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Prevention and Management of Postoperative Pain in Laparoscopic Cholecystectomy

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Abstract

Laparoscopic cholecystectomy is the mainstay treatment of benign biliary disease. Pain continues to be an important issue after laparoscopic cholecystectomy resulting in prolonged admissions or readmissions. With significant variations in analgesic protocols a unified approach is necessary to provide standardised interventions to reduce pain. Opioids and non-steroidal anti-inflammatory drugs (NSAIDs) are generally used for management of postoperative pain after LC. The choice of different drugs, the timing and route of their administration as well as the dosages are variable. This prevents the mechanical introduction of recommendations, given in literature, into the daily practice of a particular institution. However, the clinical value of infiltration of wounds with local anaesthetics (LA), their intraperitoneal application, as well as the choice and dosages of LA still remain controversial.

Keywords: Postoperative Pain, Laparoscopic Cholecystectomy, Opioids.

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1. Introduction

Recovery after Laparoscopic Cholecystectomy (LC) is usually rapid and most patients may be discharged from hospital the same day or the next day. However, although LC results in substantially less severe discomfort compared with the open surgery, postoperative pain (POP) can still be considerable. Pain can result in increased postoperative morbidity and delayed hospital discharge, issues that have health economic implications as LC can often be performed on a day surgery setting [1]. Postoperative pain following laparoscopic cholecystectomy can be influenced by various risk factors. Surgical factors play a role, with longer durations of the surgical procedure often associated with increased postoperative pain. The volume and pressure of gas used for pneumoperitoneum, as well as the type of gas employed, can also impact pain levels. Higher gas volumes, elevated pressure, and certain gas types, such as carbon dioxide, have been linked to greater postoperative pain. the rate of insufflation of carbon dioxide has been found to influence the incidence of shoulder tip pain, with lower rates of insufflation resulting in lower rates of pain [2]. The volume of residual gas left in the abdomen after surgery has been found to correlate with postoperative pain. However, there is a discrepancy between studies regarding the correlation between the duration or extent of pneumoperitoneum (the presence of gas in the abdominal cavity) and pain. Bile spillage during laparoscopic cholecystectomy has been associated with faster resolution of the pneumoperitoneum, possibly due to subsequent lavage and displacement of carbon dioxide. However, bile spillage itself does not lead to increased pain or slower postoperative recovery. It is also important to standardize certain variables, such as the use of suxamethonium for anesthesia induction, due to its potential side effect of muscle pain [3].

Patient-related factors are another consideration. Preoperative inflammation, particularly in cases of acute cholecystitis, may sensitize the central nervous system, resulting in heightened postoperative pain. Female patients, in some studies, have shown a tendency to experience higher levels of pain after laparoscopic cholecystectomy compared to males. Age also plays a role, with advanced age identified as a risk factor for increased postoperative pain. Older patients may exhibit reduced pain tolerance and diminished physiological reserve, contributing to higher pain levels [4]. Body mass index (BMI) is an additional risk factor. Higher BMI has been associated with increased postoperative pain, potentially due to factors such as increased tissue trauma during surgery, challenges in establishing pneumoperitoneum, and extended surgical duration. Moreover, Psychological factors should not be overlooked. Anxiety, depression, and catastrophizing tendencies can influence pain perception, potentially leading to higher levels of postoperative pain [5]. The ability of the somatosensory system to detect noxious and potentially tissue-damaging stimuli is an important protective mechanism that involves multiple interacting peripheral and central mechanisms. The neural processes underlying the encoding and processing of noxious stimuli are defined as 'nociception'. In addition to these sensory effects, the perception and subjective experience of 'pain' is multi factorial and will be influenced by psychological and environmental factors in every individual. Acute pain perception begins with activation of specific sensory nerves, termed nociceptors. These are unencapsulated free nerve endings that are present in the skin, deep somatic tissue and viscera. Providing the stimulus is suitably intense, high threshold nociceptors will still activate in the absence of actual tissue damage. Nociceptors activation leads to an increase in H^+ and K^+ concentration. Nociceptors can be divided into two main classes; A-delta and C fibers [6].

Multiple tracts and centers exist within the central nervous systems which are responsible for the transmission, modulation and perception of noxious stimuli. It is important to realize that these areas should not be considered as fixed or functioning in isolation. Rather, they are subject to change from both descending and ascending pathways and can alter or expand their connections to interact with adjacent nerves. Cell bodies of afferent nerves lie in the dorsal root ganglion (DRG) with fibers synapsing in the dorsal horn of the spinal cord. The output from the dorsal horn is however dependent on other neuronal input to the synapse. Afferent neurons may divide prior to entering the cord and send branches cephalic or caudal in the longitudinal tract of Lissauer before synapsing with dorsal horn neurons. The result of this being that a single C-fiber afferent may be responsible for innervating dorsal horn neurons at multiple spinal levels. The grey matter of the spinal cord can be divided into ten physiologically and histological distinct layers known as rexed lamina. Laminae 1 to 6 and 10 are the sites that sensory nerves synapse with dorsal horn cells and are important in pain transmission. Laminas 7-9 are involved with motor function [7].

Physiology of Pain

Noxious and potentially tissue-damaging stimuli is an important protective mechanism that activates nociceptors and transduction into action potentials for conduction to the central nervous system. Nociceptors are stimulated by chemical, thermal or mechanical damage and trigger the nociceptive impulses. Nociceptive primary afferents are widely distributed throughout the body (skin, muscle, joints, viscera, meninges) and comprise both lightly myelinated A-delta fibers (diameter 2-5 mm) and slow-conducting unmyelinated C-fibers (diameter <2 mm). These fibers enter the dorsal horn of the spinal cord and synapse at different sites (Aδ at laminae II and V, C at laminae II) [8]. The substantia gelatinosa (lamina II) integrates these inputs and second-order neurons form the ascending spinothalamic and spinoreticular pathways on the contralateral side. The larger AB fibres conducting "touch" and descending pathways stimulate inhibitory interneurons within the substantia gelatinosa and inhibit C fibre nociceptive inputs. This is the basis of the gate theory of pain. Pain may be modified by altering the neural pathway from its origin at the nociceptor to its interpretation within the central nervous system by various agents. Psychological factors that influence the experience of pain include the processes of attention, other cognitive processes (e.g., memory, learning, thought processing, beliefs and mood), behavioural responses, and interactions with the person's environment [9].

Mechanisms of pain following laparoscopic procedures

In contrast to the largely somatic nature of postoperative pain following open cholycystectomy, the pain experienced after laparoscopic surgery includes elements of both somatic and visceral origin, The postoperative pain following laparoscopic surgeries is often a sharp pain that is typically localized in the abdomen, The causes of this pain involve the puncturing of the abdominal wall and the introduction of trocars and sutures [10]. The exact mechanisms of visceral pain following laparoscopy are not fully understood. Proposed mechanisms include stretching of the diaphragm, which can cause shoulder tip pain due to phrenic nerve irritation. However, the short duration of the pain and the fact that the diaphragm is elevated by the pneumoperitoneum make it unlikely that the main phrenic nerve is mechanically injured. It is suggested that subdiaphragmatic fibers may be stretched by the increased concavity of the diaphragm induced by the pneumoperitoneum. Loss of visceral surface tension after pneumoperitoneum creation may also contribute to increased weight on the diaphragmatic attachments of the liver, leading to shoulder tip pain. Some studies argue that more severe pain is observed in the left shoulder tip due to protection of the right diaphragm by the liver. Neuropathic pain can be elicited by various stimuli, including chemical irritation, ischemia, and compression. Attempts to alleviate shoulder tip pain through gas aspiration or local anesthesia to the diaphragm have shown only moderate success. Phrenic nerve block after anesthesia induction has been found to significantly reduce the incidence of shoulder tip pain [11]. Pneumoperitoneum can cause pain through potential trauma to the peritoneum. Peritoneal biopsies taken after laparoscopy have shown peritoneal inflammation, capillary and neuronal rupture, and granulocyte infiltration. Decreased levels of free radical scavengers in peritoneal biopsies have been strongly correlated with exposure to carbon dioxide and the duration of the procedure. On the other hand, minimal changes have been noted in superoxide anion release from macrophages after carbon dioxide pneumoperitoneum compared to exposure of the peritoneal cavity to air. However, it should be noted that these findings may not directly apply to operative laparoscopic procedures with longer pneumoperitoneum durations [12].

Another potential mechanism of pain is the formation of intraperitoneal carbonic acid from carbon dioxide. Localized peritoneal acidosis has been demonstrated in a previous study with carbon dioxide pneumoperitoneum, and the degree of acidosis is related to the duration of pneumoperitoneum and intra-abdominal pressure. Intraperitoneal acidosis has also been observed in humans after carbon dioxide pneumoperitoneum, and it has been noted in a small number of patients undergoing argon pneumoperitoneum, suggesting that acidosis may arise from local ischemia. Saline solution may help in diluting the acid rather than restoring visceral surface tension, as proposed by some researchers [13]. Apart from local effects, systemic hypercarbia (elevated carbon dioxide levels in the bloodstream) during pneumoperitoneum may cause excitation of the sympathetic nervous system, leading to an amplification of the local tissue inflammatory response. Splanchnic mucosal ischemia, even in healthy patients, has been observed after pneumoperitoneum and is another potential mechanism of postoperative pain. In the gynecological literature, it has been noted that the type of intra-abdominal procedure can influence the degree of postoperative pain. For example, patients tend to experience more pain after laparoscopic sterilization compared to diagnostic laparoscopy, despite the duration of the tubal ligation procedure being shorter. The method of sterilization used also affects pain levels. It remains uncertain whether similar differences in pain exist between different general surgical operations. Therefore, the origin of pain after laparoscopic cholecystectomy is multifactorial, involving pain from the incision sites, the presence of pneumoperitoneum, and the cholecystectomy itself [11].

Prevention and management of postoperative pain in laparoscopic cholecystectomy:

A crucial aspect of Enhanced Recovery after Surgery (ERAS) protocols is preoperative optimization, which prepares patients physically and nutritionally before surgery. Ensuring proper nutrition, hydration, and minimizing fasting can help mitigate the stress response and reduce postoperative pain. Techniques like carbohydrate loading contribute to improved patient comfort and lower pain levels after laparoscopic cholecystectomy [14]. Implementing preoperative pain management strategies can significantly impact postoperative pain levels following laparoscopic cholecystectomy. For instance, preemptive analgesia involves giving pain relief medications before surgery to prevent or lessen pain development. Research indicates that administering NSAIDs or acetaminophen before surgery can effectively reduce postoperative pain and minimize the requirement for intraoperative and postoperative opioids [15]. Preemptive analgesia, which involves providing pain relief before pain begins, is an effective strategy for managing postoperative pain after laparoscopic cholecystectomy. This approach helps prevent the central sensitization of pain pathways, which can result in reduced pain intensity for patients. Studies indicate that preemptive analgesia improves pain control and lowers the need for additional postoperative medications [16]. Effective intraoperative pain control is key to minimizing postoperative pain following laparoscopic cholecystectomy. Techniques such as administering local anesthesia at the surgical site or employing regional anesthesia methods, such as the transversus abdominis plane (TAP) block, can significantly alleviate postoperative discomfort. By interrupting pain pathways during the surgery, these methods contribute to reduced pain postoperatively and lower the dependence on systemic pain medications [17].

Multimodal analgesia generally incorporates opioids for managing severe pain, NSAIDs for their anti-inflammatory effects, and local anesthetics for targeted relief. In the context of laparoscopic cholecystectomy, the reliance on opioids is reduced by using NSAIDs and local anesthetics. NSAIDs are effective in alleviating pain and inflammation without causing the gastrointestinal issues often associated with opioids, while local anesthetics offer prompt pain relief at the surgical site, enhancing overall pain management [18]. Dexamethasone is an effective adjunct in postoperative pain management, demonstrating benefits such as reduced opioid consumption, significant pain relief, and a favorable safety profile. Its use, particularly in intravenous or intraperitoneal forms, can enhance recovery outcomes for patients undergoing various surgical procedures [19].

The addition of intraperitoneal dexamethasone to local anesthetics appears to be an effective strategy for improving postoperative pain control following laparoscopic procedures. The combination provides superior analgesia compared to local anesthetics alone, potentially leading to reduced opioid requirements and enhanced recovery [20]. Combining pharmacological treatments with non-pharmacological strategies can improve postoperative pain management after laparoscopic cholecystectomy. Non-pharmacological methods, including relaxation techniques and physical therapy, can work alongside conventional pain medications to provide comprehensive pain relief. This integrated approach addresses both physical and emotional components of pain, leading to better overall control and increased patient satisfaction [21]. Continuous infusion analgesia, including methods like continuous epidural or intrathecal analgesia, provides ongoing pain relief after laparoscopic cholecystectomy. These techniques deliver a steady stream of analgesics, ensuring consistent pain management and lowering pain levels during the recovery period. Continuous infusion is especially advantageous for patients experiencing moderate to severe pain [22]. Patient-controlled analgesia (PCA) offers a tailored method for managing postoperative pain following laparoscopic cholecystectomy. By allowing patients to self-administer pain relief within defined limits, PCA enhances personal control over pain management. Research indicates that PCA can decrease the overall opioid consumption and provide more effective pain relief, leading to higher patient satisfaction [23]. Adopting various postoperative analgesic strategies, such as multimodal analgesia, can greatly influence pain management effectiveness after laparoscopic cholecystectomy. Combining opioids with NSAIDs and additional analgesics like gabapentin improves pain relief and decreases the need for opioids. This multimodal approach targets pain through multiple mechanisms, enhancing overall pain control and minimizing side effects [24].

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