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Post-Operative Pain Management: A Modern Approach

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ABSTRACT

Post-operative pain may influence the content of postoperative stress response. New approaches focus on optimizing pain management by using preemptive, preventive, and multimodal analgesia. This includes continuous wound perfusion for 3–5 days postoperatively and adding omega-6 fatty acid derivatives to local anesthetics as well as lidocaine and several alpha-2 agonists to various analgesics. Dose fractionation strengthens the intense analgesic component of opioids. The application of ethylene requires elevated endogenous ligands in the brain tissues and the intimate contact of exogenous ligands with specific anti-nociceptive receptors. Recognition of acute on chronic pain facilitates tailoring of post-operative pain management to the individual patient. Neuro-immune mechanisms pave the way for a ban on immunosuppressive opioid-sparing agents in major surgery. (Cooney & Quinlan-Colwell, 2020)

Keywords: Post-operative pain, Physical pain, Nociceptive and neuropathic pain, mixed post-operative pain, Acute post-operative pain, Opioids, Chronic pain, Acute on chronic pain, Endogenous ligands, Posterior horn, Neuro-immune interactions, Anesthetic concentrations, Omega-6 fatty acid derivatives, Multimodal analgesia, Preemptive analgesia, Dose fractionation, Continuous perfusion.

1. Introduction

Postoperative pain is a clinical entity of significant importance because of potential short- and long-term adverse effects. Because of the diverse surgical population and the constant advancements in surgical techniques, postoperative pain management remains complex, sometimes addressed inappropriately. The pathophysiology of postoperative pain, including the role of peripheral nociceptors and the challenges of assessing postoperative pain, will be addressed. Factors that aggravate postoperative pain, such as preoperative pain, anxiety and depression, and comorbidities such as hypertension, and the potential consequences of inadequately treated postoperative pain will be discussed. Currently, there are a myriad of modalities available for postoperative pain management, and intervention should be multimodal and guided by mechanisms of action and evidence-based data for each modality. Techniques that are available for postoperative pain management will be comprehensively addressed, including the available pharmacologic and non-pharmacological options. Promising modalities under current investigation, including drug and gene therapy, will be discussed, and future challenges and opportunities will be presented, with a focus on providing solutions. (Gao et al., 2023)

1.1. Scope and Importance of Post-Operative Pain Management

Pain is an inherent part of the majority of surgical procedures. It is a complex psychological, social, and physical phenomenon. In general, pain is considered a protective mechanism to prevent tissue damage. This protection comes from the fact that the sensory perception of pain makes the subject react reflexively by withdrawing the affected part from the pain stimulus, thereby minimizing the damage. The importance of pain modulation comes from the characteristic that the sensation of pain remains the same over time even though there is a progressive aggravation of the underlying tissue damage. Thus, its primary function is to signal danger to the damage of tissue, promoting defensive reflexes that protect the tissue from additional damage. However, in a surgical context, pain becomes critical when it is both strong and long-

lasting. In certain situations, when there is a disproportionate sensation of pain or when conjecture exists about the probable duration of the painful condition, pain interruption becomes desirable. This is particularly frequent in postoperative pain management. (Jain et al.2024)

2. Physiology of Pain

When we recognize that a patient might be in pain, we must understand the physiology and the nature of that pain, i.e., nociceptive or neuropathic, to be able to understand that patient's pain. Nociceptive pain is the result of a noxious stimulus on normal tissue, leading to the release of inflammatory mediators, all of which produce chemonociception. In the first phase of nociception, these inflammatory mediators cause hyperalgesia and allodynia, particularly when there is a sucking and draining wound, as in a mastectomy or orthopedic surgery. These mediators also produce peripheral sensitization of nociceptors and the second phase of nociception. It is this peripheral sensitization that causes an increased response to a given stimulus, hyperalgesia and allodynia, and a reduced threshold of nociception, all of which can be ameliorated with a peripheral nerve block. It also leads to an enhanced response to second pain, and this aching referred pain is neuropathic.

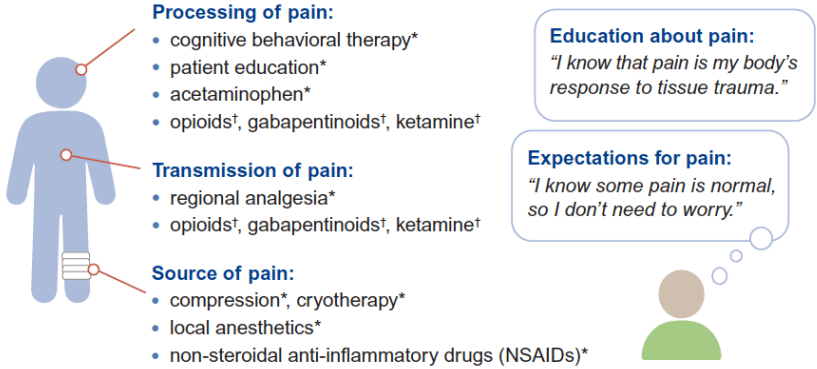
Strong opioids are used to block end-stage nociception. For anesthetists, giving a bolus dose of an opioid for induction of anesthesia appears to block both first and second phase nociception in many patients, allowing for immediate extubation and analgesic drugs post-operatively. However, when used post-operatively, these drugs produce severe side effects, and the use of patches or other techniques to block the influx of first and second phase chemonociception through peripheral nerve block or local anesthetics injected extraperiosteally along the line of the wound before wound closure seems to be a very good way of avoiding excessive opioids post-operatively. This also enhances recovery and reduces the incidence of post-operative cognitive impairment; patients talk more to their carers in the first few hours post-operatively, which could be important in the early detection of post-operative related morbidity such as confusion. (Rigal et al.2021)

2.1. Nociceptive Pathways

The first step in the management of pain is an understanding of the components of the pain-inducing stimuli. The sensation of pain does not have a single pathway but is actually the result of the interaction of a number of different stimuli and feedback loops at many levels along the pathway of transmission from the receptor to the site of interpretation in the upper CNS. Pain is much more than just a response to noxious stimuli. Instead, it is the result of a transduction process of a damaging event at the level of the receptors of the tissue involved. Painless stimuli such as a light touch, which are mediated by low-grade input from the skin or by innocuous heat or cold, are transduced by a different medium.

Secondly, not all sensations of pain that are perceived reach the level of pain appreciation in the brain. Some isolation of the primitive reflex from the stimulus may occur at the level of the spinal cord. This evidence comes from the fact that a complete section of the spinal cord, such as might occur with an upper cervical cord injury, can totally abolish the ability to connect the stimulus to the areas of the brain that can

understand the extent of the nociceptive stimuli. In the animal model, the animal senses pain in the legs, as evidenced by an appropriate motor response to a noxious stimulus, but the animal's behavior leads observers to believe that the animal is otherwise free of pain. (Yang et al., 2024)



3. Assessment of Pain

The assessment of pain starts with the patient's self-report. In adults who can report pain, a simple, valid self-report measure such as the NRS should be used. It is important that health care professionals appreciate that the patient's self-report of pain is always the single most reliable indicator of the presence and intensity of pain. Whenever possible, pain reports should be obtained from the patient himself, not from family members, visitors, or health professionals who may be accompanying the patient. However, pain can (but not always) be assessed in people who are impaired in their cognitive and communication abilities using observational scales developed and validated for specific populations. In these circumstances, a change or variation observed in pain behavior should be interpreted as a response to pain; professionals should not assume that the intervention or treatment is or is not effective in reducing pain unless the person experiencing pain is able to self-report.

In children 8 months to 7 years of age, self-report may be impossible. A widely used self-report measure of pain is the Faces Pain Scale, which consists of a series of cartoon-like images of facial expressions that reflect an increase in brow bulge and marks by a description of the patient's pain. If the patient is able to speak, in addition to a self-report or possible self-report, an assessment of the pain should include bringing the intensity of the observed expression of pain (if possible) in relation to the infant's ability to self-report, to be confirmed (or not) by an observable increase in pain behavior during interventions and, hopefully also, during pain relief. In children older than 4 years and in teenagers, it is possible to obtain self-report of pain ratings, using a numeric or facial scale. Whenever possible, self-report of pain or self-report of interference with function due to pain should be confirmed in nonverbal children and the very young by either the child participating in the interview or the observing staff adjusting analgesia established on the basis of the child's regular activities. The long-term effect on the child's functioning and behavior is an important part of pain

assessment, as well as the serial assessment of self-report to provide ongoing pain assessment. (Nock et al.2022)

3.1. Tools and Scales for Pain Assessment

Assessment of acute pain in children following major surgery presents a challenge to the medical staff. It is a subjective experience, and neonates, pre-verbal infants, and children are not always able to express themselves. In older children, the perception of pain, its degree, and its relationship to the circumstances related to the injury will vary individually. Previous experiences, temperament, cultural background, and age can influence the observable signs of pain and the ability of medical staff to interpret the degree of pain present. The stress of the disease event and pre-operative fears may affect the child's behavior and the perception of pain. Infants are especially vulnerable to pain, and untreated severe pain may have an adverse effect on the neurological development and psychological function of the child. (Harrison, 2021)

Therefore, a tool for the assessment of post-operative pain in pre-verbal children is essential. Recognition of the signs of pain is the first step, because a careful assessment should provide a better indication of whether pain actually exists. Prompt recognition and assessment of pain are necessary in order to assure effective relief of the symptom and planning of any additional diagnostic procedures. The assessment process begins with the parents, who should be considered the "experts" since they have presumably spent hours or days with the child at home.

4. Pharmacological Interventions

So far, adequate analgesia could be provided by opioids administered as single entities or in the form of an adjuvant in treating moderate or severe pain. Acetaminophen is regularly used as a basic adjuvant and an essential part of multimodal analgesia, together with some anti-inflammatory or neuropathic drugs and antibiotics. A three-stage 'analgesic ladder' is suggested to alleviate cancer pain, but most of its tenets are applicable to pain stemming from other causes. In treating mild pain, oral nonsteroidal anti-inflammatory drugs (NSAIDs) should be administered alone or in conjunction with acetaminophen. Certain strong opioids or specific adjuvants could be used additionally, if needed, in the course of moderate to severe pain management.

Non-opioid analgesics are mainly used to treat mild and moderate pain or as an adjuvant to opioids in managing severe pain. NSAIDs, acetaminophen, and some antiepileptic or antidepressant agents are well established for this indication. The use of other pain relievers is less common and based on experimental or unmutated practice data. New drugs are now being developed for opioid-dependent conditions to provide non-opioid analgesia. In post-operative pain management, preference should be given to potent non-opioid analgesic adjuvants in view of the risk associated with opioids when considering an adequate balance of pain relief and appropriate safety. Their effectiveness in a multimodal intervention regimen for post-surgical pain can be successfully applied if this knowledge is kept up to date. The present review outlines both familiar and less widely applied non-opioid analgesic adjuncts for the treatment of postsurgical pain, highlighting their place in contemporary multimodal pain management. (El-Boghdadly et al.2024)

4.1. Opioids

Opioids are commonly used for post-operative pain management. They bind to receptors in the central and peripheral nervous system and exert their action at various sites. This may result in respiratory depression, nausea, vomiting, itch, constipation, and sedation. They are also widely used for inducing and maintaining general anesthesia, as most of the anesthetic agents produce analgesia adequate for anesthesia but not post-surgical pain relief, and so analgesia is the most common clinical reason requiring medical attention after an operation. They may be administered systemically through many routes such as oral, nasal, subcutaneous, intramuscular, and intravenous, or may be used in regional blocks as peripheral administration.

There are risks and limitations to opioid administration. Side effects such as respiratory depression, nausea, vomiting, constipation, urinary retention, and sedation may hinder their use. Tolerance may develop with prolonged administration. All these side effects are a significant burden to patients who have just undergone an operation. Tolerance is affected by a decrease in receptor number, affinity, functional coupling, or an increase in efflux transport in the cellular membrane and contributes to the shortcomings of long-term opioid administration. Opioid-sparing strategies are therefore necessary.

5. Non-Pharmacological Interventions

In order to optimize pain management, the utilization of non-pharmacological interventions aimed at augmenting pain relief from pharmaceutical interventions, while minimizing side effects and the risk of addiction, is recommended. To date, educational and informative interventions with and without multimedia, distraction, massage, and touch, pre-medication exposure with benzodiazepines, classical music, aromatherapy with lavender oil, relaxation techniques, and cognitive-behavioral coaching have been studied and have shown varying degrees of usefulness for pain relief. However, no official guidelines for the direct implementation of such interventions are currently available.

Acupuncture has also shown some positive results for acute postoperative pain after gastrointestinal, musculoskeletal, and orthopedic procedures. However, no acute postoperative guidelines exist for its application, and a previous systematic review found inconsistent results for its use in this area. Optimally, the use of non-pharmacological interventions with high returns that a poor patient can adapt to his needs will ultimately allow for a more patient-centered multimodal analgesia. The clinician must be familiar with different inexpensive and safe interventions that can provide a meaningful and positive patient pain experience without incurring the disadvantages of opioid administration, which prolongs hospital stays and increases the risk of addiction, chronic opioid abuse, and the related risk of adverse effects. The increasing availability of evidence-based non-pharmacological interventions will help guide perioperative physicians in the selection of practical alternatives that can improve patient care in aged care units without additional costs. (Lu et al.2021)

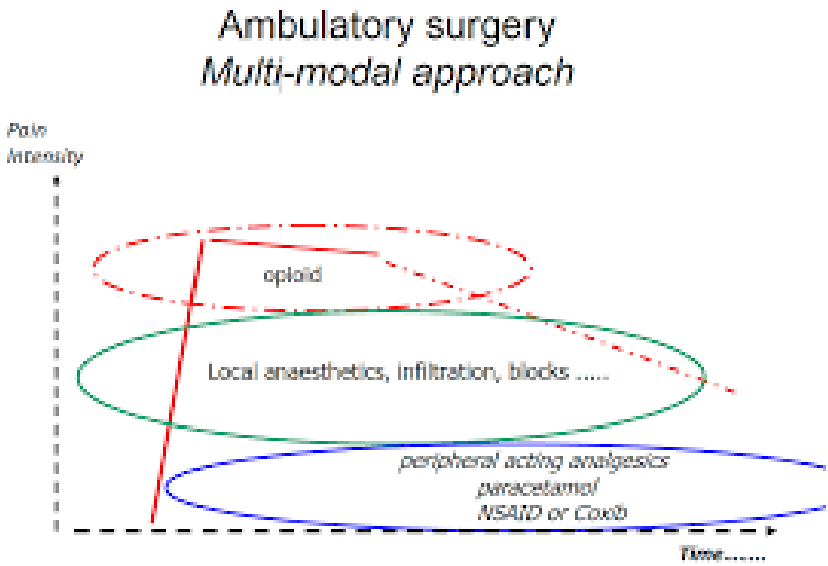
5.1. Physical Therapy

Postoperative thoracic exercises are important for patients undergoing thoracic surgery. Doing physical therapy exercises before the operation is important, and their regular practice before and after surgery increases functional capacity. In postoperative patients, persistent incision and surrounding muscle pain may be present. However, although preventable, chronic post-thoracotomy pain can also cause significant problems. The use of thoracic intravenous analgesic approaches, including pain catheters after surgery, intraoperative or postoperative incisional wound infusions, and postsurgical nerve blocks, has decreased acute incisional pain. However, it is still an important source of morbidity in patients after thoracic surgery. As pain following thoracic surgery causes intensity and location variability, it is a multi-dimensional situation and requires multi-modal approaches. This subject's expertise examines many centers ranging from pain centers to regional anesthesiology units. Patients are no longer assessed in the postoperative period when neuropathic pains begin and chronic pain treatments are started. The model of the expert system has changed to offer multi-dimensional treatments beforehand. (Hu et al., 2021)

It recommends conservative, interventional, and psychological treatments also during the perioperative period for the development of persistent post-thoracotomy pain. In the preoperative period, information about thoracic surgery and the presence of patients complaining about chronic thoracic pain should be recognized. Identifying the risk factors and even using pain scoring systems and conducting preventive treatments prior to the final condition help reduce the side effects and the financial burden of drug treatment during the postoperative period. Many protocols used in the postoperative period are becoming widespread in preventing pain during the perioperative period. For example, physiotherapy is only for patients who had postoperative pain and appeared in the treatment process. This procedure is actually important for the prophylaxis and treatment of chronic post-thoracotomy pain. Therefore, the aim of this review is to emphasize the importance of preoperative physiotherapy exercises in an anatomic sense as well as discuss various applications and their advantages.

6. Multimodal Approaches

There seems to be an increasing acceptance among surgeons, anaesthetists, and patients for approaches to postoperative pain management that do not rely upon the exclusive provision of analgesics based on opioids. These are frequently referred to as 'multimodal' treatments, albeit there are a number of approaches to this, and not all are truly multimodal. For that to be the case, the modality should deal with the pain at its peripheral source, and not simply by diverse approaches to a central mode of analgesic action. Given that any unimodal approach will almost certainly be imperfect because of the multiple mechanisms involved in the generation of postoperative pain, it seems logical to combine treatments in a multimodal way. There are substantial implications for perioperative management when multimodal approaches are used. The treatment combination can only be effective if the analgesics work by different routes and sites of action and ideally lead to future generations of combination drugs. Because the treatments act at different loci and have different pharmacodynamic properties, this should permit the use of lower doses of any given drug and reduce the incidence of adverse effects. (Sherman et al.2020)



6.1. Rationale and Benefits

The concept of preemptive analgesia is based on the fact that tissue and nerve trajectories will result in modification of central pain pathways. These changes can be amplified by a second injury, such as incision and resection, which can lead to uncontrolled pain in the immediate postoperative period, and preemption becomes necessary to control it. Therefore, continuous blockade intra- and postoperatively is necessary to avoid pain at its worst time, optimizing nociception and preventing structural and functional changes in the CNS. It should be emphasized that effective analgesia avoids the suffering of an animal and allows the professional to comply with the indicated anesthetic protocol for advanced surgical treatment with a good gain in postoperative recovery time. Benefits were noticed in decreasing the activity of the hypothalamic-pituitary-adrenal (HPA) axis, avoiding exaggerated release of cortisol, essential to decrease the risk of infection. Locoregional anesthetics directly reduce the release of corticotropin and cortisone, decreasing metabolic disturbances related to stress responses, and accelerating the resolution of ileus, thus accelerating postoperative recovery, proportional to the extent and effectiveness of analgesia provided, recovery that ends three days after surgery. It is recommended that a blockade ends the following day if kept at home and two to three days if kept in the hospital. This type of approach will minimize the use of long-term analgesics and the use of sedatives, while the professional complies with all ethical principles. Finally, it values clinical examination for proper guidance of the therapeutic measures. (Passias et al.2023)

7. Regional Anesthesia Techniques

If a major surgical procedure is planned on an extremity, the use of regional anesthesia techniques is extremely useful for postoperative analgesia. Indeed, numerous clinical trials confirm that regional block techniques offer more effective acute pain relief and

greater patient satisfaction compared with general anesthesia combined with parenteral opioid administration. The optimal time for performing peripheral and neuraxial block or the sequence of the different blocks to be performed is still a matter of debate. In terms of premedication, some anesthesiologists consider sedative premedication necessary for a child so they are less agitated in the operating room before loss of consciousness during the induction of anesthesia, and a sedative might also be useful to counteract the itching and burning sensations that some children experience after the administration of the local anesthetic. (Albrecht & Chin, 2020)

A continuous femoral block is useful in diagnostic and therapeutic procedures performed on the distal half of the femur, including patella surgery, reimplantation of the lower limb, and polytrauma. A single-injection block is made at 1-3 cm lateral to the femoral artery, with the bevel of the needle directed toward the artery and with an initial ECG output of 0.2-0.5 millivolts. The needle is advanced toward the femoral nerve sheath, and after the induction of motor evoked potentials, a specified volume of levobupivacaine or ropivacaine is administered with the risk of systemic toxicity. Other peripheral nerve block techniques that may be useful in children include: block of the ilioinguinal and iliohypogastric nerves and genitofemoral block in the brachial axillary area.

7.1. Peripheral Nerve Blocks

Large evidence supports the role of peripheral nerve blocks in the management of postoperative pain. This modern approach is called a multimodal or balanced analgesic technique. A peripheral nerve block can provide high-quality intra- and early postoperative analgesia. It has been revealed that catheter-based techniques can block pain impulses from the periphery and decrease the neuroendocrine response to the surgical procedure and high levels of opioid analgesics, which can cause acute tolerance. Any peripheral nerve block technique allows avoiding side effects and enables the total population of patients to benefit from this method. Blocks improve early movement after surgery, reduce the risk of peri- and postoperative infections and delirium, and prevent the development of neuropathic pain and postoperative chronic pain. (You et al.2021)

Single-shot peripheral nerve blocks are the most widely used techniques, which provide a prolonged postoperative analgesic effect but do not eliminate the pain that can occur in the late postoperative period. The possibility of accidental damage to blood vessels, nerve roots, or spinal nerves, as well as a high percentage of inadequate nerve block formation, can be attributed to the drawbacks of the single-shot peripheral nerve block technique. The catheterization of the plexus or an individual nerve structure provides the possibility of prolonged pain relief and allows extending the postoperative period of sympathetic nerve block in an attempt to affect the development of chronic pain, in particular, to prevent the development of post-mastectomy lymphedema.

8. Patient Education and Empowerment

Patient education is recognized as an integral part of pain management. Pain education programs are designed to impart information to patients about ways they can independently manage their pain. They also provide greater insight into the pain

process, what is happening to their bodies, why pain management strategies work, and, in short, how to be an active participant in their management program. Patients who understand what is happening to them are able to answer important questions such as 'Have I given pain relief a chance to work?' and 'Is it time to mobilize and minimize the inactivity that perpetuates pain?'

Education helps patients and families provide a caring and supportive atmosphere for recovery from pain. Regrettably, however, despite the availability of a number of approaches and interventions to manage postoperative pain, under-treatment of pain is still prevalent. Studies continue to find that, until now, the problem of pain under-treatment has not been solved regardless of the introduction of new products or standards for the management of pain. Failure to provide adequate pain treatment is particularly important when the market is filled with so many new potent opioids to handle moderate to severe pain. (Mika, 2022)

8.1. Role of Patient in Pain Management

One of the most important demands for better pain treatment is to involve patients in their treatment. This requires that patients are informed about their situation and what can be done to improve pain management. Health workers have to provide information that patients can understand and use. This also includes being able to make decisions on which options to choose. Another aspect is the patient's own management of pain. Today, many operations are performed as outpatient procedures with no stay in the hospital. This means that the patient has to manage his or her pain at home. If analgesia fails or if the patient is not instructed properly, this may result in unnecessary readmissions. However, patients vary in their perceptions and abilities, and their needs in post-operative pain management. It is therefore very important to tailor pain management to the physical, medical, psychological, and sociocultural needs of individual patients. Nurses have an important role in providing support to patients and their families. Relatives or community support, such as visits at home, may be necessary. (Jaleta et al., 2021)

9. Barriers to Effective Pain Management

As with any new strategy or clinical concept, there is no choice but to also acknowledge the practical, political, and educational issues or barriers that currently serve to impede its dissemination and implementation. Our knowledge of the biology of acute pain, particularly post-operative pain, has improved its clinical management, and although much has been achieved, further improvement is still a desirable outcome. Unfortunately, despite the existence of many clinical guidelines aimed at improving the standard of pain management in health care, many patients still experience high levels of pain. Barriers to effective pain management include fear of addiction, concerns about tolerance, inadequate knowledge about the assessment and management of acute pain, and negative patient attitudes toward analgesics such as opioids.

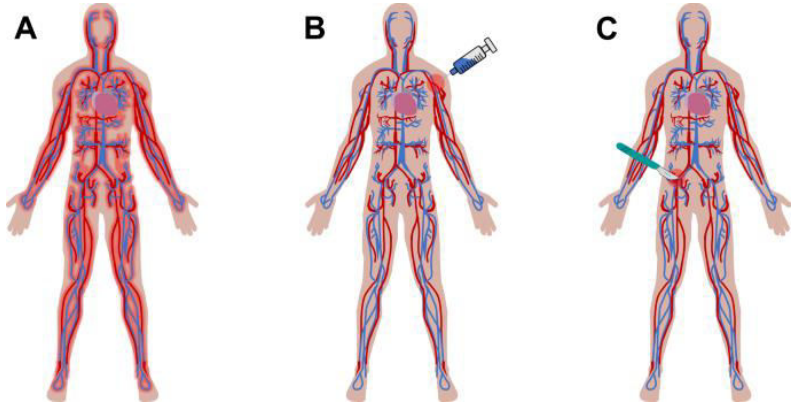
A lack of understanding about how to use opioids effectively, in conjunction with the experience of patients failing to achieve satisfactory pain relief while using these agents, understandably leads to a situation where opioids are often used

inappropriately. Consequently, ineffective pain management is a major public health issue in which the attitudes and knowledge of individual professionals, patients, and the wider community all play an important role. Established pain services are expensive to run, and many hospitals continue to undervalue the concept of pain relief as an important outcome measure for potentially painful surgical procedures. This tends to result in insufficient numbers of appropriately skilled staff who consistently apply the best available treatment modalities to patients in pain. In conclusion, while further improvements in effective pain management are desirable, the challenge is to decrease the barriers that impede its widespread implementation. (Li et al., 2021)

9.1. Healthcare System Factors

Finally, patients may have limited financial capacity to purchase large quantities of postoperative analgesics, which can perturb their current needs. Providing adequate medications for longer than necessary may provoke overuse of those substances, another possibly unsafe behavior. Affluent migration predisposes that many citizens, especially those working abroad, do not have health insurance coverage in their country of residence or employment. Each policy reinforces others and creates an irrational framework, which affects pain management standards as well.

Patients can also suffer as a result of more complex processes than those included in regular pain management protocols. Many specifically at-risk patients who agreed to postoperative analgesic recommendations from surgeons, ward nurses, and their operational department briefings may reject advice from comprehensive pre-anesthesia check-ups. Undergoing surgery may have involved decisions influenced by multiple stresses, not only about the operation and its outcome, but also who would provide support through the experience, how to maintain confidentiality, when to inform one's family, when and where to have surgery, and how to pay for the procedure. The added interest in analgesia for variable periods after the operation is necessarily different from the underlying surgical risks against which the planned anesthetic will be weighed. Given complex cases that brace a lot of anxiety, further encouragement is indicated. (Gray et al., 2021)



10. Emerging Technologies in Pain Management

One of the most scientifically interesting fields in pain research is being explored by the use of virtual reality. Visual imagery can modulate brain responses to painful stimuli. Virtual reality offers a unique way of conveying visual information in 3D space. An immersive and realistic sense of simulation may lead to distraction because tasks are more enjoyable, and attention is focused away from the perception of noxious stimuli. The key potential advantage of VR distraction appears to be the ability to manipulate visual information so that painful surgical procedures can be made to seem less threatening or appear to have halted. This also would be the goal of using VR at the bedside of patients who are fearful of future surgical procedures. The use of a self-hypnosis virtual reality system may be effective for providing anxiolysis and analgesia in many patients who are to undergo medical procedures with intravenous sedation. Music is another environmental factor that may be useful in enhancing patient comfort during ambulatory surgery. (Bosso et al.2023)

Preoperative counseling as well as dosing information regarding postoperative medications have improved ambulatory postoperative outcomes. Substantial progress has also been made in improvements in the pharmacological treatment of established pain, and substantial change is occurring as new avenues of research are realized. Despite the availability of PCA, patients' reluctance to push the button can determine the efficacy of postoperative analgesia. In order to improve patient satisfaction and postoperative recuperation while reducing total pain medication, great efforts have been made in creating treatment alternatives to PCA systems used today. One interesting technological breakthrough that totally bypasses the involvement of medical doctors is contained in the Patient Safety System developed by a company. Their system, possibly combined with telemedicine technology, may also turn the way in which current pain management technologies look completely around.

10.1. Virtual Reality

Virtual reality (VR) refers to three-dimensional, interactive graphical environments designed to provide the viewer with the feeling of actually being in a virtual world. The user normally dons a head-mounted display (HMD), which includes a liquid crystal display (LCD) or silicon micro display, optics, and head-tracking motion sensors. This system allows the user to look around the virtual environment and feel surrounded by it. Virtual worlds are often derived from computer-aided design (CAD) drawings, architectural plans, or other plans. The interactive environment utilizes sophisticated software to reduce the time lag between changes in head position and head orientation. This ensures a continuous real-time 3D view of the virtual environment, helping the user to orient and behave naturally and to experience the illusion of being in a real place.

A variety of commercial tools is employed to support the development of virtual worlds and their incorporation into user applications. These tools are usually based on high-quality software applications that are not accessible to the typical developer. The typical VR system has four interrelated components: i) the graphical system that generates two large, slightly different images from slightly different viewpoints to produce a sense of depth when a binocular viewer is used; ii) the head-tracking system

rendering the head-mounted display (HMD) able to detect the position and orientation of the user's head and to update the view correspondingly; iii) the sensor-IO system that connects to the user's data glove, data suit, or a six-degree-of-freedom motion platform providing the force-feedback interface; and iv) the host computer that receives the data from the prior three components and generates the images in real time according to the user's viewpoint.

Commonly, the primary function of VR is to entertain the user and to preoccupy them with a false cognitive focus. The applications usually include games, travel, and rock concerts. VR redirects attention from suffering. Its utilization for acute therapy during and after medical interventions is, however, unexplored. Although typical side effects of pharmaceuticals such as secondary nausea, somnolence, constipation, and psychotropic dizziness might be exacerbated by VR in some cases, the non-pharmacologic aid offered by VR to supplement or replace pharmaceuticals cannot be dismissed lightly. Studies in varying medical conditions have shown a reduction of subjective pain intensity by VR. Not all patients display favorable reactions. Reasons for non-participation and minimized analgesic performance are today uncertain. They may involve behavioral random walk, which requires a great deal of control, and they may partly be due to social drawbacks. It is not yet known in which types of VR scenarios these interventions work or fail, or which factors are responsible for reducing or increasing cyber sickness and anxiety. (Ramaswamy & Wodehouse, 2021)

For some patients, interactivity and belief in the cyber setting can be used to render the therapy more engaging and fun; sound effects and extra hardware may have a minor or greater impact on pain relief, engagement in a pain game, and appreciation compared to the first generation. Even though the cost of a VR session is not minor, a main question is the total amount of money. The delivery of so-called constant care to patients in private homes also has to manage constant feedback from telerehabilitation. For patients supported in private homes, controlling hardware failures, ensuring the VR system, conducting standard verification, and ongoing technical help will probably raise costs. Providing the positive effects of VR as analgesia by using videos of real virtual worlds should not dishearten efforts to enhance VR technology as a pain control tool.

11. Ethical Considerations

The effective management of post-operative pain has significant implications in medical law and in the increasing field of health care ethics. A patient in pain has a fundamental right to adequate treatment, and nurses, fortunately, are often in a position to guarantee this. Administration of effective pain relief can result in a student nurse briefly 'trumping' a more senior doctor. Health care ethics concern traditional philosophical questions about right and wrong, and responsibility and obligation. The central concepts include the principles, codes, and rules in medicine, the health care providers, and the ethos of medicine. The emphasis in this modern approach is upon the sufficiency of these for the protection and well-being of the right to health and the conduct and behavior of health care professionals. They all apply to the management of post-operative pain.

Some patients may consider that post-operative pain results in a deprivation of liberty and, as a consequence, may look for compensation when adherence to their beliefs is

not followed. If the claim is successful, how can this loss or harm be quantified? Does pain result in a reduction in quality of life? Can there be an infringement of human dignity with an acceptable level of anesthesia or analgesia? Pain may be considered to be a continuum, from mild discomfort to severe suffering, influenced by a wide range of interconnected variables. Therefore, qualitative as well as quantitative research may be used to add to our understanding from the patient's perspective. If a detailed pain history is taken, how can the patient's right to privacy be maintained? Is it ethical not to inform any patient who is able to communicate about what will occur during the operation and about the range of techniques that will be used to control his or her post-operative pain? (Cohen et al., 2021)(Ferro et al.2021)

11.1. Balancing Pain Relief and Opioid Risks

Pain is a complex and subjective experience that can affect every aspect of a person's life. There are two different types of pain: acute and chronic. Acute pain frequently requires intervention by the anesthesiologist and postoperative nursing staff. When acute pain is not managed, the patient may have poor short-term and long-term outcomes. As a result, uncontrolled acute pain may lead to chronic pain. Physicians tend to provide the just-in-case or polypharmacy approach for pain without consideration of the risks to the patients. Uncontrolled acute pain, coupled with the postoperative use of opioids, can lead to side effects and unacceptable risks. Optimization of pain relief benefits should involve minimizing opioid use. Preemptive analgesia, procedures to reduce pain and inflammation that use interventional techniques on peripheral nerves, is a new strategy offered by dependable and helpful postoperative pain relief through better patient handover.

Combining these methods and replacing old agents with new agents may bring about transformation of perioperative acute pain management with a goal of value-added analgesia, which provides the patient with the right pain relief with a chance of the least negative effect. Use of a rational approach with the understanding of drug pharmacology and drug kinetics, avoiding or reducing polypharmacy, concomitant use of multiple drugs, and the ideal use of multimodal analgesia can save the patients from adverse events and suboptimal results. Such a strategy minimizes the risks to our patients and preserves the secret recipe of delivering an individual type of the best analgesia cocktail. Information on immediate drug benefits should also be provided to the patients preoperatively, including the documentation of potential harmful effects of any medication. Furthermore, plans to deal with the most day-to-day occurrences, potential drug–drug interactions, and any recent changes in lifestyle should also be properly organized and identified for any drug prescribed by the physician.

12. Future Directions in Post-Operative Pain Management

The future looks bright for post-operative pain management. Multimodal treatment regimens and modern analgesic formulations that facilitate post-operative pain management will continue to evolve and improve. Expanded access in secondary care and community settings will mean that treatment concepts that focus on sustained release and administration techniques, including perineural and local anesthetic treatment, will continue to gain importance. Particular attention will be paid not only

to the multimodal treatment of analgesia through different routes but also to co-administration of fluid.

Participants from various regional countries were invited because of their expertise in the field of post-operative pain treatment and their potential involvement in shaping relevant principles of post-operative pain management for use by Eastern European practitioners. These principles will be developed on the basis of the current evidence and guidelines over the coming months and, after considering other relevant aspects, will be disseminated through national societies using procedures consistent with the practices applied in the formulation and handling of existing guidelines.

12.1. Precision Medicine

The aim of precision medicine is to provide the right treatment to the right patient at the right time, by taking into account that the cause of a disease and its prognosis may be significantly different between individuals. Effective analgesia is fundamental to achieving enhanced recovery and for reducing morbidity and healthcare-associated costs. Since a one-size-fits-all strategy often fails in the context of postoperative pain management, one of our main challenges is to understand and optimize the large inter-patient variability in analgesic responses. Consequently, applying the precision medicine approach for postoperative care can be valid and very helpful. Indeed, applying the precision medicine approach for patients undergoing elective surgery is a realistic initiative. Surgery is pre-scheduled, standardized, and allows significant patient pre-selection. Patients often share similar clinical conditions favoring homogeneous groups. Currently, personalized anesthesiology and postoperative pain therapy are possible and can be optimized by integrating clinical and molecular information such as patient pre-operative physical and mental status, medical history, medical history of first-degree relatives, avoiding inappropriate surgical stress, screening for predisposing psychocognitive factors, pain hypersensitivity, and performing genotyping analyses of crucial pharmacokinetic and pharmacodynamic genes. Such patient-tailored care should now be extended to all elective surgical patients. (Khan et al., 2020)

13. Conclusion

Although the human body is a very complex structure and the management of post-operative pain involves many intricate processes, the pathway to achieving that goal is relatively straightforward. Most surgical teams are aware of the tools available to treat post-operative pain but too many are reluctant to employ them adequately or let those patients who really need them have access; often overtreatment is better than undertreatment in pain management. Post-operative pain is a significant source of patient dissatisfaction and a major cause of increased length of stay in hospital after surgery. Deaths or serious complications from the treatment of post-operative pain with appropriate intravenous opioid analgesia are highly unlikely. There is no reason to deny appropriate analgesia to anyone who is in severe pain.

All patients have a right to expect appropriate alleviation of pain, their greatest concern, at the time of surgery. Like all “rights”, this must be balanced against their individual needs and the ability to ensure that inappropriate doses of analgesia are not administered, either inadvertently or otherwise. To ensure that all appropriate patients

receive adequate pain relief to support their recovery from major surgery requires a dedicated team approach involving the patient themselves as well as the hospital, local community support and the surgical team.

13.1. Summarizing Key Points

Post-operative pain management: a modern approach is directed toward delivering an underpinning body of evidence supporting best practice in acute and chronic pain management and also the use of quality improvement methodology and innovation in the provision of acute pain management services. The essential message is to address the information, systems, and the patients so that an optimal approach is delivered. While individual patients and individual settings might suggest that such sophisticated services are not necessary, it is incumbent on professional care providers to offer the best in structured and evidence-based pain management by default. The ability to individualize care is underpinned by a structured approach; avoidance of excess pain is a physiological and reasonable goal; empowering and understanding the physiology of pain and pain management means care can be supported and not hindered by placebo therapy, by the organized approach to care and the opportunity to develop a positive expectation of relief as care is delivered. Societal expectations to have a pain-free experience can be managed in a supported manner. (Baamer)

Briefly summarizing key points associated with a new approach to post-operative pain management, this text reinforces a number of important points. A strategy for anesthetic management must always work in tandem with an appropriate approach to post-operative pain management; the interrelationship between anesthetic techniques and the duration and type of post-operative pain is crucial. A specific demonstration of shortened hospital stay with less opioid used post-surgery is an example of better patient care delivered with multimodal pain management. This example should become the expected standard. It is essential to see this text as reinforcing the goal of structured delivery of known best practice and not only as a manual for the occasional patient with complex pain problems. Suboptimal continues to be the norm for too many.

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