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Transcutaneous Electrical Nerve Stimulation (TENS) as an Alternative Perioperative Pain Treatment

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ABSTRACT

Perioperative pain is a significant medical issue affecting over 80% of surgical patients annually. Currently, perioperative pain is one of the leading causes of a decreased quality of life. The most common treatments for perioperative pain, such as opioids and non-steroidal anti-inflammatory drugs (NSAIDs), have many serious adverse effects, especially when used long-term. As a result, clinicians must find and assess some alternative treatments that will reduce the perioperative pain level and harm their patients the least. Recently, non-pharmacological treatments have been gaining popularity for their pain-relieving abilities with few side effects. Transcutaneous electrical nerve stimulation (TENS) has shown the potential to lower the number of analgesics consumed by surgical patients and to be an effective non-pharmacological treatment for perioperative pain with no severe side effects. However, previous studies show that there is not much knowledge of TENS and its consequences. Overall, the usage of transcutaneous electrical nerve stimulation during the perioperative experience is understudied and underrepresented. Thus, this report aims to explain further and explore the role of TENS as an alternative treatment for perioperative pain.

Introduction

Pain

Pain is an experience that affects everyone differently. It is one of the most common causes of medical visits, an inability to work, and medicine intake (Institute of Medicine, 2011). The International Association for the Study of Pain (IASP) defines pain as an unpleasant sensory and emotional experience related to or potentially related to tissue damage (IASP, 2022). Furthermore, acute pain refers to pain that develops rapidly and is temporary or short-lasting (Institute of Medicine, 2011). In general, acute pain usually lasts for less than three months and dissipates when there are no present factors causing it. Conversely, persistent, or chronic pain lasts over several months (National Center for Complementary and Integrative Health, 2018). Most cases of perioperative pain can be considered acute, but 10% to 50% of postoperative pain cases might develop into chronic pain (Institute of Medicine, 2011).

From the approximately 100 million surgeries performed each year, over 80% of the surgical patients from these procedures report postoperative pain (IASP, 2021). Less than half of surgical patients report that they receive adequate pain relief, and 88% of those patients report that their pain is moderate, severe, or extreme (Institute of Medicine, 2011). Not only does inadequate pain control lead to more unnecessary pain, but it is also associated with many adverse side effects. Such side effects include an increased recovery time from surgery, higher rates of impaired function, higher risk of developing chronic postoperative pain, increased mor-

bidity, and decreased patient quality of life (Gan, 2017). With the significant number of surgical patients reporting inadequate pain relief, it is imperative that potential pain treatments are assessed carefully and that the most efficient pain treatments possible are given to these individuals.

Opioids

Opioids have been used to treat pain for thousands of years, with the oldest use of opioid medication originating from the Sumerians (Benyamin et al., 2008). An opioid can be defined as any substance that acts on opioid receptors in the central nervous system and peripheral tissues (Garimella & Cellini, 2013). Opioids stimulate the secretions of the body's endorphins (Shannon et al., 2007). The principal function of endorphins is to inhibit the communication of pain signals, resulting in their pain-relieving and euphoric effects (Lyden & Binswanger, 2019). Opioids can have different origins. Natural opioids originate from the seed pod of opium poppy plants. Presently, there are also semi-synthetic and synthetic opioids that are made in laboratories. All of these types of opioids (natural, semi-synthetic, and synthetic) have pain-relieving effects and are prescribed to patients suffering from perioperative pain.

The intake of opioids causes severe side effects such as hypoventilation, sedation, vomiting, dizziness, a buildup of tolerance to opioids, constipation, and nausea (Benyamin et al., 2008). As a result, this limits their use as a treatment for pain. More seriously, improper use of opioid medication can lead to addiction and dependency. This is primarily because of their euphoric effects, which make these drugs highly addictive, potentially leading to a drug overdose. Opioids cause the most deaths from drug overdose in the United States. The number of opioid-related drug overdose deaths increased from 21,088 in 2010 to 68,630 in 2020 (U.S. Department of Health and Human Services, 2022). In addition, the economic costs of opioid overdose are estimated to be more than $78.5 billion in the United States alone. There are several causes for the increase in opioid overdose deaths. The leading cause of opioid-related drug overdose deaths can be attributed to the use of illegal, synthetic opioids such as illicit heroin and fentanyl. Another cause of these drug overdose deaths is the surge in opioid prescriptions (Shipton et al., 2018). As a result of the significant number of opioid prescriptions, patients may develop an addiction to opioids, causing them to try to obtain and use illicit opioids. The surge in opioid prescriptions can be linked back to decades-old scientific articles. Some of these articles were promoted by pharmaceutical companies to market their products. These articles stated that opioids were safe to prescribe, and that opioid addiction is rare in patients that do not have a history of drug addiction (Porter and Hick, 1980). However, since then, many scientific articles have been published countering these statements (Benyamin et al., 2008; Lyden & Binswanger, 2019; Shipton et al., 2018). The Centers for Disease Control and Prevention (CDC) recommends using opioids only as needed and when other pain-treatment therapies are ineffective (Dowell et al., 2022). Despite the dangerous side effects that were found to be correlated with the usage of opioids, they are still widely prescribed.

Non-Steroidal Anti-Inflammatory Drugs

Non-steroidal anti-inflammatory drugs or NSAIDs are another popular pharmacological treatment used to treat perioperative pain. Some NSAIDs are available over the counter, while others need a prescription. Like opioids, NSAIDs are mostly taken as a pill. Generally, NSAIDs inhibit cyclooxygenases (COXs), enzymes involved in prostaglandins' creation. Prostaglandin H2 is a molecule that is related to inflammation, pain, and fever (Parvizi & Kim, 2010). Because of their analgesic properties, NSAIDs are commonly used with opioids to lower a patient's opioid dosage and therefore lessen the adverse side effects of opioids (John et al., 2017). The most common NSAIDs that do not need a prescription include ibuprofen, aspirin, and naproxen (Ghlichloo & Gerriets, 2022).

Although previous studies show that NSAIDs provide adequate postoperative pain relief for surgical patients (Derry et al., 2009; Isola et al., 2019; Pereira et al., 2020) and generally cause fewer adverse side effects compared to opioids (Holdgate & Pollock, 2004), they still have the potential to cause adverse events in patients such as high blood pressure, dyspepsia, kidney toxicity, and increased risk of heart attack and stroke when used as a short-term treatment (Soloman, 2022). This can be seen especially in patients that use high dosages of NSAIDs and in patients with gastrointestinal and cardiovascular comorbidities. In addition, adverse event reactions resulting from the intake of NSAIDs account for 30% of hospital emissions (Davis & Robson, 2016). Gastrointestinal complications from NSAIDs are estimated to have caused 16,500 deaths in the United States annually (Parvizi & Kim, 2010). Thus, they should also be used limitedly and with caution. Nonselective NSAIDs are the leading cause of the adverse effects associated with NSAIDs. Nonselective NSAIDs inhibit COX-1 and COX-2 enzymes, while selective NSAIDs only inhibit COX-2 enzymes. COX-1 enzymes play a significant role in creating thromboxane A2 and prostaglandins, which direct the mucosal barrier of the gastrointestinal tract and other bodily functions. Selective NSAIDs are considered the ideal medication to achieve the anti-inflammatory, fever-reducing, and analgesic properties of NSAIDs, as COX-2 enzymes create prostaglandins associated with pain, fever, and inflammation (Wongrakpanich et al., 2018). COX-2 enzymes are not expressed throughout the parts of the body, unlike COX-1 enzymes. They are expressed in sites of inflammation (Ghlichloo & Gerriets, 2022). However, most NSAIDs are nonselective (Zhu et al., 2018). Generally, the use of nonselective NSAIDs is encouraged because studies have shown that selective NSAIDs increase the risk of cardiovascular injury (Funk & FitzGerald, 2007). Like opioids, the potentially harmful side effects of NSAIDs lead to more restrictions on pain medication intake, further worsening the problem of inadequate pain relief.

Non-Pharmacological Treatments

As a result of the adverse side effects associated with these popular analgesics, practitioners must assess alternative treatments before prescribing these potentially harmful drugs to patients suffering from perioperative pain. Recently, non-pharmacological treatments have seen an upwards trend in popularity because of their ability to relieve pain with little to no adverse side effects and at low costs (Allred et al., 2010). Non-pharmacological treatments or therapies refer to treatments for pain that do not involve drugs. They can treat mild pain individually or be used as an addition to analgesics to lower the number of analgesics like opioids and NSAIDs consumed by a patient for moderate to severe pain (Engwall & Duppils, 2009). Many non-pharmacological treatments have been shown to reduce pain, including music, cold therapy, and transcutaneous electrical nerve stimulation (TENS). However, there is not much research on these perioperative pain treatments (Komann et al., 2019). Furthermore, recent studies observing patients with postoperative pain found that there was not high usage of non-pharmacological treatments for pain in the hospital setting, and many clinicians did not encourage the use of non-pharmacological treatments (Kidanemariam et al., 2020; Sharma et al., 2020). This shows that there might be a lack of awareness of non-pharmacologic therapies as a treatment for pain during the perioperative experience.

Transcutaneous Electrical Nerve Stimulation (TENS)

Transcutaneous electrical nerve stimulation (TENS) is one of the many non-pharmacological treatments that can be defined as a technique where electrical stimulation is applied throughout the skin's surface for pain relief (Johnson, 2007). Presently, a TENS device or unit is used to generate electrical currents. In general, a TENS device is small and programmable. It comprises a set of electrodes, a battery, and an electrical signal generator. Many different types of TENS devices are available on the market. This device allows patients to adjust the electrical current strengths, patterns, and durations based on their pain type and intensity (Kerai et al., 2014).

There are many TENS techniques, and they relieve pain differently. Some TENS techniques include conventional TENS, acupuncture-like TENS, and intense TENS. TENS may be used for both acute and chronic perioperative pain. (Johnson, 2007). Compared to pharmacological analgesics, TENS is non-invasive, meaning it is not a tool that enters the body, is cheaper, and is safer (Kerai et al., 2014). Thus, it shows potential as an alternative perioperative pain treatment to analgesics.

Conventional Transcutaneous Electrical Nerve Stimulation

Conventional transcutaneous electrical nerve stimulation (TENS) is the most common technique to relieve perioperative pain. It refers to a low intensity (non-painful) with feelings of paresthesia or "pins-and-needles," small pulse width (50-200μs), and high frequency (50Hz to 100Hz) TENS treatment (Charlton, 2008). The electrodes or electrical currents are generally placed on painful areas for the conventional TENS technique. Many theories have explained the pain-relieving properties of conventional TENS. One popular theory is the gate control theory proposed by Melzack and Wall (Melzack & Wall, 1965). This theory suggests that there is a "gate" in the spinal cord that either inhibits or allows pain receptors to reach the brain.

Furthermore, the activity of large nerve fibers can inhibit the activity of tiny nociceptive (pain-related) nerve fibers in the central nervous system. Therefore, receptors that take low-frequency electrical currents from the skin carried by the large A-beta fibers to the spinal cord can hinder the transmission of pain receptors to the brain when applied to painful areas. As a result, conventional TENS can cause the brain to perceive less pain (Banerjee & Johnson, 2013; Johnson, 2007; Kerai et al., 2014).

Acupuncture-Like Transcutaneous Electrical Nerve Stimulation

Acupuncture-Like transcutaneous electrical nerve stimulation (AL-TENS) is described as a high intensity (maximum tolerance), long pulse width (100-400μs), and low frequency (2Hz to 4Hz) TENS treatment which is hyperstimulation (Charlton, 2008). During AL-TENS, electrodes or electrical currents may be placed in various places, including acupuncture points, trigger points, and myotomes. This TENS treatment's rationale is similar to that of traditional acupuncture, which gives it its name. It is a variant of conventional TENS and can be used as an alternative treatment if conventional TENS does not work or is insufficient for a surgical patient with perioperative pain. AL-TENS aims to relieve pain by generating muscle twitches with low-frequency electrical currents, stimulating tiny nerve fibers (A-delta) to release endogenous opioids in the central nervous system (Banerjee & Johnson, 2013; Johnson, 2007). Endogenous opioids are peptides that bind to opioid receptors and occur throughout the central nervous system. They relieve pain in the same way as opioid drugs; however, they occur naturally in the body, unlike synthesized opioid drugs that are associated with many dangerous side effects (Shannon et al., 2007).

Intense Transcutaneous Electrical Nerve Stimulation

Intense transcutaneous electrical nerve stimulation (TENS) refers to a high intensity and high frequency (up to 200Hz) TENS treatment. The electrodes or electrical currents used during intense TENS are commonly placed on nerves and sites of pain. As a result of this technique's high intensity, this treatment is administered for only short periods of time. The reasoning behind intense TENS' pain-relieving effects is that the electrical currents stimulate tiny nerve fibers (A-delta), inhibiting pain receptors from reaching the central nervous system and eliciting analgesic effects. In addition, because this technique is uncomfortable or painful for patients, it can also be used as a counterirritant in minor surgeries (Banerjee & Johnson, 2013; Johnson, 2007).

Effectiveness of Transcutaneous Electrical Nerve Stimulation

The usage of Transcutaneous Electrical Nerve Stimulation as a treatment for perioperative pain is still under debate and understudied (Li & Song, 2017). However, several studies support the idea of TENS as an effective perioperative pain treatment which can also reduce the number of analgesics consumed by surgical patients. One study observing the effects of TENS on postoperative pain following surgery using gamma nail insertion to fix extracapsular hip fracture found that TENS reduced pain intensity while walking in elderly patients (El-boim-Gabyzon et al., 2019). In another study, TENS significantly reduced pain and opioid intake in patients experiencing postoperative pain after arthroscopic rotator cuff repair (Mahure et al., 2017). A different study showed the same results, with the utilization of TENS for postoperative pain following open inguinal hernia surgery being found to reduce pain and analgesic intake in surgical patients (Parseliunas et al., 2021). Although TENS has been shown to be successful in reducing perioperative pain in several studies, it should not replace analgesics that have been researched intensively for moderate or severe pain. To our knowledge, there are no side effects of TENS, but the sensation that TENS produces might be uncomfortable for some patients.

The Future of Transcutaneous Electrical Nerve Stimulation in the Perioperative Experience

Although transcutaneous electrical nerve stimulation (TENS) and non-pharmacological treatments have been shown to be effective and efficient pain treatments in several clinical trials, they are not used frequently as a perioperative pain treatment in hospitals. This may be because there is not much concrete evidence on the effectiveness of these treatments for perioperative pain, and there might be a lack of awareness of the potential pain-relieving abilities of these treatments. If more attention is put on this topic in the future, it is possible for TENS and non-pharmacological treatments, in general, to become staple pain treatments during the perioperative experience.

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