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Review article

Anesthesia for patients undergoing orthopedic oncologic surgeries

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Abstract When planning an anesthetic for patients undergoing orthopedic oncologic surgeries, numerous factors must be considered. Preoperative evaluation may elucidate significant co-morbidities or side effects secondary to chemotherapy or radiation, which can affect anesthetic choices. Procedures vary in length and complexity and pose challenges in both positioning and in planning to minimize blood loss. Many anesthetic techniques are available to provide both intraoperative anesthesia and postoperative analgesia, while the type of thromboprophylaxis and analgesic adjuvants that will be administered needs to be defined. This review focuses on approaches to use when caring for patients undergoing orthopedic oncologic procedures.

1. Introduction

The National Cancer Institute reports that there were approximately 2,600 new cases of primary bone malignancies in 2009 as well as numerous other metastatic bone tumors. Despite the relatively common frequency, there is a paucity of information about the delivery of anesthesia for orthopedic oncologic surgeries. There are preoperative, intraoperative, and postoperative concerns specific to these patients and procedures which, therefore, merit discussion.

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2. Primary bone sarcomas

There are three common primary bone sarcomas. Osteosarcoma, the most common bone sarcoma, has an incidence of 4.6 per million people. The majority of these tumors occur in patients between 10 and 19 years of age, but there is also an association with Paget's disease in adults who are older than 40. Fifty percent of osteosarcomas arise around the knee, and they are also often seen in the upper arm. Ewing's sarcoma is primarily a disease of adolescence, with a peak incidence of about three cases per million in the 15 to 19-year age group. Although rare, Ewing's sarcoma is the second most common bone sarcoma affecting children and adolescents. It is more prevalent in men; it affects Caucasians primarily; and it frequently occurs in the spine, pelvis, arm, or leg. Chondrosarcoma is the most common bone sarcoma in adults. It mainly affects patients greater than age 50. The incidence is 8 per million people. Chondrosarcomas arise most commonly from the pelvis, upper femur, and shoulder girdle [1]. The prognosis of chondrosarcoma varies depending on the primary location and extent of spread.

3. Metastatic tumors

Metastatic bone tumors occur more frequently than primary tumors. The exact incidence of metastatic bone disease is difficult to quantify because of the large number of primary cancers that may spread to the skeleton. Breast and prostate cancers tend to be the most common causes of bony metastases [2], with up to 70% of patients with advanced disease developing bone metastases. Lung, kidney, thyroid, colon, stomach, bladder, uterine, and rectal malignancies also metastasize to the bone in 15% to 30% of cases [2]. It is estimated that 350,000 people a year die with concomitant bone metastases [2].

4. Preoperative considerations

Patients who undergo surgery for bony tumors often have received considerable medical treatment prior to surgery. Possible side effects of preoperative chemotherapy are shown in Table 1. Patients who have undergone chemotherapy or radiation therapy may have significant anemia and thrombocytopenia, and thus might benefit from preoperative exogenous erythropoietin administration and packed red blood cell (PRBC) or platelet transfusions. Obtaining adequate intravenous (IV) access and invasive monitors in preparation for fluid resuscitation and possible transfusions, may prove challenging secondary to ongoing oncologic treatments. If the possibility of large blood loss from a highly vascular tumor is expected, preoperative embolization of the tumor may be beneficial and should be considered [3].

Communication with the surgeon is mandatory prior to orthopedic oncologic surgeries. It allows the anesthesiologist to appreciate the subtleties of each specific procedure and to permit the planning for appropriate monitoring and access.

Table 1 Chemotherapeutic agents and their common side effects

Chemotherapeutic Agent	Side effects
DNA-altering drugs	
Cyclophosphamide	Hemorrhagic cystitis Myelosuppression
Cisplatin	Myelosuppression Nephrotoxicity
Mechlorethamine	Myelosuppression Dermatitis
Carboplatin	Myelosuppression Peripheral neuropathy Immune hypersensitivity reaction
Anti-tumor antibiotics	
Doxorubicin	Myelosuppression Cardiomyopathy Arrhythmias
Bleomycin	Pulmonary fibrosis
Idarubicin	Myelosuppression Hepatotoxicity
Antimetabolites	
Gemcitabine	Myelosuppression
Methotrexate	Hepatotoxicity Ulcerative stomatitis Myelosuppression
Cytarabine	Myelosuppression Hyperuricemia
Etopiside	Myelosuppression Hypotension
Antimitotic drugs	
Vincristine	Motor weakness Peripheral neuropathy Hyponatremia
Vinblastine	Myelosuppression Ulcer/blister formation
Paclitaxel	Myelosuppression Paresthesia
Docetaxel	Myelosuppression
Monoclonal antibody	
Cetuximab	Skin changes Electrolyte disturbances
Other	
Gefitinib	Diarrhea Interstitial lung disease
Imatinib	Edema

All information adapted from Micromedex/PDR. (http://www.thomsonhc.com/hcs/librarian, Sept 2010).
DNA = deoxyribonucleic acid.

5. Intraoperative considerations

There is huge variability of complexity and duration of orthopedic oncologic surgeries (Table 2). In fact, there are approximately 50 different types of procedures performed by orthopedic oncology surgeons. While a bone biopsy may take less than an hour, a hemipelvectomy may extend more than 12 hours and occasionally require staging. Many procedures often require major neurovascular dissection, removal of significant bone and/or muscle, replacement of large segments of bone and adjacent joints that may also necessitate significant cement boluses for fixation, and rotational and free flaps. A clear understanding of what the surgery entails allows for proper positioning, airway management, and postoperative planning.

Table 2 Commonly performed orthopedic oncologic surgeries

Above-the-knee and below-the-knee amputation
Above elbow amputation
Currettage of benign and benign aggressive bone tumors and bone grafting
Distal femur resection with bone and soft-tissue reconstruction
Excision of soft-tissue masses
Fixation of pathological fractures and impending fractures
Forequarter amputation
Hemipelvectomy
Hip disarticulation
Long-stem arthroplasties and cemented nails
Proximal femur resection with bone and soft-tissue reconstruction
Proximal humerus resection with bone and soft-tissue reconstruction
Proximal tibia resection with bone and soft-tissue reconstruction
Total scapula resection and reconstruction, including multiple muscle flaps
Radical lymph node dissections
Radical pelvic resections with limb preservation
Radical soft-tissue sarcoma resection with major neurovascular dissections and muscle flaps
Radical synovectomy of knee and other joints
Sacrectomy
Shoulder disarticulation

5.1. Positioning

Tumors may arise in any portion of the musculoskeletal system. Thus, surgeons employ a variety of positions to facilitate specific procedures; occasionally intraoperative repositioning is necessary. Vigilance is mandatory and patients must be placed in anatomic positions with pressure points padded to prevent compression or stretch-related injuries.

When a patient is placed in the supine position, if the upper extremities are abducted they should remain supinated and padded at no more than 90 degrees to prevent stretch or pressure on the brachial plexus. The patient's head should remain in a neutral position, placed on a gel pad or donut, and occasionally adjusted so as to decrease the incidence of pressure alopecia.

When placing a patient in the lateral decubitus position, several factors are important in preventing positioning injuries. The operating room table must be well padded. Both during movement and once properly placed, the patient's head and neck must be protected. The neck is maintained in a neutral and midline position, and there should be no excessive pressure on the eyes and dependent ear. An axillary roll is placed to prevent pressure on, and stretching of, the neurovascular bundle in the axilla and to prevent disturbed blood flow to the dependent arm and hand. The dependent upper extremity should be monitored to ensure that perfusion is maintained.

For the prone position, the patient's neck is maintained in a neutral position during and after positioning to decrease the risk of spinal cord ischemia and stretching of the brachial plexus. The eyes should be checked routinely to ensure that there is no pressure applied directly to the globe. Prone positioning has been implicated in the occurrence of postoperative visual loss, especially when accompanied by large blood loss or prolonged surgical duration. Depending on the area of surgery, the arms are placed either up and adjacent to the head with the elbows flexed or adducted alongside the patient. In each case, the arms should be padded to prevent compression injuries. Excessive pressure on the breasts also must be avoided. The abdomen should not be compressed because excessive pressure may compromise ventilation and decrease venous return from the lower extremities.

Poor patient positioning may result in devastating outcomes. The anesthesiologist and surgeon should be aware of the common pitfalls and attempt to avoid preventable injuries.

5.2. Blood loss

Tumors are relatively vascular structures and thus are prone to bleeding throughout the intraoperative period. Renal cell and thyroid metastases cause significant neovascularization to the area, often hemorrhaging dramatically during surgery, much more so than other types of bony metastases. Preoperative embolization of these types of metastases should be considered to minimize bleeding during the surgical procedure. The location of the metastasis is also an important factor in determining the degree of hemorrhage during surgery. Pelvic metastases often hemorrhage significantly regardless of histological subtype, and should be considered for preoperative embolization, especially when lesions are large. Myeloma may affect multiple systems from direct spread of tumor and Bence-Jones proteins. Patients may appear deceptively healthy yet have compromised organ systems. This situation becomes apparent when they are stressed by the surgical procedure. Unfortunately, cell salvage cannot be routinely used because it may increase the risk of spreading or showering tumor cells systemically. Although there is some promising research on the effectiveness of filtration and irradiation to reduce the tumor load of salvaged blood, no definitive trials yet have shown the safety of its use [4].

Autologous transfusions do not improve long-term outcomes over exogenous donor red blood cell transfusions [5]. Use of autologous predonation must be weighed against the possibility of perioperative anemia resulting from poorly timed donations. There is a higher incidence of transfusion in patients following autologous donation despite an unremarkable difference in blood loss [6]. Interestingly both autologous and allogeneic transfusions have been implicated in transfusion-related immunomodulation, and both have been associated with decreased disease-free survival [4].

Acute normovolemic hemodilution (ANH) is another technique used to decrease the incidence of perioperative transfusions. This technique involves phlebotomizing a patient and at the same time replacing the withdrawn intravascular volume with crystalloid or colloid. The blood withdrawn from the patient is frequently kept at room temperature, to be returned to the patient later in the procedure, no longer than 8 hours after collection. This action has shown some efficacy in reducing allogeneic blood transfusions in cardiac and miscellaneous procedures, though not with orthopedic surgeries [7]. Zohar et al. compared tranexamic acid with ANH to decrease intraoperative blood loss in patients undergoing total knee replacement [8]. They found that ANH was associated with significantly higher intraoperative fluid and vasopressor requirements. This may be a result of lower blood viscosity secondary to hemodilution, which leads to decreased systemic vascular resistance.

Because patients with cancer are often hypercoaguable, use of antifibrinolytic agents remains controversial. There are many misconceptions that antifibrinolytics cause an increase in thrombus formation, possibly leading to deep vein thromboses (DVTs) and emboli. In reality, these medications stabilize existing clots and do not directly produce thrombosis. Multiple studies looking at outcomes following administration of antifibrinolytics versus placebos have failed to show an increased incidence of postoperative thromboses [8-14]. The Cochrane Database completed a meta-analysis of more than 200 studies consisting of over 20,000 patients, and showed a decrease in blood loss without any increase in risk of thrombus formation with the use of aprotinin, epsilon-aminocaproic acid (EACA), or tranexamic acid [13].

Early data showed the promise of decreasing blood loss with aprotinin, but the development of renal failure associated with its use has led to its withdrawal from the market. Epsilon-aminocaproic acid and tranexamic acid remain viable options for minimizing perioperative blood transfusions. Although there are little data comparing the effects of EACA and tranexamic acid on blood loss specifically in orthopedic procedures, it appears that tranexamic acid is more efficacious in other surgeries involving large blood loss [7]. Tranexamic acid, a synthetic lysine analogue, acts as a competitive inhibitor of plasmin and plasminogen. In one study of patients undergoing multilevel spine surgeries, a high-dose tranexamic acid regimen (loading pts with two grams of tranexamic acid followed by a maintenance infusion of 100 mg/hr) resulted in significant reductions of intraoperative blood loss (mean 311 mL vs. 584 mL) and blood transfusions (mean 93 mL vs. 531 mL) when compared with placebo [9]. The dosing regimen most commonly described is a 10 mg/kg loading dose followed by a one mg/kg/hr infusion; it decreases intraoperative transfusion and blood loss in spine cancer patients undergoing intralesional tumor excision and instrumentation [10]. Contraindications to tranexamic acid include hypersensitivity to it, acquired defective color vision, subarachnoid hemorrhage, and active intravascular clotting processes, such as disseminated intravascular coagulation.

Epsilon-aminocaproic acid is also a lysine analogue that has been used to decrease intraoperative blood transfusions. In a recent meta-analysis, Zufferey et al. found limited data that specifically evaluated EACA in orthopedic oncologic surgeries; however, the available information showed that EACA was not efficacious in preventing perioperative PRBC transfusions. This same study did find tranexamic acid beneficial [14]. The Cochrane Database, which showed a blood-sparing effect with EACA, evaluated all surgeries while the Zufferey et al. study was limited to orthopedic procedures. The effectiveness of EACA–but not its safety profile – remains controversial.

5.3. Anesthetic technique

Since primary bone tumors and metastases may arise anywhere, certain anatomic locations lend themselves to specialized anesthetic techniques that provide not only intraoperative anesthesia but also postoperative analgesia.

5.4. Upper extremity tumors

Similar to other upper extremity surgeries, tumor resections of the upper extremity often lend themselves to regional anesthetic techniques. Depending on the location of the tumor, an interscalene, supraclavicular, infraclavicular, or axillary block may provide both excellent surgical anesthesia and postoperative analgesia. Placement of an indwelling nerve catheter provides excellent continuous postoperative analgesia. If the procedure is expected to produce a large amount of blood loss, extend to areas not covered by the regional nerve block, involve difficult positioning, or long duration, then general anesthesia (GA) is also used. In some cases, if the surgery is performed solely with GA, the surgeon may opt to place a perineural, subfascial, or subcutaneous catheter prior to wound closure for postoperative infusion of local anesthetics. Such catheter placement is particularly suitable for cases in which a major neurovascular bundle has been exposed and dissected to remove the tumor.

5.5. Lower extremity tumors

Like upper extremity tumor resections, procedures of the lower extremity also may be performed with regional anesthetic techniques alone or in combination with GA.

Some of the most challenging anesthetics are for resection of metastatic tumors involving the femur. These procedures may be necessary for pathologic fractures or impending fractures requiring resection and stabilization by arthroplasty or hemiarthroplasty of the hip. Patients presenting for these procedures often have other metastatic lesions as well as significant perioperative pain, which may impede placement of regional blocks. This pain may be managed in several ways, depending on patient preference and relative contraindications. Weinbroum [15] found that epidural anesthesia is more efficacious in treating postoperative pain in patients with orthopedic tumors than IV patient-controlled analgesia (IV PCA) therapy. Though this technique is beneficial postoperatively, some anesthesiologists avoid intraoperative neuraxial anesthesia in these patients because of sympathectomy combined with the likelihood of large blood loss, rendering intraoperative blood pressure (BP) management challenging. One option is preoperatively to place an epidural catheter for use in the postoperative period, followed by GA for the surgery. In patients who have a contraindication to neuraxial anesthesia, such as those who are coagulopathic or thrombocytopenic, a fascia iliaca block or 3-in-1 femoral nerve block with or without a sciatic block may be considered for postoperative analgesia [16,17]. These techniques may be particularly beneficial to the oncologic patient who has become tolerant to opioids as well as those patients who will require postoperative anticoagulation.

Patients undergoing cemented total hip arthroplasties and hemiarthroplasties, as well as vertebroplasty or knee arthroplasty, are at risk for bone cement implantation syndrome. Hypoxia and hypotension and/or unexpected loss of consciousness are hallmarks of bone cement implantation syndrome. The highest incidence occurs in cemented long-stem hip hemiarthroplasties for pathologic fractures in patients with significant metastatic disease, preexisting medical conditions, and previously noninstrumented femoral canals. Multiple models of etiology exist, including reaction to methylmethacrylate monomers released into circulation, emboli during cement and prosthesis insertion, histamine release, complement activation, and endogenous cannabinoid-mediated vasodilatation. The development of bone cement implantation syndrome likely is secondary to a combination of these processes, and the contribution of each model is patient-dependent [18]. There is an increased incidence of adverse reactions during cementation and insertion of the long-stem prosthesis versus the standard hip prostheses. This increased incidence is not necessarily secondary to bone modified by tumor being more susceptible than healthy bone to reactions from methylmethacrylate. The population of patients with metastatic disease is likely more susceptible as a result of underlying illness and overall fragility of multiple systems affected by cancer, chemotherapy, and radiation effects, malnutrition, anemia, and dehydration. Pulmonary metastases may further compromise a patient’s ability to compensate for any reactions induced by the methylmethacrylate. Compared with other orthopedic surgical procedures that often use cement, such as total hip replacement, prostheses and intramedullary rods that are placed in cancer patients often require significantly more cement because long-stem prostheses and long rods are usually used to span the entire length of the bone. In one retrospective study of 55 patients who underwent long-stem prosthesis insertions for femoral tumors, hypotension, requirement for sympathomimetic agents, or oxygen desaturation occurred in 62% of patients [19]. This same study also showed a higher incidence of postoperative oxygen desaturation in patients who received the longer-stemmed prostheses [19]. There have been no definitive studies determining how to prevent bone cement implantation syndrome. Endotracheal intubation, with its ability to deliver positive pressure ventilation, should be used in patients likely to experience bone cement implantation syndrome. The treatment, once it occurs, remains supportive.

5.6. Spine and pelvic tumors

Management of patients undergoing surgeries for tumors that involve the spine or pelvis is particularly complicated because of the possibility of massive and ongoing hemorrhage. Placing an arterial catheter for continuous BP monitoring and sampling, ensuring the availability of PRBCs and other blood products, and acquiring adequate IV access are imperative prior to surgical incision. Rapid-infusion devices are often helpful.

A series of 6 patients undergoing sacrectomies showed an intraoperative blood loss ranging from 2,450 to 6,800 mL [20]. Because of the vascular nature of sacral tumors, some clinicians advocate preoperative embolization of the mass prior to surgery. This action may decrease intraoperative blood loss but surgery should proceed soon after embolization because collateral flow can be reestablished within 24 hours. Another study described 4 patients in whom an aortic balloon was used to reduce both surgical time and intraoperative bleeding [3].

Other frequent truncal tumor sites are in the vertebrae. Vertebrectomy for localized lesions resembles the typical laminectomy. This procedure may involve multiple patient positions, sometimes requiring alternation between supine and prone positioning. The monitoring of somatosensory-evoked potentials (SSEPs) and motor-evoked potentials (MEPs), as well as electromyography (EMG), may necessitate the use of total IV anesthesia (TIVA) and avoidance of neuromuscular blockade. In some cases, MEPs and EMG may impede pulse oximetry and noninvasive BP monitoring secondary to motion artifacts. Therefore, constant communication between the anesthesiologist, surgeon, and electrophysiologist is essential.

In pelvic and spinal tumor cases, the use of neuraxial anesthesia for intraoperative and postoperative analgesia may be considered. Preservative-free morphine or epidural analgesia may be highly efficacious in decreasing postoperative pain. For spine surgery, intraoperative instillation of intrathecal morphine, without local anesthetic, is beneficial for postoperative analgesia. Boezaart et al. examined intrathecal morphine in major lumbar spinal surgery and compared morphine 0.2 mg, 0.3 mg, and 0.4 mg boluses. They found that morphine 0.3 mg provided superior analgesia to that of the 0.2 mg group, equivalent analgesia to that with the highest dose (0.4 mg), and that it had no respiratory depressive effects [21].

6. Postoperative considerations

6.1. Pain

Preemptive analgesia is based on the premise that blocking the response to noxious stimuli prior to the surgical insult can lead to a decrease in postoperative pain. In reality, it has been difficult to show a true difference. A meta-analysis comparing non-steroidal anti-inflammatory drugs (NSAID), pre-incisional opioids, N-methyl-D-aspartic acid (NMDA) receptor antagonists, and regional anesthesia has shown conflicting results [22]. The meta-analysis study showed that, other than a beneficial effect of epidural anesthesia at certain postoperative times, there was little advantage to using any of the attempted preemptive interventions [22]. Specifically, epidural analgesia is more efficacious than IV PCA in orthopedic oncologic patients [15]. Postoperative pain is significant in orthopedic patients. Chung et al. examined pain patterns in the recovery unit and found that orthopedic patients had the highest incidence of pain in the ambulatory setting [23]. There are many approaches to controlling postoperative pain, each of which must be tailored to the preoperative and postoperative course of the patient.

Oncologic patients often have pain prior to their surgery and are also receiving significant amounts of opioids to control it. The anesthesiologist needs an accurate idea of the patient's opioid tolerance and requirements, and should plan accordingly for the postoperative period when an escalated dosing regimen will likely be necessary. Opioid equivalents are shown in Table 3. The addition of methadone, which possesses opioid mu and NMDA receptor activity, may be helpful. A study of 3,400 patients showed that administration of 5 mg to 10 mg of methadone preoperatively, and then every 8 hours postoperatively, was safe and effective for pain control [24]. Sustained-release (SR) opioids such as oxycodone SR or a fentanyl patch may be helpful but should not be used in opioid-naïve patients.

Table 3 Opioid equivalents to 10 mg of intravenous morphine

Drug	Dosage (parenteral)
Hydromorphone	1.5 mg
Meperidine	100 mg
Fentanyl	100 μg
Alfentanil	500 μg
Methadone	10 mg
Codeine	70 mg
Butorphanol	2 mg
Nalbuphine	10 mg

All equivalents obtained from Gutstein HB, Akil H. Opioid analgesics. In: Brunton LL, Lazo JS, Parker KL, editors. Goodman and Gilman's the Pharmacological Basis of Therapeutics; 11th edn. New York: McGraw-Hill; 2006. p. 547-90.

The benefits of other adjuvants for pain control have been shown. In a study examining the use of oral dextromethorphan, an opioid analgesic commonly used as an antitussive drug, in conjunction with either epidural or IV PCA, a decrease in the amount of analgesics was required postoperatively in the dextromethorphan groups (epidural and IV PCA) when compared with placebo. There was also a lower frequency of nausea and vomiting, earlier ambulation, and a shortened hospital stay in those receiving dextromethorphan [25]. Clonidine, an alpha-2 antagonist, was hypothesized to be an analgesic adjuvant, but no study has shown that the benefits of oral clonidine in prolonging analgesia outweigh the adverse effects of sedation and hypotension.

In cases where an IV PCA is used, other adjuvants may also be of benefit. Ketamine, an NMDA antagonist, in subanesthetic doses causes a significant decrease in postoperative pain, specifically in opioid-tolerant patients [26]. Memantine, an NMDA antagonist used to treat Alzheimer's disease, also may be useful in the treatment postoperative pain [6]. The NMDA antagonists are believed to help prevent "wind-up" pain, which is a state of severe pain brought on by repeated C nerve fiber stimulation.

The management of postoperative pain proves difficult and often requires a multimodal approach to achieve success. Parenteral opioids alone rarely provide adequate analgesia; the addition of an NSAID is frequently beneficial. Other techniques such as opioid switching as well as the addition of NMDA antagonists need further investigation [22,27]. When complex cases with the possibility of significant postoperative pain arise, it may be wise to use a multidisciplinary approach. A team, including an anesthesiologist, surgeon, pain physician, and physiatrist, may help to devise a plan that will minimize the orthopedic oncologic patient's postoperative discomfort and maximize his or her ability to participate in therapy.

6.2. Thromboprophylaxis

Venous thromboembolism remains a serious postoperative complication. It is estimated that deep venous thrombosis (DVT) occurs at a rate of 45% to 69% following hip replacement surgery without prophylaxis [28]. Intermittent compression devices are efficacious in preventing the formation of DVTs, decreasing the risk to 14% [28]. There are numerous pharmacological agents that provide thromboprophylaxis, including warfarin, low-dose heparin, low-molecular-weight-heparins, and aspirin. In a retrospective review of patients with bone or soft-tissue sarcomas who underwent orthopedic oncologic surgery, pharmacological prophylaxis reduced the incidence of DVT to 4% [29].

Postoperative DVT prophylaxis is of particular concern to the anesthesiologist when an epidural has been placed for postoperative analgesia. The approach to neuraxial anesthesia

Table 4 American Society of Regional Anesthesia anticoagulation and neuraxial anesthesia guidelines: 2002

Drug	Drug to neuraxial anesthesia time	Neuraxial anesthesia to drug time	Drug to epidural catheter removal time	Epidural catheter removal to drug time
Heparin	N/A	1 hr	2-4 hrs plus coagulation profile	1 hr
Low-molecular-weight-heparin		Prophylactic dosing	12 hrs	2 hrs
prophylactic dose	12 hrs	Twice daily – 24 hrs		
treatment dose	24 hrs	Single daily –12 hrs		
Coumadin	4-5 days plus coagulation panel	N/A	When INR < 1.5	N/A
Clopidogrel	7 days	N/A	N/A	N/A
Ticlopidine	14 days	N/A	N/A	N/A
Aspirin	N/A	N/A	N/A	N/A
NSAIDs	N/A	N/A	N/A	N/A
Fondaparinux	Not evaluated	Not evaluated	Not evaluated	Not evaluated

Horlocker TT, Benzon HT, Brown DL, et al. ASRA Second Consensus Conference on Neuraxial Anesthesia and Anticoagulation. April 25-28, 2002 http://www.asra.com/consensus-statements/2.html.
INR = international normalized ratio, NSAIDs = nonsteroidal anti-inflammatory drugs.

in patients who are receiving anticoagulation has been described in the American Society of Regional Anesthesia (ASRA) consensus guidelines (Table 4).

Superficial peripheral perineural catheters are not subject to these guidelines and may be placed and maintained in the presence of active thromboprophylaxis.

6.3. Nausea and vomiting

The etiology of postoperative nausea and vomiting (PONV) is multifactorial. The type of procedure, length of exposure to inhalational anesthetics, use of nitrous oxide, use of opioids, and specific patient factors may affect the incidence of PONV. Frequently, oncologic patients become opioid-dependent and tolerant preoperatively and may require larger doses intraoperatively for adequate analgesia; either the escalated doses or the presence of pain could lead to nausea and vomiting. A variety of pharmacologic agents are available to reduce the incidence of PONV. The serotonin ($5HT_3$) inhibitors, including ondansetron, granisetron, dolasetron, and palonosetron are the most commonly used. The addition of other antiemetics such as metoclopramide, droperidol, promethazine, and prochlorperazine, which act primarily through dopaminergic antagonism, may act as effective adjuvants. Dexamethasone is effective for PONV prophylaxis; however, its mechanism of action is unknown, though it could be due to a decrease in prostaglandin synthesis. Administration of low-dose propofol (0.5 mg/kg) at the conclusion of surgery also is effective in the prevention of PONV [30].

7. Conclusion

Orthopedic oncologic surgeries are challenging for the anesthesiologist. Patients must receive a thorough preoperative evaluation to elucidate significant comorbidities and to ensure optimization prior to the procedure. Orthopedic oncologic surgeries vary in length and complexity; the potential for massive blood loss and hemodynamic instability must be appreciated and the intraoperative use of antifibrinolytics considered. The use of regional anesthesia or peripheral or neuraxial block as a sole anesthetic may be effective alone or in combination with GA, but the postoperative plan for thromboprophylaxis also must be defined prior to choosing a technique. Pain control in the postoperative setting may be particularly challenging and it usually requires a multimodal approach. A well formulated anesthetic plan, created by effective communication between the anesthesiologist and surgeon, is essential to ensure optimal patient outcomes.

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