Scientific Research Publishing

Open Journal of Anesthesiology, 2017, 7, 175-183
http://www.scirp.org/journal/ojanes
ISSN Online: 2164-5558
ISSN Print: 2164-5531

Age and Gender-Related Differences in Hypotensive and Hypertensive Responses to Stellate Ganglion Block

Shigeru Yokota[1*], Chikuni Taneyama[1], Hiroshi Goto[2]

[1]Chishukai Taneyama Clinic, Nagano, Japan
[2]Department of Anesthesiology, University of Kansas Medical Center, Kansas City, USA
Email: *sigeru-yokota@suwa.jrc.or.jp

How to cite this paper: Yokota, S., Taneyama1, C. and Goto, H. (2017) Age and Gender-Related Differences in Hypotensive and Hypertensive Responses to Stellate Ganglion Block. *Open Journal of Anesthesiology*, **7**, 175-183.
https://doi.org/10.4236/ojanes.2017.77019

Received: June 12, 2017
Accepted: July 21, 2017
Published: July 24, 2017

Abstract

Purpose: The aim of the current study was to investigate: 1) Whether there is an association between age and changes in systolic blood pressure (SBP) after stellate ganglion block (SGB), and 2) Whether gender plays a role in hypotensive and hypertensive responses to SGB. **Methods:** We retrospectively reviewed SBP changes (ΔSBP) due to SGB, which were performed on 1641 subjects. SBP 30 min after SGB was compared to the baseline values. For the age study, average age of both sexes was calculated for six ranges of ΔSBP. For the gender study, the numbers of subjects (%) in various ranges of positive and negative values of ΔSBP were compared between men and women. **Results:** There was a significant association between age and both increasing ($p < 0.05$) and decreasing ($p < 0.01$) ΔSBP. Higher occurrence rates of negative ΔSBP were found in men as compared to women. On the other hand, higher occurrence rates of positive ΔSBP were found in women as compared to men. In addition, both men and women were found to have increasing ages as ΔSBP values get more positive or more negative. **Conclusions:** There was an association between age and blood pressure changes after SGB and the association is most likely due to age-related alteration of cardiovascular functions. The different changes of SBP between men and women after SGB may well be attributable to gender differences of autonomic nervous regulation; sympathetic dominant man versus, parasympathetic dominant women.

Keywords

Stellate Ganglion Block, Hypertension, Hypotension, Gender, Age

1. Introduction

Both right and left stellate ganglion block (SGB) will induce not only hypoten-

sion but also paradoxical hypertension [1] [2]. It is well recognized that aging process is accompanied by alterations of cardiovascular functions such as deterioration of compensatory baroreflex integrity [3] [4] and fractal hemodynamics [5] [6].

Recently, many studies revealed not only age-related but also gender-related differences in autonomic control of heart rate and blood pressure regulation [7] [8] [9]. There is a predominance of sympathetic vascular regulation in men compared with a dominant parasympathetic influence in women [10]. Resting sympathetic vasomotor tone tends to be decreased in women, and baroreflex blood pressure buffering is less effective in women than men [11].

It was found that baroreflex sensitivity, assessed by a head-up tilt test is significantly attenuated after either right and left SGBs [12]. However, no studies have looked at age-related and gender differences in blood pressure changes after SGB.

The main purpose of the current study was, therefore, to investigate: 1) Whether there is an association between age and changes in systolic blood pressure after SGB, 2) Whether there are gender differences in hypotensive and hypertensive responses to SGB.

2. Methods

With approval of the Ethics Committee at the Anesthesia and Pain Relief, Chishukai Taneyama Clinic, April 25, 2009 (Shiojiri City, Nagano Prefecture, Japan), SBP which had been recorded routinely before and 30 min after SGB were retrospectively analyzed for a total of 1641 (first time) and also a total of all repeated 49,351 successful and uncomplicated SGBs, which were performed over 14 years (2001 year to 2014 year) on 1641 patients (961 women, 58.7 ± 15.7 years old and 680 men, 56.3 ± 16.6 years old). Patients did not show the signs of successful SGB were excluded from the study. Written informed consent for the block procedure was obtained from each patient, but no informed consent was obtained for the study as this study was a retrospective review of routine recording of SBP, and subjects' age and sex stored in an electronic database. SBP 30 min after SGB was compared to the baseline values (ΔSBP) with age and gender considerations.

Patients received a series of SGBs for various disorders, such as complex regional pain syndrome type 1, thoracic outlet syndrome, cervical spondylosis, tension headache, and etc. Patients were placed on a table in the supine position in a procedure room with background music and a fragrance-producing unit, and the room temperature was kept constant at 23.0˚C. Systolic BP was measured from the contralateral upper arm with an automatic sphygmomanometer and the lead II electrocardiogram was monitored continuously.

After baseline SBP measurements, a standardized blind technique of SGB was performed by two anesthesiologist pain specialists with 6 ml of 1% mepivacaine using the anterior paratracheal approach at the level of C6 transverse process.

Evidence of Horner's syndrome (ptosis, myosis and enophthalmos) on the ipsilateral side was considered a successful block, and SBP was recorded 30 min after the procedure.

For the age study, average ages were calculated for 6 different ranges ΔSBP; less than −50 mmHg, between −49 and −25 mmHg, between −24 and −1 mmHg, between 0 and +24 mmHg, between +25 and +50 mmHg and more than +50 mmHg. Non-repeated measures ANOVA followed by Bonferoni correction were used for statistical analysis.

For the gender difference study, the number of subjects (%) corresponding to ΔSBP ≤ −1 mmHg and ≥ +1 mmHg were compared between men and women for the first time SGB and all repeated SGBs. Furthermore, number of men and women (%) and their average age corresponding to negative ΔSBP below and above 1× and 2 times median values (−13 and −26 mmHg) and corresponding to positive ΔSBP below and above 1× and 2 times median values (+11 and +22 mmHg) were compared between two genders. Comparison was carried out using Chi square test.

All values were expressed as mean ± SD, and statistical analysis were performed using Excel Statistical Program File Excel® Statistical Program File ystat2006.xls for Windows. $P < 0.05$ was considered statistically significant.

3. Results

Average age corresponding to 6 different ranges of ΔSBP was shown in Figure 1. Average age with ΔSBP −50 mmHg and ≥ +50 mmHg were significantly higher than those with ΔSBP between −25 ~ −49 mmHg and +25 ~ +49 mmHg, respectfully. There were significant differences between % number for men and % number for women; more men had negative ΔSBP than women, and more

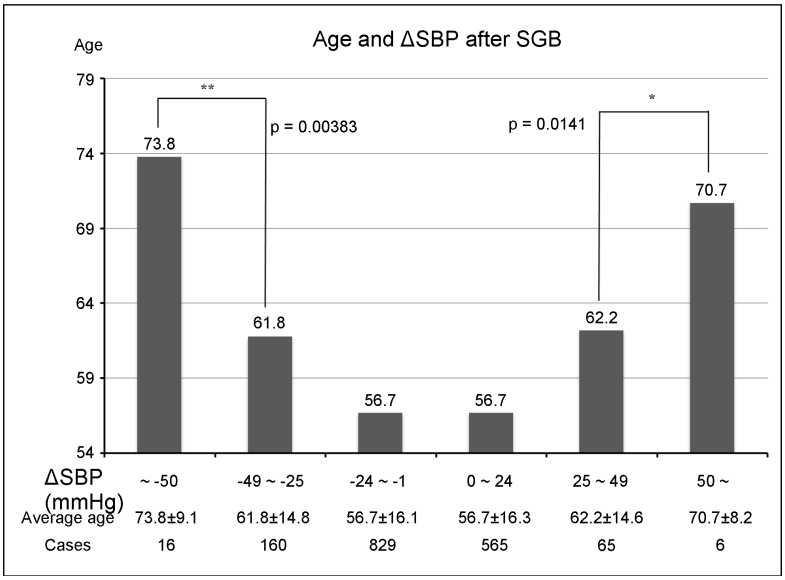

Figure 1. There were significant associations between average age and not only decreasing but also increasing systolic blood pressure changes (ΔSBP). **p < 0.01, *p < 0.05.

women had positive ΔSBP than men for the first time SGB and also for all repeated SGBs (Table 1 and Table 2).

Table 3 shows that % number for men is significantly higher than % number for women with ΔSBP below the median value (−13 mmHg). Average age gets higher in both genders when ΔSBP gets more negative (Table 3). Table 4 shows that % number for women is significantly higher than that for men with ΔSBP higher than both median (+11 mmHg) and ×2 median values (+22 mmHg), ($p < 0.01$ and $p < 0.05$, respectively). Average age gets higher in both genders when ΔSBP gets more positive (Table 4).

Table 1. Number of subjects (and %) with ΔSBP ≤ −1 mmHg, = 0 mmHg and ΔSBP ≥ +1 mmHg groups for men and women at the first time stellate ganglion block.

ΔSBP	Women	Men	Total
≤−1	555 (57.8%)	450 (66.2%)**	1005 (61.2%)
=0	30 (3.1%)	20 (3.0%)	50 (3.0%)
≥+1	376 (39.1%)**	210 (30.8%)	586 (35.7%)

**p < 0.01: ≤−1; women vs. men (p = 0.000559), ≥+1; women vs. men (p = 0.000596).

Table 2. Number of subjects (and %) with ΔSBP ≤ −1 mmHg, = 0 mmHg and ΔSBP ≥ +1 mmHg groups for men and women after all repeated treatments of SGB.

	Women	Men	Total
Times	28,193	21,158	49,351
≤−1	15,760 (55.9%)	13,572 (64.1%)**	29,332 (59.4%)
=0	724 (3.1%)	517 (2.4%)	1241 (2.5%)
≥+1	11,709 (41.5%)**	7069 (33.4%)	18,778 (38.0%)

**p < 0.01: ≤−1; women vs. men (p = 2.13E−76), ≥+1; women vs. men (p = 7.32E−75).

Table 3. Number of subjects (and %) and average age corresponding to above and below median values for men and women. (a) Median value: −13 mmHg; (b) Median value × 2: −26 mmHg.

(a)

	Women		Men	
Cases (%)	961 (100%)		680 (100%)	
ΔSBP ≤ −1 mmHg	555 (57.8%)		450 (66.1%)	
	Cases	Ages (y.o)	Cases	Ages (y.o)
<−14	254 (26.4%)	62.2 ± 14.5##	224 (32.9%)**	57.7 ± 16.3#
≥−13	301 (31.3%)	56.7 ± 16.3	226 (33.2%)	54.5 ± 16.3

**p < 0.01: women vs. men in lower −14 mmHg (p = 0.00424), ##p < 0.01: upper vs. lower median ΔSBP (p = 0.0000198), #p < 0.05: upper vs. lower median ΔSBP (p = 0.0188).

(b)

	Women		Men	
	Cases	Ages (y.o)	Cases	Ages (y.o)
<−27	81 (8.4%)	65.0 ± 13.2##	69 (10.1%)	61.3 ± 16.6##
≥−26	474 (49.3%)	58.2 ± 15.9	381 (56.0%)	55.2 ± 16.2

##p < 0.01: upper vs. lower Median × 2 (women: p = 0.000176, men: p = 0.00220).

Table 4. Number of subjects (and %) and average age corresponding to above and below median values for men and women. (a) Median value: +11 mmHg, (b) Median value × 2: +22 mmHg.

(a)

	Women		Men	
Cases (%)	961 (100%)		680 (100%)	
ΔSBP ≥ 1 mmHg	376 (39.1%)		210 (30.9%)	
	Cases	Ages (y.o)	Cases	Ages (y.o)
≤+11	205 (21.3%)	56.6 ± 16.6	117 (17.2%)	56.7 ± 16.5
>+12	171 (17.8%)**	59.6 ± 14.6#	93 (13.7%)	57.8 ± 17.9

**p < 0.01: women vs. men in upper +12 mmHg (p = 0.00253), #p < 0.05: upper vs. lower median ΔSBP (p = 0.0271).

(b)

	Women		Men	
	Cases	Ages (y.o)	Cases	Ages (y.o)
≤+22	311 (32.4%)	57.2 ± 16.1	180 (26.4%)	56.1 ± 17.1
>+23	65 (6.8%)*	61.0 ± 13.9#	30 (4.4%)	63.4 ± 17.0#

*p < 0.05: women vs. men in upper +22 mmHg (p = 0.0444), #p < 0.05: upper vs. lower median × 2 ΔSBP (women: p = 0.0395, men: p = 0.0141).

4. Discussion

The main findings of the current study were: 1) Significant associations were found between age and not only decreasing but also increasing blood pressure changes after stellate ganglion block (SGB). 2) Men were found to have a higher occurrence rate of lowering blood pressure response to SGB. On the other hand, women were found to have a higher occurrence rate of increasing blood pressure response to SGB.

Age difference study:

It is generally accepted that aging is associated with decreased baroreflex sensitivity, increasing blood pressure, and morphologically and functional changes in vasculature [3] [4] [8] [13] [14]. Furthermore, age-related reduction in the complexity of hemodynamic variability has been reported [5] [6]. By blocking the cardiac sympathetic pathway, SGB will decrease myocardial contractility and heart rate, resulting in hypotension, and the degree of hypotension will be depending partly on the degree of baroreflex integrity. Therefore, the association between age and decreasing blood pressure after SGB (**Figure 1**) is, at least in part, due to age-related deterioration of baroreflex sensitivity. Baroreflex sensitivity decreases roughly in a linear fashion from age 20 to 80 years in both genders [3]. Other possible aging processes such as pre-existing hypertension and arteriosclerosis might exaggerate hypotensive response to SGB. It is also speculated that loss of complexity of hemodynamic variability in the aging process might be one contributing factor to enhance hypotensive response to SGB. This is because loss for complexity of blood pressure and HR variability has been implicated in impaired hemodynamic homeostasis [5] [6] [12] [15].

It is not clearly understood the mechanism of paradoxical hypertensive response to SGB. Even, severe hypertension (SBP > 200 mmHg) after SGB has been reported [2]. It was demonstrated that SGB could paradoxically increase tibial nerve muscle sympathetic activity, suggesting an overall increase in sympathetic outflow from the central nervous system [16]. Because solution injected around the stellate ganglions spreads to surrounding areas [17], adjacently located vagal inhibitory afferents such as the aortic depressor nerve could be blocked with SGB. If the vagal afferents are blocked, diminished aortic depressor nerve discharge to the cardiovascular center in the medulla can trigger arterial baroreflex, leading to increased sympathetic outflow from the central nervous system.

Because of functional aging process in the vasculature [14], elder patients tend to have exaggerated hypertensive response to laryngoscopy and endotracheal intubation which increase sympathetic nervous activity [18]. It is, therefore, possible that some elderly subjects had exaggerated hypertensive response to SGB when the paradoxically increased sympathetic nerve activity occurred.

Gender difference study with age considerations:

Our study revealed that occurrence rate of decreased SBP responding to SGB is higher in men as compared to women, and occurrence rate of increased SBP responding to SGB is higher in women as compared to men (Tables). Many studies have shown gender differences in autonomic cardiovascular regulation [3] [7] [10]. There is a predominance of sympathetic vascular regulation in men compared to women. On the other hand, women have a dominant parasympathetic influence as compared to men [11] [19] [20]. It is possible that cardiovascular inhibitory action of SGB may be exaggerated in sympathetic predominant men. Because women have enhanced parasympathetic activity [9] [19], it can be speculated that even partially blocked vagal afferents could induce stronger high pressure baroreflex, leading to higher occurrence rate of increased SBP responding to SGB as compared to men. It is interesting to note that 6 cases of severe hypertension (SBP > 200 mmHg) were reported after SGB and five of six patients were women [2].

Further analysis of SBP changes between men and women responding to SGB was performed by dividing number of subjects into two sections by utilizing median and two times of median values of $\Delta SBP \leq -1$ mmHg and $\Delta SBP \geq 1$ mmHg (**Table 3** and **Table 4**). Occurrence rate of SBP change ($-\Delta SBP$) below one median value (−13 mmHg) is higher in men compared to women. On the other hand, occurrence rate of SBP change ($+\Delta SBP$) above one median (+12 mmHg) but also above two median values (+22 mmHg) is higher in women as compared to men. Thus, status of parasympathetic predominance in women may be more influencing factor as compared to status of sympathetic predominance in men as far as SBP changes responding to SGB are concerned.

Table 3 and **Table 4** show that age of both men and women get older as SBP changes get either more negative or positive, supporting the result of the figure.

Limitation:

The limitations of this study are as follows: A blind technique for SGB had been used, and blood pressure changes were retrospectively analyzed in our study as other many previous studies in which the effects of SGB on hemodynamics were evaluated. Recently, ultrasound-guided SGB has gained popularity and the total amount of local anesthetics can be reduced for successful SGB. Therefore, our results could be different if the ultrasound-guided SGB technique had been used. It would be, therefore, interesting to study in the future, the effects of ultrasound-guided SGBs on age-related and gender-related differences in blood pressure changes responding to stellate ganglion block.

We could not examine whether or not there were any differences in cardiopulmonary conditions, medical disorders, medications and smoking history between men and women. We believe, however, that the large patient population should warrant evaluating gender-related differences in blood pressure respond to SGB.

In summary, it was found that there was an association between age and not only decreasing blood pressure but also increasing blood pressure after stellate ganglion block, presumably due to age-related deterioration of cardiovascular functions. Increased sympathetic activities in men and enhanced parasympathetic activities in women may be contributing factor for a higher occurrence rate of decreased blood pressure in men and higher occurrence rate of increasing blood pressure in women, responding to stellate ganglion block.

Institution

Chishukai Taneyama Clinic and University of Kansas Medical Center.

Conflicts of Interest

The Authors declare no Conflict of Interest.

Source of Funding

Institutional and departmental sources.

IRB

This Study approved by the Human Ethics Committee at the Chishukai Taneyama Clinic. April 25, 2009. (Shiojiri City, 399-0732 Nagano Prefecture, Japan, Phone: +81263531010, E-mail: taneyama@taneyama-iin.jp)

References

[1] Yokota, S., Taneyama, C. and Goto, H. (2013) Effects of Right or Left Stellate Ganglion Block on Systemic Blood Pressure And Heart Rate. *Open Journal of Anesthesiology*, **3**, 143-147.

[2] Kimura, T., Nishiwaki, K., Yokota, S., Komatsu, T. and Shimada, Y. (2005) Severe Hypertension after Stellate Ganglion Block. *British Journal of Anaesthesia*, **94**, 840-

842. https://doi.org/10.1093/bja/aei134

[3] Laitinen, T., Hartikainen, J., Vanninen, E., Niskanen, L., Geelen, G. and Länsimies E. (1998) Age and Gender Dependency of Baroreflex Sensitivity in Healthy Subjects. *Journal of Applied Physiology*, **84**, 576-583.

[4] Duke, P.C., Wade, J.G., Hickey, R.F. and Larson, C.P. (1976) The Effects of Age on Baroreceptor Reflex Function in Man. *Canadian Anaesthetists' Society Journal*, **23**, 111-124. https://doi.org/10.1007/BF03005682

[5] Goldberger, A.L., Amaral, L.A., Hausdorff, J.M., Ivanov, P.C., Peng, C.K. and Stanley, H.E. (2002) Fractal Dynamics in Physiology: Alterations with Disease and Aging. *Proceedings of the National Academy of Sciences of the United States of America*, **99**, 2466-2472. https://doi.org/10.1073/pnas.012579499

[6] Lipsitz, L.A. and Goldberger, A.L. (1992) Loss of "Complexity" and Aging; Potential Applications of Fractals and Chaos Theory of Senescence. *The Journal of the American Medical Association*, **267**, 1806-1809. https://doi.org/10.1001/jama.1992.03480130122036

[7] Ryan, S.M., Goldberger, A.L., Pincus, S.M., Mietus, J. and Lipsitz, L.A. (1994) Gender and Age-Related Differences in Heart Rate Dynamics: Are Women More Complex than Men? *Journal of the American College of Cardiology*, **24**, 1700-1707. https://doi.org/10.1016/0735-1097(94)90177-5

[8] Liao, D., Barnes, R.W., Chambless, L.E., SimpsonJr, R.J., Sorlie, P. and Heiss, G. (1995) Age, Race, and Sex Differences in Autonomic Cardiac Function Measured by Spectral Analysis of Heart Rate Variability: The ARIC Study. *American Journal of Cardiology*, **76**, 906-912.

[9] Huikuri, H.V., Pikkujämsä, S.M., Airaksinen, K.E., Ikäheimo, M.J., Rantala, A.O., Kauma, H., *et al*. (1996) Sex-Related Differences in Autonomic Modulation of Heart Rate in Middle-Aged Subjects. *Circulation*, **94**, 122-125. https://doi.org/10.1016/S0002-9149(99)80260-4

[10] Evans, J.M., Ziegler, M.G., Patwardhan, A.R., Ott, J.B., Kim, C.S., Leonelli, F.M., *et al*. (2001) Gender Differences in Autonomic Cardiovascular Regulation: Spectral, Hormonal, and Hemodynamic Indexes. *Journal of Applied Physiology*, **91**, 2611-2618.

[11] Christou, D.D., Jones, P.P., Jordan, J., Diedrich, A., Robertson, D. and Seals, D.R. (2005) Women Have Lower Tonic Autonomic Support of Arterial Blood Pressure and Less Effective Baroreflex Buffering Than Men. *Circulation*, **111**, 494-498. https://doi.org/10.1161/01.CIR.0000153864.24034.A6

[12] Taneyama, C. and Goto, H. (2009) Fractal Cardiovascular Dynamics and Baroreflex Sensitivity after Stellate Ganglion Block. *Anesthesia & Analgesia*, **109**, 1335-1340. https://doi.org/10.1213/ane.0b013e3181b018d8

[13] Kuo, T.B., Lin, T., Yang, C.C., Li, C.L., Chen, C.F. and Chou, P. (1999) Effect of Aging on Gender Differences in Neural Control of Heart Rate. *American Journal of Physiology*, **277**, H2233-H2239.

[14] Barodka, V.M., Joshi, B.L., Berkowitz, D.E., Hogue, C.W. and Nyhan, D. (2011) Implications of Vascular Aging. *Anesthesia & Analgesia*, **112**, 1048-1060. https://doi.org/10.1213/ANE.0b013e3182147e3c

[15] Taneyama, C., Yokota, S. and Goto, H. (2013) Patients with Complex Regional Pain Syndrome Type 1: Fractal Dynamics of Heart Rate Variability and Baroreflex Evaluations. *The Clinical Journal of Pain*, **29**, 962-966. https://doi.org/10.1097/AJP.0b013e31827da343

[16] Ikeda, T., Iwase, S., Sugiyama, Y., Matsukawa, T., Mano, T., Doi, M., *et al*. (1996) Stellate Ganglion Block is Associated with Increased Tibial Nerve Muscle Sympathetic Activity in Humans. *Anesthesiology*, **84**, 843-850. https://doi.org/10.1097/00000542-199604000-00011

[17] Guntumukkala, M. and Hardy, P.A. (1991) Spread of Injectate after Stellate Ganglion Block in Man: An Anatomical Study. *British Journal of Anaesthesia*, **66**, 643-644.

[18] Bullington, J., Mouton Perry, S.M., Rigby, J., Pinkerton, M., Rogers, D., Lewis, T.C., *et al*. (1989) The Effect of Advancing Age on the Sympathetic Response to Laryngoscopy and Tracheal Intubation. *Anesthesia & Analgesia*, **68**, 603-608. https://doi.org/10.1213/00000539-198905000-00010

[19] Barnett, S.R., Morin, R.J., Kiely, D.K., Gagnon, M., Azhar, G., Knight, E.L., *et al*. (1999) Effects of Age and Gender on Autonomic Control of Blood Pressure Dynamics. *Hypertension*, **33**, 1195-1200. https://doi.org/10.1161/01.HYP.33.5.1195

[20] Tank, J., Diedrich, A., Szczech, E., Luft, F.C. and Jordan, J. (2005) Baroreflex Regulation of Heart Rate and Sympathetic Vasomotor Tone in Women and Men. *Hypertension*, **45**, 1159-1164. https://doi.org/10.1161/01.HYP.0000165695.98915.9a