LITERATURE REVIEW

Role of Physical Medicine and Rehabilitation in Phantom Pain Management

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ABSTRACT

Limb amputation often results in the alteration of painful (phantom and stump pain) and nonpainful sensory experiences (phantom sensation). It is important to know the characteristics of sensory experiences to avoid mistakes in identifying phantom pain. Phantom pain can cause disability for patient, disturbance in mobility, and deteriorate the quality of post-amputated patient. Management of phantom pain include pharmacology treatment, surgery, anasthesia also psychotherapy. Physical medicine and rehabilitation program such as physical therapy, biofeedback, desensitization, occupational therapy, mirror therapy, and applying prosthesis should be performed not only to manage the pain, but also to improve functional level to increase patient's quality of life.

Key Words: Amputation; Phantom limb pain; Stump pain; Sensation; Rehabilitation.

INTRODUCTION

Pain felt in body part that already non existing often happened for about 50-80 % in post amputation patient, or about 0.5%-100% according to another study.[1,2] It can be varies depend on the method, population of the study, and difficulty to differentiate *phantom pain*, phantom sensation and stump pain. Onset of *phantom pain* can be different in every person. A prospective study finds 65 % of phantom pain occur 6 months post amputation, and 59 % occur two years post amputation.[2-4]

Phantom pain can cause disability for patient, disturbance in mobility, and degrade the quality of patient post amputation. It becomes important reason that patient should get medical treatment.5 Management of phantom pain include pharmacology treatment, operation, anesthesia also psychotherapy. Physical medicine and rehabilitation also has role in treating the pain, such as physical therapy, *biofeedback*, desentsitization, occupational therapy, mirror therapy, dan applying prosthesis.[1,6]

There is presumption that the etiology of phantom pain consists of central and peripheral factors. Psychological factor is not suggested as the cause, but it can affect the progression and

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severity of phantom pain.1 The characteristic of the pain is important to differentiate from *non-painful phantom limb sensation (phantom sensation), and residual-limb pain*.[1,2]

The purpose of this article is to increase the knowledge about phantom pain in order to give comprehensive Physical Medicine and Rehabilitation (PMR) treatment.

DISCUSSION

1. Definition

The definition of phantom pain is pain sensation that felt at the body part that is actually not existing anymore post amputation.[2] Phantom pain usually happens in amputation of extremities, but it had been reported in cases with post tooth extraction, and mastectomy.[5] According to its pathophysiology, phantom pain is a neuropathic pain.[7,8]

2. Pathophsyiology

Changes in central system are presumed as the main cause of phantom pain, and it is aggravated by peripheral factor. Ambroise Paré postulated that peripheral factor and central pain memory is the cause of phantom pain. Psychological factor is not the direct cause of it but it can affected the progression or severity of phantom pain.[1]

2.1 Central Factor

2.1.1. Cortical Reorganization and Neuroplasticity

Cortical reorganization theory was the most oftenly suggested to explain phantom pain. Experimental study shown that motor and somatosensoric cortex had changed after patient got amputation.

An experimental research shows that the somatosensory and the motor cortex experience neuroplasticity after the amputation of limbs. The literature states that the cortex area that is responsible to the amputated limb was taken over by other adjacent areas, both the primary somatosensory cortex (S1) and the motor cortex (M1). The size of area that has cortical reorganization depends on the extent of the deafferentated area. The broader deafferentation area, the wider is cortical reorganization. A study using functional MRI research on hand gestures and lips, as well as phantom limb movements in 14 upper limb amputee found only patients with phantom pain that led to the reorganization of cortical areas S1 and M1. Area that represent lips shifted to the area previously occupied by deafferentated hand, as described in Figure 1.[9]

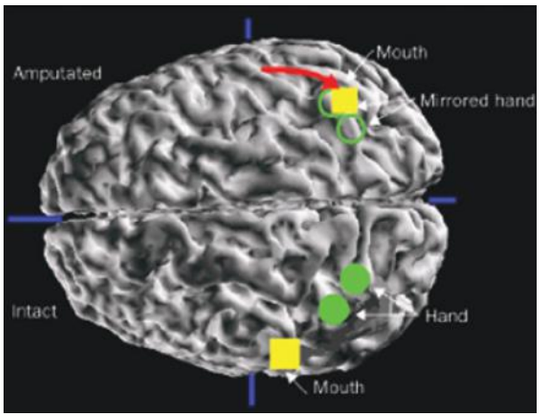

Figure 1. Localization of a normal hand in transpositioned to the contralateral side of the amputation. Areas that represent the lips have invaded areas previously represented the hand (amputated).[1]

2.1.2 *Body Scheme*

Head and Holmes in 1912 initially declared the concept of body as a representation scheme that is constantly changing in different locations in the brain that can be filled by a particular body part. Body scheme can be modified by the presence of nerve impulses coming from the sensory touch, proprioceptive, visual and vestibular. Therefore, it is flexible and acquired through experience.

Schwoebel et al define the body scheme as a representation of the dynamic of the relative position of a body part that is derived from the input motor and sensory diverse (proprioceptive, vestibular, tactile, visual, efference copy - neural copy of a movement command) which interacts with the motor system by initiating movement. Body scheme can be said to be a mold around the body, so if there are changes in the body such as the amputation led to the perception of phantom limb.[9]

2.1.3 Neuromatrix

This theory suggests that the body-self neuromatrix is a network of neurons in the brain that integrates with a variety of input / feedback from the body, which includes the somatosensory, limbic, visual, and thalamocortical components, and produces output / output triggers pain or other meaningful experiences. Neuromatrix includes the dimension of sensory, affective, and cognitive pain as described in Figure 2.[9,10]

Internal awareness of human body has existed in the brain, and are activated by the input / input variable that has been presented in Figure 2. Patterns of activity generated in the brain are updated by the conscious awareness and perception of the body and the self, called neurosignature. Melzack suggested that phantom pain due to reduced input / input that varies from limb to neuromatrix causing abnormal neurosignature.[9,10]

2.1.4 Other Theory

Ramachandran and Hirstein presume that there are at least five components that contribute to the phantom pain: (1) the residual limb neuromas; (2) cortical remapping; (3) monitoring corollary discharge from the motor commands to the limbs; (4) body image; (5) a strong memory of the pain and posture of the limb involved. This theory emphasizes that these five components work together and reinforce each other.[9]

Another theory puts forward by Ramachandran and Hirstein is the learned paralysis. This theory suggests a link between the phantom arm movement controls. The brain does not receive feedback in the form of confirmation upon movement command originated from the limb that has been amputated. Thus, the loss of ability to control motion and phantom is perceived as paralysis.9 Weeks et al. suspect that phantom pain as a result of a phenomenon called as the proprioceptive memory as the internal proprioceptive awareness of a limb and location. It retains the memory of specific position of the limbs.

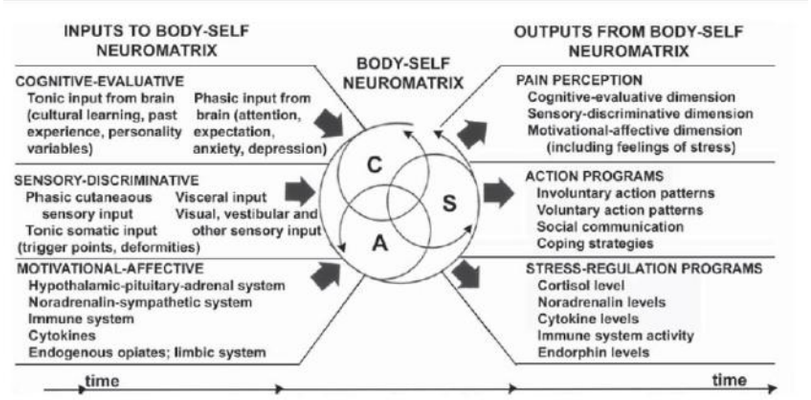

Figure 2. Factors that contribute to body-self neuromatrix composed of sensory, affective, and cognitive. Neuromatrix generate output patterns of the multi-dimensional experience of pain and the response behavior and homeostatic.[10]

When the amputee awareness of the amputated limb that is derived from the visual system is gone, however, the proprioceptive memory remains intact. The remaining active nerves associated with the amputated body part causes a false representation of the existence of these body parts. Sensation of muscle cramping, or joint fatigue can be explained by the activation of proprioceptive memory.[9]

2.2 Peripheral Factor

Changes at the peripheral level are considered as a determinant factor of phantom pain. This is supported by studies that illustrate the relationship between the moderate pain of residual limb and phantom pain. There is a hypothesis that the peripheral mechanism of phantom pain produces ectopic discharge from the stump neuroma. When peripheral nerve injury occurs, axons grow and form neuroma on the residual limb. This neuroma is constructed as a results of disorganized endings C-fibers and demyelinated A-fibers accumulation spontaneously. At the same time, the upregulation of sodium channels and rise of pressure and cold temperature following the nerve injury stimulate the production of ectopic discharge. Moreover, ephapses or the non-functional connection between the adjacent axons also play role in this process. However, some cases show the establishment phantom pain before the formation of post-amputation neuroma. The abnormal input from neuroma is suggested to improve the reorganization of central map. It indicates the interaction between the peripheral and central factors to generate phantom pain.[1,9]

Another source of ectopic discharge is the dorsal root ganglion (DRG). It can intensify the discharge protrudes from the residual limb, or may trigger cross-excitation and depolarization of the adjacent neurons. Neural activity on the stump can be anesthetized locally, but the spontaneous process derived from the DRG will continue to occur. There are several factors contribute to pain, such as location of nerve injury and post injury condition; temperature; oxygen supply; and local inflammation.[1]

Additionally, sympathetic nervous system also plays a role in the development of phantom pain through several mechanisms, called as sympathetic triggered ephaptic transmission, sympathetic activation of nociceptors and mechano receptor activation of the low threshold that triggers the neurons of the spinal cord. Sympathetic discharge may occur due to emotional distress when the level of circulating epinephrine increases and triggers neuronal activity in the neuroma. Adrenegic blocking agents or sympathetic blockade surgery may alleviate the phantom pain. In contrast, the injection of epinephrine can excite phantom pain.

Sympathetic dysregulation decreases blood flow near the surface of the limb causes burning phantom limb pain. An observation using hand videothermogram in patient who had amputation of the left little finger showed decrease in blood flow at the time of burning phantom pain intensity increased (Figure 3).[11]

The onset and intensity described as squeezing phantom pain are correlated with strained muscles in the residual limb. Surface electromyography shows muscle tension in the residual limb preceding the cramping and squeezing phantom pain. It cannot be imposed on any other description of phantom pain.[1]

Peripheral factor is not the primary cause of phantom pain. It is because pain can occur even without pathology on the residual limb.

Peripheral factors act as the modulation of phantom pain, in which the central factors also play a role. The occurrence of phantom pain of peripheral and central factors can be seen in the following diagram (Figure 4).[1]

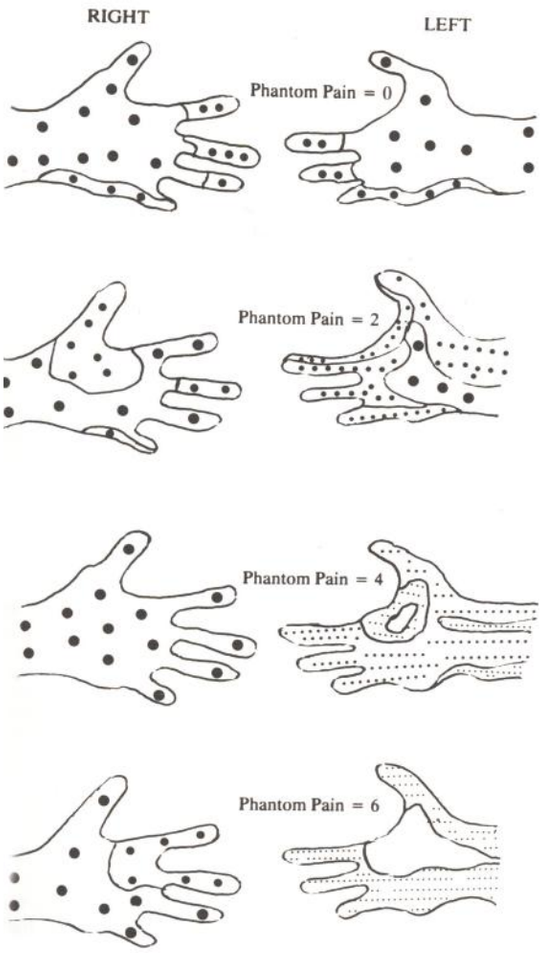

Figure 3. The relationship between the intensity of burning phantom pain and blood flow close to the surface. The greatest point marks the warmest area and a blank area indicates the coldest areas. An empty area having the same temperature with room temperature. Burning phantom pain intensity assessed on a scale of 0-10.[11]

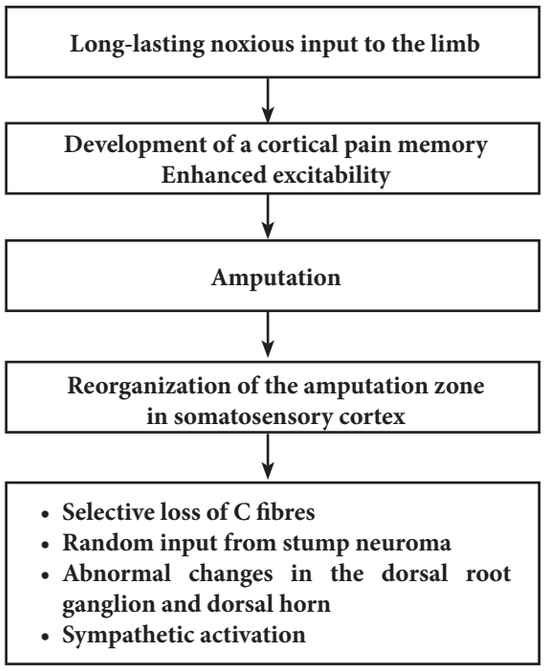

Figure 4. Factors that play a role in the occurrence of phantom pain.[1]

2.3 Psychological Factor

Losing a limb is a traumatic experience and some patients may experience symptoms of psychological disorders, such as depression, anxiety, self-pity and isolation. However, there is no corroborating evidence showing that phantom pain is a form of psychological disorders. Empirical evidence on the psychological traits in patients who experience phantom pain in comparison to the control group showed that patients with phantom pain had normal psychological profile. However, phantom pain is triggered and raised back or relapse in the presence of psychosocial factors.[1,12]

A longitudinal study by Arena et al. shows a significant relationship between stress and the onset or exacerbation episodes of phantom pain. It is mediated by the sympathetic nervous system activity and increase muscle tension. Cognition factor also plays a role in the modulation of phantom pain, where patients have less coping

strategies are more affected because of the pain. Therefore, self-control is primary to successful coping. In addition to psychological factor, it can predict the occurrence of pre-amputation phantom pain. Patient is less likely to get more support prior to pre-amputation phantom pain experience.[1,12]

3. Clinical manifestation

The onset of phantom pain is various. A study reports 65% of subjects experienced phantom pain 6 months after amputation, and 59% appeared two years post-amputation (Walsh, 2010). Another found it's incidence, in which 10% within six months and 25% two years post-amputation.2 Moreover, a prospective study by Richardson acquires 92.3% of 52 patients experienced phantom pain in the first week post-amputation, while 78.8% six months after.[12]

The pain experienced by the patient is described as shooting, pricking, pins and needles, stabbing, burning, cramping, throbbing, or crushing which occur continuously or intermittently. Some patients feel the pain as crushing, twisting, such as needle stick, or the malposition of the missing body parts.[1,7]

A study by Ephraim involving 57 amputees with phantom pain intensity score average was 2.05 and a numerical scale of 0-10 at 24 months post-amputation. Another study with a sample of 914 amputees indicates three levels of pain, namely: 38.9% of severe pain (pain score 7-10 on a scale of 0-10); 26.4% of moderate pain (pain score of 5-6 on a scale of 0-10); and 34.7% of mild pain (pain score 1-4 on a scale of 0-10). Pain intensity was higher in the distal part of an amputated limb, such as fingers and palms on the upper extremities; toes, foot and ankle in the lower extremities.[12]

Telescoping was reported in 30% of patients who underwent amputation. The term describes the retraction of the phantom to the residual limb, and in many cases is the disappearance of the phantom in the residual limb, which might be accompanied by a shrinking of the phantom limb. This phenomenon is positively associated with the intensity of phantom pain.[1]

4. Risk Factor

There is evidence that pre-amputation pain increases the risk of phantom pain. It can be a manifestation of pre-amputation pain.[7] The risk factors set forth from a multivariate study by Dijkstra, consists of gender; reason for amputation; site of amputation; Bilateral / unilateral; age of patient age when amputation takes place; level of amputation; and onset of phantom pain.[5]

A study by Weiss and Lindell shows that the highest pain intensity is experienced by group of patients with amputation due to vascular diseases. However, Dijkstra finds insignificant differences on the incidence of phantom pain due to any causes of amputation, such as vascular disease, trauma, and cancer. The study concludes bilateral amputation on lower limbs is the greatest risk factor of phantom pain. There are two levels of amputation, the proximal (above or through the elbow or knee) and distal (below the elbow or knee) amputation. Distal amputation has higher risk than the proximal amputation. Furthermore, older patients are more likely to experience phantom pain. Meanwhile, the incidence is not affected by gender. Table 1 explains the risk of experiencing phantom pain ranged from 0.33 to 0.99 differs by age, limb involved, level of amputation, and bilateral or unilateral limb.[5]

Table 1. Phantom pain predictions based on risk factors[5]

Age	Upper Limb		Lower Limb			
	Distal	Proximal	Distal		Proximal	
	Single	Single	Single	Bilateral	Single	Bilateral
10	0.33	0.48	0.53	0.83	0.68	0.91
20	0.39	0.56	0.60	0.87	0.74	0.93
30	0.46	0.63	0.66	0.90	0.79	0.95
40	0.54	0.69	0.73	0.92	0.84	0.96
50	0.61	0.75	0.78	0.94	0.87	0.97
60	0.67	0.80	0.83	0.96	0.90	0.98
70	0.73	0.84	0.86	0.97	0.92	0.98
80	0.79	0.88	0.89	0.97	0.94	0.99

5. Differential Diagnosis

The incidence of phantom pain in previous studies varies due to the different method and population setting in each study. It leads to inability to differentiate among phantom pain, phantom sensation and stump pain. It is therefore important to know the characteristics of other phenomena in order to avoid mistakes in identifying phantom pain.[2]

Stump pain or also known as residual-limb pain originates from the remaining part of the limb that has been amputated.2 It is generally experienced as early postoperative pain which will disappear as the healing process of the wound completes. However, many patients experience the pain despite of healed surgical wounds. A study by Pezzin found prevalence of chronic pain due to stump was about 5-100%. A survey on 78 patients with traumatic amputee shows 14.1% has persistent severe pain. It also occurs in patients amputated for medical reasons other than traumatic. Pain is described as pressing, throbbing, burning, squeezing or stabbing. Some patients experience spontaneous movement of the stump, from smooth movement to pounding the small and strong muscle contractions. Stump pain is closely related to phantom pain. Studies by Carlen found that phantom pain is reduced with an improvement in the pathologic stump. In addition, a survey on 648 amputees, stump pain are experienced by 61% of amputees with phantom pain and 39% without phantom pain.[12] Phantom sensation is a sensation perceived that is derived from the amputated body parts, which is said to have no sensation, but almost all patients who have had amputation experience it. The pains intervals are vary from daily, weekly, monthly or yearly. The sensation felt very real, sometimes in the form of posture or movement of the body part that has been amputated. Unlike the phantom pain, phantom sensation does not cause clinical problems.[2,12]

6. Impact of Phantom Pain

Phantom pain can cause interference ambulation and mobilization, thereby reducing the quality of life of patients with amputations. Several studies have been conducted to search the effects of phantom pain on quality of life of patients. A study found that patients with phantom pain experienced anxiety disorders and depression. Emotional disturbance can then affect the quality of life of patients. Another study found that patients with phantom pain have worse quality of life than patients who did not experience phantom pain. The quality of life aspects include impaired physical function, social function, involvement because of physical problems, involvement due to emotional problems, mental health, and general health perceptions.[5,13,14]

7. Management

7.1 Surgery

Surgery for neuroma, or amputation at a higher level has an important role in managing stump and phantom pain. However, the current revision of the stump is only performed in the presence of clear pathology. Persistent pain in the stump after complete healing is not an indication for amputation at a higher level.

Another surgical procedure to cope with phantom pain include neurectomy, symphatectomy, rhizotomy, cordotomy and tractotomy. Surgery may relieve the pain but do not rule out the possibility of pain to recur. The action of spinal cord stimulation and deep brain stimulation are considered effective as a treatment of phantom pain.[1,12]

7.2 Anesthesia

Phantom pain post-amputation in some cases have similarities with the pain that is felt before amputation. Moreover, patients who experience severe pain before amputation have higher risk of developing phantom pain. It is the underlying idea to do an act of pre-emptive analgesia. It is aimed at preventing the occurrence of chronic pain. It acts as an initial treatment of acute pain that arises before or during surgery. Regimens commonly used are bupivacaine and diamorphine.[1,12]

A study by Bach observes the effect of epidural analgesia that were given 72 hours prior to amputation compared to controls, and shows that a group that received epidural analgesia has less phantom pain incidence six months post amputation in comparison to the control group. Nonetheless, another study by Lambert found that the administration of epidural bupivacaine or diamorphine pre- and post amputation is not better than intra- and post-amputation, where the incidence of phantom pain is almost the same between the two groups within 3 days, six and 12 months post-amputation.[1,12]

8. PMR Role in Management of *Phantom Pain*

Knowledge and understanding of the characteristics and mechanisms of phantom pain is growing in line with the various studies that have been done, but the success to overcome phantom pain is still limited. There is no consensus about the gold standard therapy for phantom pain, thus the management is mostly done by empirical therapy, which includes treatment with a trial-and-error. High success therapy includes pharmacological and non pharmacological approaches specific to the symptoms experienced by patients.[4,9]

8.1 Medicines

Phantom pain is included in neuropathic pain, thus the effective treatments, such as administration of opioids, anticonvulsants, lidocaine / mexiletine, clonidine, ketamine, amitriptyline, nonsteroidal anti-inflammatory drugs (NSAIDs), beta-blockers, N-methyl D-aspartate (NMDA) receptor antagonists, muscle relaxants, nerve blocks, and calcitonin.

Medicines that are often used in the treatment of phantom pain consist of tricyclic antidepressants, anticonvulsants, and opioids. Positive results on several studies of pharmacological therapy should be observed further because most of the studies had limited sample size, and lack of long-term effects and safety outcomes. Pharmacologic therapy should be given based on patient's complaint and condition. However, the consideration of pharmacological therapy to decrease the pain should outweigh its side effects. It is therefore important to involve

patient in making decision regarding the drug of choice.[9,12]

Acetaminophen and Nonsteroidal Anti-Inflammatory Drugs (NSAIDs)

A cross-sectional study found that acetaminophen and NSAIDs were the most common drugs used in addressing the phantom pain. A survey on 590 amputee veterans of the UK obtained 53% experiencing phantom pain. A total of 53% consumed acetaminophen and 37% of them received a combination acetaminophenopoid. The highest satisfaction levels (more than half of the respondents) were obtained from the combination of acetaminophenopoid, or NSAIDs.[15,16]

Anticonvulsant

Gabapentin is known as an anti-seizure and often used in the treatment of neuropathic pain. The randomized, double blind, placebo-controlled, and cross-over study found that gabapentin is effective to reduce phantom pain significantly in comparison to placebo. The administered dose is 300 mg / day and then titrated up to a tolerable dose (maximum dose of 2400 mg / day) within 6 weeks.[9,17]

Tricyclic Antidepressant

Tricyclic antidepressant medications have effectiveness in addressing neuropathic pain. The randomized, double-blind, and placebo-controlled study examined the effectiveness of amitriptyline in patients post-amputation found that amitriptyline effectively decreases the intensity, duration, and frequency of phantom pain and stump pain, and improving the quality of life of patients. The dose given is 25 mg once at night, 3 days titrated up to a tolerable maximum dose (75mg) for 28 days. However, another randomized study found that amytriptyline reduces phantom pain or residual limb pain effectively.[18,19]

NMDA Receptor Antagonists

Memantine reduces phantom pain significantly based on a case report and a recent double-blinded and placebo-controlled study on memantine administration for 4 weeks after amputation.[9]

Morphine

Morphine is a class of opioids that is proven to effectively reduce phantom pain. A randomized, double-blind, and placebo-controlled study found that crossover administration of morphine to reduce pain intensity showed better results in comparison to placebo or mexiletine. The given initial dose of 15 mg sustained release morphine (one capsule per day) and titrated in accordance to the perceived pain (maximum dose of 180 mg per day). The dose is then maintained for 2 weeks, and then reduced by 25% every 3 days. A similar study design as above in comparing other type of morphine with placebo have found that morphine reduces the pain significantly and reduces cortical reorganization as evidenced by neuroimaging. However, Wu found common side effect of constipation. Moreover, other side effects are considered when choosing morphine instead of other therapy by physician and patients.[9,20]

Other opioids are also effective and well tolerated to resolve various kinds of pain, including neuropathic pain that is tramadol. A randomized, double-blind, placebo-controlled study examined the effectiveness of tramadol in patients after amputation with oral dose of 100 mg slow release tramadol twice a day, and titrated up for 3 days up to a tolerable dose or maximum dose (400mg / day) and maintained for 28 days. Tramadol is effectively lowering the intensity of phantom pain and stump pain.

Phantom and stump pain duration changed from intermittent to complete dismissal at the final week of the study and improve patients' quality of life.[19]

8.2 Non Pharmacological Treatment

8.2.1 *Phantom Exercise*

There is a study examining the effectiveness of phantom exercise as an adjunctive therapy of prosthetic training in patients with phantom pain. The steps of exercise includes revealing the position of how phantom pain is felt; resembling phantom limb position intact (contralateral); moving both limbs with the inverse movement from the initial position; and back to the starting position. A set of exercise is repeated 15 times or until the pain is gone. Patients are suggested to perform the exercise under supervision of a physiotherapist for four weeks before continuing independently. After six months, the evaluation reveals significant decrease of phantom pain in terms of intensity and frequency. This exercise is perform on the basis of mental imagery.[21]

8.2.2 *Trans Cutaneous Electrical Nerve Stimulation*

Electrical therapy that is used to overcome acute and chronic pain is trans cutaneous electrical nerve stimulation (TENS). Studies that examined the use of TENS on the residual limb or a trigger point along the nerve paths of residual phantom limb pain show significant decrease by 66% compared to placebo. There are other studies that TENS applied to the intact side of body or contralateral side, show better result than given in the residual limb.[9]

8.2.3 Excitatory sensory discrimination

Tactile disorders are common in the nervous system after injury. In the complex regional pain syndrome (CRPS) with phantom pain sensory that decrease sharply are associated with the reorganization of primary sensory cortex and to pain. The provision of sensory discrimination training can reduce pain, increase sensory acuity and normalize cortical reorganization.[22]

Previous studies found that the existence of discrimination tactile settle for at least 10 seconds after visual input from the 2 minutes-stimulated area stopped and given visible shadow of a hand. This may increase the sensitivity of the contralateral hands, which is not seen or given stimulus at least 3 minutes later. It is confirmed by a study by Moseley, which maintained a sharp increase sensory stimulation 2 days after administration. The possibility of such responses reflect the changing response of visuo-tactile cells in S1, affect modulation of S1 neurons via bimodal or visual cells in the secondary somatosensory cortex (S2), thus, it can normalize cortical reorganization. In contrast to sensory discrimination, tactile stimulation alone did not increase sensory sharply in patients with CRPS.[22]

The treatment provided in the study by Moseley patients with CRPS used two probes with diameters of 2 mm and 12 mm respectively to be applied to the 5 points of the involved hands in random sequence. Facing + skin condition is to observe the reflection of the unstimulated hand by facing the stimulated hand. The only skin condition is looking directly into an unstimulated hand. The facing only condition is looking in the direction of the stimulated hand in the absence of a mirror and the normal hand is hidden.[22]

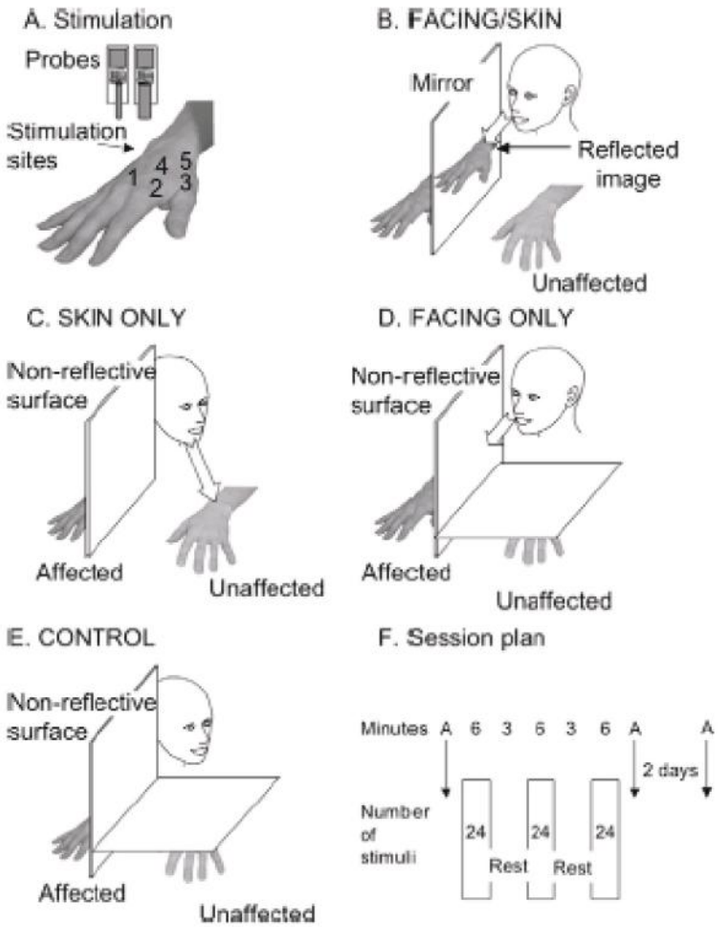

Figure 5. Sensory stimuli discrimination given to the conditions facing + skin; skin conditions only; facing conditions only, and control.[22]

8.2.4 Vibration

A study comparing the effects of vibration with placebo in 24 patients with chronic phantom pain were employed in these following methods. Vibration is done in some places, namely: in the pain area; proximal to the pain area; 2-3 cm paravertebral in the nerve roots related to the pain area, the trigger point near the pain area; contralateral of the area of the pain; acupuncture points approaching the pain area; all the muscles or tendons of the pain area; or the antagonist muscles. Vibration is done twice a day, 25 minutes in duration for 30 days by using a frequency of 100 Hz. It can be done at home using a small probe or large, with mild or moderate pressure. A decrease in pain intensity is obtained when the vibration performed on the antagonist muscles, and conversely an increase in the intensity of pain when the vibration is done on the agonist muscle of pain area. Pain reduction of more than 50% was found in 10 patients with mild to moderate pain, including 7 patients with complete pain disappearance. Patients who experience severe pain experienced a decrease in pain by 50% or less. Those who experienced pain reduction less than 50% may last up to three hours after vibration. Those who have declined of pain for more than 50% may last longer, i.e. more than three hours. Giving medium pressure (2kg) gave greater pain reduction than the light pressure (0.1 kg). The use of large probes (800cm2) produced

greater pain reduction than with a small probe ($6cm^2$). Four patients received vibration therapy twice a day for 45 minutes immediately after amputation did not experience phantom pain until 12-16 months later.[23]

8.2.5 *Massage*

Studies by Carel found that phantom pain is reduced with an improvement in the pathology of the stump. Cramping and squeezing phantom pain often preceded the muscle tension in the residual limb. Soft tissue or muscle shortens or dysfunction can be treated with massage. Thus, it is expected to reduce the pain experienced by the patient. In addition to reduce muscle tension, massage can improve the residual limb blood circulation, reduce edema and repair tissues surrounding the scar.

Application of massage can be done on a stump, on the muscles or soft tissues above the amputation area, or around the soft tissues of the proximal end portion of the limb involved. Massage can also be given with the aim to reduce stress and anxiety which is said to play a role in increasing the intensity of phantom pain.[1,4,24]

8.2.6 Mirror Therapy

Ramachandran and Roger's-Ramachandran explained the benefits of mirror therapy in the treatment of phantom pain. Hypothesis underlying the effectiveness of this therapy is the mechanisms of cortical reorganization.[25]

Figure 6. Patient can see the image of the arm that is still intact.[26]

Patients with cramping phantom pain complaint had decreased pain after exercise with mirror therapy session. The efficacy of mirror therapy was about 60% based on evidence where 9 out of 15 patients with phantom pain in the upper extremities experienced decline in pain remarkably. Moreover, a randomized controlled study by Chan found the effectiveness of mirror therapy on lower extremity. Patients with amputated limb use mirror therapy to produce a shadow box of the relevant limb that remains intact, resulting in a visual illusion of two intact limbs (Figure 6). Exercise by performing specific movements of the intact limb for 15 minutes a day within 4 weeks. One of the training procedures proposed by Brodic destined for phantom pain in the lower limbs is shown in Figure 7. It is stated that significant pain reduction is recorded in patients receiving mirror therapy compared to control patients.[9,25,27]

The effect of mirror therapy varies depending on the type of pain. Some studies have found its effectiveness to reduce deep somatic pain (pressure and proprioceptive sense pain) is superior to superficial pain (warmth sense and nociceptive pain).[26]

Descriptions of superficial pain include nociceptive pain sensation, which is described as knife-like, sawing, electric shock like, tingling, pricking, shooting, sticking or piercing, stabbing, and stinging; and temperature sensation, such as freezing, and burning. Deep somatic pain is associated with pressure sensation, such as taut, pressing, crushing, throbbing and dull; and the proprioceptive senses of movement and posture, such as clenching, twisting, cramp-like and tearing.[28]

Figure 7. Mirror therapy for patients with lower limb amputations.[9]

8.2.7 *Biofeedback*

Some studies suggest that phantom pain is described as burning or tingling that is associated with decreased blood flow to the extremities, while cramping phantom pain associated with frequent spasms in the residual limb. Treatment with biofeedback trigger vasodilatation or decrease of strain on the residual limb to help reduce phantom pain. Thermal biofeedback and relaxation and warning exercises are beneficial to alleviate burning pain. On the other hand, cramping pain can be relieved by muscle tension biofeedback while being alert to tension muscle during exercises to control muscle tension that occurs in the residual limb.[1,11]

8.2.8 *Virtual Reality*

There is a case study involving 8 amputees (4 upper and 4 lower limbs) who had post-amputation phantom pain for 1-13 in immersive virtual reality program (IVR). Patients using the IVR system to perform multiple commands, such as moving as directed by virtual representation of the board that are lit alternately; hitting or kicking a virtual ball; following the movement of virtual and direct stimulus to a specific stimulus virtual targets. Contralateral limb movements are translated into movements by phantom limb in a virtual environment (Figure 9). Exercises perform using the IVR system for 30 minutes, seven to ten repetitions are sufficient to patients to feel the control of phantom limb movement. In turn, patients will feel the phantom pain disappears gradually. Further studies with a larger number of samples and the control group is required to determine the effectiveness of an IVR system.[29]

Figure 9. The patient moves the contralateral limb (left) which is then translated into phantom limb movement to perform the assigned command.[29]

8.2.9 *Cognitive Behavioral Treatment (CBT)*

Pain is described as a complex experience that is not only influenced by pathophysiologic cause of the pain is also cognition, affect, and behavior of a person. CBT, as pain management consists of three basic components. The first component is a treatment that helps patients to understand or having rationale on both cognitive function and behavior that influence the experience of pain, and emphasizes on individual role on pain control. The second component is the coping skill training, where various cognitive and behavior training strategies are employed to cope with the pain. Progressive relaxation technique and exercise with brief cue-controlled relaxation is used to reduce muscle tension and emotional distress, and divert attention from pain. Setting activities by scheduling regular fun activities are expected to help patients improve the level and capacity of activities that can be carried out by the patient. Cognitive restructuring helps patients to identify and counter negative thoughts of pain to a mind that is adaptive and troubleshooting. The third component includes the application of and maintaining coping skills that have been learned. Patients are expected to apply their skills in overcoming the problem gradually. Patients are taught about methods to resolve the problem, so they can analyze and make plans if pain or other problems occur. CBT as pain management is performed within 8-10 weeks, once a week in a small group of 4-8 patients.[30]

8.2.10 Prosthetic

Functional or myoelectric prosthesis is believed to be a way to cope with phantom pain, especially if the patient uses prosthetic, proprioseptic which extends up to wear prosthetic body parts. Patients can feel the movement and sensation of the prosthetic related to visual and functional inputs replacing the function of the lost limb. Its usage is associated with the smaller cortical reorganization phantom pain.[1,31]

CONCLUSION

Phantom pain is often experienced by post amputation patients in which the onset may affect different characteristics of patients. Pain causes problem in mobilization that in turn might impair quality of life of patients. Phantom pain treatment standards have not been established, thus current treatment of phantom pain is often based on empirical, through trial-and-error. Procedures in the field of physical medicine and rehabilitation involving pharmacologic and non-pharmacologic therapies are expected to reduce phantom pain.

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