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Preoperative left stellate ganglion block: Does it offer arrhythmia-protection during off-pump CABG surgery? A randomized clinical trial

Essam Abd Allah[a], Mohammed Abdelmonem Bakr[a], Sara Abdallah Abdelrahman[a], Ahmed M. Taha[b] and Emad Zarief Kamel[a]

[a]Departments of Anesthesia and ICU, Faculty of Medicine, Assiut University, Assiut, Egypt; [b]Cardiothoracic Surgery, Faculty of Medicine, Assiut University, Assiut, Egypt

ABSTRACT

Background: Cardiac arrhythmias are not uncommon during and after coronary artery bypass graft cardiac surgeries. Preliminary studies showed the preventive effects of stellate ganglion block upon cardiac arrhythmias; however, this could be the 1st study focusing upon intraoperative arrhythmias during offpump coronary artery bypass graft surgery as a main goal.

Methods: This is a randomized controlled trial. The study involved forty adult patients undergoing elective offpump coronary artery bypass graft surgery. Twenty patients received left SGB with 10 ml of 2% lidocaine before induction of anesthesia (B group), and twenty patients as a control group (A group). Intraoperative and 24-hours postoperative electrocardiogram and hemodynamics were monitored, in addition to the mean postoperative 24-hours inotropic score.

Results: There was a significantly higher incidence of intraoperative arrhythmias in the control group in the form of bradyarrhythmia (25%), supraventricular tachycardia (30%), atrial fibrillation (5%), ventricular tachycardia (10%), and ventricular fibrillation (5%) in comparison to the block group where atrial fibrillation occurred only in 4 patients (20%) with the *p* value of 0.007. Mean arterial blood pressure and heart rate showed significantly lower values in the SGB group intraoperatively. Postoperative mean 24-hour inotropic score and hemodynamics showed insignificant differences.

Conclusion: Preoperative left stellate ganglion block can decrease incidence of arrhythmias during offpump coronary artery bypass graft surgeries. The technique showed a safe profile upon hemodynamics during the study period.

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Stellate ganglion block; offpump CABG; cardiac arrhythmia

1. Introduction

Cardiac arrhythmia could be the most common complication which occurs during and after surgeries. Postoperative atrial fibrillation (AF) has a very high incidence; it occurs after coronary artery bypass graft (CABG) surgery and valve replacement surgeries in up to 40% and 50% of patients respectively [1]. Peioperative cardiac arrhymia increases the hospital stay especially with expected complications, e.g. hemodynamic intability, thromboembolic preoblems, and/or stroke [2].

The burden of arrhythmia depends upon their duration, ventricular response rate, and the underlying cardiac status. Young patients can tolerate such perioperative problem; however, elders with diseased myocardium could not [3,4].

For prevention of cardiac arrhythmias during and after offpump coronary artery bypass graft (OPCAB) surgeries, a lot of modalities have been utilized, e.g., prophylactic amiodarone, magnesium sulfate, and betablockers [5–7]. Preoperative stellate ganglion block (SGB) can lower the incidence and duration of postoperative atrial fibrillation (AF) as mentioned by preliminary studies. Researchers suggested that SGB must be a feasible and an applicable maneuver to be done in the cardiac operative rooms [8,9,9]. Atrial fibrillation as the most common postoperative arrhythmia can be inhibited through SGB. Such block can regulate the autonomic and immune function in such a way to prevent the occurrence and maintenance of AF [10,11].

We suppose that this could be the first clinical trial involving and evaluating the implication of preoperative SGB upon the incidence of perioperative arrhythmias in patients undergoing OPCAB.

Primary study goal included the incidence of intraoperative and postoperative arrhythmia. **The secondary goals** included the effects of SGB upon intraoperative hemodynamics, postoperative inotropic score, and ICU stay.

2. Methods

This is a randomized controlled trial started with local ethical committee approval then registration in clinical

CONTACT Emad Zarief Kamel emadzarief@aun.edu.eg Department of Anesthesia, Faculty of Medicine, Assiut University Hospital, Assiut 74111, Egypt,

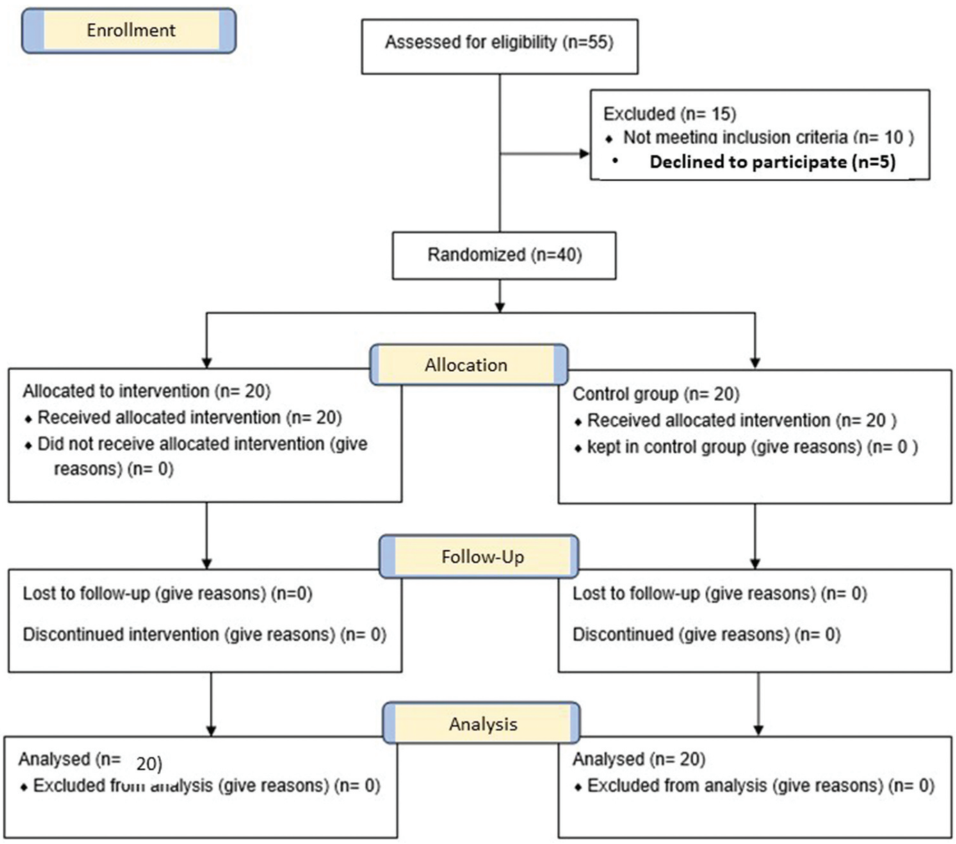

Figure 1. CONSORT flow chart of the participants.

trials.gov under the number of NCT03450226. The provision of written informed consent was obtained from forty adult patients undergoing elective OPCAB as shown in the CONSORT flow-chart (Figure 1). The study was adhered to all the ethical principles of latest Declaration of Helsinki.

Inclusion criteria included adult patients of bother gender, of American Society of Anesthesiologist (ASA; II and III) with an ejection fraction of > 50% with no evidence of heart failure, and no history of antiarrhythmic before surgery. **Exclusion criteria** included emergency surgeries, presence of vasopressor or inotropic support, patients, implanted pacemaker or cardioverter and any conduction abnormality, sever right coronary artery stenosis, valvular heart disease, atrial enlargement, thrombolytic therapy, coagulation disorders, allergy to local anesthetic, carotid vascular disease as defined by ipsilateral prior carotid endarterectomy or carotid stent, superficial infection at the proposed puncture site, contralateral phrenic or laryngeal nerve palsies, chronic obstructive lung disease, and morbid obesity.

Participants were randomly and equally allocated into one of two equal groups through computer-generated random numbers.

- Control group A (n = 20): control group with no intervention.
- Stellate ganglion block (SGB) group B (n = 20): received left SGB with 10 ml of 2% lidocaine.

2.1. *Anesthetic technique*

An intravenous line was inserted on the dorsum of right hand, then intravenous midazolam premedication was given in a dose of 0.05–0.1 mg/kg. Left SGB was performed in the operating room immediately prior to the induction of anesthesia. Left stellate ganglion block (LSGB) [12] was performed under ultrasound guidance using a 7.5 MHz probe (Site-Rite ultrasound system, Bard Access, Inc., USA). A Paratracheal out of plane technique was done as follows: regional anesthesia blunt needle 22 G, 50 mm (Stimuplex A®; B Braun, Melsung, Germany) was advanced via the prevertebral fascia until its tip reached within the longus colli muscle. Injection of 2% lidocaine 10 ml solution with a resultant longus colli compartment bulge with caudal and cephalad spread (ultrasound verified). Confirmation of the SGB success was detected by warming of left upper limb (at least 1°C increase) using adult skin temperature probe (Mindray MR403B Reusable 2 Pin Adult Skin Temperature Probe) and left Horner's syndrome.

Before induction, arterial line was placed under local anesthesia. Induction was achieved by fentanyl (3–-4 µg/kg) and propofol (1–2 mg/kg), followed by cisatracurium (0.15 mg/kg) to facilitate endotracheal intubation, then volume-controlled ventilation was instituted with parameters set to maintain normocarbia. Central venous pressure line was applied in the right internal jugular vein. Anesthesia was maintained by isoflurane in oxygen and air (FiO2 = 0.5), fentanyl infusion (1 µg/kg/hour), and cisatracurium infusion (1–2 µg/kg/min) for maintenance of muscle relaxation. Intraoperative monitoring included electrocardiogram, invasive systemic blood pressure, central venous pressure, O_2 saturation by pulse oximetry, end-tidal CO_2 by capnography, arterial blood gases, core body temperature using nasopharyngeal probe, and urine output. Operative procedure was done through midline sternotomy and by the same surgical team.

2.2. Management of arrhythmia

Initially we asked for temporary stoppage of cardiac manipulation and checked up arterial blood gas and potassium level. Bradycardia (heart rate < 40 beat/minute) with hemodynamic instability (20% drop of the mean arterial blood pressure) was treated by intravenous atropine in a dose of 0.3–0.5 mg. For the treatment of supraventricular tachycardia (SVT), AF, or ventricular tachycardia (VT) with stable hemodynamics, intravenous amiodarone (150 mg over 10 minutes, then 1 mg/minute for 6 hours, then 0.5 mg/minutes for 18 hours); however, in the case of hemodynamic instability, synchronized direct current (DC) cardioversion in a dose of 120–200 J (biphasic) was utilized for AF and SVT. Ventricular fibrillation (VF) and VT with hemodynamic instability were treated by non-synchronized DC at a starting energy dose of 100 J (biphasic) [13–15].

Upon arrival to the ICU, fentanyl infusion was reduced to 0.5 µg/kg/min. Hemodynamic changes were managed by optimizing the intravascular volume and/or the inotropic support with systolic blood pressure ≥ 100 mm Hg as a target and a hematocrit ratio of 30–35%. The patient was extubated when fulfilling the following criteria: fully conscious with good motor power, hemodynamically stable, has normal arterial blood gases and acid base, normothermic, and pain-free.

Inotropic score [16] was calculated according to the formula: [dopamine dose (µg/kg/min) + dobutamine dose (µg/kg/min) + 100 x epinephrine dose (µg/kg/min)]. The inotropic score (IS) was evaluated every hour. The mean 24 hours score achieved by averaging the hourly scores for 24 hours; the maximum 24 hours IS was the highest value during the first 24 hours of the study.

3. Statistical analysis

A sample size of 36 patients (18 in each group) was obtained through the use of G*Power 3 software with an error probability of 0.05 and 80% power on a one-tailed test. The sample size was also guided by previous study done by Garneau et al. [17].The sample was raised to include 40 patients to compensate for any patient's dropout. Data were analyzed using the computer program IBM, SPSS (Statistical Package for Social Sciences), Version 22, 2015. Normality of data was verified by Kolmogorov-Smirnov test. The incidence of arrhythmias was presented as numbers and percentages and analyzed using Fisher's exact test. Other categorical data were given as numbers and percentages and studied by Chi-square test. Continuous parametric numerical variables were presented as mean ± standard deviation (SD) and groups comparison was done through the independent samples *t*-test for normally distributed data. Continuous non-parametric data were presented as median and interquartile range and groups comparison was done through Mann-Whitney test. The *p* value <0.05 was considered statistically significant.

4. Results

The 40 patients in the two groups have completed the study and were comparable regarding their demographic, preoperative clinical data, and operative details as shown in Table 1. There was no significant difference between both groups regarding such issues.

Variable types of arrhythmias have occurred in both groups after anesthesia induction and during the whole follow-up period. The incidence of arrhythmia during the anastomosis was significantly lower in the SGB group in comparison to control group with *p* value of 0.007. Bradyarrhythmia occurred in four patients in SGB group, whereas in the control group, patients have bradyarrhythmia, SVT, VT, VF. Variable types of arrhythmias have occurred in both groups during the early postoperative 24 hours with no significant difference between both groups (Table 2).

Table 1. Demographic and clinical data of the studied groups.

Variables	Control group (A) (*n* = 20)	Block group (B) (*n* = 20)	*p* value
Age (years)	55.25 ± 4.4	53.95 ± 7.3	0.98
BMI %	28.62 ± 6.5	29.46 ± 6.1	0.67
Male/Female	16/4	18/2	0.66
Medical diseases	5(25%)	9(45%)	
• Hypertension	5(25%)	2(10%)	0.18
• Diabetes mellitus	1(5%)	3(15%)	
• COPD	5(25%)	1(5%)	
• Diabetic +Hypertension	1(5%)	0(0%)	
• Epilepsy			
NYHA classification	15(75%)	14(70%)	0.72
• II	5(25%)	6(30%)	
• III			
Echocardiography	55.95 ± 7.9	56.50 ± 7.7	0.825
• Ejection fraction %	8(40%)	6(30%)	0.751
• Hypokinesia	6(30%)	6(30%)	
• Akinesia			

Data are presented as ratio, mean± standard deviation (SD) or number (percentage). *p*< 0.05 is considered statistically significant.

Table 2. The incidence of intra and postoperative arrhythmias in the studied groups.

Timing	Arrhythmia	Control group (n = 20)	Block group (n = 20)	p value
Pre-procedure	Sinus rhythm	20 (100%)	20 (100%)	N. A
Post-procedure	Bradyarrhythmia	-	2 (10%)	0.147
Postinduction	Bradyarrhythmia	-	2 (10%)	0.147
During anastomosis	Bradyarrhythmia	5 (25%)	4 (20%)	0.007*
	SVT	6 (30%)	-	
	AF	1 (5%)	-	
	VT	2 (10%)	-	
	VF	1(5%)	-	
After declamping	Bradyarrhythmia	2 (10%)	2 (10%)	0.09
	SVT	4 (20%)	-	
	AF	1 (5%)	-	
	VT	3 (15%)	1 (5%)	
	VF	1 (5%)	-	
Skin closure	Bradyarrhythmia	1 (5%)	1(5%)	0.83
	SVT	2 (10%)	1(5%)	
			-	
At ICU	Bradyarrhythmia	1 (5%)	1 (5%)	0.59
	SVT	1 (5%)		
3 hrs.	SVT	1(5%)	0 (0%)	0.31
6 hrs.	AF	0(0%)	1(5%)	0.36
	SVT	1(5%)	0(0%)	
12 hrs.	VT	1(5%)	0(0%)	0.31
24 hrs.	sinus	20(100%)	20(100%)	N. A
Whole ICU stay	Arrhythmia	5	4	0.23

Data are presented as number (percentage). SVT supraventricular tachycardia, AF atrial fibrillation, VT ventricular tachycardia, VF ventricular fibrillation. * $p< 0.05$ is considered statistically significant.

Mean arterial blood pressure and heart rate showed significant differences with lower values in the SGB group after anesthesia induction, during the whole operative time and until the arrival into the ICU. During the ICU stay there was no significant difference between both groups regarding mean blood pressure and heart rate (Figure 2). The maximum and mean-24 hours IS during the postoperative follow-up period showed insignificant differences between the two groups. The operative details, ICU and hospital stay showed insignificant differences between groups (Table 3).

Serum potassium and magnesium showed insignificant differences between the two groups as shown in Table 4.

5. Discussion

In the current study, we have evaluated the effects of SGB regarding its antiarrhythmic effect with evaluation of variable arrhythmias incidence during the intraoperative and post-operative 24 hours. The incidence of arrhythmia was significantly lower during graft anastomosis in SGB group in comparison to the control group. In the SGB group, only four patients developed bradyarrhythmia during anastomosis time of grafts. In control group, five patients developed bradyarrhythmia, six patients developed SVT, one patient developed AF, two patients developed VT, and one developed VF during anastomosis time of grafts.

Raut et al mentioned that left stellate ganglion is an important weapon in the hand of anesthetists. They stated that left SGB can decrease the sympathetic tone to the heart; hence, decrease the incidence of arrhythmia especially in cases with myocardial infarction. The mechanism by which left SGB sympathectomy reduces arrhythmia could be assumed to the increased left ventricular threshold for fibrillation due to decreased release of norepinephrine [18].

Schwartz and coworkers early proved the efficacy of cardiac sympathetic innervation interruption through the left SGB to treat ventricular arrhythmias. They had mentioned that such denervation can increase the ventricular arrhythmia threshold [19].

In agreement with our findings, a pilot study done by Connors et al. upon 25 patients underwent open-heart surgery under cardiopulmonary bypass. They performed ultrasonographic guided left SGB just after anesthesia induction and mentioned that postoperative AF incidence was reduced to 18.2% in comparison to their historical institution rate which was 27% [20].

A systematic review created by Fudim et al. mentioned that ventricular arrhythmia burden was reduced with SGB; however, randomized controlled trials are required for approval of the efficacy and safety of SGB [21].

An experimental study was done in 2018 by Lefthiorites et al. [10]; it involved the electrophysiologic properties of the left atrium and the inducibility of AF in 36 patients who suffered paroxysmal atrial fibrillation. The study denoted that unilateral SGB reduced the effective refractory period of the left atrium, shortened the duration and the incidence of AF.

Schwartz et al. published an interesting finding and noted that there could be a difference in the sympathetic tone influencing the heart between the left and

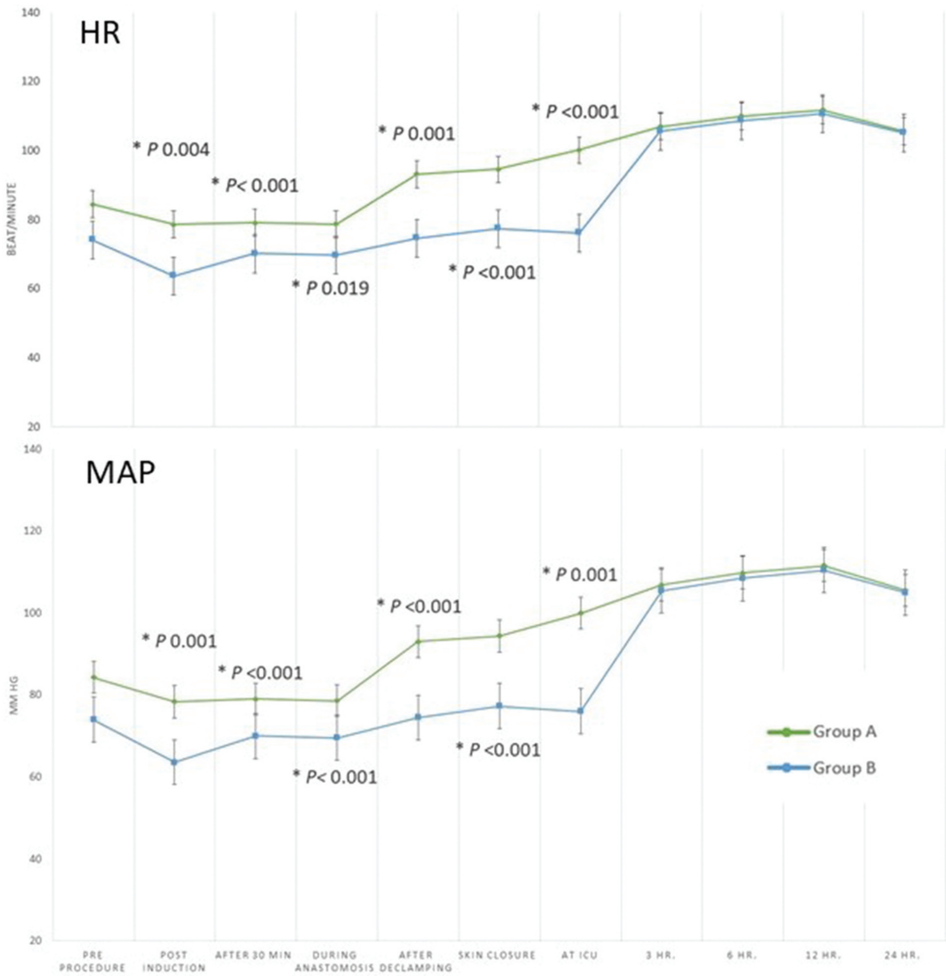

Figure 2. Perioperative changes of the heart rate and mean blood pressure changes in the studied groups.
Data are expressed as mean ± SE. Group A: control group, Group B: Stellate ganglion block. (*) significant difference between the two groups. *p value* < 0.05 was considered significant.

Table 3. Operative and ICU variables of the studied groups.

Variables	Control group (A) (n = 20)	Block group (B) (n = 20)	p value
Operation time (hrs.)	5.58 ± 1.0	5.94 ± 0.9	0.22
Number of grafts median (range)	2 (1–3)	3(1–3)	0.67
Duration of MV (hours)	3.2 ± 1.4	3.4 ± 1.3	0.63
ICU stay (days)	1.8 ± 0.83	1.7 ± 0.78	0.87
hospital stay (days)	7 ± 1.3	6.5 ± 1.1	0.14
Maximum inotropic score	142.50 ± 31.8	127.45 ± 26.9	0.717
Mean 24 hr. inotropic score	5.583 ± 1.3	5.299 ± 1.1	0.870

Data are presented as mean ± standard deviation (SD) or median (range). p< 0.05 is considered statistically significant.

Table 4. Perioperative serum potassium and magnesium (mmol/L) in the studied groups.

Timing	Control group (A) n = 20	Block group (B) n = 20	p value
Serum potassium			
Pre-procedure	3.95 ± 0.6	3.83 ± 0.6	0.53
During anastomosis	3.59 ± 0.9	3.49 ± 0.4	0.79
Skin closure	3.54 ± 0.8	3.37 ± 0.4	0.67
At ICU	3.51 ± 0.7	3.41 ± 0.3	0.27
3 hr.	3.29 ± 0.4	3.34 ± 0.3	0.52
6 hr.	3.32 ± 0.4	3.56 ± 0.6	0.38
12 hr.	3.42 ± 0.5	3.42 ± 0.4	0.79
24 hr.	3.88 ± 0.5	3.64 ± 0.5	0.14
Serum magnesium			
Preoperative	1.1 ± 0.1	1 ± 0.16	0.27
Postoperative 24 hrs.	1.92 ± 0.15	1.90 ± 0.18	0.16

Data are presented as mean ± standard deviation (SD). * p < 0.05 is considered statistically significant.

the right stellate ganglion. They run an experiment on dogs after stellate ganglion block and had found reduction of the incidence of ventricular ectopic during and after coronary arteries occlusion by 60 seconds [22].

Another study done by Wu et al. and involved 90 cancer patients who had underwent thoracoscopic surgery for lung cancer and randomized into two groups; either to received SGB through ultrasonographic injection of 5 ml ropivacaine 5% or to be in the control group. They found that the incidence of supraventricular tachycardia during the postoperative 48-hour follow-up period was significantly reduced in SGB group in comparison to the control group with 11.6 (5/43) vs. 31.8% (14/44), respectively with P = 0.023 [23].

Ultrasonographic SGB which we have used in this study carries safety through real-time visualization of needle entry, so that we can avoid inadvertent intravascular, epidural, intrathecal, and/or recurrent laryngeal nerve injury [18].

In the current work, hemodynamics including mean blood pressure and heart rate showed intraoperative significantly lower values in SGB group only; however, the readings were within the clinically accepted values. The theory which assumes that SGB can offer some hemodynamic modulation when stressful situations are suspected has been published before. Chen et al. utilized right SGB in a group of elderly patients undergoing elective laparoscopic pneumoperitoneum and compared to another similar control group. The study denoted that HR, MBP, and rate pressure product were significantly lower in the SGB group during the whole intraoperative period ($P < 0.05$ or 0.01). They noted that SGB can offer more hemodynamic stability through blocking sympathetic stimulation which occurs with CO_2 insufflation. They concluded that SGB can protect the myocardium and suppress stress response in such group of patients [24].

Regarding the safety of SGB, it was approved by Han and coworkers, where they had studied the effect of SGB (right versus left) in 16 healthy personnel upon hemodynamics including mean blood pressure, heart rate, cardiac index, and systemic vascular resistance. They concluded that SGB in general did not affect the hemodynamics and could be a hemodynamic safe maneuver [25].

The above-mentioned studies [24,25] focussed upon the impact and correlations between the SGB maneuver upon hemodynamics; so that we can expect and explain why our study results show insignificant difference between the two groups regarding the inotropic score.

5.1. Limitations

There could be a need for longer period of follow-up regarding postoperative cardiac events (arrhythmia).

5.2. Conclusion

Preoperative left SGB offers reasonable protection against intraoperative arrhythmias during off-pump coronary artery bypass surgery, with a safe profile upon intraoperative and postoperative hemodynamics.

Disclosure statement

All authors have no conflicts of interest to report. All the authors of the manuscript received any remuneration. Further, the authors have not received any reimbursement or honorarium in any other manner. All the authors are members of the Faculty of Medicine Assiut University and practicing interventional pain physicians.

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Notes on contributors

Dr. Essam Abd Allah helped by having full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Dr. Mohammed Abdelmonem Bakr helped by taking responsibility for the integrity of the data and the accuracy of the data analysis.

Dr. Sara Abdallah Abdelrahman helped by designed the study protocol and data collection.

Dr. Ahmed M. Taha helped by doing all surgical interventions.

Dr. Emad Zarief Kamel helped by managing the statistical analysis literature searches and summaries of previous related work and wrote the first draft of the manuscript.

ORCID

Mohammed Abdelmonem Bakr http://orcid.org/0000-0002-6879-6987
Emad Zarief Kamel http://orcid.org/0000-0002-7540-6203

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