Bali Medical Journal (Bali Med J) 2016, Volume 5, Number 1: 31-35
P-ISSN.2089-1180, E-ISSN.2302-2914

Stereotactic Radiosurgery for Classical Trigeminal Neuralgia

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Trigeminal neuralgia is a debilitating pain syndrome with a distinct symptom mainly excruciating facial pain that tends to come and go unpredictably in sudden shock-like attacks. Medical management remains the primary treatment for classical trigeminal neuralgia. When medical therapy failed, surgery with microvascular decompression can be performed. Radiosurgery can be offered for classical trigeminal neuralgia patients who are not surgical candidate or surgery refusal and they should not in acute pain condition. Radiosurgery is widely used because of good therapeutic result and low complication rate. Weakness of this technique is a latency period, which is time required for pain relief. It usually ranges from 1 to 2 months. This review enlightens the important role of radiosurgery in the treatment of classical trigeminal neuralgia.

Keywords: pain, radiosurgery, trigeminal.

DOI: 10.15562/bmj.v5i1.191

Cite This Article: Kodrat, H., Novirianthy, R. 2016. Stereotactic Radiosurgery for Classical Trigeminal Neuralgia. *Bali Medical Journal* 5(1): 31-35. DOI:10.15562/bmj.v5i1.191

INTRODUCTION

Based on the International Association for the Study of Pain (IASP) definition, trigeminal neuralgia is sudden, usually unilateral, severe, brief, stabbing, and recurrent episodes of pain in the distribution of one or more branches of trigeminal nerve. Based on the classification of the International Headache Society (IHS), trigeminal neuralgia is classified in to classical (essential or idiopathic) trigeminal neuralgia and symptomatic trigeminal neuralgia. The cause of classical trigeminal neuralgia is idiopathic or vascular compression to trigeminal nerve. While symptomatic trigeminal neuralgia is caused by demonstrable abnormality such as secondary to tumors, multiple sclerosis and abnormalities in the structure of the skull base. [1-4] The incidence of trigeminal neuralgia is 4.3 per 100.000 persons per year. The incidence is more predominant in women than men and increases with age.[5]

SYMPTOMS

Trigeminal neuralgia is characterized by recurrent facial pain in the area innervated by the trigeminal nerve. Trigeminal nerve consists of three branches, which innervate areas of the forehead, face and chin.

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Most pain arises in the area of the face or chin. Pain in trigeminal neuralgia is characteristics by paroxysmal intense facial pain such as electric shock, burning, crushing, exploding or shooting pain, causing severe stress on the sufferer. Pain in trigeminal neuralgia can be triggered by chewing, drinking or eating cold, cold wind and a touch on the face. There is pain-free period between two trigeminal neuralgia attacks. [1,4,6,7]

There is no abnormality can be found on physical examination in classical trigeminal neuralgia. If there is symptom such as abnormal sensation in the trigeminal innervation, loss of corneal reflex, or weakness in the muscles of the face, we must consider symptomatic trigeminal neuralgia, and we have to explore for the secondary cause, such as trigeminal schwannoma or Meckel cave meningioma.[1,3,4]

PATHOPHYSIOLOGY

The etiology of classical trigeminal neuralgia remains unclear. One of the theories explains the presumption that classical trigeminal neuralgia is caused by demyelination of nerve impulses, which produces abnormal nerve transmission. Surgical specimens showed demyelination of nerve axons, which was located near the beginning of the trigeminal nerve. From experimental study result, it was found that demyelination of nerve caused ectopic impulses which delivered light touch sensation to adjacent nociceptive nerve fiber.[2,3,8]

Present theory explains that demyelination is caused by compression of the trigeminal nerve root

by abnormal lying and arched blood vessel. In the radiology examination, we can observe that the vessel located next to the root of trigeminal nerve is superior cerebellar artery. This theory is strengthened by the surgical approach, which separating blood vessel from the root of trigeminal nerve can reduce the symptoms of trigeminal neuralgia. This theory is also applied in case of multiple sclerosis and tumor that compress the trigeminal nerve. [2,3,8]

RADIOLOGY

Trigeminal neuralgia patient is recommended to undergo brain MRI examination as an initial evaluation. Brain MRI examination aims to differentiate between classical trigeminal neuralgia and symptomatic trigeminal neuralgia. MRI can diagnose intracranial tumors and multiple sclerosis. Intracranial tumors, which produce trigeminal neuralgia symptoms, are tumors located at the base of skull and cerebello-pontine angle. Tumors in this area generally can be trigeminal schwannoma, Meckel cavity meningioma and large vestibular schwannoma, which compress trigeminal nerve. MRI can also detect neurovascular contact, which are thought to contribute as the cause of classical trigeminal neuralgia.[1,3,4]

TREATMENT OPTIONS

Currently, there are several modalities for the treatment of classical trigeminal neuralgia, but there is no existing modality with satisfactory result, which have a low recurrence rate and low morbidity and mortality.[1-3,7,9-11]

The first line therapy in trigeminal neuralgia is medical treatment. The prescription of anticonvulsants such as carbamazepine is an effective treatment. Other drugs that can be prescribe in trigeminal neuralgia include baclofen, gabapentin and clonazepin.[3,5]

If the result of medical treatment is insufficient, we must consider surgical procedures. There are several surgical procedures, such as glycerol injections, micro-balloon compression, radiofrequency rhizotomi and microvascular decompression. Pain-free response after surgery ranges from 79-94% and the recurrence rate 16-45% .[3,7,12,13]

The treatment of choice for classical trigeminal neuralgia is microvascular decompression. It has the best pain free rate among others and with the lowest trigeminal nerve dysfunction. From several studies, the pain free rate after microvascular decompression is about 92-98% and the relapse rate is 1-6%. Complications from microvascular decompression procedure might be deaf, cerebrospinal fluid leakage and meningitis. However, microvascular decompression success rate depends on the expertise and experience of the neurosurgeon. Glycerol injection has the lowest pain-free rate.[13]

STEREOTACTIC RADIOSURGERY

Stereotactic radiosurgery was used in the treatment of classical trigeminal neuralgia, first introduced by Dr. Lars Leksell using the gamma knife in 1968. Because of non-invasiveness and the availability of high-quality three-dimensional MR imaging (for precise targeting of normal structures), this technique is widely used in the 1990's.[2,11,12]

Stereotactic radiosurgery implies the delivery of a single large dose of focused radiation, with the application of a three-dimensional coordinate system to locate small targets inside the skull cavity and stereotactic frame immobilization. The use of high dose radiation in radiosurgery will require three-dimensional mapping technique to guide radiosurgery procedure so it can produce accurate target localization while minimizing radiation dose to surrounding normal tissue.[14]

Stereotactic radiosurgery is one of the treatment options in medically refractory classical trigeminal neuralgia. Stereotactic radiosurgery is performed in the case of medically refractory classical trigeminal neuralgia patients, who can't undergo micro vascular decompression procedure due to co-morbidities or surgery refusal. Radiosurgery is widely used because of good therapeutic result and low complication rate. Although the pain free rate is lower than micro vascular decompression, radiosurgery is the preferred treatment option for the patient because it has low complication rate. The most common complication of radiosurgery in classical trigeminal neuralgia is facial numbness. Radiosurgery has weakness in the latency period for pain relief. Because of it, radiosurgery is not recommended for patient that requires immediate pain relief.[8,10,13]

Based on the guidelines from Japan, UCLA and IRSA, it can be summarized in figure 1.[3,7,8]

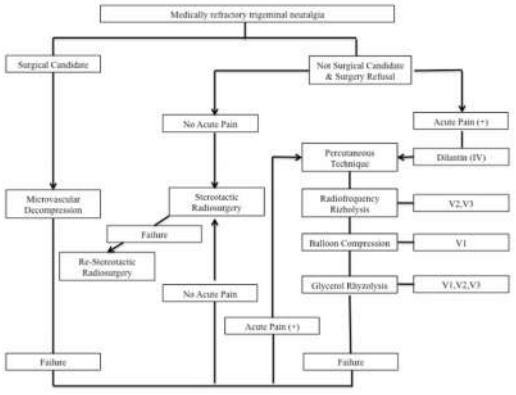

Figure 1
Algorithm management used for selection of treatment modalities among patients with medically refractory trigeminal neuralgia.[3,7,8]

Park et al reported that stereotactic radiosurgery had the same efficacy for medically refractory trigeminal neuralgia between, which underwent radiosurgery as a first treatment (primary) compared with, which underwent other surgical procedure before radiosurgery (secondary).[15]

From reported series with duration of follow-up 12-75 months, they can be concluded, the prescribed dose for radiosurgery in classical trigeminal neuralgia was on the rage 60-90 Gy and in the most studies was 70-90 Gy. The pain-free rate was 82-96%, the relapse rate was 5-34% relapse rates, and the rate of facial numbness complication was 3-45%. Kondziolka et al. reported poorer pain relief when prescribed dose was below 70 Gy and trigeminal nerve necrosis occurred when prescribed dose > 100 Gy.[8,11,16]

In general, target definition in classical trigeminal neuralgia radiosurgery is the root entry zone (REZ), which located within 2-4 mm of the brainstem (figure 2). The rationale for this target definition in REZ is based on pathophysiology where demyelination occurs at transition zone. Transition zone, which is suspected the most radiosensitive area in trigeminal nerve, is an area where central nervous myelin produced by oligodendrocyte meet peripheral nervous myelin produced by Schwann cells. Based on micro vascular decompression experience, this is the most common where neurovascular contact is found. This target definition is used by Pittsburg group and many radiosurgery centers.[2,3,7-10,16]

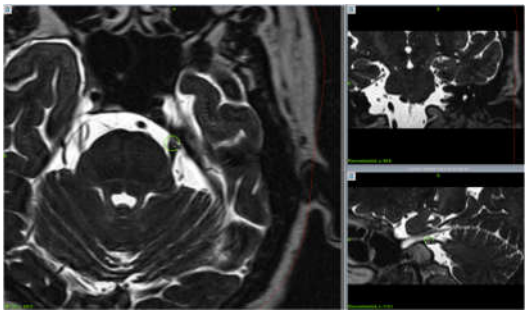

Figure 2
Target definition in radiosurgery for trigeminal neuralgia at REZ. The prescription dose was 80 Gy at isocenter. The green line represents 50% isodose line.

Another target definition is the retro Gasserian region, which is located at the trigeminal incisula at the height of the petrous bone. Retro Gasserian region technique is developed by Jean Regis from Marsailles group. The advantages of this technique are adequately far from the brain stem, so that it can more easily give higher doses without giving excessive doses to brainstem.[7,12]

Studies of the trigeminal neuralgia pathogenesis indicate that partial demyelination of the REZ by mechanical injury can produce abnormal action potential. The focus of demyelination can change impulse transmission delivered in the trigeminal nerve circuits. Micro-vascular decompression is successful in pain relief by modifying the trigeminal function in neurovascular contact area. This is the rationale for placement of the iso center in trigemal neuralgia radiosurgery. The effect of radiosurgery in reducing demyelination, which plays a role for stabilizing impulse transmission, is still unclear.[2,3,8,11]

We should know in trigeminal neuralgia radiosurgery, there is latency period before pain disappeared or reduced, it's usually approximately 1-2 months. Drug should not be reduced or stop until the pain relief.[9]

The most common side effect is the patient underwent radiosurgery was facial numbness. To assess the degree of numbness, we can use available scoring system such as facial numbness score from Barrow Neurological Institute (BNI) (Table 1). Other side effects that can be found are reduction of corneal sensation, anesthesia dolorosa and motor weakness in trigeminal nerve innervation .[3,9,16]

Table 1. Pain intensity score and facial numbness score according Borrow Neurological Institute (BNI)[8.17]

Grade	Description
BNI pain intensity score	
I	No trigeminal pain, no medication
II	Occasional pain, not requiring medication
IIIa	No pain, continued medication
IIIb	Persistent pain, controlled with medication
IV	Some pain, not adequately controlled with medication
V	Severe pain/ no pain relief
BNI facial numbness score	
I	No facial numbness
II	Mild facial numbness, not bothersome
III	Facial numbness, somewhat bothersome
IV	Facial numbness, very bothersome

Repeat radiosurgery can also be administered to patients with recurrent or persistent pain after the first radiosurgery, but consequently it will increase the probability of facial numbness complication. The dose, which can be administered in re-radiosurgery, is 50-90 Gy. It is recommended the interval between initial radiosurgery and re-radiosurgery is not less than 6 months to reduce morbidity. [3,17]

FOLLOW-UP

Follow-up for trigeminal neuralgia patients is usually done with conducting history and physical

examination. Evaluating the response for pain relief and side effects such as facial numbness can be measured based on the Barrow Neurological Institute (BNI) scoring system (Table 1). Follow-up intervals are usually done every 3 monthly, 6 monthly and yearly.[3,9,16]

MRI follow-up examination is not recommended unless there are clinical symptoms thoughts to be caused by radiation necrosis. Radiation necrosis tend to occur in the nucleus area of the trigeminal nerve in pons due to proximity to REZ.[3,18]

In conclusion, Stereotactic radiosurgery is one of the treatment modalities in medically refractory trigeminal neuralgia. Due to the non-invasiveness of this technique, it becomes an option in patients who refuse or are medically contra-indicated to micro-vascular decompression. Weakness of this technique is a latency period, which is time required for pain relief. It usually ranges from 1 to 2 months.

Radiosurgery is delivered to REZ, where demyelination is occurred, probably due to neuro-vascular contact. This demyelination is thought to contribute as the cause of trigeminal neuralgia. The iso center prescribed dose usually ranges 75-90 Gy. We must also notice for the brainstem dose not more than 12 Gy.

For follow-up, we can perform clinical examination. The treatment response can be evaluated with scale such as Barrow Neurological Institute (BNI) scale. Is advisable to perform follow up with the same scale we use before delivery the treatment. With the uniform scale, we can compare the treatment efficacy among multiple modalities.

CONFLICT OF INTEREST

The authors affirm no conflict of interest in this study.

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