

Retrospective Study

e Analysis of the Hemodynamic Response During Radiofrequency Thermocoagulation in Trigeminal Neuralgia

Jae Yoon Lee, MD, Ji Hoon Park, MD, PhD, and Ji Hee Hong, MD, PhD

From: Keimyung University
Dongsan Hospital Department
of Anesthesiology and Pain
Medicine, Dalseo-gu, Daegu,
Republic of Korea

Address Correspondence:
Ji H. Hong, MD, PhD
Department of Anesthesiology
and Pain Medicine, Keimyung
University Dongsan Hospital
1095 Dalgubeol-daero
Dalseo-gu, Daegu, 42601
Republic of Korea
E-mail: swon13@daum.net

Disclaimer: There was no external
funding in the preparation of this
manuscript.

Conflict of interest: Each author
certifies that he or she, or a
member of his or her immediate
family, has no commercial
association (i.e., consultancies,
stock ownership, equity interest,
patent/licensing arrangements,
etc.) that might pose a conflict of
interest in connection with the
submitted manuscript.

Manuscript received: 03-31-2022
Revised manuscript received:
06-10-2022
Accepted for publication:
06-29-2022

Free full manuscript:
www.painphysicianjournal.com

Background: Radiofrequency thermocoagulation (RFT) of the trigeminal ganglion is an excellent treatment option for medically intractable trigeminal neuralgia. However, this procedure can manifest abrupt changes in cardiovascular responses. With abrupt cardiovascular changes, a sudden trigeminocardiac reflex can occur during RFT of the trigeminal ganglion.

Objectives: The primary endpoint of this study was to identify the critical point at which RFT causes abrupt hemodynamic response changes. The secondary endpoint of this study was to evaluate the occurrence of the trigeminocardiac reflex.

Study Design: Retrospective design.

Setting: An interventional pain management practice in The Republic of Korea (South Korea).

Methods: Forty patients who received trigeminal ganglion RFT under C-arm guidance due to intractable facial pain were included. We checked and recorded the blood pressure and heart rate at baseline (before RFT), immediately before and after entering the foramen ovale (FO), during electrical stimulation, during thermal heating, and 30 minutes post-RFT. Also, we recorded the presence or absence of the trigeminocardiac reflex during RFT.

Results: Heart rate during thermal heating increased more than 20% compared to baseline (87.6 beats/min vs 69 beats/min, $P < 0.001$). The mean arterial pressure showed an increase of more than 15% compared to baseline when the cannula entered the FO (106.4 mmHg vs 90.9 mmHg, $P < 0.001$) and during thermal heating (106.3 mmHg vs 90.9 mmHg, $P < 0.001$). Sudden bradycardia was observed in 25% (10/40) of the patients. Among 10 patients who showed sudden bradycardia, it was observed when the cannula entered the FO (15%, 6/40), during electrical stimulation (5%, 2/40), and during heating (5%, 2/40).

Limitations: This study included 40 patients who received trigeminal ganglion RFT, which is a low number to clarify the real incidence of the trigeminocardiac reflex during RFT.

Conclusion: FO puncturing, electrical stimulation, and thermal heating demonstrated an abrupt increase in heart rate and mean arterial pressure. The incidence of sudden bradycardia during RFT of the trigeminal ganglion was 25%. Most cases of bradycardia were observed during FO puncturing.

Key words: Radiofrequency thermocoagulation, cardiovascular responses, trigeminocardiac reflex, bradycardia

Pain Physician 2022; 25:E1057-E1062

Trigeminal neuralgia (TN) is the most common disabling cranial neuralgia among the elderly population. The recently reported incidence of TN in the Republic of Korea (South Korea) was

100.21/100,000; the men to women ratio was 1:2.14 (1). The characteristic clinical features of TN include a recurring electric-like shock and stabbing pain in the divisions of the trigeminal nerve (1,2).

Carbamazepine has been advocated as an initial treatment for TN. However, 10%-15% of TN cases demonstrate a minimal response to this therapy, with various side effects including hepatic toxicity, cardiac conduction block, dizziness, skin rash, and loss of coordination (1,3). Radiofrequency thermocoagulation (RFT) of the trigeminal ganglion is an alternative option for patients whose pain is intractable or who show serious adverse effects to medication. The reported success rate of RFT ranges from 80% to 97%, although symptoms of TN can recur even after RFT (4,5).

RFT targeting the trigeminal ganglion is challenging even for experienced pain physicians. Due to technical difficulties, this procedure can manifest abrupt cardiovascular response changes. RFT of the trigeminal ganglion always requires puncturing the foramen ovale (FO), electrical stimulation, and finally, thermal heating. Among the procedure steps of RFT, puncturing the FO and thermal heating can lead to a significant increase in blood pressure and heart rate (6). With abrupt hemodynamic changes, a sudden trigeminocardiac reflex can occur during RFT of the trigeminal ganglion. The trigeminocardiac reflex can cause serious bradycardia or even sinus arrest (6-9). Uncontrolled hypertension and sudden trigeminocardiac reflex can lead to unwanted serious complications during RFT (8,9).

The primary endpoint of this study was to identify the critical point at which RFT causes abrupt hemodynamic response changes. The secondary endpoint of this study was to evaluate the occurrence of the trigeminocardiac reflex.

METHODS

Patients

This study was designed retrospectively after the approval of our institutional review board (2022-01-082). Patients who received trigeminal ganglion RFT under C-arm guidance due to intractable facial pain in spite of taking medication and ultrasound-guided nerve block were included. Patients were enrolled from February 2018 through March 2022. Before RFT, all patients were treated with carbamazepine (400 mg/d) and ultrasound-guided supraorbital, infraorbital, or mental nerve block.

A diagnosis of TN was made according to the beta version of the Third Edition of the International Classification of Headache Disorders (ICHD3-beta) (10). A magnetic resonance imaging study was conducted on

all patients to identify any vascular compression or tumor around the trigeminal ganglion. Before inclusion, patients with uncontrolled hypertension, medically intractable arrhythmia, or secondary TN were excluded. Patients who received trigeminal ganglion RFT for a condition other than TN were also excluded.

We used Clinical Data Warehouse v 2.5 (CDW, Planit Healthcare) to identify patients who received trigeminal ganglion RFT under the diagnosis of TN using the key words "trigeminal neuralgia and radiofrequency."

Intravenous Anesthesia and Hemodynamic Changes Monitoring

RFT was performed with the patient under light sedation in order to avoid severe pain and anxiety during the procedure. Initially, intravenous midazolam at 0.02 mg/kg and sufentanil 5 µg were used to maintain light sedation so that the patient could cooperate and answer during electrical stimulation. If patients complained of severe pain during RFT of the trigeminal ganglion, additional midazolam and sufentanil were injected. Electrocardiography, pulse oximetry, and blood pressure were measured during the entire RFT procedure and for 30 minutes after the completion of RFT. Oxygen (3 L/min) was supplied using a facial mask.

According to our previous experiences with RFT of the trigeminal ganglion and a previous report on hemodynamic changes during RFT (6), we assumed that the critical points at which abrupt hemodynamic changes are manifested are immediately before and after entering the FO, during electrical stimulation, and during thermal heating. Therefore, we routinely checked and recorded the changes in blood pressure and heart rate at baseline (before RFT), immediately before and after entering the FO, during electrical stimulation, during thermal heating, and 30 minutes after the completion of RFT. Also, we recorded the presence or absence and the timing of the appearance of the trigeminocardiac reflex during RFT. A heart rate less than 50 beats/min was considered to be bradycardia.

RFT Procedure

In order to facilitate visualization of the FO, the patient was placed supine with the neck extended and chin up. If the patient was confirmed to be in supine with neck extension, the FO was searched for using a C-arm with caudal tilting 30°-35° and with a right or left side ipsilateral oblique rotation of 15°-20°. After clear visualization of the FO, skin infiltration with 1% lidocaine was done 2-3 cm lateral to the angle of the lips.

We used an RF cannula of 22G, 10 cm, and a 2-mm or 5-mm active tip. After identifying the clear location of the FO, the cannula was advanced into the center of the FO using a tunnel view. When it was thought that the cannula reached just in front of the FO in the lateral view, nicardipine one mg or sufentanil 5 μ g was injected to minimize the increase in blood pressure.

After successfully entering the FO, the cannula was advanced until the junction and beyond the petroclival line in the case of maxillary (V2) and ophthalmic (V1) division of the trigeminal nerve, respectively (Figs. 1A, 1B). In case of TN of the mandibular (V3) division, the cannula was advanced 2-3 mm further just after entering the FO, but it was not advanced until the junction of the petroclival line (Fig. 1C). If a patient had facial pain of both the maxillary and mandibular divisions, thermal heating was performed initially at the location of the maxillary division. Subsequently, the cannula was withdrawn slightly to perform additional thermal heating at the mandibular division.

Once the cannula was determined to be in the proper position according to the lateral view of the C-arm, electrical stimulation ranging from 0.1 V-0.3 V at 50 Hz was applied as the next step. We asked patients if the electrical sensory stimulation was felt at the original site of the facial pain. If an inadequate or weak electrical sensory stimulation was felt on the face, the cannula was moved slightly under C-arm guidance according to the effect of the stimulation. If successful electrical stimulation was obtained in the maxillary or mandibular area of the face, thermal heating was performed once at 70°C-75°C for 60 seconds.

After finishing the RFT procedure, the patient was

moved to a recovery room and vital signs were monitored. After resting for at least an hour, the patient was checked for possible side effects of intravenous anesthesia and RFT. If the patient was fully awake with stable vital signs, that patient was discharged under the aid of a guardian.

Statistics

Values are presented as the mean (SD) or number of patients (%). A repeated measure of analysis of variance (ANOVA) was used to compare the mean values of heart rate and mean arterial pressure between baseline and critical points (before and after entering the FO, during electrical stimulation, and during thermal heating). Demographic data and the incidence of bradycardia were analyzed using the χ^2 test. $P < 0.05$ was considered to be statistically significant. Statistical evaluations were performed using SPSS version 22.0 (IBM Corporation).

RESULTS

Forty patients who received RFT of the trigeminal ganglion were evaluated. Thirty patients and the remaining 10 patients received RFT using 5 mm and 2 mm active tip, respectively.

Thirty-nine patients (39/40, 97.5%) reported pain relief of 85%-100%, whereas one patient had only minimal pain relief after RFT. There were no serious cardiovascular or cerebrovascular complications.

The number of women patients was slightly higher than men patients (Table 1).

Significant changes in heart rate and blood pressure were found after entering the FO, during electri-

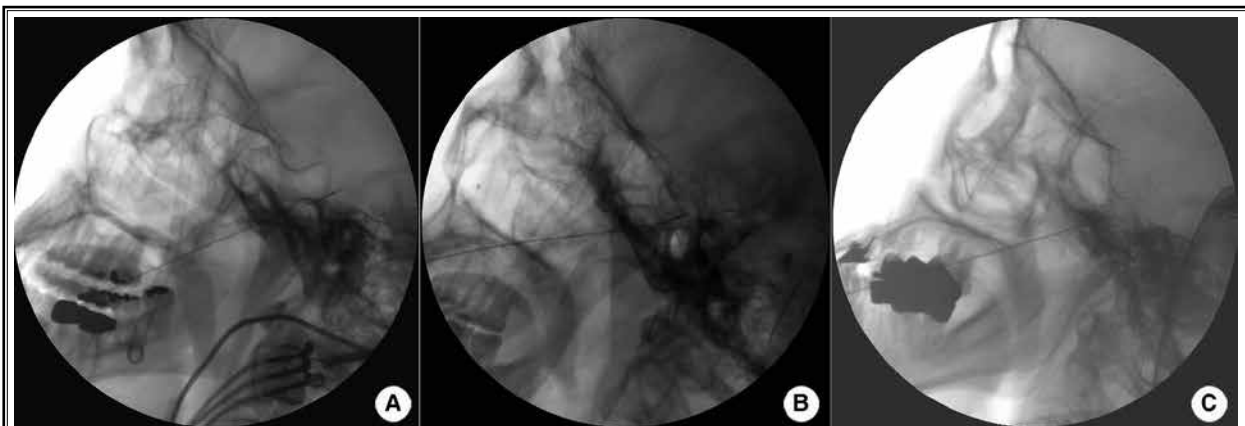


Fig. 1. Lateral fluoroscopic image showing the position of the radiofrequency cannula in the trigeminal division of V1 (A), V2 (B), and V3 (C).

cal stimulation, and during thermal heating (Figs. 2A, 2B). The heart rate during thermal heating showed an increase of more than 20% compared to baseline (87.6 beats/min vs 69 beats/min, $P < 0.001$, Fig. 2A). An increase in heart rate was also observed after entering the FO and during electrical stimulation; however, the degree of increase was attenuated compared to that after thermal heating (Fig. 2A).

The mean arterial pressure was increased by more than 15% compared to baseline when the cannula entered the FO (106.4 mmHg vs 90.9 mmHg, $P < 0.001$, Fig. 2B) and thermal heating (106.3 mmHg vs 90.9 mmHg, $P < 0.001$, Fig. 2B). An increase in mean arterial pressure was also observed during electrical stimulation, although this was attenuated compared to the time points of after entering the FO and during thermal heating (Fig. 2B).

Sudden bradycardia was observed in 25% (10/40) of patients. Among the 10 patients who showed sudden bradycardia, it was observed when the cannula entered

the FO (15%, 6/40), during electrical stimulation (5%, 2/40), and during heating (5%, 2/40) (Table 2). All patients who experienced bradycardia recovered after an injection of atropine (0.4 mg) or temporary suspension of the RFT procedure for 5-10 seconds.

DISCUSSION

This study clearly demonstrates the possibility of an abrupt increase in heart rate and mean arterial pressure during FO puncturing, during electrical stimulation, and during thermal heating. However, cardiovascular changes during electrical stimulation were more attenuated compared to those observed during FO puncturing and thermal heating. A previous study (6) also demonstrated that increases in heart rate and mean arterial pressure during electrical stimulation were not statistically significant compared to the values of prestimulation. In this study, we used an opioid and midazolam before and during the RFT to minimize an abrupt increase in cardiovascular changes. Despite this, thermal heating caused an increase in heart rate and mean arterial pressure by at least 20% and 15%, respectively, implying that more active measures should be taken to prevent such dramatic cardiovascular changes.

Since most patients diagnosed with TN are elderly (1), TN is often accompanied by serious comorbidities, such as neurovascular or cardiovascular disease. Indeed, a recent case report (11) described hemodynamic management during gasserian ganglion rhizotomy in a patient with an aneurysm of the anterior communicating artery. The patient was successfully managed with the use of nicardipine (11). If a patient with TN has a cerebral aneurysm as a comorbidity, inadequate management of abrupt hemodynamic changes during RFT can cause fatal complications.

An intravenous drip of sodium nitroprusside (0.5 $\mu\text{g}/\text{kg}/\text{min}$) during trigeminal ganglion compression could prevent dramatic elevation of systolic blood pres-

Table 1. Demographic data and affected trigeminal branch.

Age (years)	64.8 \pm 13.7
Gender (M/W)	19 (38.8%)/21(42.9%)
Body mass index (kg/m ²)	25.5 \pm 3.7
Trigeminal branch	
V1	1 (2.5%)
V2	17 (42.5%)
V3	14 (35.0%)
V1+V2	2 (5.0%)
V2+V3	6 (15.0%)
Total	40 (100%)

Values are mean (SD) or number of patients.

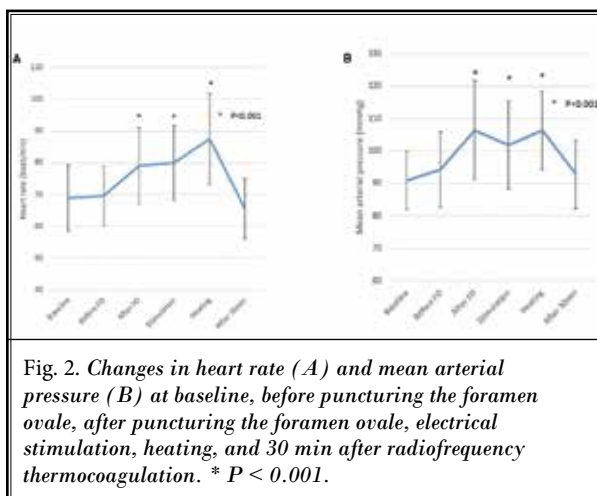


Fig. 2. Changes in heart rate (A) and mean arterial pressure (B) at baseline, before puncturing the foramen ovale, after puncturing the foramen ovale, electrical stimulation, heating, and 30 min after radiofrequency thermocoagulation. * $P < 0.001$.

Table 2. Incidence and timing of occurrence of sudden bradycardia.

Bradycardia	
Baseline	0 (0%)
Before foramen ovale puncturing	0 (0%)
After foramen ovale puncturing	6/40 (15%)
Electrical stimulation	2 /40 (5%)
Heating	2 /40 (5%)
30 min after procedure	0 (0%)
Total	10/40 (25%)

sure compared to a control group (7). However, such use of sodium nitroprusside could not prevent bradycardia (7). Most RFT or compression of the trigeminal ganglion is performed under intravenous sedation anesthesia or even general anesthesia (12). We believe that sedatives and opioids currently used during intravenous anesthesia may be insufficient to minimize abrupt hemodynamic changes, suggesting that active use of antihypertensive medications should be considered. Further study is required to identify the most suitable antihypertensive medications and actual dosage to prevent abrupt hemodynamic changes. A previous study (13) suggested that arterial hypertensive responses triggered by thermal heating of the trigeminal ganglion and roots cannot be attenuated by elevating doses of analgesic medication.

The RFT of the trigeminal ganglion causes serious pain during FO puncturing and thermal heating. A previous study demonstrated that FO puncturing can result in the preferential stimulation of A δ fibers and a decrease in heart rate (14). In contrast to FO puncturing, electrical stimulation and thermal heating during RFT can cause stimulation of C-fibers with resulting blood pressure and heart rate increases (14). When the arterial hypertensive response occurs, the adrenal gland plays a more critical role than the perivascular sympathetic terminal, given that the levels of adrenaline are higher than those of noradrenaline (6,14).

The incidence of sudden bradycardia as a manifestation of the trigeminocardiac reflex in this study was 25%. Bradycardia occurred most often when the cannula entered the FO, but was also observed during electrical stimulation and thermal heating, albeit with a lower incidence. According to a previous study (6), the incidence of bradycardia during RFT was 12.5%, which is lower than that observed in our study. In this previous study, the appearance of bradycardia was observed during FO puncturing, but not during electrical stimulation or thermal heating (6).

The trigeminocardiac reflex is a brainstem reflex that can manifest as sudden bradycardia, asystole, apnea, hypotension, and gastric hypermotility. When the trigeminocardiac reflex is encountered upon manipulation around the vicinity of any trigeminal nerve, at least a 20% decrease in mean arterial pressure and heart rate is observed (8). The trigeminocardiac reflex

can be subtyped according to the location of the trigger, which includes central and peripheral types. The central trigeminocardiac reflex indicates that the trigger stimulus is located in the intracranial course from the trigeminal ganglion to the brainstem (8,9). The peripheral trigeminocardiac reflex indicates that the trigger stimulus is located in the trigeminal nerve anywhere along its course outside the trigeminal ganglion (8,9).

The appearance of an abrupt vagal-mediated response can be observed anywhere along the course of the trigeminal nerve. Moreover, a trigeminal nerve-mediated stimulus is related to coactivation of the sympathetic and parasympathetic system, which is thought to be less prominent in the central type trigeminocardiac reflex (8).

As a prevention and treatment option for trigeminocardiac reflex, immediate interruption of the surgical maneuver or needling seems to be enough to restore the heart rate and blood pressure (6-8,14). However, if bradycardia and hypotension seem to be intractable even after ceasing the manipulation, the administration of anticholinergics should be considered. Bradycardia and hypotension can result from not only excessive vagal stimulation but also reduced sympathetic tone (8).

Limitations

This study has several limitations. First, we included only 40 patients with TN who received trigeminal ganglion RFT, which is a low number to be able to clarify the real incidence of trigeminocardiac reflex during RFT. Therefore, further study with a larger number of patients is required. Second, hypotension can subsequently follow when bradycardia appears (7-9). However, we could not determine if hypotension followed or not because the appearance of bradycardia was so brief.

CONCLUSION

In conclusion, the periods of FO puncturing, electrical stimulation, and thermal heating demonstrated an abrupt increase in heart rate and mean arterial pressure. The incidence of sudden bradycardia during RFT of the trigeminal ganglion was 25%. Most cases of bradycardia were observed during FO puncturing.

REFERENCES

1. Lee CH, Jang HY, Won HS, Kim JS, Kim YD. Epidemiology of trigeminal neuralgia: An electronic population health data study in Korea. *Korean J Pain* 2021; 34:332-338.
2. Jones MR, Urits I, Ehrhardt KP, et al. A comprehensive review of trigeminal neuralgia. *Curr Pain Headache Rep* 2019; 23:74.
3. Maarbjerg S, Di Stefano G, Bendtsen L, Cruccu G. Trigeminal neuralgia - Diagnosis and treatment. *Cephalalgia* 2017; 37:648-657.
4. Gunduz HB, Cevik OM, Asilturk M, et al. Percutaneous radiofrequency thermocoagulation in trigeminal neuralgia: Analysis of early and late outcomes of 156 cases and 209 interventions. *J Korean Neurosurg Soc* 2021; 64:827-836.
5. Kanpolat Y, Savas A, Bekar A, Berk C. Percutaneous controlled radiofrequency trigeminal rhizotomy for the treatment of idiopathic trigeminal neuralgia: 25-year experience with 1,600 patients. *Neurosurgery* 2001; 48:524-532; discussion 532-534.
6. Meng Q, Zhang W, Yang Y, Zhou M, Li X. Cardiovascular responses during percutaneous radiofrequency thermocoagulation therapy in primary trigeminal neuralgia. *J Neurosurg Anesthesiol* 2008; 20:131-135.
7. Wang CM, Guan ZY, Zhang J, et al. Comparative study of trigeminocardiac reflex after trigeminal ganglion compression during total intravenous anesthesia. *J Neurosurg Anesthesiol* 2015; 27:16-20.
8. Chowdhury T, Mendelowith D, Golanov E, et al. Trigemino-cardiac reflex: The current clinical and physiological knowledge. *J Neurosurg Anesthesiol* 2015; 27:136-147.
9. Chowdhury T, Cappellani RB, Schaller B. Retrogasserian glycerol rhizolysis: First description of occurrence trigeminocardiac reflex. *J Neurosurg Anesthesiol* 2014; 26:86-87.
10. Maarbjerg S, Sørensen MT, Gozalov A, Bendtsen L, Olesen J. Field-testing of the ICHD-3 beta diagnostic criteria for classical trigeminal neuralgia. *Cephalalgia* 2015; 35:291-300.
11. Lee YH, Hong JH, Shin HK. Gasserian ganglion radiofrequency thermoablation in a patient with aneurysm of the anterior communicating artery -A case report. *Anesth Pain Med (Seoul)* 2021; 16:382-386.
12. Bilotta F, Spinelli F, Centola G, Caramia R, Rosa G. A comparison of propofol and sevoflurane anaesthesia for percutaneous trigeminal ganglion compression. *Eur J Anaesthesiol* 2005; 22:233-235.
13. Sweet WH, Poletti CE, Roberts JT. Dangerous rises in blood pressure upon heating of trigeminal rootlets; increased bleeding times in patients with trigeminal neuralgia. *Neurosurgery* 1985; 17:843-844.
14. Dominguez J, Lobato RD, Rivas JJ, et al. Changes in systemic blood pressure and cardiac rhythm induced by therapeutic compression of the trigeminal ganglion. *Neurosurgery* 1994; 34:422-427; discussion 427-428.