Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.47750/jptcp.2023.30.08.043

Efficacy of superior cervical ganglion (SCG) block on the incidence and severity of vasospasm after middle cerebral artery (MCA) aneurysmal surgery using transcranial Doppler (TCD): A Randomized controlled trial

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Submitted: 11 February 2023; Accepted: 17 March 2023; Published: 21 April 2023

ABSTRACT

Background: In this study we assess blood flow velocity in middle cerebral artery measured by transcranial Doppler (TCD) to determine the efficacy of superior cervical ganglion (SCG) block in decreasing incidence or severity of vasospasm after middle cerebral artery (MCA) aneurysmal surgery.

Methods: A total number of 36 patients were included in this study. The study was designed to recruit ASA I-II patients who have ruptured aneurysm and subarachnoid hemorrhage (SAH), aged from 18 to 70 years undergoing MCA aneurysmal surgeries. They were randomly divided by computer designed lists then concealed in closed envelopes into two equal groups (18/group): Group (A): control study & Group (B): superior cervical block. Results: The findings demonstrated that the mean flow velocity (MFV) after SCGB was reduced in day 3 and day 7 postoperative which was detected by TCD from MFV in day 0 preoperative, and also there was decrease in Lindegaard ratio after SCGB in concomitant with decrease in MFV.

Conclusion: Superior cervical ganglion block may be effective in reducing MFV in middle cerebral artery which is detected by transcranial doppler, so it may lead to improve mild and moderate vasospasm after subarachnoid haemorrhage with haemodynamic stability after injection and without complications occurred.

Keywords: *Superior cervical ganglion, middle cerebral artery aneurysm and transcranial Doppler*

INTRODUCTION

Sympathetic innervation to the face and head is by superior cervical ganglion (SCG), which is the most cranial part of the sympathetic chain. It is suited in a plication of the prevertebral fascia anterior to the longuscapitis muscle and dorsal to the internal carotid artery, posteromedial to the vagus nerve at c3 level. It's mainly located at the level of the transverse processes of the second and third cervical vertebrae. However, it may reach caudally to the upper border of the fourth cervical vertebra (1).

Superior cervical ganglion block was previously tried in managing neuropathic pain, neuropathic pain in head and face region was investigated in patients using ganglionic local opioid analgesia (GLOA) at the superior cervical ganglion (SCG). The short-term analgesic effect of the first blockade by GLOA was significant with a mean pain reduction of 52% ($p < 0.001$) (2).

Superior cervical ganglion block also used as an alternative treatment to tinnuits not responding to conventional therapy, it increase cochlear blood flow and this can explain the efficacy of block (3).

Superior cervical ganglion block was used to improve cerebral perfusion in patients with cerebral vasospasm after aSAH (4)

The sympathetic system also has a role in the pathogenesis of this process, cervical sympathetic stimulation leads to constriction in intracerebral vessels and dilation occurs when these fibers are interrupted. Efflux and reuptake of the neurotransmitter may be prevented by sympathectomy (4) .

Transcranial doppler (TCD) is a non-invasive technique which can be used to observe velocity, direction and properties of blood flow in the cerebral arteries by means of a pulsed ultrasonic beam, based on the Doppler effect of ultrasounds concerning frequency variations in sound waves as a result of relative motion between source and signal receiver (5–7) it was previously used in traumatic brain injury (TBI), stroke, anaesthesia and intensive care.

Therefore,we assess blood flow velocity in middle cerebral artery measured by transcranial Doppler to determine the efficacy of SCG block in decreasing incidence or severity of vasospasm after MCA aneurysm surgery.

METHODS

This randomized controlled study was conducted at neurosurgery operating room at Kasr Al-Ainy hospital, faculty of medicine, Cairo University, after approval of the Ethics committee (MD-251-2019). and written patients consent.

ASA I-II patients who have ruptured aneurysm and subarachnoid hemorrhage (SAH), aged from 18 to 70 years with Glasgow coma scale (GCS) 13-15 undergoing MCA aneurysmal surgeries were enrolled in this study. Patients who had contraindications to regional anesthesia (Bleeding disorders, Use of any anti-coagulants, local infection) and known allergy to local anesthetics were excluded from the study.

All patients were subjected to systematic preoperative assessment including history taking, physical examination, review of the results of routine investigations(CBC, coagulation profile, kidney functions ,liver functions), Glasgow coma scale (GCS),(ECG,ECHO if indicated) and a baseline TCD (TCD0) was done.

On arrival to the preparation room: A 20 gauge IV cannula was inserted into a peripheral vein.

Patients were then transferred to the operating room where basic monitoring Electrocardiography (ECG), Non-invasive Blood Pressure (NIBP) and pulse oximetry were attached. General anesthesia was induced in a standardized way with propofol 1.5-2.5mg/kg, fentanyl 2 μ/kg and atracurium 0.5mg/kg. Patients were mechanically ventilated (TV6-8ml/kg, RR 10-14permin to keep ET co2 30:35mmHg).

Maintenance of anaesthesia with isoflurane 1.5:2% and atracurium infusion.

Invasive blood pressure and central venous line were attached; Baseline heart rate and mean arterial blood pressure were recorded.

Intracranial tension (ICT) was assessed by brain relaxation score, Brain relaxation was scored by asking the surgeon upon opening the dura on a four-point scale: 1 = perfectly relaxed, 2 = satisfactorily relaxed, 3 = firm brain, 4 = bulging brain.

And it was reduced by proper positioning, hyperventilation to keep ETCO2 30-35 mmhg, additional dose of fentanyl up to 5mic/kg and after the dura was opened and the brain is still tight, (0.25to1g/kg) of mannitol will be given.

Group (A): control study, no block will be performed.

Group (B): superior cervical sympathetic ganglion block was carried out with the patient lying supine on an operative table with X-ray imaging. Under X-ray guidance, a 23-gauge top-pole needle with an active tip of 5 mm was inserted for the test blockade.

In lateral projection, the entry point of the needle was directed at the level of the facet joint of the third and fourth cervical vertebrae. The direction of radiographic projection was changed in such a way that the facetal column was projected over the anterolateral aspect of the vertebral bodies. We disinfected the puncture site with 60% chlorhexidine in alcohol, the needle was introduced parallel to the radiographic projection and was projected as a dot approximately1 cm anterior to the spine .The radiographic projection was then changed to lateral, and the needle was slowly advanced until the tip was situated at the anterior border of the third cervical vertebra. On the anteroposterior projection, the tip of the needle was projected over the lateral part of the facetal column. When the tip of the needle was in position, 0.3mL of Omnipaque is injected. On the transverse projection, the contrast was distinctly anterior to anterior border of the vertebral bodies , and in the anteroposterior projection, the contrast was seen spreading in a space overlying the facetal column in a cranial as well as caudal direction(3).

During the test blockade, bupivacaine 0.25% 1.5mL and 2mg dexamethasone was injected. Hemodynamics data were recorded.

Emergence and recovery

Atracurium was stopped after closure of the Dura. And isoflurane was discontinued after good respiratory attempts and regain of muscle power.

Neuromuscular blockade was reversed with neostigmine (0.05mg/kg) and atropine 0.01mg/kg and endotracheal tube was removed. If extubation was not been done the patients were transferred to the ICU and mechanically ventilated, if patients extubated after 24 hours, they were included in the study. If they still intubated for more than 24 hours, they were been excluded.

Patients were transferred to postoperative ICU, where patients were monitored for any clinical signs of vasospasm(altered level of consciousness, new focal neurological deficit, increasing headache, meningismus and fever) for 14 days ,any complication(Nerve injury, Hematoma formation, LA toxicity, Sensory or motor deficit, respiratory depression).

Calcium channel blocker (nimodipine) was given to all patients (60mg/4hours orally/NG).Hypertensive, hypervolemic hemodilution (triple H therapy) was recommended in the treatment of vasospasm , it begins with intravascular volume expansion with crystalloid or colloid .vasoactive infusionswas added if hypervolemia alone was inadequate. TCD was done postoperative at day 3 and day 7.

Primary outcome was Blood flow velocity in middle cerebral artery measured by transcranial Doppler. Other outcomes included incidence or severity of MCA postoperative spasm over14 days, Hemodynamics (heart rate, mean arterial blood pressure) and sao2.

Statistical Analysis

Using MedCalc Software version 14.10.2 (MedCalc Sofware bvba, Ostend, Belgium), we calculated a conservative sample size that could detect 10% difference in arterial flow velocity (i.e. 15cm/s) between the two study groups. A minimum number of 34 patients (17 patients per group) were calculated to have a study power of 80% and alpha error of 0.05. The number was increased to 36 patients (18 patients per group) to compensate for possible drop-outs.

Statistical Package of Social Science Software program (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.) were used for statistically analysis. Categorical data was presented as frequencies (%) and analyzed using chi-square test. Continuous data was presented as means (standard deviations) or medians (quartiles). Testing for normality was carried out using Kolmogorov or Shapiro tests. Data was analyzed using unpaired student t-test or Mann Whitney test as appropriate. Repeated measures were analyzed using two-way analysis of variance (ANOVA) test with post-hoc

Benferroni test. A P value less than 0.05 was considered statistically significant.

RESULTS

Thirty-six patients were available for final analysis. The two study groups namely control and superior cervical ganglion block groups were comparable with regard to age, gender and medical history of chronic illnesses with no statistical difference between the two groups.

Regarding ipsilateral side to surgical interference Mean Flow Velocity (MFV)

On day zero pre-operative

In group A MFV ranged from 70.00 to 132.00cm/sec, with Median of 115.00 cm/sec, 1st quartile of 95.60 cm/sec and 3rd quartile of 128.00cm/sec. There were 9 patients with MFV≥ 120cm/sec while in group B MFV ranged from 60.00 to 135.00 cm/sec, with Median of 124.50cm/sec, 1st quartile of 80.00cm/sec and 3rd quartile of 129.00cm/sec. There were 10 patients with MFV≥ 120 cm/sec which was statistically insignificant.

On the 3rd day post-operative

In group A MFV ranged from 75.00 to 135.00 cm/sec, with Median of 124.00cm/sec, 1st quartile of 100.25cm/sec and 3rd quartile of 130.00cm/sec. There were 12 patients showed increase in MFV ≥ 120cm/sec, while in group B MFV ranged from 55.00 to 125.00cm/sec, with Median of 104.00cm/sec, 1st quartile of 66.80 cm/sec and 3rd quartile of 120.00cm/sec. There were 6 patients showed decrease in MFV <120cm/sec and 5 patients had MFV ≥ 120 cm/sec in comparison with day 0 with (p-value 0.006) which was statistically significant.

On the 7th day post-operative

In group A MFV ranged from 65.00 to 130.00cm/sec, with Median of 120.00cm/sec, 1st quartile of 105.00cm/sec and 3rd quartile of 128.00cm/sec. There were 10 patients showed increase in MFV ≥ 120cm/sec, where 2 patients showed decrease in MFV <120cm/sec in comparison to day 3 while in group B MFV ranged from 50.00 to 122.00cm/sec, with Median of 99.00cm/sec, 1st quartile of 65.00cm/sec and 3rd quartile of 112.00cm/sec. There were 2 patients still showed increase in MFV ≥ 120cm/sec MFV while there were 3 patients showed decrease in MFV < 120cm/sec in comparison with day 3 with (p value 0.003) which was statistically significant as shown in table (1) and figure (1) below.

TABLE 1: Comparison between both groups regarding ipsilateral side to surgical interference mean flow velocity at day 0, day3 and day7

	Group A (control)			Group B (superior cervical block)			P value
	Median	1st quartile	3rd quartile	Median	1st quartile	3rd quartile	
D0 preoperative MCA MFV (cm/s)	115.00	95.60	128.00	124.50	80.00	129.00	0.938
D3 postoperative MCA MFV (cm/s)	124.00	100.25	130.00	104.00	66.80	120.00	0.006
D7 postoperative MCA MFV (cm/s)	120.00	105.00	128.00	99.00	65.00	112.00	0.003

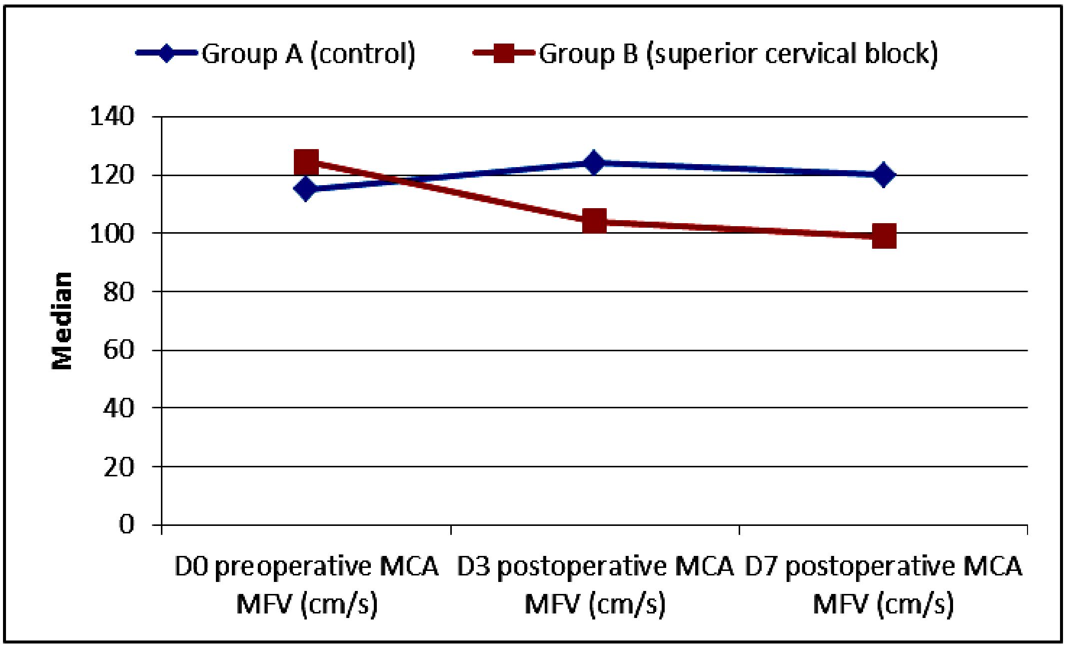

FIGURE 1: Comparison between groups regarding ipsilateral side to surgical interference mean flow velocity at day 0, day3 and day7

Regarding ipsilateral side to surgical interference Lindegaard ratio

On day zero pre-operative: In group A Lr ranged from 1.10 to 5.50, with Median of 3.20, 1st quartile of 2.00 and 3rd quartile of 4.70. There were 9 patients had lindegaard ratio from 3.4 to 5.5 (mild to moderate vasospasm) who already had increased velocity ≥ 120cm/sec and only 1 patient had lindegaard ratio of 3 with velocity < 120cm/sec which indicates hyperemia while in group B Lr ranged from 1.20 to 6.00, with Median of 4.00, 1st quartile of 2.50 and 3rd quartile of 4.50. There were 10 patients with lindegaard ratio from 4 to 6 (mild to moderate vasospasm) who already had increased velocity ≥ 120cm/sec, which was statistically insignificant.

On the 3rd day post-operative:

In group A Lr ranged from 0.80 to 6.00, with Median of 3.75, 1st quartile of 2.70 and 3rd quartile of 5.00. There were 11 patients with lindegaard ratio from 3 to 6 (mild to moderate vasospasm) who already had increased velocity ≥ 120cm/sec and only 1 patient had lindegaard ratio 2.9 with MFV 120cm/sec which indicates hyperemia while in group B Lr ranged from 1.1 to 3.8, with Median of 2.60, 1st quartile of 2.00 and 3rd quartile of 3.40. there were 6 patients showed decrease in lindegaard ratio (Lr ≤ 3) in comparison to day 0 who already had decreased velocity ≤ 120cm/sec with (p value 0.012) which was statistically significant.

On the 7th day post-operative

In group A Lr ranged from 1.50 to 5.20, with Median of 3.25, 1st quartile of 2.40 and 3rd quartile of 4.00. There were 10 patients with lindegaard ratio from 3.1 to5.2 (mild to moderate vasospasm) while in group B Lr ranged from 1.00 to 3.20, with Median of 2.25, 1st quartile of 2.00 and 3rd quartile of 2.80, there were only 2 patients had lindegaard ratio from 3.1 to 3.2 (mild vasospasm) while the other patients showed decrease in lindegaard ratio < 3 with (p value 0.020) which was statistically significant as shown in table (2) and figure (2) below.

TABLE 2: Comparison between both groups regarding ipsilateral side to surgical interference Lindegaard ratio velocity at day 0, day3 and day7

	Group A (control)			Group B (superior cervical block)			P value
	Median	1st quartile	3rd quartile	Median	1st quartile	3rd quartile	
D0 preoperative Lindegaard ratio	3.20	2.00	4.70	4.00	2.50	4.50	0.673
D3 postoperative Lindegaard ratio	3.75	2.70	5.00	2.60	2.00	3.40	0.012
D7 postoperative Lindegaard ratio	3.25	2.40	4.00	2.25	2.00	2.80	0.020

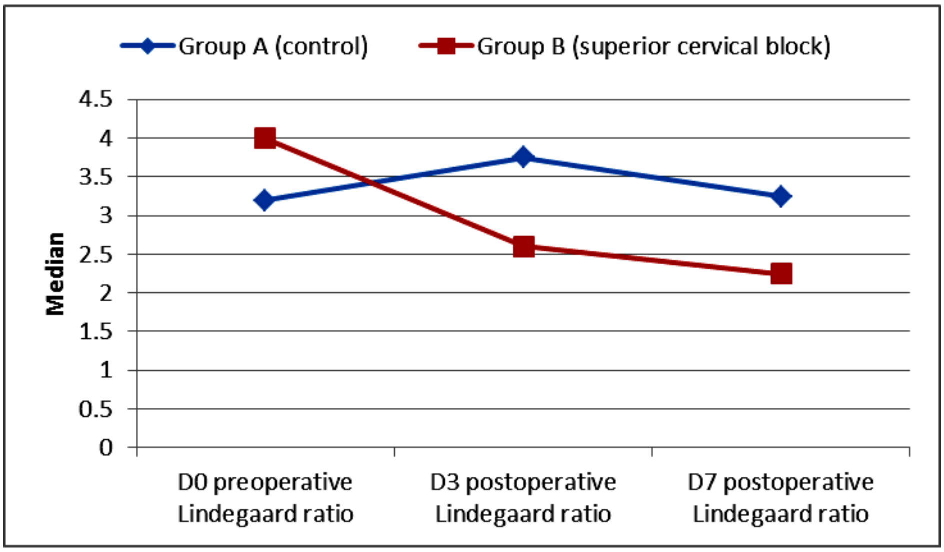

FIGURE 2: Comparison between groups regarding ipsilateral side to surgical interference Lindegaard ratio at day 0, day3 and day7

There were no statistical difference between the two groups regarding hemodynamics (heart rate, mean arterial blood pressure) and sao2.

DISCUSSION

The current study showed that superior cervical ganglion block may decrease mean flow velocity in cerebral arteries and decrease vasospasm, which detected by measuring MFV and lindegaard ratio using TCD.

Transcranial doppler (TCD) is a non-invasive technique which can be used to observe velocity, direction and properties of blood flow in the cerebral arteries by means of a pulsed ultrasonic beam, based on the doppler effect of ultrasounds concerning frequency variations in sound waves as a result of relative motion between source and signal receiver(5,7).

Li et al., (2018) (8) studied vasospasm after SAH in 90 patients using TCD and stated that TCD is good in prediction, diagnosis of vasospasm and blood flow velocities of cerebral arteries increased gradually after the occurrence of SAH, and blood flow velocities at 4-6 days after the prevalence were significantly higher than those at 1-3 days after the occurrence., and that is why we used TCD as a tool for measurement of vasospasm.

Also several studies like Nassar et al., (2019)(9) stated that TCD are valuable method for early detection of vasospasm following aSAH, through measuring the mean flow velocities (MFV) of cerebral arteries and that save time and allow for early interventions .

As regard superior cervical ganglion block and vasospasm, the cerebral vasculature receives a noradrenergic sympathetic nerve supply mainly through the fibers that originate in cervical ganglion accompanying the carotid artery, and project into ipsilateral cerebral hemisphere.(10) Cerebral vasculature, especially pial vessels, is densely innervated with noradrenergic sympathetic nerve fibers mainly from superior cervical ganglion.(4) Blockade of sympathetic nerve activity or reversal of over-activity may dilate intracerebral vessels improving cerebral blood flow.

The present study showed that there were decrease in MFV in middle cerebral artery in group B who received SCGB as mentioned before , also there was a decrease in lindegaard ratio <3 in concomitant with decrease in MFV which indicated a decrease in vasospasm.

Treggiari et al., (2003) (4) studied the effect of cervical sympathectomy in improving cerebral perfusion after aneurysmal subarachnoid hemorrhage vasospasm. They found that superior cervical ganglion block improves cerebral perfusion and effective in reversing mild to moderate vasospasm which is concomitant with our study.

Jain et al., (2011)(10) studied the effect of cervical sympathectomy by stellate ganglion block in the treatment of aneurysmal subarachnoid hemorrhage vasospam after surgical clipping and they assessed the results by using TCD as mentioned before, they said that stellate ganglion block is effective in improving cerebral perfusion by relieving symptomatic cerebral vasospasm. This is concomitant with our study that cervical sympathectomy can be used in relieving symptoms of cerebral vasospasm but we used superior cervical ganglion block.

In a study done by Yang et al ., (2020)(11) 80 patients with aneurysmal SAH were divided into 2 groups; control group and observational group, all patients treated with craniotomy removal hematoma, at the end of surgery the control group was given nimodipine while the observational group stellate ganglion block was given on the basis of nimodipine , blood flow velocity in middle cerebral artery was assessed by TCD before operation and after 6, 24 hours of operation. They found that MCA velocity after 6, 24 hours were significantly lower than that in control group; (100.8 ± 8.2cm/s) vs. (123.5 ± 9.9cm/s) and (89.7 ± 5.3cm/s) vs. (118.9±7.1cm/s) and there was statistical difference ($P<0.01$), and this is concomitant with our study in that blood flow velocity after superior cervical ganglion block was lower than the control group that was assessed by TCD.

In a randomized controlled study done by Zhang et al., (2021)(12) about the effects of stellate ganglion block on early brain injury in subarachnoid hemorrhage patients ,they measured MFV in MCA and basilar artery by TCD, stellate group patients received the block at the craniotomy side in the day of surgery before induction of anesthesia and on the second, fourth and six day after surgery, they found that there were increased in mean flow velocity in MCA and basilar artery after surgery but the increased in velocity was lower in stellate group 20% to 50% increase than control group 100% increase.

Our study has several limitations. Small total number of symptomatic patients was a limitation and more studies should be done on patients who had severe vasospasm. A large randomized controlled trial is needed to compare the efficacy of SCGB with other treatment modalities for cerebral vasospasm.

CONCLUSION

Superior cervical ganglion block may be effective in reducing MFV in middle cerebral artery which is detected by trans cranial doppler (TCD), so it may lead to improve mild and moderate vasospasm after subarachnoid haemorrhage with haemodynamic stability after injection and without complications occurred.

Declaration of interests

The authors declare that they have no conflict of interest with this work.

Funding

no funding.

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