 mg BD	Can cause bradycardia and hypotension Abrupt withdrawal can cause hypertension
Dexmedetomidine	α-2 agonist	IV loading 0.5–1.0 mcg/kg over 10 min Infusion 0.2–1.0 mcg/kg/h	More specific α-2 action than clonidine Can cause bradycardia and hypotension
Magnesium sulphate	NMDA antagonism Anti-inflammatory	Loading dose 30–50 mg/kg Maintainence 8–15 mg/kg/h	Can cause vasodilation, bradycardia, and hypotension Monitoring is required for toxicity in case of renal dysfunction
Lignocaine	Sodium channel blocker	IV bolus 1.5 mg/kg Infusion 1–2 mg/kg/h	Can cause conduction block, dizziness, seizures, and bradycardia
Pregabalin	Anticonvulsant	150–600 mg/day in 2–3 divided dose	Sedation, dizziness, and respiratory depression (if combined with opioids)
Gabapentin	Anticonvulsant	PO 300–1200 mg TDS	Can cause dizziness, drowsiness, and water retention

Table 4. Common Nonopioid Analgesics Used as a Part of Multimodal Analgesia in Orthopaedic Oncological Surgeries.[3,23] BD, twice a day; IV, intravenous; PO, peroral; TDS, 3 times a day

Methadone is a long-acting opioid with unique pharmacokinetics that can be administered as a single dose at the induction of anaesthesia. Methadone is a pure mu agonist and has additional NMDA antagonism that can prevent chronic hyperalgesia and tolerance.[24] Randomised clinical trials have shown decreased requirements for postoperative analgesics with intraoperative use of methadone in various surgical procedures. More clinical trials are required to establish dosing, adverse effects, safety, and efficacy of methadone.

Phantom limb pain and sensations are distressing symptoms to patients, and the pathophysiology encompasses complex changes in peripheral, spinal, and cortical neural organisation. Proposed mechanisms for the prevention of phantom limb pain include intense pre-emptive analgesia by afferent blockade of pain pathways by regional/neuraxial anaesthesia. Alternatively, perineural catheter placement pre- or intraoperatively followed by local anaesthetic infusion for 72 hours postoperatively can help prevent phantom limb pain. Treatment of phantom limb pain is similar to the management of neuropathic pain. Gabapentinoids, antidepressants, anticonvulsants (carbamazepine), steroids, and NMDA antagonists have been used as pharmacological modalities.[23] Cognitive behaviour therapy, transcutaneous stimulation, and acupuncture therapy are other nonpharmacological methods with unproven benefits.[25]

Thromboprophylaxis

Venous thromboembolism remains an important postoperative complication due to added risk factors of major orthopaedic surgery, prosthetic reconstructions, and cancer itself. Patients with hip replacement surgeries and lower limb surgeries are more prone to developing venous thromboembolism.[26,27] Thromboprophylaxis with intermittent pneumatic compression devices and pharmacological agents like low-molecular-weight heparin are used to decrease the incidence of venous thromboembolism. Patients on anticoagulation therapy and indwelling neuraxial catheters are managed according to American Society of Regional Anaesthesia and Pain Medicine ASRA guidelines.[28]

EARLY RECOVERY AFTER SURGERY IN ORTHOPAEDIC ONCOLOGICAL SURGERY

Enhanced recovery after surgery (ERAS) is an evidence-based, multidisciplinary, multimodal approach to reduce hospital length of stay by reducing surgical stress and minimising physiological disturbances. ERAS protocols have been well established in spine surgeries and knee and hip arthroplasties.[29,30] Rehabilitation strategies include pain management, early mobilization, and physiotherapy and prosthesis, psychosocial, and vocational support.[31,32] ERAS protocols can be designed and implemented in institutions that provide surgical treatment for orthopaedic oncological disease.

SUMMARY

Perioperative management of orthopaedic oncological patients requires a multidisciplinary approach. Regional/neuraxial anaesthesia alone or in combination with general anaesthesia can be applied depending on the location of the tumour and the extent of resections. Multimodal analgesia is essential for pain management, recovery, and rehabilitation.

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