Sympathetic ganglionectomy for facial blushing using application of laser speckle flow graph

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ABSTRACT

Objective: Endoscopic thoracic sympathectomy at the second rib level is considered effective as a therapeutic treatment for facial blushing. However, 10% to 15% of patients do not benefit from this intervention. No additional procedure has been developed for this disorder. Recently, ganglionectomy using application of laser speckle flow graph has been evaluated for the treatment of compensatory sweating. We report our results of ganglionectomy for facial blushing as a redo surgery.

Methods: Between August 2012 and April 2017, 8 patients with facial blushing who underwent an initial sympathectomy reported symptom recurrence. Seven patients had undergone transection of the sympathetic trunk at the second rib and 1 patient had undergone transection of the sympathetic trunk at the second and third ribs. These patients were treated using ganglionectomy guided by application of laser speckle flow graph. After temporary decreases in facial skin blood perfusion were confirmed by stimulating the sympathetic ganglions, ganglionectomy was performed.

Results: All patients' symptoms improved. There were no side effects, including deterioration of compensatory sweating, worsening of gustatory sweating, or Horner syndrome. There were no cases of mortality or conversion to open surgery.

Conclusions: This study shows the effectiveness of ganglionectomy for the treatment of facial blushing, representing a new treatment option for this condition. Considering the mechanism of facial blushing, it is important to recognize that ganglionectomy is effective after the interception of the sympathetic trunk on the cranial side. (J Thorac Cardiovasc Surg 2018;156:1326-31)

Decreased skin blood flow can be seen with electrical stimulation of the sympathetic nerve.

Central Message

This study shows the effectiveness of ganglionectomy for the treatment of facial blushing, representing a new treatment option for this condition.

Perspective

Endoscopic thoracic sympathectomy at the second rib level is considered effective as a therapeutic treatment for facial blushing. However, 10% to 15% of patients do not benefit from this intervention. We report our results of ganglionectomy for facial blushing as a redo surgery. In this case series, all patients' symptoms improved with no intra- or postoperative complications.

See Editorial Commentary page 1332.

Facial blushing is a devastating condition that affects patient's quality of life. The effectiveness of sympathectomy for facial blushing, a redness of the face brought on by emotional or social stress, has been reported.^{1,2} However, there are 10% to 15% of patients who do not benefit from currently available treatments.^{1,2} Some patients report recurrence of symptoms within a short

period, and others show no improvement immediately after sympathectomy.^{1,2} Further complicating patient outcome, the effect of sympathectomy appears on only 1 side of the face, similar to Harlequin syndrome.³ Sympathectomy has been known to induce compensatory sweating as a severe side effect. Thus, patients who have no amelioration of facial blushing have the possibility of developing only adverse effects after treatment. Some patients without improvement of facial blushing experience

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Abbreviations and Acronyms

B	= both
F	= female
G2	= the second ganglion
G3	= the third ganglion
G4	= the fourth ganglion
L	= left
LSFG	= laser speckle flow graph
M	= male
Mo	= moderate
Mi	= mild
R	= right
ROI	= region of interest
S	= satisfied
Se	= severe
T2	= transection on the second rib
T3	= transection on the third rib
V	= very satisfied

moderate to severe compensatory sweating. Almost all of these patients desire to achieve a decrease in facial blushing by any means.

We have performed more than 12,000 sympathectomies to date, and very well understand the mechanism of facial blushing. The sympathetic neuron circuit of facial blushing is thought to lie in the sympathetic chain on the second rib; thus, the interruption of the sympathetic chain using knife dissection, clip appliance, laser ablation, or electrocautery was reported to be effective treatment. However, patients with no amelioration of facial blushing after sympathectomy of the second rib might have a sympathetic neuron circuit at another position. When the correct position of the neuron circuit is identified, improvement in facial blushing can be achieved with appropriate resection. We retrospectively examined the results of the reoperated patients while observing for intraoperative skin blood perfusion of the face.

METHODS

Between August 2012 and April 2017, 8 patients with facial blushing who showed insufficient results after first sympathectomy were included in this study under approval of the institutional review board at Yamamoto-Hidehiro Clinic. These patients underwent the first sympathectomy between July 2000 and August 2012. Six patients underwent simple transection of the sympathetic trunk at the second rib and 2 patients underwent transection of the sympathetic trunk at the second and third ribs. Improvement of facial blushing disappeared between 2 weeks and 1 year after sympathectomy in all patients, and all patients developed moderate to severe compensatory sweating.

All patients received a detailed consultation to evaluate personal, professional, and social handicaps related to facial blushing. Preoperative chest computed tomography imaging was performed to exclude lung or pleural disorders. All patients were assessed for the amount and area of compensatory sweating after the first sympathectomy. Additionally, a detailed medical history, including demographic data and clinical status, was documented. Informed consent was obtained in writing

at least 1 day before surgery after careful explanation of the surgical procedure.

SURGICAL PROCEDURE

Ganglionectomy was performed for all patients unilaterally. On the basis of the evaluation of facial blushing and compensatory sweating, each procedure was performed with an interval of >6 months, including the summer season. The procedure was performed under general anesthesia using single lung ventilation. The patient was placed in a half-sitting position with arms abducted. Equipment included a thoracoscope, 2 mm in diameter (2-mm MiniSite Gold Laparoscope, United States Surgical Corporation, Norwalk, Conn, or 2-mm K11605AA Miniature Straight Forward, Karl Storz, Tuttlingen, Germany) and needle surgery devices consisting of 2 or 3 pieces used in the manner described by Yamamoto et al.^{4,5}

A 3.0-mm skin incision was made on the midaxillary line in the armpit. After temporary disconnection of the endotracheal tube, the device was inserted, and saline solution or air was passed through the inside tube by means of a 10-mL syringe. When the tip of the central tube reached the pleural cavity, loss of resistance to the syringe was felt. Then, the central tube was removed, and the thoracoscope was inserted. The sympathetic chain and ganglions were identified at the level of the second, third, fourth, and fifth costal heads using intraoperative chest x-ray. When pneumo-pleural adhesions were found, all adhesions were divided at the location nearest to the lung as possible. When intraoperative monitoring using laser speckle flow graph (LSFG; described below) indicated the position of the target, ganglionectomy was performed. In ganglionectomy, the sympathetic ganglion must be sufficiently lifted and completely removed. Because there are many blood vessels approaching the ganglion, care must be taken to avoid excessive bleeding. All the lateral branches must be confirmed meticulously and dissected at their origin (Video 1).

After confirmation of the absence of bleeding and air leaks, the lung was inflated by the anesthetist. Air in the pleural space was expelled through the lumen of the scope sheath and the scope itself was then removed from the scope sheath. Sufficient expansion of the lung was confirmed with a second placement of the scope, and then the scope and scope sheath were fully removed. Thoracotomy tubes were not used, and the wound was closed with sterile surgical tape. All patients were discharged on the day of surgery.

INTRAOPERATIVE MONITORING

LSFG devices (LSFG-ANW, Soft Care Co, Ltd, Fukuoka, Japan or OZ-2, Omegawave, Tokyo, Japan) were applied to identify the correct position of the sympathetic nerve and ganglion associated with facial

VIDEO 1. The ganglion must be lifted from chest wall and completely removed. Because many blood vessels exist close to the ganglion, the procedure must be performed carefully. The location of all the lateral branches can be confirmed using a needlescope, 2 mm in diameter. Ganglionectomy can be performed through a single skin incision of 3 mm length. Video available at: [http://www.jtcvsonline.org/article/S0022-5223\(18\)30346-5/fulltext](http://www.jtcvsonline.org/article/S0022-5223(18)30346-5/fulltext).

blushing. Transient changes of facial skin perfusion in the LSFG were monitored while stimulating each sympathetic nerve and ganglion using an electro surgical unit (50-400 V, 3-30 kHz; MS7000AS; Senko Medical Manufacturing Co, Ltd, Tokyo, Japan). The sympathetic nerves and ganglia where transient decrease of facial

skin blood perfusion was observed with electrostimulation implied that the target neural circuit relating to facial blushing was included.

FOLLOW-UP AND DATA COLLECTION

Follow-up was conducted on return visits or through telephone, fax, postal mail, or e-mail at 3 and 6 months after the surgery. A minimum of 1 return visit was required between 3 and 6 months for the assessment of compensatory sweating. Patients were required to fill out a detailed questionnaire. The data collected included resolution of symptoms, postoperative complications, the severity of compensatory sweating, incidence of symptom recurrence, and satisfaction levels of the redo surgery.

RESULTS

Eight patients were included, and 10 ganglionectomies were performed. The descriptive variables of each patient are summarized in Table 1.

Patient number 5 underwent surgery on the right side (surgery number 5) and the left side (surgery number 6). Similarly, patient number 6 underwent right as well as left surgeries (operation numbers 7 and 8, respectively). A summary of information concerning patients' initial sympathectomies is shown in Table 2.

Surgery details are reported in Table 3. Mean surgery time was 38.1 ± 5.3 minutes; this time was calculated from the time of skin incision to the application of the sterile surgical tape on the wound. This excluded anesthesia induction and reversal time.

TABLE 1. Descriptive variables of each patient

Patient number	1	2	3	4	5		6		7	8
Operation number	1	2	3	4	5	6	7	8	9	10
Age, y	26	28	35	20	31		38		36	46
Sex	F	M	M	F	F		F		M	M
Position of the first sympathectomy	T2	T2	T2	T2	T2		T2		T2 and T3	T2 and T3
Severance of compensatory sweating	Se	Se	Mo	Se	Mo		Mo	Mo	Se	Mi
Recurred side	R	L	L	R	B		B		L	L
Surgery side	R	L	L	R	R	L	R	L	L	L
Surgery time of the second procedure, min	35	40	46	30	31	40	36	40	45	38
Adhesion	—	—	+	—	—	—	—	+	—	—
Reaction level of laser speckle flow graph	G2	G2	G2 and G3	G3	G2 and G3	G2 and G3	G2	G2	G2 and G3	G3 and G4
Level of ganglionectomy	G2	G2	G2 and G3	G3	G2 and G3	G2 and G3	G2	G2	G2 and G3	G3 and G4
Follow-up length, mo	51	48	44	6	35	28	30	24	18	38
Severance of compensatory sweating after the second surgery	Se	Se	Mi	Mo	Mo	Mi	Mo	Mo	Mo	Mi
Satisfaction levels of the second surgery	S	S	V	V	V	V	V	V	V	V

F, Female; M, male; T2, transection on the second rib; T3, transection on the third rib; Se, severe; Mo, moderate; Mi, mild; R, right; L, left; B, both; G2, the second ganglion; G3, the third ganglion; G4, the fourth ganglion; S, satisfied; V, very satisfied.

TABLE 2. Patient characteristics

Characteristic	Result
Age (range), y	32.5 ± 8.0 (20-46)
Sex, M/F	4/4
Position of transection at the first sympathectomy, n	
On the second only	6
On the second and third rib	2
Recurred side of facial blushing, n	
Both sides	2
Right side	2
Left side	4

M, Male; F, female.

In all 10 lateral procedures, a temporary decrease in facial skin blood perfusion was observed when stimulating sympathetic ganglions using LSFG (Figures 1 and 2). Ganglionectomy was performed at the same level where the reaction of LSFG was found. Four laterals ended the ganglionectomy of the second, 1 lateral ended ganglionectomy of the third, 4 laterals ended ganglionectomy of the second and the third, and 1 lateral ended ganglionectomy of the third and fourth (Table 1). No conversion to open surgery was necessary, and there were no cases of mortality and no intraoperative complications. Postoperative complications including Horner syndrome or pneumothorax were not observed. All patients were discharged on the day of surgery.

A summary of patients' postoperative course is shown in Table 4. Mean follow-up interval was 32.2 months. Immediate amelioration of facial blushing was present after ganglionectomy, and recurrence of facial blushing was not reported during follow-up. The satisfaction rate was 100%, and there was improvement in compensatory sweating in 3 patients (30%).

DISCUSSION

We have experience performing many sympathectomies for the treatment of hyperhidrosis; we know that facial

TABLE 3. Surgery details

Variable	Value
Level of ganglionectomy, n	
Second ganglion	4
Third ganglion	1
Second and third ganglions	4
Third and fourth ganglions	1
Mean surgery time (range), min	38.1 ± 5.3 (26-46)
Intraoperative complication, n	
Bleeding	0
Air leakage	0
Postoperative complication, n	
Horner syndrome	0
Pneumothorax	0

FIGURE 1. Monitor view of laser speckle flow graph. Blood flow image upon electrical stimulation of the third thoracic sympathetic ganglion in patient number 4. Decreased skin blood perfusion can be observed on the right side of the face.

blushing improves in many cases and does not progress after this treatment. However, we do not know the details of the genesis and neural circuit of facial blushing.

In patients who had no effects after transection of the sympathetic chain, it is hypothesized that there is another neural circuit that does not lie within the transected area. We believe this hypothesis on the basis of >12,000 experiences with many redo surgeries for hyperhidrosis, gustatory sweating, and facial blushing.

Sympathectomy has been performed without any monitoring, thus we do not think that a good result is achieved in many cases. It is necessary to monitor the basic function of the sympathetic nerve to predict postoperative outcome. Three actions, including sudomotor action, pilomotor action, and vasomotor action are known to be associated with sympathetic nerve function. We used the vasomotor function of the sympathetic nerve as an intraoperative monitor. This function only works during anesthesia and allows observation of changes in blood perfusion using LSFG (Video 2).

LSFG devices can evaluate skin blood perfusion noninvasively. The laser speckle phenomenon is an interference event observed when coherent light sources, such as lasers, are scattered by a diffusing surface. The speckle pattern appears in accordance with blood flow velocity.^{6,7} We applied LSFG techniques to treat facial blushing. This change could be repeatedly observed while electrically stimulating each sympathetic nerve (Videos 3 and 4). Even if the sympathetic nerve is only touched because reactivity is high, a reaction might appear. However, it is susceptible to overheating. When an energy

FIGURE 2. Monitor view of laser speckle flow graph. Two regions of interest (ROIs) are shown on the cheeks of both sides of the face in patient number 4. The trend graph at the right lower corner shows the decrease in skin blood perfusion in ROI 1 on the right cheek, at the 5871st frame of the image. A phenomenal difference can be observed between ROI 1 and ROI 2.

device is used for electrical stimulation, it is necessary to be careful not to overheat the ganglion. The skin area where the reaction of LSFG was identified using electric stimulation allows for complete resection of the sympathetic neuron, as in ganglionectomy. Insufficient ablation and clip appliance are considered factors associated with this recurrence.

The patients' facial skin temperature increased after ganglionectomy. Because the changes associated with LSFG ends rapidly within several seconds, the change in blood perfusion does not promptly reflect changes in the

skin temperature of the face. The decrease in skin blood perfusion identified with stimulation rose postoperatively. In preliminary measurements, facial skin temperature increased approximately 1° after ganglionectomy in all patients. Blood perfusion of the outer layer of the skin

TABLE 4. Postoperative follow-up

Variable	Value
Mean follow-up (range), mo	32.2 ± 14.0 (6-51)
Immediate postoperative amelioration of facial blushing	10 (100)
Recurrence of facial blushing	0 (0)
Deterioration of compensatory sweating	0 (0)
Improvement of compensatory sweating	3 (30)
Satisfaction levels of the second surgery	
Very satisfied	8 (80)
Satisfied	2 (20)
Dissatisfied	0 (0)
Very dissatisfied	0 (0)

Data are presented as n (%) except where otherwise noted.

VIDEO 2. A transient decrease in skin blood perfusion was seen on the face at the time of resection of the sympathetic nerve. Changes in skin blood perfusion are identified intraoperatively by changes in color: red color indicates a sufficient volume of skin blood perfusion. A laser speckle flow graph device (LSFG-ANW; Soft Care Co, Ltd, Fukuoka, Japan) was used. Video available at: [http://www.jtcvsonline.org/article/S0022-5223\(18\)30346-5/fulltext](http://www.jtcvsonline.org/article/S0022-5223(18)30346-5/fulltext).

VIDEO 3. A temporary decrease in skin blood perfusion was seen repeatedly upon electrical stimulation of the third ganglion. Repeatability was very high. A laser speckle flow graph device (LSFG-ANW; Softcare Co Ltd, Japan) was used. Video available at: [http://www.jtcvsonline.org/article/S0022-5223\(18\)30346-5/fulltext](http://www.jtcvsonline.org/article/S0022-5223(18)30346-5/fulltext).

was observed in LSFG, and the blood perfusion of deeper tissues was not measured. It is thought that a temperature rise occurred because of the vasodilatation of deeper tissues because of ganglionectomy. Overabundance of the kineticism of the blood vessel of the outer skin layer might be related to the etiology of facial blushing.

Side effects of this treatment are possible with an expanded excision range. In patients who underwent sympathectomy, the phenomenon of intolerable sweating appears in the summer season. This is thought to occur because the temperature of the head increases because of the loss of evaporative cooling of facial sweat postoperatively. This is called compensatory sweating. However, among patients who naturally sweat very little on the face, we do not see the tendency toward increased sweating in the summer. Patients who naturally sweat

VIDEO 4. A temporary decrease in skin blood perfusion was seen repeatedly upon electrical stimulation of the third ganglion. Repeatability was very high. A laser speckle flow graph device (OZ-2; Omegawave, Tokyo, Japan) was used. Video available at: [http://www.jtcvsonline.org/article/S0022-5223\(18\)30346-5/fulltext](http://www.jtcvsonline.org/article/S0022-5223(18)30346-5/fulltext).

heavily on the body during summer usually show significantly facial sweating. The patients in this study showed naturally low sweating of the face in the summer. Therefore, there were no reports of a decrease or change in facial sweating after the first sympathectomy and the second ganglionectomy in all patients. No patients in this study required cooling their body in the summer.

The mechanisms of compensatory sweating is unknown, but it is certain that sympathetic nerves stimulate sweat glands in the skin area where compensatory sweating appears. Therefore, sympathetic nerves related to compensatory sweating should exist. In the patients who showed improvement in compensatory sweating, it is thought that the passage of the sympathetic nerve was blocked by ganglionectomy.

We have reported successful surgical treatment using identification and resection of the sympathetic nerve responsible for compensatory sweating.⁸ In this study, compensatory sweating decreased after ganglionectomy in 3 patients (patient numbers 3, 5, and 7). It is thought that the hyperactivated sympathetic nerves relating to facial blushing and compensatory sweating might have been removed.

CONCLUSIONS

When considering the mechanism of facial blushing, it is important to recognize that ganglionectomy is effective after the interception of the sympathetic trunk on the second rib. There are many features of the sympathetic nerve circuit that are unknown. When transection of the upper sympathetic chain is unsuccessful, the method reported herein represents an alternative therapeutic option.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support.

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