

Trigeminal Neuralgia and Radiofrequency Lesioning

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Abstract

Trigeminal Neuralgia is a disorder that is characterized with electrical-type shocking pain in the face and jaw. This pain may either present as sharp unbearable pain unilateral or bilaterally. There is no definite etiology for this condition. There are various treatment methods that are currently being used to relieve the pain. One of the pharmacological treatments is Carbamazepine and the most prevalent surgical treatments include Gamma Knife Surgery (GKS), Microvascular Decompression (MVD) and Radiofrequency Lesioning (RFL). Although, MVD is the most used surgical method it is not an option for all the patients due to the intensity of the procedure. RFL is used when MVD is not suitable. In this paper we present the various treatments and Monte-Carlo based pharmacokinetic simulations of Carbamazepine in treatment of Trigeminal Neuralgia.

Keywords: trigeminal neuralgia; radiofrequency lesioning.

1. Introduction

Trigeminal neuralgia (TN) (tic douloureux) is a neuropathic pain (NP) which is characterized by lancinating pain in the trigeminal nerve distribution (Jia and Li, 2010; Watson, 2012), (Watson, 2012). Trigeminal neuralgia can be presented with chronic pain or acute pain depending on the cause, which varies with the patients. Chronic pain differs greatly from acute pain in terms of the pain persistence and adaptation (Besson, 1999). TN is the most successfully treated NP both medically and surgically (Watson, 2012). Trigeminal neuralgia is associated with poor activity of daily living, suicidal attempts and an overall decreased quality of life due to the unbearable pain.

2. Etiology and Pathophysiology

The etiology of TN is a scientific mystery. The pathophysiology is unclear because there are counter examples for all the current theories. Vascular compression of the dorsal root of the trigeminal nerve is the most accepted cause of TN. There are various reason that could cause vascular compression as described in *Table 1* (Punyani and Jasuja, 2012). However, some patients present with trigeminal neuralgia and no nerve compression. Also, there are cases where the trigeminal nerve is being compressed yet the patient is not suffering from trigeminal neuralgia. A 12 year study have shown that trigeminal neuralgia has been associated with zone demyelination of the nerve root entry in multiple sclerosis (MS) patient and nerve root vascular compression patients (Abhinav *et al.*, 2012). Another hypothesis is the TN is caused by the entrapment of the maxillary and mandibular nerves when they cross the ovale and rotundum foramen (Abhinav *et al.*, 2012; Besson, 1999). The newest theory is bioresonance. Neurosurgeons De-ZeJia and Gang Li, state that when the vibration frequency of a structure surrounding the trigeminal nerve becomes close to its normal frequency, the resonance of the trigeminal nerve occurs⁴. This occurrence can damage the nerves fibers preventing them from transmitting the correct impulses which can result in TN.

Table 1. Various Etiological Factors for Trigeminal Neuralgia. Adapted from(Punyani and Jasuja, 2012).

- A. Compression of the trigeminal nerve root caused by:*
- 1) Intracranial vascular abnormalities e.g. aberrant loop of the superior cerebellar artery, aneurysm of the intrapetrous portion on the internal carotid artery*
 - 2) Intracranial tumours*
 - 3) Petrous ridge (Basilar compression)*
 - 4) Foreign object*
 - 5) Bone lesion such as osteoma*
- B. Multiple Sclerosis*
- C. Others*
- 1) Trauma*
 - 2) Viral infection (postherpetic neuralgia)*
 - 3) Ratner's jaw bone cavities*
 - 4) Infiltrative disorders of the trigeminal nerve root, gasserian ganglion and nerve*
 - 5) Familial occurrence as reported in CharcotMarie Tooth disease*
 - 6) Sarcoidosis and Lyme disease neuropathy*
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3. Diagnosis

TN is characterized by brief electric-like pains (Brisman, 2011) that are excruciating. Patients usually describe it as feeling like they are being cut with a knife, or getting shocked in the face. TN is presented most often as a unilateral pain (Emril and Ho, 2010). Out the three branches of the trigeminal nerve the maxillary branch is the most frequently affected⁶. According to the International Headache Society (IHS), the increasing frequency of posterior fossa exploration and magnetic resonance imaging has demonstrated that many, possibly most, patients with this condition have compression of the trigeminal root by tortuous or aberrant vessels (IHS, 2013). Currently TN is placed in two categories: the classic TN and the symptomatic TN. The classic TN is the most common form and it is due to the vascular compression of the nerve. The symptomatic TN is when the patient is showing all the signs and symptoms of TN but the nerve is not being compressed. The criteria to diagnose classical and symptomatic TN are the same except for an additional prerequisite for the symptomatic TN as seen in *Table 2* (IHS, 2013). According to IHS, the extra prerequisite is causative lesion, other than vascular compression, has been demonstrated by special investigations and/or posterior fossa exploration (IHS, 2013).

Table 2. IHS Diagnostic Criteria for Symptomatic TN. Adapted from(IHS, 2013).

Diagnostic criteria:

- A. Paroxysmal attacks of pain lasting from a fraction of a second to 2 minutes, with or without persistence of aching between paroxysms, affecting one or more divisions of the trigeminal nerve and fulfilling criteria B and C*
- B. Pain has at least one of the following characteristics:*
- 1) intense, sharp, superficial or stabbing*
 - 2) precipitated from trigger areas or by trigger factors*
- C. Attacks are stereotyped in the individual patient*
- D. A causative lesion, other than vascular compression, has been demonstrated by special investigations and/or posterior fossa exploration*

Symptomatic:

- A. Paroxysmal attacks of pain lasting from a fraction of a second to 2 minutes, with or without persistence of aching between paroxysms, affecting one or more divisions of the trigeminal nerve and fulfilling criteria B and C*
- B. Pain has at least one of the following characteristics:*
- 1) intense, sharp, superficial or stabbing*
 - 2) precipitated from trigger areas or by trigger factors*
- C. Attacks are stereotyped in the individual patient*
- D. A causative lesion, other than vascular compression, has been demonstrated by special investigations and/or posterior fossa exploration*
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4. Treatment Methods for Trigeminal Neuralgia

Pharmacological treatments

The ultimate goal of any treatment is to reduce pain and relieve symptoms (Punyani and Jasuja, 2012). The first line of treatment for TN is the used anticonvulsant drug, carbamazepine. Surgical methods are left when all drugs have been exhausted with little to no relief to the patient. Carbamazepine is the primary drug used for the initial treatment of TN (Punyani and Jasuja, 2012) due to its high efficacy in relieving symptoms. In a prospectively collected study establishing the population pharmacokinetics of carbamazepine from 121 patients aged 60 years or older, the population parameters showed the apparent clearance (CL/F) of carbamazepine in this community-dwelling elderly population was estimated to be 3.59 L/h with an interindividual variability of 18.1%. Moreover, the volume of distribution (V/F) was estimated to be 102 L with an interindividual variability of 74.7% (Punyawudho *et al.*, 2012). Other drugs used in the treatment of TN also include, Oxcarbazepine, Phenytoin, Lamotrigine, Gabapentin and Topiramate. As with any drugs, there are side effects to consider when administering these drugs.

Surgical Treatments

TN does not have a surgical treatment that is 100 % efficient. All of the procedures come with risks and benefits. As of 2005, about 8000 TN patients were undergoing surgical treatment in the United States (Kim J Burchiel, 2014). Surgery is proposed to patient whose TN is unresponsive to pharmacotherapy or if they are sensitive to possible side effects (Kim J Burchiel, 2014). Some patients can be treated with any of the surgical treatment available with the same probability on the outcome. In cases like that, personal preference and experience, attitudes toward risk on behalf of the patient and the surgeon, and clinical factors (such as the patient's age and health) generally suggest one procedure over another (Tatli *et al.*, 2008).

Alcohol or Phenol Injection

Alcohol or phenol is injected within several locations of the trigeminal nerve. The goal of this procedure is to destroy selective pain fibers (Kim J Burchiel, 2014). This procedure is rarely used nowadays because of its low success rate and high recurrence rate within a short period of time.

Microvascular Decompression (MVD)

MVD surgery is suggested for patients younger than 70 years old (Kim J Burchiel, 2014). One of the reasons is because of the possible complications that can arise when the patient goes under general anesthesia for the procedure. Although, healthy older patient can sustain it is not recommended. MVD is performed after an examination of the trigeminal nerve at or near its point of entry into the brain stem (Barker *et al.*, 1996). Then the compressing arteries or veins are repositioned with stents (Barker *et al.*, 1996). A study conducted by Peter J. Jannetta *et al.*, concluded that MVD is a safe and effective treatment for trigeminal neuralgia (Barker *et al.*, 1996). This conclusion is based on successful results of 1185 patients who underwent MVD.

Trigeminal Root Compression

This procedure is an option for TN patients who do not show any signs of vascular compression. It works by compressing the trigeminal nerve which causes a neuropraxia process in the nerve with a class 1 neuropathy (Revuelta-Gutierrez *et al.*, 2013). This result is used to explain the resulting therapeutic and side effect of the procedure. A study shows that all patients who underwent the root compression were pain free (Revuelta-Gutierrez *et al.*, 2013), however the relapsed time was very short, and others needed to be supplemented by drugs.

Gamma Knife Surgery (GKS)

GKS is a non-invasive stereotactic technique that utilizes a focused beam of radiation to target the root of the trigeminal nerve (Emril and Ho, 2010). TN patients do not prefer this method because the pain relief is delayed in some cases. GKS also has some side effect with the most common one being facial numbness (Karam *et al.*, 2014). This procedure is most used by the elderly who cannot undergo MVD. Studies have shown GKS treatment to have increased the quality of life of the patient during 1 year (Azar *et al.*, 2009). The patients were not in pain, they were socially and physically able to perform activity of daily living.

Radiofrequency Lesioning (RFL)

The procedure is called radio frequency because it uses the same frequency as an AM radio which is approximately 500 kHz of electromagnetic radiation (Vallejo *et al.*, 2010). RFL is a healing procedure with immediate effect. RFL is sometimes preferred in elderly patients with limited life expectancy (Tatli *et al.*, 2008). This preference is caused by the fact that RFL is an easy procedure with minimal side effects and provides relief for a shorter period of time than microvascular. RFL is also the treatment option for any patients not responding to pharmacotherapy, patients that are in poor health condition or young patients who cannot tolerate the risk of posterior fossa surgery (Lord and Bogduk, 2002). It is also worth mentioning that RFL is used sometimes based on a bias recommendation of the physician. Most Physicians tend to be better or more knowledgeable at one particular procedure over another, so sometime unconsciously they will suggest one procedure over another.

RFL Technique

Various diagnostics test are used to reassure the exact origin of the pain before the RFL procedure. RFL causes pain relief by generating a thermal lesion to the trigeminal nerve (Kapur, 2005). The thermal lesioning is created as a result of the heat produced in the tissue around the electrode tip (Sim *et al.*, 2007). For a complete and detailed listing of the RFL technique you can refer directly to the work of DilKapur (Kapur, 2005) and Mahesh Chaudhari (Chaudhari, 2011). To briefly summarize the process, a radiofrequency electrode is inserted through the foramen ovale and positioned among the sensory rootlets (Lord and Bogduk, 2002). In the case of TN an 18-gauge with a 2mm tip electrode is used (Chaudhari, 2011). Recent techniques have included devices that can measure impedance and use this information to apply low intensity current to the needle to help locate nervous tissue (Kapur, 2005). The patient is anesthetized during the actual lesioning of the nerve but is awakened toward the end phase in order to assess the efficacy of the procedure.

RFL post-operatively and complications

Studies have shown that patients with typical symptoms have good long-term results. One of the most discomforting possible complications of RFL for TN patients is the resulting facial numbness. The numbness is permanent in the region of the face that was supplied by the lesioned portion of the trigeminal nerve (Ritter *et al.*, 2009). TN is so painful that patients prefer the numbness over the agonizing pain. The two most common problems following numbness are dysaesthesia and anaesthesia dolorosa (Lord and Bogduk, 2002). There is also a high occurrence (~21%) of corneal anesthesia. Patients suffering from the latter have to have regular eye checkups to prevent further more severe eye conditions.

5. Conclusion

RFL is an effective, accurate and precise procedure that provides efficient pain relief to TN sufferers. RFL is suggested in the elderly because it is more beneficial to them in terms of low morbidity and mortality (Emril and Ho, 2010; Kim J Burchiel, 2014). Studies show that RFL provided a high initial pain relief, with a pain free rate of 50.4% after a 5 year follow up (Tatli *et al.*, 2008). After 37 years of experience in the TN field and based on the results from their most recent study, Humberto Santo Neto *et al.* concluded that TN is a lifelong disease that requires expert strategies with life-long duration (Bozkurt *et al.*, 2012).

6. Acknowledgements

This work was supported by NIH T32 GM008685 Clinical Pharmacology Training Grant.

7. Conflicts of Interest

The authors declare no conflict of interest.

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