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Effects of stellate ganglion block on the perioperative hemodynamics for coronary artery bypass grafting surgery

Mohamed S. Shorbagy, Mona R. Hosny and Wael Abdelmoneim

Faculty of Medicine, Ain-Shams University Cairo, Cairo, Egypt

ABSTRACT

Background: Stellate ganglion block (SGB) is a successful technique that can potentially maintain hemodynamics and terminate fatal arrhythmia. We aimed to study the efficacy of SGB on hemodynamic changes after on pump coronary artery bypass grafting (CABG) surgery.
Methods: Forty patients who underwent CABG surgery at the Cardiac Surgical Academy Ain Shams University Hospital were randomly allocated to receive SGB or placebo between June 2020 and February 2021. After fulfilling the inclusion criteria, patients were classified as American Society of Anesthesiologists III and IV. Patients were randomly assigned to one of two groups utilizing a computer-generated block number in a sealed envelope. Group S (20 patients) received SGB, and Group C (20 patients) included matched controls who received a placebo solution in the SGB. Primary outcome was perioperative changes in heart rate and systolic and diastolic blood pressures.

Secondary outcomes included the incidence of atrial and ventricular fibrillation, and myocardial ischemia in addition to the times from ICU admission to extubation, ICU stay, and hospital stay.
Results: A statistically substantial increase in systolic and diastolic blood pressure as well as increased incidence of AF and VF was found in the control group compared to the SGB group with p values <0.001, <0.001, 0.037, and 0.028, respectively.
Conclusion: SGB can reduce the hemodynamic responses to surgery and anesthesia, intraoperative tachyarrhythmias, and ICU and hospital stays.

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KEYWORDS
Hemodynamic responses; CABG; SGB; stellate ganglion block

1. Introduction

Cardiac dysrhythmia is considered one of the most prevalent postoperative complications. Postoperative atrial fibrillation (POAF) is characterized by a high occurrence, such as following valve replacement as well as coronary artery bypass graft (CABG) surgeries in 50% and 40% of patients, respectively [1]. Perioperative cardiac arrhythmia prolongs hospitalization, particularly when complications, such as stroke, thromboembolic problems, and hemodynamic instability, are expected [2].

The severity of arrhythmia is determined by the underlying cardiac status, duration, as well as rate of ventricular response. Young patients may tolerate these perioperative complications. Nevertheless, elder cases with diseased myocardium cannot [3]. Reperfusion injury and myocardial stunning are well-known complications after cardiopulmonary bypass (CPB). However, the patient's condition could be critical and can end in mortality if the injury causes complications. It is controversial whether preoperative SGB could attenuate or lessen the severity of these complications [4].

The stellate ganglia are formed when the first thoracic and inferior cervical ganglions fuse [5]. These ganglia effectively manage pain and treat diseases caused by sympathetic overstimulation [6] by increasing the blood flow, regulating the central nervous system, and improving hemodynamics [7,8].

Researchers have demonstrated that SGB is a viable and feasible procedure in cardiac operating rooms [9]. As the most prevalent postoperative arrhythmia, AF can be inhibited through SGB. This block can modulate the immunological as well as autonomic function to avoid AF occurrence and maintenance [10]. Since they contain specific cardiac sympathetic nerves, stellate ganglia's impacts on the cardiovascular system are still controversial [5]. They are expected to attenuate cardiovascular disturbances, including anginal pain [11].

This study aimed to determine whether SGB can decrease ischemic changes after CPB and its severe consequences for hemodynamic instability and the occurrence of perioperative arrhythmias. Therefore, we attempted to achieve early weaning, extubation, and enhanced postoperative recovery under the effect of SGB.

CONTACT Wael Abdelmoneim waelelswefi@med.asu.edu.eg Faculty of Medicine, Ain-Shams University Cairo, Cairo, Egypt

2. Materials and methods

A prospective randomized controlled study of 40 patients with physical status classification III and IV of the American Society of Anesthesiologists (ASA) was conducted at the Cardiac Surgical Academy Ain Shams University Hospital from the beginning of January 2020 till June 2020, following the approval from the ethical committee of Ain Shams University (FMASU R3/2020) on 22 January 2020 and all patients provided written informed consent number, with a registration number of NCT04439058.

Inclusion criteria included patients aged 50–70 years who underwent CABG surgery. The exclusion criteria included any contraindication to SGB (allergy to local anesthetics, severe chronic obstructive pulmonary disease, unstable cervical spine, contralateral laryngeal or phrenic nerve paralysis, and infection at the injection site). Additionally, patients with recent myocardial infarction, unstable angina, heart rate less than 60 beat/min, low ejection fraction (less than 40%), emergency CABG, left main coronary artery disease, and patients on thrombolytic or anticoagulant therapy were excluded.

All patients were premedicated using intravenous midazolam (0.05 mg/kg). The block was performed through 2 L of oxygen delivered via an oxygen face mask with pulse oximetry and five-lead ECG. In addition, an arterial catheter was inserted in all patients under local anesthesia.

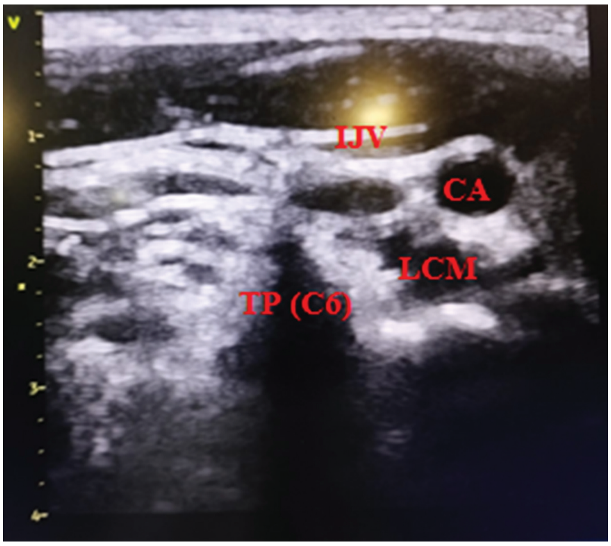

Figure 1. Structures viewed by ultrasound.

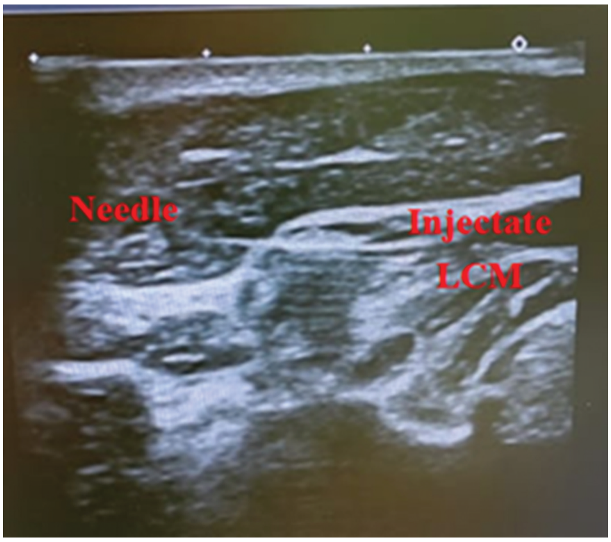

Figure 2. Needle and injection.

2.1. Stellate ganglion block

The patient was positioned supine with the head tilted slightly to the right and slightly extended to perform US guided left SBG. US probe was positioned at the cricoid cartilage level. The transverse process of the sixth cervical vertebra was recognized by its prominent anterior tubercle. The longus colli muscle and its covering prevertebral fascia were identified anterior to the C6 vertebral body and deep to the carotid artery (Figure 1).

After skin infiltration using a local anesthetic, the needle was inserted from the lateral to medial position aiming to inject local anesthesia deep into prevertebral fascia and above the longus coli muscle (Figure 2).

We used a GE (venue 40) US machine with a high-frequency linear probe, with an imaging depth of 4 cm, and a short-bevel 22 gauge needle was used.

Patients in group S received 8 mL of bupivacaine 0.25%, whereas those in the control group received 8 mL of normal saline (an equivalent volume).

Following SGB, subjects were observed for signs of successful block in the form of an increase in temperature of at least 1°C in the ipsilateral arm detected using an adult skin temperature probe compared with the baseline value or any evidence of Horner's syndrome.

Anesthetic techniques were standardized for all cases. In addition, standard monitoring such as ECG with automated ST segment analysis, pulse oximetry, end-tidal capnography, and continuous measurement of urine output, nasopharyngeal temperature, invasive blood pressure, and central venous pressure was carried out.

Balanced smooth induction of anesthesia was achieved with fentanyl (2–5 µg/kg), propofol (1–2 mg/kg), pancuronium (0.1 mg/kg), and inhaled isoflurane (0.5–1%). The trachea was intubated, patients were mechanically ventilated with oxygen and air, and ventilation parameters were adjusted to maintain normocarbia.

Before the initiation of CPB, the patients received intravenous heparin (300–500 units/kg) to achieve an ACT of >480 seconds. CPB was instituted via an ascending aortic cannula and a right atrial cannula. Pump flow was adjusted to (2.4 L/min/m^2) to achieve a mean arterial pressure of 50–80 mmHg. Cardiac arrest was achieved with cold antegrade blood cardioplegia. Lactate-enriched ringer solution was added to the CPB circuit to maintain reservoir volume when needed, and packed red blood cells would be added when hemoglobin decreases to less than 7 g/dL. After the patients rewarming to 37°C, separation from CPB, reversal of heparin by protamine (1:1), and sternal closure was achieved.

Primary outcome was perioperative changes in heart rate and mean arterial blood pressure.

Heart rate was recorded 2 min after induction, after bypass, after skin closure, and after extubation. While mean arterial blood pressure was recorded 2 min after induction, during bypass, after bypass, after skin closure, and after extubation

Secondary outcomes included the incidence of atrial and ventricular fibrillation, and myocardial ischemia in addition to the times from ICU admission to extubation, ICU stay, and hospital stay.

Myocardial troponin T levels were measured as a predictor of cardiac injury at the following intervals (on ICU admission, 1st, 2nd, and 3rd postoperative days).

The total cumulative dosages of all drugs, such as inotropes as well as vasodilators, were measured at the beginning of CPB, 30 min after the start of CPB, and at the conclusion of the operation.

The case was extubated after meeting these criteria: normothermic, hemodynamically stable, pain-free, completely conscious with good motor power, as well as normal acid-base and arterial blood gases. Time from ICU admission to tracheal extubation, ICU stay, and hospital stay in days postoperative were recorded.

2.1.1. Sample size calculation

With a power of 0.9 as well as an α-value of 0.05, a power analysis was carried out to calculate the adequate sample size to demonstrate a statistically significant difference between the group proportions and occurrences of postoperative side effects as indicated by the findings of the preliminary study. The computed sample size for each group was at least 20. They were randomly assigned to two groups utilizing a computer-generated block number inside a sealed envelope. In addition, statistical analysis was performed utilizing the two-sided z-test with pooled variance. The significance level achieved using this design is <0.05.

2.1.2. Statistical Analysis

Version 21.0 of the Statistical Package for Social Science (Chicago, IL, USA) and Microsoft® Excel 2016 (Microsoft, Seattle, WA, USA) were utilized for analyzing data. Quantitative data with parametric distribution were expressed as mean ± standard deviation and compared between two groups using the independent t-test, while non-parametric data were presented as median with interquartile range and compared between the two groups using the Mann–Whitney test. Additionally, qualitative data were expressed as percentages as well as numbers and compared between the two groups utilizing the chi-square test. The confidence interval was set to 95%, and the accepted error margin was set to 5%. Therefore, the level of statistical significance was set at a p-value of $P < 0.05$.

3. Results

Our study showed no statistically significant differences between the two studied groups in relation to body mass index (BMI), age, gender, ASA status, medical history, preoperative medications, duration of bypass, duration of aortic cross-clamping, and the number of grafts, as shown in (Table 1).

Table 1. Demographic data of patients and surgeries in both groups.

Variable	SGB group (*n* = 20)	Control group (*n* = 20)	*P* value
Age (years)	61.9 ± 4.45	63.3 ± 6.31	0.423[a]
Males	11(55)	8(40)	0.342[b]
BMI (kg/m^2)	26.8 ± 1.51	27.3 ± 1.93	0.377[a]
ASA status (III/IV)	12/8	15/5	0.311[b]
Medical history			0.720[b]
DM	9(45)	8(40)	
Hypertension	11(55)	12(60)	
Arrhythmia			
Yes	0(0.0)	9(45)	<0.001
No	20(100)	11(55)	
Preoperative Medications			
B-blockers	20(100)	17(85)	0.072[b]
CCBs	19(95)	17(85)	0.292[b]
ACE-I	17(85)	16(80)	0.677[b]
Aspirin	19(95)	15(75)	0.077[b]
Statins	20(100)	18(90)	0.147[b]
Bypass time (min)	76.65 ± 18.3	75.01 ± 16.62	0.767[a]
Aortic cross-clamping time (min)	43.75 ± 13.16	42.08 ± 12.6	0.670[a]

BMI: Body mass index, DM: Diabetes mellitus, CCBs: Calcium channel blockers.
ACE-I: Angiotensin-converting enzyme inhibitors. Data are presented as mean ± SD, count (%).

Table 2. Intraoperative hemodynamic variables.

Mean art. Bl pr. (mmHg)		SGB group No. = 20	Control group No. = 20	Test value	*P*-value	Sig.
After induction	Mean ± SD	59.40 ± 6.68	61.60 ± 6.65	−2.490•	0.017	S
	Range	55–76	55–73			
During bypass	Mean ± SD	59.75 ± 6.06	67.05 ± 4.84	−4.210•	0.000	HS
	Range	49–70	59–76			
After bypass	Mean ± SD	63.85 ± 7.51	68.90 ± 6.78	−2.231	0.032	S
	Range	56–75	56–77			
After skin closure	Mean ± SD	70.25 ± 5.33	74.25 ± 4.67	−2.525•	0.016	S
	Range	59–79	67–82			
After extubation	Mean ± SD	71.75 ± 6.50	73.05 ± 5.68	−0.674•	0.505	NS
	Range	59–81	59–80			
Mean HR (beat per minute)		**SGB group No. = 20**	**Control group No. = 20**	**Test value**	*P*-value	**Sig.**
After induction	Mean ± SD	70.25 ± 6.79	76.00 ± 5.31	−2.983•	0.005	HS
	Range	58–83	66–85			
After bypass	Mean ± SD	69.10 ± 3.96	76.20 ± 4.95	−5.011•	0.000	HS
	Range	59–77	68–85			
After skin closure	Mean ± SD	76.75 ± 5.71	80.85 ± 3.60	−2.715•	0.010	S
	Range	68–88	76–90			
After extubation	Mean ± SD	80.20 ± 6.18	83.50 ± 6.17	−1.690•	0.099	NS
	Range	69–90	74–94			

Data are presented as mean ± SD and range. $P < 0.05$ is considered significant.

Table 3. Intraoperative vasodilators and inotropes need and incidence of atrial and ventricular fibrillation.

Variables	SGB group No. = 20	Control group No. = 20	*P*-value
Vasodilators	9(45.0%)	11(55.0%)	0.527
Inotropes	7 (35.0%)	6 (30.0%)	0.736
Atrial fibrillation	1 [5]	6(30)	0.037
Ventricular fibrillation	2 [10]	8(40)	0.028

Data are presented as count (%). $P < 0.05$ is considered significant.

The study found a substantial increase in mean arterial blood pressure in the control group than in the SGB group in periods of after induction (p-value 0.017), during bypass (p-value 0.000), after bypass (p-value 0.032), and after skin closure (p-value 0.016), but there was no statistical difference in the after extubation period (p-value 0.505).

The same results were also found for heart rate which increased in the control group than in the SGB group in periods of after induction (p-value 0.005), after bypass (p-value 0.000), and after skin closure (p-value 0.010), but there was no statistical difference in the after extubation period (p-value 0.099) (Table 2).

In addition, there were no substantial differences between both groups in terms of the intraoperative use of vasodilators and inotropes (p-value = 0.527 and 0.736). The incidence of atrial fibrillation and ventricular fibrillation was also found to be higher in control group (6(30%) and 8(40%)) than in SGB group (1(5%) and 2(10%)) with p-values 0.037 and 0.028, respectively (Table 3).

Table 4. Comparison between both groups regarding cardiac troponin T levels at serial points of measurements.

Cardiac troponin T	SGB group (*n* = 20)	Control group (*n* = 20)	*P*-value
On ICU admission (ng/mL)	0.052 ± 0.024	0.080 ± 0.065	0.072
1st postoperative day (ng/mL)	0.090 ± 0.094	0.137 ± 0.127	0.188
2nd postoperative day (ng/mL)	0.087 ± 0.082	0.164 ± 0.114	0.018
3rd postoperative day (ng/mL)	0.094 ± 0.086	0.249 ± 0.062	0.000

Data are presented as mean ± SD.
P-values were measured by Mann–Whitney test. $P < 0.05$ is considered significant.
Mean cTnT (ng/mL).

Postoperative cardiac troponin level was lower in the blocked group compared to the control group at the 2nd and 3rd postoperative days as indicated in (Table 4).

Time from ICU admission to extubation (hours), ICU stay (days), and hospital stay (days) were significantly shorter in the SGB group than controls (p-value = 0.024, 0.008, and 0.001, respectively). The mean changes in time to extubation, ICU stay, and hospital stay were 0.55 ± 0.13%, 0.44 ± 0.12%, and 1.43 ± 0.12%, respectively (Table 5).

4. Discussion

Particularly among the elderly, perioperative arrhythmias, which frequently indicate the existence of underlying metabolic imbalances or cardiopulmonary disease, are common complications in cardiac

Table 5. Comparison between both groups regarding the times from ICU admission to extubation, ICU stay, and hospital stay (LOS).

	SGB group (*n* = 20)	Control group (*n* = 20)	Mean changes %	*P*-value
Time from ICU admission to extubation (hours)	2.65 ± 1.12	3.20 ± 1.25	0.55 ± 0.13	0.024
ICU stay (days)	2.21 ± 0.55	2.65 ± 0.43	0.44 ± 0.12	0.008
Hospital stay (days)	5.82 ± 0.48	7.25 ± 0.36	1.43 ± 0.12	<0.001

surgeries. Numerous methods, including beta-blockers, prophylactic magnesium, and amiodarone, have been used for the management of cardiac arrhythmias after and during off-pump OPCAB operations. According to preliminary studies, preoperative SGB reduces both postoperative AF duration and incidence [1].

The protective effect of SGB on the heart (primary outcome) is induced by its negative inotropic and chronotropic effects by decreasing the sympathetic outflow to the sinus node and the ventricles achieving hemodynamic stability [8,9]. Consequently, our study included 40 patients with ASA physical status classifications III and IV and aimed to determine whether SGB could decrease ischemic changes after CPB and its severe complications of hemodynamic instability and the occurrence of perioperative arrhythmias.

In our study, the SGB group demonstrated significantly lower values of heart rate and arterial blood pressure compared to controls, proving that SGB could significantly stabilize the heart rate and blood pressure, and the tendency to use vasopressors or inotropes was thereby almost negligible. Our study aligns with Fujik et al. [12] and Garneau et al. [13]. In addition, Kashima et al. [14] found that the right SGB predominates the sympathetic effect on both the myocardium and the sinus node as compared with the left. Nevertheless, the results are contradictory to those of Park et al. [15], who illustrated that the heart rate rises after left SGB. Also, Egawa et al. [16] found bradycardia during right SGB. Additionally, Yokota et al. [17] found no changes in heart rate when performing the left SGB, as well as a rise in systolic blood pressure. Gopal et al. [18] also revealed no difference in hemodynamic parameters (MAP, DBP, SBP, and heart rate) following SGB administration.

If AF occurs intraoperatively or in the early or late postoperative period, it may have a dramatic effect on the cardiac perfusion and may predispose to congestive heart failure, increasing the incidence of stroke, length of ICU stays, and hospital discharge. The present study showed a significantly lower number of patients who experienced AF among SGB than in the control group. This finding is consistent with Dionyssios et al. [19], who concluded that unilateral temporary SGB reduced the inducibility of AF and its duration. Furthermore, Gadhinglajkar et al. [20] found that left SGB alleviates arrhythmias risk in cases with prolonged QT interval syndrome as well as myocardial infarction.

This study found less postoperative cardiac injury as confirmed by low troponin levels and the findings of Wei et al. [21], who suggested that SGB may have an antioxidative impact against acute myocardial injury and may be effective and safe for protecting against cardiac damage induced by oxidative stress. In addition, this was supported by Gopal et al. [18], who illustrated that Left SGB substantially increased the diameter of Left Internal Mammary Artery and prevented its spasm and thus may improve surgical outcomes.

The current findings indicated negligible intraoperative arrhythmias and insignificant use of vasoactive agents or inotropes. This finding is consistent with Yildirim et al. [22] who found that the incidence of AF, requirement for inotropic agents, as well as ST-segment elevation were all reduced, which may improve the surgical outcome.

Also, stellate ganglion block group showed decreased incidence of ventricular fibrillation, which agreed with Hayase et al. who used percutaneous stellate ganglion block to suppress resistant ventricular fibrillation and Rajesh et al. who noticed stellate block treatment effect on refractory VF [23].

Our study revealed that the SGB group required a shorter time from ICU admission to extubation, as well as ICU and hospital stay, than controls. Nonetheless, these data were inconsistent with Abd Allah et al. [9], who concluded that the hospital and ICU stay revealed no statistically significant differences between both groups.

SGB is an effective therapy option for undifferentiated post-CABG hemodynamics. Even though one qualified anesthesiologist conducted SGB on patients without difficulties, SGB is not advised as a daily practice as there are possible significant problems linked to block, such as pneumothorax, epidural, or subarachnoid injections, phrenic nerve block or recurrent laryngeal, and vertebral artery puncture [11].

The current study has a number of limitations, such as not including a placebo as the third arm of this study, the relatively small sample size to obtain definitive results, and no follow-up was performed for any of the patients after hospital discharge for any new angiographic findings.

5. Conclusion

SGB can reduce hemodynamic responses to surgery and anesthesia, intraoperative tachyarrhythmias, and ICU and hospital stays.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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