Multimodal Analgesic Plans for Cancer Surgeries

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11.1 Introduction

Pain is recognized as *fifth vital sign*. Optimal perioperative pain management not only improves overall surgical outcome but also improves patient satisfaction [1]. This requires adequate assessment preoperatively, a proper plan for pain relief and its execution during the surgical intervention which continues in the postoperative period. A prior discussion with patients allays anxiety and fear of pain for the surgical intervention. In the recent era, advancement in the surgical techniques has led to more invasive to lesser invasive like endoscope or laparoscopically assisted procedures. This has a benefit of lesser tissue trauma and thus lesser pain. On the other hand, the number of complex procedures has increased and thus need for proper planning and execution of pain management is essential. The pain management is an essential responsibility for the anesthesiologist; however, understanding the basic concepts of pain management would help the surgeons in accomplishing an effective perioperative pain management. The key to success for pain relief is to create a fine balance by judicious usage of the wide array of pain relief modalities and newer analgesic agents, thus avoiding both under- and over-treatment and creating a pain-free experience for the patient.

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11.2 Importance of Pain Management: Systemic Effects of Inadequate Pain Relief

The *IASP definition of pain* is "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage." [2] The term *nociception* describes neural responses to traumatic or noxious stimuli producing pain. Acute pain is caused by noxious stimulation due to injury, a disease process, or the abnormal function of muscle or viscera. Chronic pain is the one which persists beyond the usual course of an acute process or beyond a reasonable healing time (varying from 1 to 6 months). There are differences in pain perception in various patient populations. Unrelieved pain plays a major part in activation of the stress response to injury. The following are the unwanted systemic effects of inadequate pain relief [3]:

- Stimulation of sympathetic nervous system, leading to increase in heart rate, blood pressure, systemic vascular resistance, increased cardiac work load, and myocardial oxygen demand.

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- Catabolic hormone release and decrease in anabolic hormones causing greater protein breakdown, hyperglycemia, sodium and water retention.
- Impairment of immune function due to depression of the reticulo-endothelial system.
- Increased coagulability, predisposing to thromboembolism.
- Decreased regional blood flow to the skin and impaired wound healing.
- Impaired pulmonary function can occur in upper abdominal or thoracic surgeries, leading to atelectasis and hypoxemia. Other respiratory effects include increase in minute ventilation and work of breathing.
- Gastrointestinal and urinary effects include increased sphincter tone and decreased motility causing ileus and urinary retention.
- Psychological consequences can occur in the form of sleep deprivation and post-traumatic stress disorder (PTSD).
- Development of chronic pain state from prolonged or severe acute pain, known as chronic persistent post-surgical pain (PPSP).

11.3 Pain Pathways

There are four physiological processes involved in acute nociceptive pain: transduction, transmission, modulation, and perception. There are two broad types of acute (nociceptive) pain: *Somatic pain* (categorized into superficial and deep) and *Visceral pain* (categorized into true localized and referred pain) [4]. Three neural pathways transmit pain from the periphery to the cerebral cortex. First-order neurons send their axons into the spinal cord through the dorsal spinal root at each cervical, thoracic, lumbar, and sacral level. On entering the spinal cord, they segregate into large myelinated fibers medially and small, unmyelinated fibers laterally. Pain fibers travel in Lissauer's tract before synapsing with second-order neurons in ipsilateral dorsal horn. These neurons are either nociceptive-specific or wide dynamic range *(WDR) neurons*. Referred pain is because of the convergence between visceral and somatic sensory inputs in the *dorsal laminae* [5]. The spinothalamic tract running anterolaterally in the white matter is the major pain pathway. The *medial spinothalamic tract* ascends to the medial thalamus and mediates the autonomic and unpleasant emotional aspects of pain. The *lateral spinothalamic tract* ascends to ventral posterolateral thalamic nuclei and carries specific pain sensations like location, intensity, and duration. There are several alternate pain pathways, like the spinoreticular and spinocervical tracts, which are responsible for other sensations associated with pain. *Thalamus* is the site for third-order neurons. They send fibers to the *somatosensory areas I and II,* present, respectively, in postcentral gyrus and the Sylvian fissure of the brain [6]. The main chemical mediators of pain are *substance P and calcitonin* gene-related peptide. Modulation of pain (either at the peripheral or central levels) is responsible for either inhibition or facilitation of pain.

11.4 Assessment of Pain

Assessment of pain is a very important and essential. It is a prerequisite to optimal pain management. There are various scales and scores used for pain assessment both in adults and children. Since pain is a subjective experience, sociocultural background and psychological aspects of the individual patients must be considered. Both self-reporting and functional assessment of pain are vital. Uni-dimensional scales available for pain measurement include verbal (*VDS—verbal descriptor scale*), numerical (*VNRS—verbal numerical rating scale*), and visual (*VAS—visual analog scale*) [7]. VAS is the simplest scale where a 10 cm line is shown to the patient, starting from "no pain" and ending with "worst possible pain." The distance between the two marks is measured in millimeters, giving a VAS score of 1–100. VNRS uses a scale of zero to ten, where 0 signifies "no pain" and 10 reflects "worst imaginable pain." VDS is a descriptive pain scale to rate the severity of pain, in the form of "no pain," "mild pain," "moderate pain," and "severe pain." Functional assessment of pain is equally important in the current era of day care surgery. Activity

impairment due to pain can be ranked into three categories [8] by the *functional activity score (FAS)*: A—no limitation; B—mild limitation; and C—significant limitation. Pain in children has to be assessed differently and can be quite a challenging task. There are several observational scales available in infants and children [9] who are unable to self-report pain: *r-FLACC* (Revised face, legs, activity, cry, consolability) tool; *NCCPC-PV* (Non-Communicating Children's Pain Checklist-Postoperative Version); *NAPI* (Nursing Assessment of Pain Intensity); and *CRIES* scale for neonates (Crying, Requires O2 for maintaining saturation > 95%, Increased vital signs, Expression and Sleepless).

The pain assessment should be a part of vital monitoring. These pain scores should be documented in the monitoring sheets of the patient. The frequency of pain assessment needs to be individualized based on the severity of surgical intervention. These assessment tools help in titration of analgesics drugs or techniques.

11.5 Modalities of Preoperative Analgesia

Modalities of pain management can be broadly divided into *pharmacological and non-pharmacological agents.* Pharmacological modalities can be further subdivided into systemic and regional agents. Non-pharmacological techniques include alternate modes of pain management like acupuncture, *TENS* (transcutaneous electrical nerve stimulation), music therapy, cognitive therapy, behavior therapy, and physical therapies [10]. Multimodal pain management should be employed for greater benefit. Systemic analgesics can be administered intravenously, intramuscularly, transmucosal, or subcutaneous. Most post-surgical patients cannot be given oral medications and hence, systemic agents are advocated, including trans-nasal preparations. The *traditional ladder approach* can be used for most situations, starting with reassurance, mild analgesics like acetaminophen, then NSAID's, weak narcotics, and finally stronger opioids, along with adjuvants [11]. Non-opioid analgesics include paracetamol, NSAID's (non-steroidal anti-inflammatory agents), COX-2 (cyclooxygenase) inhibitors, ketamine, alpha-2 agonists, and antidepressants [12]. NSAID's exhibit their analgesic effects by inhibition of cyclooxygenase and prostaglandin synthesis. Non-selective NSAID's also have effects on platelets and gastric mucosa, making the *selective COX-2 agents* [13](Celecoxib, Rofecoxib, Valdecoxib, and Parecoxib), a safer alternative.

11.6 Regional Techniques

Regional techniques are advantageous not only in providing excellent pain relief, but also in decreasing anesthetic requirements. This leads to faster recovery and improves quality of patient care. These can be divided into the following:

1. Central neuraxial blocks.
2. Peripheral nerve plexus blocks.
3. Individual selective nerve blockade.
4. Truncal blocks.
5. Intravenous regional anesthesia.

Central neuraxial blocks can be utilized for providing anesthesia for infra-umbilical surgical interventions. These blocks, specially epidural blocks, provide effective analgesia for lower limb, abdominal, and thoracic procedures. These include: *Spinal (saddle, single shot, or continuous); Epidural (caudal, lumbar, thoracic, or cervical epidural); and Combined spinal-epidural (CSE).* They can be given either by midline or paramedian approach. Ultrasound has recently been used to improve accuracy and catheter threading can be visualized. Apart from absolute and relative contraindications to neuraxial blockade, *ASRA recommendations* for patients on anticoagulants must be strictly followed to decrease the incidence of epidural hematomas [14]. As per these guidelines, ecosprin or aspirin need not be stopped and there should be a gap of 12 h between low molecular weight (LMW) Heparin administration and insertion of block needle. For unfractionated heparin, a gap of 4 h is sufficient. For patients on oral anticoagulants (warfarin), the

coagulation profile, especially the INR (international normalized ratio) should be constantly assessed.

Spinal anesthesia can be extended in the postoperative period for providing analgesia by insertion of continuous spinal catheters [15]. The drugs used include bupivacaine and ropivacaine. Spinal opioids like morphine and fentanyl have duration of analgesia approaching 12–36 h. The main fears associated with continuous spinal include risk of infection, postdural puncture headaches and cauda equina syndrome. Combined spinal-epidural anesthesia has several advantages, including lower local anesthetic blood levels with initial spinal injection and epidural catheter used for analgesia.

The Epidural analgesic regimen could be either physician/nurse controlled or it could be patient controlled. The patient satisfaction with regard to optimal analgesia is better with patient controlled analgesia. Patient controlled epidural analgesia *(PCEA)* is now being increasingly used after insertion of epidural catheters for continued postoperative analgesia. Here patient has a control over the administration of the drugs though a dedicated infusion pump which has inbuilt safety mechanism to prevent overdoses. It has been shown that a combination of local anesthetic and opioids provides better epidural analgesia at lower doses than either drug alone. Differences in lipid solubility of opioids have minimal effects systemically, but major differences when used neuraxially. The *neuraxial opioid "Teeter-Totter,"* needs to be considered by the anesthesiologist for balancing the "pros" and "cons" of each agent used for epidural analgesia [16]. *Highly lipid soluble agents* include fentanyl and sufentanil, which are associated with narrow dermatomal spread or narrow band analgesia, rapid onset, systemic absorption, lower potency (which can be potentiated by epinephrine), and have lower incidence of pruritus/nausea. *Hydrophilic agents* include morphine and hydromorphone, which have wide band analgesia, higher potency, delayed onset, lesser systemic absorption, and are ideal for longer or multi-dermatomal incisions.

Table 11.1 Correlation of surgical site and epidural catheter insertion

S. no	Surgical site	Level of epidural catheter insertion
1.	Lower extremity	L1–L4
2.	Lower abdominal	T8–T11
3.	Middle abdominal	T7–T10
4.	Upper abdominal	T6–T8
5.	Thoracic	T4–T8

L—lumbar, T—Thoracic

The site insertion of catheter in the epidural space depends on the proposed surgical plan and surgical incision site. The insertion of epidural catheter has to be congruent as per dermatomal level of analgesia required (Table 11.1) [17].

11.7 Systemic Agents

There can be several routes of delivery of analgesic medications, depending on the type of surgery and severity of pain [18]. The oral route is simple and cost-effective, but requires a functional gastrointestinal tract. The rectal route can be specifically employed in children, but has unreliable drug absorption. The subcutaneous route can be used for opioids, but has a slow onset of action. The intramuscular route can be used for both opioid and non-opioid medications, but is painful and has unpredictable drug absorption. The most preferred route is the intravenous one. It has a fast onset and doses can be titrated. Either a single dose or continuous infusion can be utilized. Newer routes of analgesic administration include transdermal and transmucosal (sublingual, buccal, or intra-nasal) ones, especially with opioids. Systemic opioids are the agents of choice in moderate to severe acute pain. The advantage of opioids is that they do not have analgesic ceiling. The main adverse effects of opioids [19] include nausea, vomiting, sedation, pruritus, respiratory depression, and constipation. They can be given intraoperatively as I.V. bolus or by postoperative infusions for analgesia. Opioids can also be administered by the following routes: oral, subcutaneous, transcutaneous, transmucosal, intra-

Table 11.2 Various drug regimens for intravenous patient controlled analgesia

S. no.	Opioid agonist	Concentration	Bolus dose	Lockout interval (minutes)	Continuous basal infusion
1.	Morphine	1 mg/mL	0.5–2.5 mg (adult) 0.01–0.03 mg/kg (pediatric)	5–10	0.01–0.03 mg/kg/Hr
2.	Fentanyl	0.01 mg/mL	10–20 mcg (adult) 0.5–1 mcg/kg (pediatric)	4–10	0.5–1 mcg/kg/Hr
3.	Meperidine	10 mg/mL	5–25 mg	5–10	–
4.	Sufentanil	0.002 mg/mL	2–5 mcg	5–15	–

muscular, intrathecal, epidural, and intra-articular. With the advent of I.V. patient controlled analgesia (IVPCA), there is optimized delivery of analgesic opioids, thus minimizing the effects of pharmacokinetic and pharmacodynamic variability in individual patients. The various *IVPCA regimens* have been employed using the opioids (Table 11.2) [20].

The *mixed opioids or partial agonists-antagonists* include buprenorphine, nalbuphine and pentazocine [21]. These agents should be avoided in patients of opioid addicts as they may precipitate withdrawal. Buprenorphine is also available as transdermal patches. Its intravenous dose is 0.03–0.1 mg and is available as 0.03 mg/mL solution. Pentazocine is available as 10 mg/mL and can be administered in a dose of 5–30 mg intravenously.

There are several adjuvants which are used in pain management. *Adjuvants* are defined as drugs with a primary indication other than pain that have analgesic properties in painful conditions [22]. They can be classified into: multi-purpose adjuvant analgesics (antidepressants, corticosteroids, alpha-2 adrenergic agonists, neuroleptics); those specific for neuropathic pain (anticonvulsants, local anesthetics, antiarrhythmics, antihistaminics, NMDA receptor antagonists); for musculoskeletal pain (centrally acting muscle relaxants, caution: it should not be confused with neuromuscular blocking drugs used intraoperatively which are different class of drugs and not used for muscular pain); for bone pain (bisphosphonates, calcitonin and radiopharmaceuticals); and those for pain from bowel obstruction (Octreotide, anticholinergics). *Alpha-2 agonists* are the most commonly used adjuvants in acute pain management [23]. They can be administered through multiple routes (intravenous, intramuscular, intrathecal, epidural, nerve plexus and trunk blocks). Clonidine hydrochloride (an imidazoline derivative) can be administered orally, intravenously, epidurally, transdermal, and topically as well. It is metabolized in liver to inactive metabolites, with a half-life of 12–16 h. Main side effects include sedation, dry mouth, hypotension, fatigue, headache and sinus bradycardia. Its oral dose is 0.1–0.6 mg daily in divided doses. Injectable form is available as 100 mcg and 500 mcg/mL solution. Its continuous epidural dose is 30–40 mcg/h and intravenous dose is 2–3 mcg/Kg. Dexmedetomidine is a multi-purpose agent with greater alpha-2 selectivity and is given as an intravenous infusion dose of 0.4–0.5 mcg/Kg/h. Its major side effects include dry mouth, bradycardia, hypotension, heart blocks and rigidity.

There are several *additives* which can be added to local anesthetics for epidural blockade, with the benefit of making it last longer, improve quality or accelerate onset of blockade. These include epinephrine, phenylephrine and bicarbonate (carbonation).

Ketamine [24] is an intraoperative anesthetic with NMDA- antagonistic properties, important in attenuating central pain sensitization and opioid tolerance. Perioperative ketamine has been shown to reduce 24-h morphine requirements and hence, the side effects. It can be administered intramuscularly, intravenously, intrathecally, and epidurally, though the neuraxial use of racemic ketamine is not recommended in view of its neurotoxicity.

11.8 Role of Ultrasound

Ultrasound (USG) has revolutionized the field of pain management. It can be used for all peripheral nerve blocks, field blocks, neuraxial block and trunk blocks. Not only has it improved the accuracy, but also has led to decrease in the dose of local anesthetics required [25]. It can be used alone or in combination with peripheral nerve stimulator. It uses high frequency (1–20 Hz) sound waves emitted from piezoelectric crystals. These waves travel through tissues of different densities and return a signal to the transducer, which deform the *piezoelectric crystals* to create an electronic voltage that is converted into a two-dimensional gray-scale image. *Hypoechoic structures* appear black or dark (sound passes through them easily) and *hyperechoic structures* appear white or bright, as they reflect most of the sound waves. There are primarily two kinds of probes: High frequency, linear probes and Low frequency, curvilinear probes. *Linear probes* provide higher resolution images with lesser tissue penetration and therefore useful for superficial nerves. *Curvilinear probes* provide better tissue penetration, with less clear images and therefore used for deeper structures. Needle insertion can be done either parallel to *("in-plane approach*") or perpendicular to ("*out-of-plane approach*") the plane of the ultrasound waves. The path of the needle can be better visualized in the in-plane approach [26] and usually recommended for beginners. In out-of-plane approach, only the tip of the needle can be visualized. Continuous catheters can also be inserted under USG guidance for continued pain relief. Individual nerves can also be visualized and blocked for selective anesthesia of the desired part of the body. This is especially useful in day care procedures, where patient can be mobilized earlier and urinary retention avoided. USG can also be used for central neuraxial blocks in difficult spines and is particularly beneficial for caudal blocks in children (who have greater propensity for anatomical variations of caudal structures).

11.9 Patient Controlled Analgesia

Patient controlled analgesia (PCA), both mechanical and electronic, has added a major boost to pain management. Not only does it obviates "*breakthrough pain,*" but also gives the patient a sense of control over their analgesia. Intravenous PCA is commonly given with opioids (Morphine, Fentanyl, Sufentanil, Remifentanil). It is a programmed electronic device which delivers a preset basal infusion dose of the analgesic agent and an additional drug delivery pump activated by the patient to deliver a pre-determined bolus or demand dose, separated by a fixed time (called *lockout interval*) [27]. The pump does not respond to further demands during the lockout period as a safety mechanism to prevent inadvertent overdose or adverse effects. Basal and bolus rates are set according to patient characteristics and extent of surgical pain. Standardized institutional protocols must be laid out for their use to prevent incorrect prescribing or drug dilution. Proper patient education and presence of trained staff is of paramount importance. PCA pumps should be operated either by the patient, nurse or the physician. "*PCA by proxy"* (demand drug delivery by any unauthorized person, including family members) can lead to significant adverse events and must be discouraged. *Nurse controlled analgesia* can be administered by trained nurses for small children under adequate monitoring.

PCA can also be applied for regional techniques for continued postoperative analgesia. A similar electronic programmed device with pre-filled drug, preset continuous infusion and bolus rates can be attached to the epidural catheters or to *contiplex (continuous nerve/plexus) catheters*. *Mechanical or electronic PCA pumps* can be used with thoracic and lumbar epidural catheters for excellent analgesia in thoracic and abdominal surgeries. Thoracic epidural analgesia (*TEA*) is also known to be beneficial in decreasing myocardial oxygen imbalances which is important for patients sus-

ceptible to myocardial ischemia. Epidural infusions also improve gut mucosal perfusion and prevent against thromboembolism. Local anesthetics can be combined with opioids and other adjuvants for infusion. The lockout interval set is usually for 20–30 min and the demand doses can be taken by the patient for better pain relief.

Patient controlled epidural analgesia (PCEA) is the cornerstone of pain management in major abdominal, pelvic and thoracic surgeries. (Fig. 11.1) Usually dilute local anesthetic is combined with opioids for superior analgesia. Table 11.3 summarizes the various regimens commonly used in PCEA for different surgeries [28]:

11.10 Plan of Analgesic Techniques for Different Surgical Interventions

Different surgeries require different methods of pain relief and multimodal pain management must be followed for optimal analgesia. Nerve blocks and analgesic regimens vary according to the site of surgery and intensity of pain. If regional techniques are contraindicated or not instituted due to any reason, then IVPCA can be instituted with opioids, supplemented with non-opioids. The approximate 24-h morphine requirements for IVPCA in adults between 20 and 70 years can be calculated with the following formula: [29].

Average first 24 hour maintenance PCA morphine requirements in adult patients after major surgery = 100 – Age.

Fig. 11.1 Patient controlled analgesia

However, the dose and requirement of opioids need to be individualized based on adequate pain relief. The dose requirement may show inter-individual variability and also based on complexity of surgeries with regard to tissue trauma. The multimodal regimen of analgesia may be based on site of the surgery.

11.10.1 Analgesia for Head and Neck Surgical Interventions

The analgesia head and neck surgical interventions can be managed with use of nerve blocks and systemic analgesics usually. Though cervical epidurals have been described for neck procedures, however, due to risk of spinal injuries it is not a common modality for pain management. The intravenous systemic analgesics include NSAIDS and opioids (morphine and fentanyl). The nerve blocks are quite popular and are important component of multimodality pain manage-

Table 11.3 Various drug regimens for patient controlled epidural analgesia (PCEA)

Surgery	Analgesic solution	Continuous rate (mL/h)	Demand dose (mL)	Lockout interval (min)
Thoracic	0.0625–0.125% bupivacaine +5 mcg/mL fentanyl	3–4	2–3	10–15
Abdominal	0.0625% bupivacaine +5 mcg/mL; or	4–6	3–4	10–15
	0.1–0.2% Ropivacaine +0.5 mcg/mL Sufentanil	3–4	2–4	10–20
Lower extremity	0.0625%–0.125% bupivacaine +5 mcg/mL fentanyl	4–6	3–4	10–15

Table 11.4 Various nerve blocks for head and neck surgery

S. no.	Name of the block	Indications	Contraindications	Drugs	Remarks
1.	Supra and infra orbital nerve block	Eye surgeries, eye lid repairs	Local infection	0.25% bupivacaine (3–4 mL)	Caution for intraorbital injections
2.	Mental nerve block	Cleft lip repair	Local infection/ hematoma	0.25% bupivacaine (5–10 mL)	B/L submental block
3.	Cervical epidural	Thyroidectomies, neck surgeries	Coagulopathies	0.125%–0.25% bupivacaine (5–10 mL in incremental and titrated doses)	Preferably done under ultrasound or fluoroscopic guidance
4.	Superficial and deep cervical plexus block	Carotid endarterectomy, superficial neck procedures, thyroid surgeries	Caution in bilateral blocks	0.25% bupivacaine (5–10 mL) 5 ml of LA injected in a fan shaped manner for superficial	–

ment. The nerve blocks used will depend on surgical intervention (Table 11.4).

11.10.2 Analgesia for Thoracic Surgical Interventions

The thoracic procedures require a tight balance between an optimal pain relief and sedation due to opioid analgesics. The use of nerve blocks is paramount in the perioperative period and decreases the respiratory morbidity. Various regional blocks have been suggested for thoracic surgical interventions (Table 11.5).

11.10.3 Analgesia for Abdominal Surgical Interventions

The perioperative analgesia for abdominal surgeries depends on the site of surgery, i.e. upper abdominal or lower abdominal. Broadly regional anesthesia is the cornerstone for providing analgesia and it may be supplemented with systemic analgesics. The various regional techniques have been described in literature and provide optimal analgesia (Table 11.6).

Table 11.5 Various nerve blocks for thoracic surgery

S. no.	Name of the block	Indications	Contraindications	Drugs	Remarks
1.	Thoracic epidural	Thoracotomies Upper thoracic Mid thoracic Lower thoracic	Coagulopathies, local infection, anticoagulants	Dilute local anesthetics + opioids +adjuvant	Preferably done when awake. Observe hemodynamics.
2.	Paravertebral	Breast surgeries, nephrectomy	Risk of local anesthetic toxicity and require multiple injections at each vertebral level	Local anesthetics 3–5 mL for each level	Watch out for pneumothorax and hypotension. Perineural catheter insertion under USG guidance
3.	Intercostal	Supplement to thoracic epidural and reconstructive surgeries; relief of pain following rib fracture, herpes, cancer	Result in the highest blood levels of local anesthetic per volume injected; increased incidence of pneumothorax	3–5 mL of local anesthetic at each desired level	Risk of intravascular injection
4.	Interpleural/ Intrapleural	Post-thoracotomy pain	Local pathology; prevent intravascular injection	3–4 mL of local anesthetics at each level	Quality of analgesia inferior to paravertebral or thoracic epidural.

Table 11.6 Various nerve blocks for abdominal surgeries

S. no.	Name of the block	Indications	Contraindications	Drugs used	Remarks
1.	Lumbar epidural	Laparotomies	Coagulopathies	Local anesthetics + opioid + adjuvants	–
2.	Transversus abdominis plane block. Two sites: Subcostal and posterior TAP	Laparoscopic surgeries, caesarian sections. Continuous catheters can be inserted and L.A infused for postoperative pain relief.	Possibility of violation of peritoneum and bowel perforation.	15–20 mL of local anesthetic injected in the plane between internal oblique and transversus abdominis muscle	Preferably done under ultrasound guidance.
3.	Rectus sheath block	Umbilical hernias, tubal ligations	Can result in local hematoma formation.	Local anesthetics	Supra or infraumblical rectus sheath block

11.10.4 Analgesia for Inguinal and Lower Limb Surgical Interventions

The regional analgesia provides adequate pain relief for inguinal and lower limb surgeries. The various regional techniques for analgesia are well described in literature and remain the cornerstone for pain management (Table 11.7).

11.10.5 Analgesia for Upper Limb Surgical Interventions

The upper limb surgical intervention can be well managed with regional anesthesia and which may be continued in perioperative period for analgesia as well (Table 11.8). With the availability of catheters, the brachial plexus block can be used for extended purpose for providing postoperative analgesia.

Table 11.7 Various nerve blocks for inguinal and lower limb surgeries

S. no.	Name of block	Indications	Precautions	Drugs	Remarks
1.	Lumbar epidural: PCEA	Hip, pelvic, and B/L knee surgeries	Coagulopathies	Bupivacaine, Ropivacaine, Levobupivacaine with or without opioids and adjuvants	
2.	Continuous spinal catheters	Same as above	Absolute asepsis and prevention of PDPH	Bupivacaine with or without opioids	
3	Caudal blocks	Herniotomies	Coagulopathies		Can be performed under USG guidance
4	Ilio-inguinal, Ilio-hypogastric nerve block	Inguinal hernia repairs	Local pathology	Bupivacaine or Ropivacaine or Levobupivacaine.	Preferably given under USG guidance
5.	Femoral nerve block	Postoperative analgesia for hip, knee, and ankle	A 3-in-1 block is required to block femoral, lateral cutaneous and obturator nerve	Local anesthetics	Local infection or lymphadenopathy can be a deterrent Continuous femoral catheters can be inserted under USG guidance.
6.	Fascia iliaca block	Anesthetizes both femoral and lateral femoral cutaneous nerves; 2 pops are felt on piercing the fascia lata and fascia iliaca	Preferably done under USG guidance for greater accuracy	30–40 mL of local anesthetics injected after negative aspiration	
7.	Lateral femoral cutaneous nerve block	Used as a supplement to femoral nerve block or for limited anesthesia of lateral thigh.	Preferably performed under USG guidance as the feeling of pop on piercing the fascia lata near the anterior superior iliac spine may not be evident	10–15 mL of local anesthetics after negative aspiration.	
8.	Obturator nerve block	For complete anesthesia of the knee and in TURP for blunting the adductor response	Both the anterior and the posterior obturator nerves can be reliably blocked under USG guidance	Local anesthetics	Adductor canal blocks can be done separately for knee arthroplasties where a continuous catheter can be inserted under USG guidance
9.	Psoas compartment block	Useful for procedures on the hip, knee, and anterior thigh.	It can be frequently complicated by retroperitoneal hematoma, intravascular injection, local anesthetic toxicity	Local anesthetics	Currently, posterior lumbar plexus blocks deposit LA within body of psoas muscle, preferably using a curvilinear USG probe

Table 11.7 (continued)

S. no.	Name of block	Indications	Precautions	Drugs	Remarks
10.	Sciatic nerve block *posterior/ classic/Labat *anterior approach *subgluteal approach *popliteal approach	For surgeries involving the hip, thigh, knee, lower leg, foot	It is preferably done under nerve stimulation and/or USG guidance to avoid complications	Local anesthetics	Sciatic nerve can be blocked at any level from the buttocks till the thigh. With use of USG, lower LA volumes are enough as compared to the landmark technique
11.	Ankle block	Surgery of the foot	Avoid epinephrine with LA; uncomfortable for patient as it entails 5 separate injections	3–5 mL local anesthetics /nerve	The fives nerves (saphenous, deep peroneal, superficial peroneal, posterior tibial, and sural nerves) can be blocked using USG.

Table 11.8 Various nerve blocks for upper limb surgeries

S. no.	Name of block	Indications	Contraindications	Drugs	Remarks
1.	Interscalene block	Surgeries of the shoulder and upper arm	Pre-existing respiratory difficulty or phrenic nerve palsy; local pathology. Preferably done under USG guidance.	Local anesthetics	Horner's syndrome, recurrent laryngeal nerve palsy, or vertebral artery injections can occur, especially in blind technique
2.	Supraclavicular block	Surgeries at or distal to the elbow	High incidence of complications like pneumothorax	30 ml of local anesthetic after negative aspiration.	Preferably done under USG guidance
3.	Infraclavicular block	For distal arm procedures; Intercostobrachial nerve spared	Vascular puncture and pneumothorax	Local anesthetics	Preferably done under USG guidance
4.	Axillary block 3 techniques: Transarterial, nerve stimulation, and USG	For distal arm procedures	Local infection and inability to abduct the arm.	Local anesthetics	Axilla is a sub-optimal site for perineural catheter placement.
5.	Blockade of terminal nerves: Median nerve, ulnar nerve, radial nerve, musculocutaneous, intercostobrachial, and digital nerve (ring) block	Selective nerve block for sensory block of specific area of interest	Local pathology	Local anesthetics	Preferably done under USG guidance.

Intravenous Regional Anesthesia (IVRA): Also known as the Bier's block, intravenous regional anesthesia is useful for extremity procedures of intermediate duration [30]. A high volume, dilute local anesthetic is injected intravenously after limb exsanguinations and sequential inflation of two tourniquets or cuffs (proximal and distal). It is a safer alternative to standard sympathetic blocks in patients with coagulation defects. Tourniquet pain is a problem and duration of postoperative pain relief is limited. Typically 40–50 mL of 0.5% lignocaine is injected, with or without adjuvants (clonidine, dexmedetomidine, or ketorolac).

11.11 Recent Advances

The advent of ultrasound has given the most needed boost to operative and point of care pain management. Almost all blocks are now performed under ultrasound guidance resulting in greater accuracy, reduced local anesthetic volumes, and visualization of drug spread as well as catheter threading leading to increased success rate and better analgesia. Newer electronic pain pumps have been developed which are user friendly, tamper-proof, with accurate alarm systems and more portable. Iontophoretic transdermal delivery system has been recently developed for fentanyl and is as safe as intravenous morphine PCA [31]. In addition, greater availability of transdermal preparations of various analgesics like diclofenac, ketorolac, buprenorphine, and fentanyl has made pain relief reach every needy patient. Newer local anesthetic drugs and their formulations like levobupivacaine, liposomal bupivacaine, and ropivacaine have improved safety profile. Ropivacaine in a concentration of 0.5–1% is used for surgical anesthesia and 0.1–0.3% concentration for analgesia. It is the only local anesthetic that has intrinsic vasoconstrictive properties. Levobupivacaine (0.5–0.75% concentration for surgical anesthesia and 0.125%–0.25% concentration for analgesia) has lesser effect on cardiac conduction and hence, decreased frequency of arrhythmias. Several newer adjuvants have increased analgesic efficacy of pain blocks. Dexmedetomidine has been experimented to have several beneficial effects in pain management, both in systemic and regional administration [32]. It has a multi-faceted role in perioperative pain management, by acting as a perfect adjuvant in epidural, spinal, peripheral nerve blocks and IVRA. *Calcitonin,* a peptide hormone with role in calcium homeostasis, has a role in treatment of acute pain due to osteoporotic vertebral fractures and reduction of acute phantom limb pain. *Gabapentin and pregabalin* (alpha-2-delta ligands) reduce the central sensitization of pain pathways after injury and hence used as preoperative medication, to decrease opioid requirements. Alternate methods of pain relief like acupuncture or acupressure, TENS, cryoanalgesia, intra-articular injections, psychotherapy, and hypnosis can be combined with the above agents for better patient satisfaction [33].

11.12 Conclusions

Pain must be recognized as a vital parameter and treated on priority basis in every surgery. Pain management is a team-effort and all members of the surgical and anesthesia team must coordinate and commit for a pain-free perioperative period. Multimodal analgesia is the dictum, starting from mild analgesics, opioids, and regional blocks. Major scientific advancements in the field of regional anesthesia, in the form of use of ultrasound guidance, continuous plexus catheters, PCA pumps, and advent of newer agents have revolutionized pain management. Patients on chronic opioids (cancer patients) have greater analgesic requirements, both intra- and postoperatively, with the risk of development of adverse effects, tolerance, dependence, and opioid-induced hyperalgesia [34]. Special precautions, with dose adjustments need to be taken in extremes of age and pregnant women. Prompt management of acute pain is essential not only for blunting the associated sympathetic nervous system response, but also for prevention of development of chronic pain states. Continued education program and in-service training on pain management must be provided for a successful outcome, both short-term and long-term.

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