Chapter

Non-Pharmacological Management of Acute Pain after Breast and Thoracic Surgery

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Abstract

Pain after thoracic and breast surgery is a common phenomenon, and it is usually influenced by various factors including surgical, patient, and cultural factors. However, the pain that patients who have undergone breast or thoracic surgery experience has either been overlooked, undermanaged, or managed solely with pharmacotherapy by healthcare providers. This oftentimes result in impacting the patients' recovery process and even quality of life. Literature has identified that inadequate pain management after breast and thoracic surgery and the resultant side effects of pharmacological therapies can be reduced by including non-pharmacological interventions into patients' care plan. Some of the recommended interventions include music, massage, aromatherapy, cold therapy, meditation, acupuncture, and transcutaneous electrical nerve stimulation. Most of these non-pharmacological therapies are easy to use, promote patients' involvement in their own care, have no or minimal side effect, and are cost-effective. Therefore, it is essential for healthcare providers to include non-pharmacological pain management in the plan of care even before surgery.

Keywords: acute pain, non-pharmacological, management, breast surgery, thoracic surgery

1. Introduction

Postoperative pain is generally short term and acute in nature. It arises from injury of tissue which resulted from surgical procedures [1, 2]. Of all surgical procedures, thoracic and breast surgeries cause significant severe postoperative pain and suffering to patients [3]. For this reason, provision of adequate and effective postoperative pain relief is the paramount goal for thoracic and breast surgery patients during postoperative period. Inadequate pain management after surgery can be caused by several reasons including limited translation of current best available evidence to guide quality pain management in clinical praxis [4]. Standardised and streamlined

pain management of patients who undergo these surgeries also requires knowledge and concept of evidence-based interventions to assure the quality and success of the management.

2. Postoperative pain after thoracic surgery

Thoracic surgery involves several pain sensitive structures with a number of pain transmission and perception; hence, patients are expected to experience severe pain within the first 72 hours after surgery [5]. Arising from surgical approaches and intraoperative manipulations of the thoracic structures, pain after thoracic surgery is commonly acute in nature with high severity in the immediate postoperative period [5]. Some of the descriptors used by patients to describe pain after thoracic surgery may be suggestive of mixed pain (acute pain and neuropathic pain), which when not adequately managed can result in chronic pain [6, 7].

Post-thoracic surgery pain has a complex mechanism that mostly occurs due to nociceptive and neuropathic signals that originate from somatic and visceral afferents [8]. Nociceptors are stimulated by the skin incision, muscle retraction, rib retraction, stretched ligaments, costochondral joint dislocation, and intercostal nerves injury [9–11].

Due to intra- and postoperative thoracic surgical approach and manipulation, noxious stimuli are transmitted by the intercostal nerve from the structures of the chest wall and pleura cavity to the nociceptive neurons in the central nervous system [8, 12]. The ipsilateral dorsal horn of the spinal cord (T4–T10) receives nociceptive somatic signals after a surgical trauma (incision, retraction, etc.) to the thoracic area [8, 11]. Then, the afferents are transmitted to the limbic system and somatosensory cortices through the contralateral anterolateral system.

Surgical manipulations of the structures of the chest including the pleura, diaphragm, or bronchi also initiate visceral stimuli. Nociceptive visceral afferents stimulated from tissue injury around bronchi and visceral pleura are transmitted by the vagus and phrenic nerves, the noxious stimuli arising from the diaphragmatic pleura are transmitted via the phrenic nerve, while mediastinum, lungs, and mediastinal pleura noxious stimuli are transmitted by the vagus nerve to the pain receptor [8]. Noxious stimuli resulting from surgical incision-induced tissue damage around the surgical sites are transmitted to the pain receptor in the central nervous system. These transmissions activate and sensitise nociceptor to develop an inflammatory response which further stimulates nociceptors and amplifies the transmission of pain, thereby increasing pain perception and hyperalgesia or increasing pain intensity at the surgical site [12].

Furthermore, noxious stimuli as afferent impulses resulting from visceral pleura irritation are referred to the ipsilateral shoulder by the phrenic nerves and become the major cause of ipsilateral shoulder pain after thoracic surgical procedures or post-thoracotomy shoulder pain [9–11]. Additionally, pain development is exaggerated by brachial plexus stretching and posterior thoracic ligaments distraction [11, 13]. Shoulder pain after thoracic surgery is often developed in the early stage or immediately after surgery lasting for a few days with usually moderate to severe intensity and mostly described by patients as an ache [14].

Compression and irritation of the intercostal nerves by chest tubes and surgical stripping or residual pleural blood may further activate inflammatory response [8, 9]. Consequently, inflammatory mediators (e.g. prostaglandins, histamine, bradykinin,

and potassium) are released [8–11]. The release of prostaglandins, neurotrophins, and interleukins contributes to the activation of nociception and sensitisation [12].

Damage to nerves, most often the intercostal nerve injury resulting from mechanical damage, rib retractor, compression, or rib fractures as well as phrenic nerve irritation from chest tube placement has been reported in the literature as major contributors to neuropathic pain. Chest tubes after thoracic surgery also cause severe pain in cases where the tubes compress the intercostal nerves. In addition, the presence of sutures or wires passed around the ribs and closer to the neurovascular bundle may result in intercostal nerves damage, thus leading to neuropathic pain [11].

In a nutshell, for most patients undergoing thoracic surgery, there are several components and mechanisms that contribute to pain development. This may be a combination of acute, somatic, visceral, and neuropathic pain. The pain may also arise from incision, rib removal or damage, injury to the intercoastal nerve, pulmonary parenchyma incision and the presence or continuous irritation from chest tubes.

3. Postoperative pain after breast surgery

At some point in breast cancer treatment trajectory, patients may undergo surgery [15]. Hence, surgery is a treatment that has become the first line of approach against breast cancer. Surgery can be either breast conserving, such as lumpectomy, or a complete removal of all breast tissue, called mastectomy. The specific surgery depends on the stage and type of tumour a patient has [16]. Women with stage I, II, and III breast cancer can be treated with breast surgery including breast conserving surgery for stage I breast cancer and mastectomy for stage II and III breast cancer [17].

Irrespective of the type of breast surgery, patients experience postoperative pain. The pain responses usually stem from the surgical procedure itself. In the immediate postoperative period, the pain experienced by breast surgery patients is usually nociceptive and acute in nature and may be moderate or severe in nature [18]. Nociceptive pain is a type of pain that is characterised by localisation around the damaged tissue and resolves within the normal healing time [19], while acute pain is a type of pain characterised by sudden onset after tissue damage and high severity [18].

The nature of postoperative pain that occurs immediately after mastectomy is complex and multimodal in nature. For pain to be experienced, an external stimulus is usually transported via thin myelinated (i.e. A-δ fibres) and non-myelinated (i.e. C-fibres) fibres whose receptivity are determined by the control of sodium/calcium or potassium channels [20]. When the stimuli transported through C-fibres are more than those transported in A-δ fibres, little or no pain is experienced and vice versa [21]. This type of pain is constantly moderated by the brain stem and cortical pathways, and there may be a facilitation or inhibition of pain that further regulates both the sensory and emotional aspects of pain [19].

With pain after mastectomy, the severity experienced by individuals varies based on the degree of modification of the contact between the synapses, nociceptors, neurons at the dorsal horn of the spinal cord, and other nociceptive signal modulation structures in the central nervous system [20]. Depending on the severity of the pain, pain management regimen is prescribed [19] that may require the use of strong pain management regimen including opioids [22].

4. Impacts of postoperative pain on patients after thoracic and breast surgery

Postsurgical pain after surgery, sub-optimal or untreated pain has profound impacts or negative effects on patients. Pain after surgery usually and directly impedes respiratory function, mobilisation, delays recovery, increase duration of hospitalisation and hospital care costs of patient [6, 23–26].

The severity of pain is usually increased due to tension on the incision as a result of movement or mobilisation, deep breathing, and/or coughing [10, 11]. As a result, postoperative altered or impaired pulmonary function as well as postoperative pulmonary complications in postoperative patients is common and becomes the main clinical impact especially after thoracic surgery due to pre-existing lung disease, surgery-related loss of parenchyma, and inadequate postsurgical pain management [9, 27].

The surgical wound continuously moves as patients breathe, move, and cough, which worsens pain. Directly, pain impedes patient's performance of deep breathing which consequently limits inspiration, decreases lung compliance, and decreases functional residual capacity, thereby leading to postoperative atelectasis and hypoxemia [8, 10]. Likewise, ineffective coughing results in retention of secretions resulting in developing postoperative pneumonia [9, 11]. Furthermore, the development of shoulder pain causes patients to splint shoulder and decrease shoulder movement which impairs and causes gradual loss of both active and passive shoulder function [13, 28].

For most women who had undergone breast surgery, the impact of acute pain varies and may be dependent on whether the surgery is breast conserving or mastectomy with or without reconstruction. Additionally, psychosocial, physiological, and other individual risk factors contribute to the impact of pain on breast surgery patients [29]. A long-term impact of acute pain after breast surgery is the occurrence of persistent pain, which could result in negative health status and poor quality of life. If acute pain after breast surgery is inadequately managed, it may negatively impact sleep, work, interpersonal relationships, and activities of daily living [30].

5. Factors influencing acute pain after thoracic and breast surgery

Pain after breast and thoracic surgery is usually influenced by several factors that can be mainly categorised into patient factors, surgical approach, and analgesics technique factors [8, 14]. Previous studies have been conducted to examine determinants of pain after thoracic surgery. These are, however, mainly focused on determinants of post-thoracotomy pain syndrome or long-lasting pain after thoracic surgery [31].

5.1 Patient factors

A few studies have been done to determine how patient factors influence postsurgical pain intensity and response. Reports from the previous literature regarding gender differences and pain perception revealed female patients are less tolerant of noxious stimuli, frequently complain of severe and diffuse pain, and have higher risk for developing chronic pain than male patients [32, 33].

Age has also been identified in existing literature as a significant predictor of post-operative pain. The pharmacokinetics of pain medications can be affected by advanced age as the older adults are more sensitive to systemic opioids. For instance, a previous study revealed that elderly patients required 40% less amount of thoracic epidural analgesia because of the difference in thoracic epidural spread in the elderly [34]. A study conducted on 1231 patients to identify the risk factors contributing to postoperative pain in a referral hospital in developing country revealed younger age, female gender, and emergency surgery [35].

Another study conducted in a university hospital in Northeast Ethiopia showed American Society of Anaesthesiologists' Physical Status Classification System class I and II, general anaesthesia, and incision length exceeding 10 cm as risk factors contributing to postoperative pain [36]. Although younger age, being female, a history of depression and anxiety, and the lack of preoperative education about pain management are more likely to increase risks of severe acute post-surgical pain, a recent literature suggests that these risks have not been evidenced in thoracic surgery patients [37]. Furthermore, increased body mass index (BMI) has been recorded in a previous study to influence severity of pain as well as delay recovery after surgery [38]. To date, current evidence has been focused on predictors of persistent pain after thoracic and breast surgery with less attention to acute pain.

Since pain experience is subjective, sensory, and emotional, psychological factors can influence pain perception and pain experience. Pre-operative anxiety, depressive mood, and catastrophising have been shown to lower pain thresholds, thus predicting a more severe post-operative pain [14]. For this reason, assessment and management of patients' preoperative anxiety, depressive mood, catastrophising, and others negative moods become another essential role for nurses in preoperative preparedness. These require establishing good rapport and relationships with patient and family member, including implication of cognitive behavioural strategies and distraction techniques [14, 37].

Previous pain experience may influence the ways of thinking and responding or coping with pain after surgery. Patients who are vigilant or too concerned about pain and have negative thought or expectation about pain may influence the way they respond to pain or report worst pain after surgery. Furthermore, the past pain experience together with socio-cultural factors influences people on constructing certain assumptions, beliefs or myths, and attitudes about pain and pain medication [39]. In addition, experiences of pain medication used as well as existing pain before the present surgery and the previous surgeries have been recorded in literature as factors influencing pain after surgery. Use of opioids, anti-depressant, anti-convulsant, and the existing pain preoperatively, especially at a previous surgical site, are revealed as the predictors of moderate to severe postoperative pain [5].

The way people express pain or give meaning to their pain experience is partly influenced by their cultural background. Cultural stereotype conformed or shared by members of the same group passed from generation to generation affects pain expression in diverse ways. Often a patients' response to pain reflects whether they are members of a stoic or emotive culture. Stoic patients, mostly from African and Asian cultures, scarcely express their pain but "grin or bear it". In particular, the stoic culture promotes not drawing attention to ones' self, especially in a negative light [40]. Additionally, openly complaining or being assertive are considered inappropriate in a stoic culture while behaving in a dignified manner is considered appropriate. For this reason, although an individual feels pain, it is not culturally appropriate to express it [40]. Moreover, African and Asian patients will avoid making demands

or questioning or bothering healthcare providers with complaints about pain. Meanwhile, emotive patients, mostly from Western cultures, are likely to verbalise their pain, prefer to have support around with an expectation that people react to their pain by validating what they are feeling [40].

Lastly, in some religion, pain acceptance hinged on a person's religious faith. For instance, Muslim patients may accept or reject pain medication based on their belief, and they could also consider their pain as God's blessing or believe that God can give them the ability to bear the pain. Meanwhile, Buddhists patients show stoicism when they experience pain and pain is viewed as common and accepting suffering leads to spiritual growth [40].

5.2 Surgical factors

The intensity of postoperative pain that a patient experience can be in part due to the technique used for the surgery [11]. Oftentimes, surgical methods or approaches that require more incisions or dissection of chest wall muscles can increase the postoperative pain intensity [11, 36]. Thoracic surgeries have been performed using several surgical techniques, and approaches mainly open thoracotomy and video-assisted thoracic surgery (VATS) [27, 41]. Although with open thoracotomy, reducing the size of the incision, using an appropriate muscle closing technique, or avoiding incising the latissimus dorsi may help reduce surgical tissue injury [11], VATS was created to limit the size of surgical incision and to avoid intercostal nerve damage in order to reduce pain after surgery [8, 11]. Thus, a longer incision and extended tissue trauma in open thoracotomy is expected to cause higher pain intensity compared with VATS [10]. Nevertheless, in women undergoing breast surgery, surgical techniques that require axillary lymph node dissection are predictive factors for severe postoperative pain [42].

6. Pharmacological pain management after thoracic and breast surgery

Current postoperative pain management methods have recommended the use of multimodal analgesia approaches to improve analgesic efficacy and minimise side effects. The multimodal analgesia is acknowledged in its significant role in all enhanced recovery after surgery pathways (ERAS) to manage pain, reduce stress responses, facilitate early mobilisation, and normal respiration [25, 43]. According to Montgomery and McNamara [44], multimodal analgesia has been acknowledged as effective pain management especially for preventing and controlling postsurgical pain as well as reducing side effects of opioid, hastening recovery, and shortening hospital stay. In the multimodal analgesia regimen, two or more analgesia and/or analgesic techniques with different mode or site of action are combined to produce more-effective analgesia than a unimodal regimen [25]. In multimodal approach, individual analgesia is recommended to be used at lower doses as this helps to reduce the side effects of each medication. Importantly, the central aim of multimodal analgesia is to avoid using opioids or reduce opioids consumption and thereby reduce the risk for opioids side effects that cause delay in recovery [25, 43].

For patients undergoing thoracic surgery, multimodal analgesia includes regional anaesthetic blockade in combination with using systemic nonopioid analgesia with opioid sparing [45]. Post-thoracic surgical pain therefore is expected to be treated with combinations of local anaesthetics, acetaminophen, non-steroidal

anti-inflammatory drugs (NSAIDs), anticonvulsants, adrenergic agonists, and opioid-sparing methods [45–47].

Meanwhile for women undergoing breast surgery, typical pain management is a combination of opioids, non-opioids, non-pharmacological techniques, anaesthesia techniques, and patient-controlled analgesia techniques [47]. With these approaches, pain management can span through the intraoperative and postoperative periods. Intraoperatively, preventive pain medications employed for mastectomy patients include drugs such as nefopam, ketamine, and bupivacaine, with or without clonidine. All these medications have been reported to significantly reduce pain intensity after BC surgery, and they have long-term effects on pain experienced after surgery [48–51]. Moreover, the techniques employed in delivering the preventive medication (e.g. thoracic paravertebral block) reduced the pain score in one study [52], while a combination of paravertebral block with propofol significantly reduced the pain score in another study [53].

For both thoracic and breast surgery patients, the non-opioid drugs such as acetaminophen, NSAIDs, local anaesthetics, and anticonvulsants are combined with opioids-sparing analgesics or lower doses of opioids to manage postoperative pain [14, 25, 45]. These non-opioids limit the adverse effects of opioids including sedation, urine retention, nausea, pruritus vomiting, and slow gastrointestinal functioning in the multimodal regimen [46]. There is limited evidence about the recommended analgesic regimen for patients undergoing breast surgery in the ERAS pathway. However, the analgesics regimen recommended as multimodal analgesia for pain management in ERAS after thoracic surgery by Mehran et al. [45] are illustrated in **Figure 1**.

7. Non-pharmacological pain management after thoracic and breast surgery

Nonpharmacological interventions are essential to multimodal postoperative pain management and have been reported in the previous literatures to effectively relieve postoperative pain [54]. Notably, non-pharmacological pain management is not clearly presented in the existing pain management in an enhanced recovery pathways because it lacks high-quality evidence to support its use [44, 45]. According to clinical practice guidelines, non-pharmacological interventions are considered as adjunctive therapies of pharmacological interventions for postoperative pain management. These are transcutaneous electrical nerve stimulation (TENS), music therapy, cognitive–behavioural techniques, breathing relaxation technique, and cold therapy, massage, and acupuncture [47]. In accordance with the recommendations from national Centre for Complementary and Alternative Medicine about non-pharmacological pain management therapies for adults, the mechanism of each intervention is summarised in **Table 1**.

Non-pharmacological therapies can be beneficial in decreasing patients' pain [56], and they are suitable for use because they are non-invasive, have more benefits than harm and can be readily used by nurses [57]. However, consideration of patients' preference when using non-pharmacological interventions is essential [47, 58].

7.1 Preoperative education

Preoperative education is defined as the provision of information to patients awaiting surgery as a means of psychological preparation for surgery and the

- Gabapentin 300 mg orally three times a day for 30 days
- Use the pediatric dosage (100 mg three times a day) for geriatric patients or those experiencing lightheadedness
- Acetaminophen 1,000 mg IV every 6 hours for 48 hours, then 1,000 mg orally every 6 hours
- Ketorolac 15 mg IV every 6 hours for 48 hours (if not contraindicated)
- Celecoxib 200 mg orally twice a day
- Famotidine 40 mg orally twice a day while receiving Ketorolac or Celebrex
- Tramadol 50 mg orally every 6 hours as needed as first rescue medication if the patient reports a pain score higher than 4 on a 10-point scale
- Hydromorphone 0.5 mg IV every 15 minutes up to 2 times as needed as second rescue medication if the pain is not relieved with tramadol
- If pain persists, a patient-controlled anesthesia pump with hydromorphone
- Ondansetron 4 mg IV every 6 hours as needed for nausea
- Controlled with celecoxib, acetaminophen, and gabapentin and continued at discharge, along with tramadol 50 mg orally 4 times a day as needed
- For breakthrough pain, patients who require rescue hydromorphone are discharged with the above medications and a prescription for a hydromorphone 2 mg orally every 4 hours as needed
- A dedicated follow-up nurse calls for all patients within 72 hours to address issues associated with pain and wound care

Figure 1.
Pain management in an enhanced recovery pathway after thoracic surgery according to Mehran et al. [45].

Non-pharmacological method	Mechanism
Preoperative education	
Acupuncture	Balances energy channels in the body that helps reduce pain
Relaxation therapies (music, meditation, aromatherapy)	Help increase energy levels and improve mood that trigger body to release endorphins
Physical therapies (massage, cold and ice application)	Relax tight muscles and decrease pain, swelling and may prevent tissue damage
Transcutaneous electrical nerve stimulation	Reduce muscle spasm and soft tissue oedema

Table 1.
Mechanism of action for various non-pharmacological methods. Adapted from national centre for complementary and integrative health (NCCIH) [55].

postsurgical recovery process [59]. Preoperative education is one of the most effective ways to control anxiety in patients awaiting surgery [60], and it serves to enhance patient involvement in their postoperative pain management through informed decision-making [47, 61]. Additionally, preoperative education allows the patient to adequately prepare for the surgery and to manage postoperative pain effectively [60].

The information provided during preoperative education usually covers the surgical process, anaesthesia, pain, and what to expect after surgery [62–64].

The key thing to remember is preoperative preparedness as well as preoperative education and counselling for appropriate pain relief and control after surgery [8, 47]. Before surgery, according to Chou and colleagues, individualised and family-oriented education as well as mutual goal setting should be allocated in relation to appropriate pain relief after surgery [47]. For instance, education about types of pain, sources of pain, when and how to report pain using pain chart, pain medications commonly used, and side effects should be included in preoperative teaching [47].

Adequate information regarding pain assessment, proposed analgesic medication and technique, complications, and its management are recommended whenever possible [8]. The patient education does not exclude non-pharmacological pain management methods or techniques according to preference of each individual patient (e.g. massage, music therapy, cold application, and distraction techniques). Encouragements to use and choose a preferred non-pharmacological therapy in combination with skill development are also performed preoperatively [46, 47]. Oftentimes, surgery-related information is provided by surgeons. However, it is more effective when the anaesthesiologist also provides patients with information related to anaesthesia alongside the information provided by the surgeon [65]. According to Chou and colleagues, effective preoperative education should include detailed information related to treatment options, type of pain, expectations, and goal setting for the pain intensity the client intend to achieve postoperatively [47]. The information that is included in a preoperative education is especially important for younger women because they have higher risk for severe postoperative pain [37].

The effectiveness of preoperative teaching using a variety of teaching strategies has been examined by the previous studies, which revealed the benefit of it [59, 66, 67]. According to Ramesh and colleagues, patients who are well informed before surgery tend to experience little pain [59]. Preoperative education can be delivered to patients individually or in groups [60] through face-to-face sessions or technological devices [47]. Information can be provided by lecture, booklets, pamphlets, videos, audiotapes, and technology-assisted devices [47, 68]. Written information can also be used to reinforce information provided verbally to patients and vice versa [60, 64]. Using either of these means, preoperative education can be provided to different surgical patients.

Irrespective of the patient education method chosen, delivering the information too quickly and inadequately can hinder the patient's understanding of and the sufficiency of the information, as well as their satisfaction with the preoperative education [60]. This includes patients awaiting all types of surgery [66], knee surgery [64], spinal surgery [62], cardiac surgery [61, 69, 70], abdominal surgery [71], renal surgery [63] and breast cancer surgery [72]. Most of the studies reported that preoperative education was effective in controlling anxiety in patients awaiting surgery and pain after surgery.

7.2 Acupuncture

Acupuncture is a non-pharmacological intervention that helps to reduce pain by stimulating specific nerve points called acupoints. Acupoints are a few dynamic, complex structures that consist of blood vessels, mast cells, and nerve fibres [73]. The acupoints are reached with the help of thin, solid metallic needles that penetrate the skin. Acupuncture technique has been used in Asia for thousands of years as part

of traditional Chinese, Japanese, and Korean medicine [74]. Acupuncture can be delivered as manual acupuncture or electroacupuncture [73, 74]. Manual acupuncture is conducted by inserting the needle into the skin at the corresponding acupoint, and then, the needle is moved in different direction to stimulate the acupoint mechanically. Meanwhile for electroacupuncture, mechanical and electrical stimulations of acupoints are achieved by passing electric currents through acupuncture needles [73].

Acupuncture is believed to be governed by three main principles which are modulating yin and yang, differentiating between primary and secondary *Qi* (i.e. vital energy), and inhibiting pathogenicity and enhancing immunity [75]. The achievement of these main principles is based on the theory of meridians, collaterals, and acupoints. Meridians ("Jing and Luo", 'links or connection') are the transport pathways for *Qi* and blood, controlling yin and yang, connecting Zang organs with Fu organs, and connecting the external and internal as well as the upper and lower body of humans [76]. Collaterals are thin networks of small interwoven channels that run throughout the body [75]. According to this theory, diseases are treatable through acupoints as they are closest to the body's surface. Through acupoints, meridian obstructions can be removed, *Qi* and blood can be controlled, inadequacies can be reinforced, and excesses can be curtailed [76].

Although acupuncture's mode of action in pain relief is not fully understood, some studies have posited that acupuncture triggers the release of endogenous opioids and neurotransmitters that are responsible for pain control [77]. Pain control begins at the acupoint where acupuncture-induced signals are generated and transmitted to the brain via the spinal cord. As the signals reach the brain, there is a rise or decline in many neurotransmitters, inflammatory factors, and pain relief modulators [73]. The ability of acupuncture to control pain depends on acupuncture manipulation, sensation, acupoint, pathological status, and the type of pain [78].

In general, the effectiveness of acupuncture has been widely contested because its mechanism is yet to be fully understood [79]. However, some systematic reviews have reported that acupuncture is effective in relieving cancer pain [80, 81], low back pain [82–84] and postoperative pain [85–87]. For women who have undergone mastectomy, acupuncture was used in one study for acute pain management and was found to be effective [77].

8. Relaxation therapies

Relaxation therapies have also been recommended for pain management after surgery [46, 47]. A few interventions belong to this group of therapies because they share some similar components and requires patient's acceptance and rapport building before its initiation [46]. These interventions include breathing exercises, music therapy, aromatherapy, and meditation [5, 46, 47].

Previous studies about relaxation therapies have focused on music therapy [88, 89], meditation [90, 91], and aromatherapy [92, 93]. These studies have supported that after breast or thoracic surgery, relaxation therapies reduce pain intensity as well as pain distress at rest, during deep breathing and turning.

8.1 Music interventions

The history of utilising music for healthcare purposes dates to the sixth century. However, Florence Nightingale recognised its importance in the clinical area in the

eighteenth century [94]. Since then, music has been widely used for anxiety reduction and pain management across various patient populations—including preoperative and postoperative patients—because it is not physically or cognitively tasking [95]. Music has also been used to control blood pressure, respiratory rates, and heart rates of various groups of patients because it promotes relaxation [5, 96–99].

The way patients respond to music differs and is mainly dependent on the patients' knowledge about the music, culture, environment, and preferences [100]. Finlay and Anil concluded in their study that the types of music that have been successfully used to improve patient outcomes include music that the listener is familiar with, prefers, and can resonate with emotionally [101], because personal preferences and familiarity can stimulate attention to the music, thus distracting patients [102].

The positive effects of music on anxiety are made possible through distraction, which occurs when lyrics or the sound of familiar music occupies the attention centre of the brain, creating meaningful auditory stimuli [100]. However, the precise mechanism of pain reduction that music elicits is not widely understood [103], though the benefits have been established through research [104]. One of the methods that music is believed to use to relieve pain is inherent in the cognitive and emotional characteristics it possesses, which allows it to act as an external and distracting stimulus [102].

Music can be used passively through listening to downloaded songs or songs on compact discs or actively through singing and drumming [100, 105]. Beyond the familiarity, culture, and environment of the patients and the mode of music delivery (i.e. active or passive), music has six main components that also influence patient's response to music. Each of these components is processed by the brain through different pathways [106]. These components include volume, tempo, rhythm, pitch, melody, and timbre. Controlling these components will result in either relaxing music or stimulating music [107], which will have different effects on patients, depending on their preference and familiarity with the music [108]. To further enhance the effectiveness of music in clinical settings, music should be set at 60 to 80 beats per minute [109], and patients should be allowed to control the volume of the music [105]. Music should also be played for 20 to 60 minutes on portable devices for individuals or public address systems for groups [100, 105, 109].

Evidence from the previous literature has revealed that music is beneficial to patients experiencing pain [106, 110], and music is effective in reducing pain among cancer patients [111] and patients awaiting surgery [112]. Previous studies have also reported that music is effective in reducing pain in patients who have undergone a bone marrow transplant [113] and knee surgery [114]. For patients undergoing breast cancer surgery, a recent systematic review also reported that music interventions effectively reduced acute postoperative pain [87].

8.2 Meditation

Meditation is the process of training one's attention and consciousness via the voluntary regulation of mental processes [115]. Meditation is an important method of understanding the nature of the mind and a means to attain a certain degree of consciousness. Meditation is a common religious practice in both the East and West. The techniques used in the East and West are similar, including "breath-oriented multitasking meditation", mindfulness meditation, and relaxation response [116]. Meditation involves a self-regulatory process that can improve symptoms through the maintenance of the balance of autonomic responses [117]. These responses include improved vital signs (i.e. pulse rate and blood pressure), cardiac activities,

and oxygen consumption [116], all of which are cardinal consequences of inadequate anxiety and pain management.

Meditation as a non-pharmacological intervention engages three main structures in the brain, including the anterior cingulate cortex, the anterior insula, and the ventromedial prefrontal cortices [118, 119]. A steady practice of meditation results in higher activities at the ventromedial prefrontal cortices, causing a greater level of anxiety reduction [119]. Meanwhile, when meditation is used for pain management, the three main structures interact with pain in the limbic–thalamic region because both pain and meditation elicit affective, sensory, and cognitive responses [118]. This interaction results in the activation of the endogenous opioid system [120].

Although meditation has three main techniques, the most commonly researched one is mindfulness meditation. In general, meditation has been found to be effective in reducing anxiety in patients undergoing cardiac surgery [121] and for pain management in patients with cancer, fibromyalgia, migraines, and irritable bowel syndrome [122], as well as for patients after abdominal surgery [91]. However, there is limited evidence on its use after breast surgery, thus creating a dearth in evidence on its effectiveness for postoperative pain management in patients undergoing breast surgery.

8.3 Aromatherapy

Aromatherapy is a botanical therapy that reinforces the therapeutic value of smell and sometimes touch during care delivery [123]. The botanical nature of this therapy involves the use of plant oil for health purposes. According to Tamaki and colleagues, aromatherapy is the application of extracted essential oils—from flowers, herbs, and other parts of the plant—to treat different illnesses [124]. The use of aromatherapy has a long history as it was practiced in ancient Mesopotamia, Egypt, China, Greece, Rome, and Israel. However, modern-day aromatherapy was developed by a French scientist who accidentally dipped his burnt hand into a jar of lavender oil, and the wound healed rapidly without a scar. Since then, modern medicine has researched the use of essential oils for health purposes [125].

Although aromatherapy's mechanism of action has been widely contested by different scientists, most believe that the link between the olfactory and limbic systems is the main pathway for its action of influencing mood and emotions [126]. Once the odour of an essential oil binds to a certain protein in the olfactory cells, it stimulates the olfactory nerve, which transmits a signal to the limbic system and the hypothalamus [125]. In the limbic system, the amygdala, which controls emotional responses, and the hippocampus, which controls explicit memory formation and retrieval, then transmit a signal to the cerebral cortex. The cerebral cortex allows interaction between thoughts and feelings and the brain centre that controls stress and hormone levels and vital signs [123]. Aside from the assimilation of essential oil through the olfactory system, it can also be assimilated through the skin and mucous membranes by diffusion [123, 125, 127, 128]. However, inhalation appears to provide the most rapid effect. Similarly, it is believed that the chemical properties and composition of an essential oil are what determines how effective a specific type of oil may be [123]. According to Halcon, there are various essential oils that can be used when delivering aromatherapy, but the commonest essential oil used in the previous studies was lavender oil through inhalation [123].

In the clinical setting, aromatherapy has been mainly used to manage pain, anxiety, agitation, nausea, and insomnia and to prevent infection. For each symptom,

the mode of application may vary from inhalation and ingestion to topical application [123]. However, most of the previous research has focused on the use of aromatherapy to control stress symptoms, especially anxiety among various patient populations including patients waiting for surgery [129–131]. This can be due to the already established understanding of the connection between aromatherapy and the limbic system, which is the centre of emotions. Meanwhile, some other studies have been conducted to test the effects of aromatherapy on the mood and pain of patients undergoing various breast cancer treatments including surgery and thoracic surgery [124, 132–137].

8.4 Physical therapies

8.4.1 Massage

Massage belongs to the group of physical therapies, and it is seen as essential to health and well-being [138] which provides pain relief either during or immediately after the intervention [47]. Massage is the use of manual methods and adjunctive treatments to positively affect patient's health and well-being. The root word of massage is from the Arabic word "mass'h", which means "press gently" [139]. Massage has gained widespread popularity for preoperative anxiety management [140] and for pain management among hospitalised patients [90, 141]. However, massage has been mostly used for pain management [142]. Massage provides relief for anxiety and pain, but its mechanism of action is yet to be understood [143]. Many scientists have suggested that massage works to relieve anxiety by promoting relaxation [139] and working on the subconscious mind to promote positive emotions [144]. Likewise, massage can relieve pain by producing a localised effect on muscles [144] and by activating non-myelinated C-fibres which inhibits the perception of pain [139].

Massage can be provided in the hospital, and it has yielded a considerable level of positive effects [145]. There are various types of massage techniques that have evolved from different cultures. The taxonomy of these techniques is based on both Western massage and Eastern massage. Eastern massage technique includes Thai massage, reflexology, acupressure, shiatsu, polarity therapy, and others. Meanwhile, Western massage technique includes Swedish, myofascial, reflexive, soft-tissue release, circulatory, lymphatic, neuromuscular massage, and others [144]. Different massage techniques may produce different effects or expected outcomes in patients. However, for pain management, patient involvement in the decision-making process about where to massage, as well as patient assessment prior to massage, may help to increase the positive effects of massage [145]. Despite the popularity of massage for pain management among postoperative patients who have undergone cardiac surgery [140, 145–149] and thoracic surgery [141, 150], only a few types of massage have been used for pain management in women undergoing breast surgery. The studies conducted among thoracic and breast surgery patients found that massage can be used routinely in the hospital to help patients who have undergone mastectomy or breast cancer surgery control their pain better [90, 140–142, 146, 151, 152].

8.4.2 Cold applications

Application of cold on the skin which may need a compression or an equipment that can recirculate mechanically for cold temperature maintenance is described as cold therapy [47]. Cold therapy is a common nursing intervention and has proven

effective in most surgeries especially open-heart surgeries by reducing patient's incisional pain [153].

Application of cold therapy is common in acute pain settings including postoperative pain settings, and its effect has been identified to be related to tissue temperature reduction at the surgical which results in localised pain relief and oedema reduction [153]. Previous studies have recorded success in the use of cold therapy in pain management after thoracic surgery. Ice pack placed on incision site reduced pain in the previous studies by reducing the temperature at the surgical site, numbness, and promoting feeling of coolness [153–156]. The implementation of cold therapy by nurses can be done independently, and patient's acceptability is feasible because it is cost-effective and easy to use [154].

8.5 Transcutaneous electrical nerve stimulation

Transcutaneous electrical nerve stimulation (TENS) is a non-pharmacological intervention that utilises low electrical currents on intact skin to stimulate nerve activities that inhibit or enhance certain nerve impulses [157]. TENS was basically developed for pain relief; however, it also enhances venous haemostasis through motor and skeletal nerve stimulation [158, 159]. TENS is an intervention that has been delivered by many healthcare providers, including nurses, because it is safe, cheap, non-invasive, and does not require physician expertise [157]. The mechanism of action of TENS is based on the gate control theory developed by Melzack [160]. TENS activates the descending inhibitory pain pathway [158] by first activating the large unmyelinated A-β fibres that prevent noxious stimuli transmission [161]. When TENS is delivered at a high frequency, certain receptors in the bloodstream (i.e. beta-endorphins) and cerebrospinal fluid (i.e. methionine-enkephalin) increase in concentration creating a myriad of opioid-receptor blockades in the rostral ventromedial medulla and the spinal cord [161].

According to Vance and colleagues, TENS has been utilised for pain management in various patient populations including patients with neck cancer, those with phantom limb pain, those undergoing labour, and those who have undergone thoracic surgery [161]. TENS has also been tested in patients undergoing cardiac surgery. Nonetheless, there are inconsistent findings on the effects of TENS on pain after surgery [158]. There is also a lack of evidence on the utilisation of TENS for anxiety prevention and in women undergoing breast cancer surgery. However, TENS may be beneficial in reducing pain in patients with undergoing breast surgery.

9. Conclusion

This chapter has elaborated the mechanisms of postoperative pain after thoracic and breast surgery, which is generally short-term and acute in nature. Inadequate pain management can exert profound and negative impacts on the recovery of patients. In addition, various patient factors and surgical factors not only predict the development and intensity of postsurgical pain, but also influence how patient responds or copes with pain after surgery. To promote the recovery after surgery, both pharmacological and non-pharmacological pain relief methods are recommended to be integrated as a multimodal pain management plan for patient awaiting surgery. Indeed, adequate, and effective multimodal pain management plans require appropriate regimen and dose of individual analgesic agents to minimise the side effects of

medication, as well as tailored non-pharmacological therapies that consider patient's preference. For future research, high-quality experimental studies are warranted to provide evidence on the delivery of non-pharmacological therapies among different populations within their unique social and cultural contexts. Moreover, exploring the mechanisms of non-pharmacological therapies on pain relief is needed to enhance the potential effects of such therapies. To enhance pain management in clinical praxis, the selection and delivery of pain management therapies should consider patient factors, especially patients' preference, to promote the efficacy of their multimodal pain management plans.

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Conflict of interest

The authors declare no conflict of interest.

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