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Ultrasound-Guided Superficial Serratus Anterior Plane Block for Cardiac Surgery with Median Sternotomy: A Retrospective Study

Medyan Sternotomili Kardiyak Cerrahide Ultrason Kılavuzluğunda Yüzeysel Serratus Anterior Plan Bloğu: Retrospektif Çalışma

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ABSTRACT

Objective: As part of multimodal analgesia regimen in cardiac surgery, the serratus anterior plane block (SAPB) is a technique regularly used in minimally invasive surgical interventions with thoracotomy. The aim of our study is to determine the analgesic efficacy of SAPB for cardiac surgery performed with sternotomy.

Methods: A total of 99 patients who underwent SAPB (Group SAP, n=43) and conventional analgesia (Group C, n=56) for coronary artery bypass graft (CABG) surgery were compared retrospectively. Demographic data, postoperative opioid use, highest pain scores, nausea-vomiting, time to start oral intake, extubation time, lenght of intensive care unit and hospital stay were recorded.

Results: Total opioid requirement, expressed in oral morphine equivalent within the first 24 hours after extubation, was found to be significantly lower in patients with SAPB (p=0.022). Similarly, both the highest reported pain scores at rest and during mobilization and also the nausea scores were found to be significantly lower in Group SAP during the same period (p=0.007, p=0.048, p=0.004). Extubation (p=0.025) and oral intake initiation time p=0.030) were shorter in Group SAP.

Conclusion: By providing analgesia of the chest tube drain site, SAPB application was associated with lower opioid consumption, pain, and nausea-vomiting among patients who underwent CABG with median sternotomy. Because of this benefit, superficial SAPB may be part of opioid-reducing multimodal analgesia in cardiac surgery.

Keywords: Serratus anterior plane block, fascial plane blocks, coronary artery bypass surgery, postoperative analgesia

ÖZ

Amaç: Kardiyak cerrahide multimodal analjezinin bir parçası olarak serratus anterior plan bloğu (SAPB) genellikle torakotomi ile minimal invaziv cerrahi müdahaleler için kullanılmaktadır. Çalışmamızın amacı, sternotomi ile yapılan kardiyak cerrahi için SAPB'nin analjezik etkinliğini belirlemektir.

Yöntem: Koroner arter baypas greftleme (KABG) cerrahisi için SAPB (Grup SAP, n=43) ve geleneksel analjezi (Grup C, n=56) yöntemi uygulanan toplam 99 hasta retrospektif olarak karşılaştırıldı. Demografik veriler, postoperatif opioid kullanımı, en yüksek ağrı skorları, bulantı-kusma, oral alıma başlama süresi, ekstübasyon süresi, yoğun bakım ünitesi ve hastanede kalış süresi kaydedildi.

Bulgular: Ekstübasyondan sonraki ilk 24 saat içinde SAPB yapılan hastalarda tüketilen toplam opioid miktarının anlamlı derecede düşük olduğu bulunmuştur (p=0.022). Benzer şekilde, dinlenme ve mobilizasyon sırasında bildirilen en yüksek ağrı skorları ve bulantı skorlarının aynı dönemde grup SAP'da anlamlı derecede düşük olduğu bulunmuştur (p=0.007, p=0.048, p=0,004). Grup SAP'da ekstübasyon (p= 0.025) ve oral alım başlama süresi (p=0.030) daha kısaydı.

Sonuç: Serratus anterior plan bloğu, göğüs tüpü drenaj bölgesinin analjezisini sağlayarak, medyan sternotomi ile KABG uygulanan hastalarda daha düşük opioid tüketimi, ağrı ve bulantı-kusma ile ilişkiliydi. Bu açılardan, yüzeysel SAPB, kalp cerrahisinde opioid azaltıcı multimodal analjezinin bir parçası olabilir.

Anahtar sözcükler: Serratus anterior plan bloğu, fasiyal düzlem blokları, koroner arter baypas cerrahisi, postoperatif analjezi

INTRODUCTION

Numerous medical and social problems associated with opioids have led to reconsideration of the use of these analgesics in intraoperative and postoperative cardiac surgery (1). Pain palliation not only reduces the risk of chronic pain, but is also an important factor in minimizing mortality and morbidity (2,3). Therefore, the goal is to provide high-quality postoperative analgesia in cardiac surgery patients using opioid-reducing techniques (3,4). Peripheral nerve blocks in the form of various facial plane chest wall blocks are used for optimal postoperative analgesia in cardiac surgery.

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Serratus anterior plane block (SAPB) is performed by superficially or deeply injecting local anesthetic into the plane of the serratus anterior muscle, at the level of the midaxillary line and the fifth rib, under ultrasound guidance. SAPB provides anesthesia of T2 to T9 dermatomes by blocking the lateral cutaneous branches of the long thoracic, thoracodorsal, and intercostal nerves (5). Mainly used in breast surgery, rib fractures, and thoracotomy to manage pain of the anterolateral chest wall, SAPB has been used in cardiac surgery for minimally invasive surgical procedures, often with thoracotomy (6,7). As far as is known, SAPB does not provide sternal analgesia, so its effect on pain palliation in cardiac surgery performed with median sternotomy has not been studied before. The sources of pain in non-minimal cardiac surgery are sternotomy, sternal retraction, sternum bracing, and the presence of chest drainage (8). The sternal innervation is transmitted by the anterior cutaneous branches of the intercostal nerves (T2-T6), and the lateral chest wall is transmitted via the T2-T9 intercostal, long thoracic and thoracodorsal nerves (9). Chest tube pain, which is often overlooked in pain management, contributes significantly to overall postoperative pain following cardiac surgery. Based on this, we hypothesized that chest tube pain palliation with SAPB would contribute to postoperative pain management.

The primary aim of this study was to compare the effects of SAPB and conventional intravenous analgesia on pain score and opioid consumption in cardiac surgery patients with sternotomy. Our secondary aim was to compare the factors affecting recovery, such as nausea-vomiting after extubation, initiation of oral intake, and mobilization in patients treated with SAPB versus the conventional analgesia technique.

MATERIAL and METHODS

After ethics committee approval (ethical no: E1-23-3216, 25.01.2023), on-pump coronary artery bypass graftings (CABG), performed consecutively between June 2022 and September 2022 in the cardiovascular surgery operating room cases, were reviewed retrospectively. Patients who required emergency operations, re-cardiac surgery, postoperative intra-aortic balloon pump/extracorporeal membrane oxygenation, who were operated for bleeding/tamponade or any reason for revision in the first postoperative three days, and patients who underwent facial plane block other than SAPB, were excluded from the study. Informed consent was obtained in accordance with the study plan. The present report was drafted in line with the Strengthening Reporting of Observational Studies in Epidemiology statement for descriptive studies.

Retrospectively, study groups were formed from patients who underwent CABG between the specified dates by the same anesthesia and surgical team. Patients undergoing SAPB were defined as Group SAP and patients treated with conventional analgesia technique were defined as Group C. According to the protocol used in our clinic, anesthesia was induced with propofol (1.5-2 mg kg^{-1}), fentanyl (1-2 µg kg^{-1}) and rocuronium (0.5-1 mg kg^{-1}) after preoxygenation. Anesthesia was maintained with sevoflurane and remifentanil infusion (0.05-0.25 µg kg^{-1} min^{-1}) with a bispectral index of 40-50. Serratus anterior plane block (bilateral, superficial), was performed in the supine position after anesthesia induction by the same experienced anesthesiologist with the help of ultrasound. A linear ultrasound probe was guided in a sagittal plane on the midaxillary line. After the facial plane between the latissimus dorsi and the serratus anterior muscle was determined at the level of the fourth and fifth ribs, a 21-G Pajunk needle was inserted into the plane according to ultrasound. After confirmation by saline hydrodissection, 20 mL of 0.25% bupivacaine was injected, for each side (total 40 mL). At the end of the surgery, 1 gr acetaminophen and 1 mg kg^{-1} tramadol iv were administered to both groups before they were transferred to the intensive care unit. It was observed that the standard anesthesia technique and postoperative care protocol were applied to both groups except for those in the SAPB. Analgesics were given according to the pain score reported in the intensive care unit.

Demographic parameters, comorbidities, ASA scoring, smoking status, and left ventricular ejection fraction (LVEF) data were recorded. Graft number, cardiopulmonary bypass (CPB), cross clamp (CC) and total procedure durations were recorded. Postoperative extubation time, length of stay in the hospital, and intensive care unit (ICU), nausea-vomiting in the first 24 hours, and the highest pain score and opioid and non-opioid analgesic amounts at rest and mobilization were recorded after the operation. Pain assessment was made from the visual analog scale (VAS, 10 cm maximum pain and 0 no pain) records available on the ICU observation sheet. In both groups, when the VAS score is higher than 4, primarily acetaminophen (10 mg kg^{-1}) and tramadol (1 mg kg^{-1}), depending on the severity and frequency of pain, and morphine (0.5 mg kg^{-1}) or fentanyl (1 µg kg^{-1}) was added. Post application, the opioids were converted to oral morphine equivalents (OME) using guidelines from the National Center for Drug and Alcohol Research and the Centers for Disease Control (10,11).

Statistical Analysis

The IBM SPSS.25.0 software was used for all data analyzed. Descriptive statistics were presented as absolute numbers (n) and percentages (%) for categorical variables, the median-interquartile range (25^{th}–75^{th} percentiles) for non-normally distributed data, and the mean±standard deviation

for normally distributed data. Categorical variables were compared using the χ^2 test. Continuous variables between those with and without SAPB were compared using the Mann-Whitney U or independent samples t-test, based on the Kolmogorov–Smirnov test for normality. For all analyses, $p<0.05$ was considered statistically significant. The number of cases between the specified dates determined the sample size and power analysis was performed on the number of patients. After the study was completed, OME (amount of opioid consumed in the first 24 hours with the difference between groups) values were used for power analysis. According to this; power analysis was made with G* Power 3.1.9.7 statistical package program; n = 99 (n1 = 56, n2 = 43), $\alpha = 0.05$, Effect Size (d) = 0.52; power = 93% was found.

RESULTS

One hundered four patients were screened for retrospective analysis, 3 patients were excluded because they were undergoing revision due to tamponade, and 2 patients were excluded because they were intubated for more than 24 hours due to respiratory problems. Of the remaining 99 patients, 43 had pre-induction SAPB (Group SAP) and there were 56 patients (Group C) who received conventional analgesia without plane block. Baseline demographic data, ASA scoring, smoking status, comorbidities, number of grafts bypassed, and procedure times were similar between groups (Table I).

Total opioid requirement, expressed in OME, within the first 24 hours after extubation was found to be significantly lower in patients with SAPB (p=0.022). Similarly, the highest reported pain scores at rest and during mobilization and nausea scores were found to be significantly lower in Group SAP during the same period (retrospectively p=0.007, p=0.048 ve p=0.004). In the following period (24-48 hours and 48-72 hours), there was no difference between the groups in the highest pain scores, opioid, and acetaminophen consumption (Table II). Extubation (6.93 ± 1.9 vs. 7.98 ± 2.4, p=0.025) and oral intake initiation time (10.70 ± 2.8 versus 11.91 ± 2.3, p=0.030) were shorter in Group SAP. The duration of mobilization, intensive care, and hospital stay were similar between groups (Figure 1).

Table I. Demographic Data and Procedure Times

	Grup C (n=56)	Grup SAP (n=43)	p*
Gender (M), n (%)	45 (80.4)	35 (81.4)	0.897
Age (years), Mean±SD	60.73 ± 8.0	60.74 ± 10.3	0.995
BMI (kg m^{-2}), Mean±SD	28.76 ± 4.2	28.60 ± 3.8	0.848
ASA II/III, n (%)	17/39 (30.4/69.6)	16/27 (37.2/62.8)	0.473
Smoking Status, n (%)			
Never smoker	29 (51.8)	14 (32.6)	0.058
Former Smoker	25 (44.6)	23 (53.5)	
Current Smoker	2 (3.6)	6 (14.0)	
HT, n (%)	37 (66.1)	25 (58.1)	0.419
DM, n (%)	28 (50.0)	16 (37.2)	0.204
COPD, n (%)	2 (3.6)	3 (7.0)	0.443
Stroke/TIA, n (%)	3 (5.4)	0 (0)	0.123
LVEF (%), Mean±SD	52.53 ± 8.2	54.16 ± 8.4	0.344
Number of Grafts, n (%)			
CABG*2	10 (17.9)	8 (18.6)	0.891
CABG* 3	20 (35.7)	18 (41.9)	
CABG* 4	21 (37.5)	13 (30.2)	
CABG* 5	5 (8.9)	4 (9.3)	
CC duration (min), Mean±SD	74.50 ± 26.6	75.27 ± 17.9	0.869
CPB duration (min), Mean±SD	111.83 ± 32.5	104.16 ± 22.6	0.170
Operation duration (min), Mean±SD	306.83 ± 61.1	291.44 ± 48.8	0.167

M: Male, **SD:** Standard deviation, **BMI:** Body mass index, **ASA:** American Society of Anesthesiologists, **HT:** Hypertension, **DM:** Diabetes mellitus, **COPD:** Chronic obstructive pulmonary disease, **TIA:** Transient ischemic attack, **LVEF:** Left ventricular ejection fraction, **CABG:** Coronary artery bypass graft, **CC:** Cross-clamp, **CPB:** Cardiopulmonary bypass.
*The independent samples t-test was used for continuous variables; the χ2 was performed for categorical variables.

DISCUSSION

In our study, SAPB application in patients who underwent CABG with median sternotomy was found to be associated with lower resting and mobilized pain scores, lower total opioid consumption, and shorter extubation time in the first 24 hours postoperatively. It was determined that patients who underwent SAPB at the same time had lower nausea scores and shorter oral intake initiation times.

Table II. Analgesic Consumption and Pain Scores

	Group C (n=56)	Group SAP (n=43)	p*
First 24 hours after extubation			
OME (mg), Mean ± SD	38.12 ± 17.1	31.51 ± 8.4	**0.022**
Acetaminophen (mg), Mean±SD	1553.57 ± 501.6	1372.0 ± 489.0	0.074
Highest reported pain score (VAS), Median (IQR)	5 (3-6)	4 (2-5)	**0.048**
Highest reported pain score-Mobilized (VAS), Median (IQR)	6 (4-8)	5 (3-6)	**0.004**
Highest reported Nausea score (VAS), Median (IQR)	1 (0-3)	0 (0-0)	**0.007**
Vomiting, n (%)	12 (21.4)	4 (9.3)	0.104
24.-48. Hours after extubation			
OME (mg), Mean±SD	13.92 ± 6.7	14.41 ± 7.0	0.728
Acetaminophen (mg), Mean ± SD	453.57 ± 316.7	372.09 ± 310.3	0.204
Highest reported pain score (VAS), Median (IQR)	3 (2-5)	3 (1-4)	0.794
Highest reported pain score-Mobilized (VAS), Median (IQR)	4 (2.5-7)	4 (2-6)	0.608
48.-72. Hours after extubation			
OME (mg), Mean ± SD	9.92 ± 7.5	9.83 ± 7.9	0.954
Acetaminophen (mg), Mean ± SD	400.00 ± 313.7	376.74 ± 322.6	0.719
Highest reported pain score (VAS), Median (IQR)	2 (1-4)	2 (1-3)	0.397
Highest reported pain score-Mobilized (VAS), Median (IQR)	3 (1.5-4)	2 (1-4)	0.505

OME: Oral morphine equivalent, **SD:** Standard deviation, **VAS:** Visual analog scale, **IQR:** Interquartile range.
*The independent samples t-test and Mann–Whitney U test were used for continuous variables; the χ2 was performed for categorical variables (n, %).

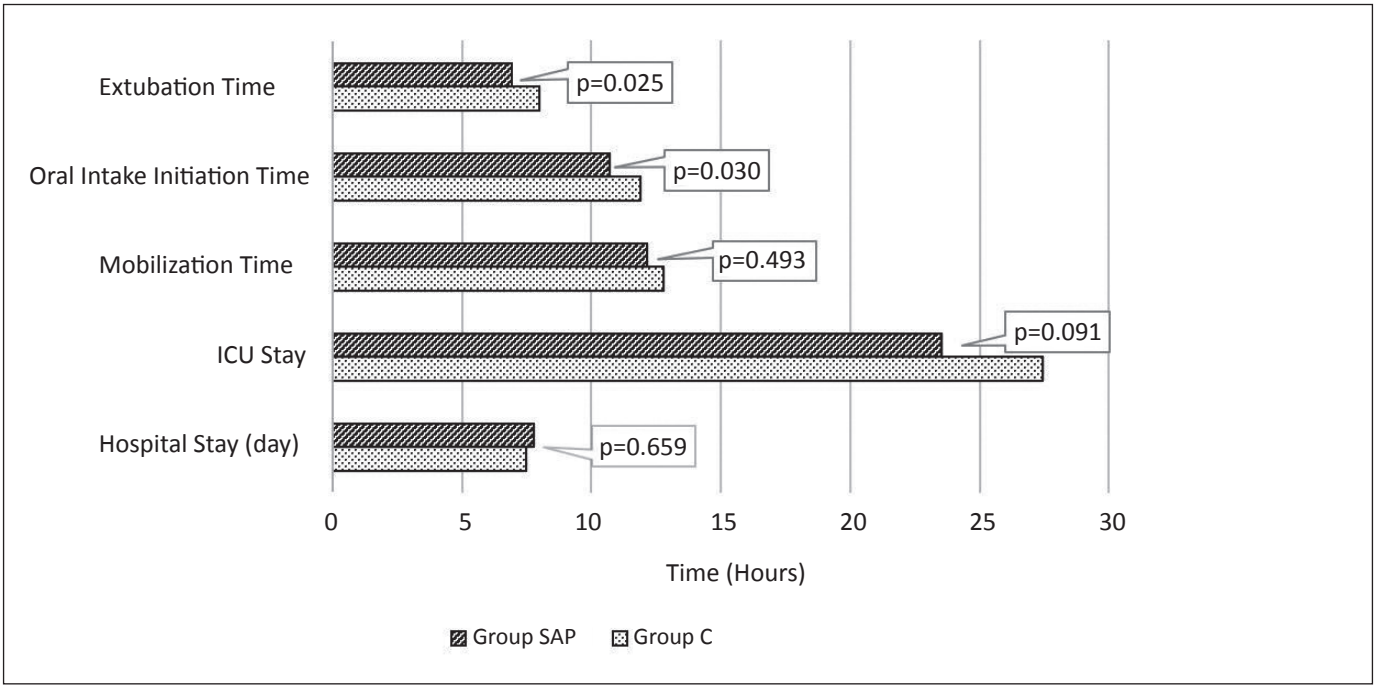

Figure 1. Postoperative recovery times.

It has been reported that the opioid-based analgesia technique in postoperative pain management after CABG is associated with respiratory depression, suppression of the cough reflex, prolonged mechanical ventilation, nausea-vomiting, suppression of intestinal motility, urinary retention, immune suppression, and increased risk of chronic pain and addiction (12,13). An important pillar of enhanced recovery after surgery is to minimize exposure to opioids to optimize pain management and reduce adverse events (14). The use of neuraxial techniques in cardiac surgery is controversial because of heparinization and potential hemodynamic instability. In cardiac surgery, facial plane blocks have become to be preferred more in postoperative analgesia because they pose less bleeding risk compared to central neuraxial blocks (15). It has been reported that erector spina plane block, parasternal-intercostal blocks and interpectoral plane blocks reduce opioid consumption and are used successfully in the management of pain after cardiac surgery with thoracotomy or sternotomy (15-17).

Serratus anterior plane block, a facial plane block, was first described by Blanco (5). Deep SAPB blocks the lateral cutaneous branches of the intercostal nerves at the T2 to T9 levels. Superficial SAPB also blocks the long thoracic (C5-7) and thoracodorsal (C6-8) nerves and is a suitable choice for procedures involving the anterolateral chest wall. (17-19). In cardiac surgery, SAPB has been shown to reduce opioid consumption and provide longer-lasting analgesia in minimally invasive procedures performed with thoracotomy (6,7). It has been reported that the serratus anterior plane block for median sternotomy does not provide complete coverage, as the sensory innervation of the anterior chest wall is transmitted by the anterior cutaneous branch of the intercostal nerves (15,16,20). However, chest tube pain, which is often overlooked in the analgesia plan, contributes significantly to the overall postoperative pain from cardiac surgery. There are studies showing that pain after cardiac surgery is frequently located in the thoracic drain sites. (21). Lateral chest wall pain from chest tube drainage decreases dramatically after removal of drainage tubes, suggesting that tube site pain control is as important as sternotomy for pain palliation in cardiac surgery (21). Thoracic drainage tube pain can potentially be transmitted via the long thoracic nerve, phrenic nerve, thoracodorsal nerve, vagus nerve, and intercostal nerves (18). In a case series reporting on patients undergoing thoracic surgery, SAPB provided a level of analgesia for chest tube-related pain that could not be achieved by thoracic paravertebral block alone (22). In a randomized controlled study, it was shown that the application of lidocaine gel to the chest tube in patients undergoing CABG reduced pain at the chest tube site and total fentanyl consumption (23). In the same study, a high percentage of patients (85% versus 30%) in the control group stated the tube insertion site as the most painful area.

In our study, due to the retrospective design, pain localization could not be questioned, but lower pain scores and decreased total opioid consumption during the first 24 hours at rest and during mobilization suggest that although superficial SAPB does not provide sternal analgesia anatomically, it improves postoperative total pain by reducing chest tube site pain. In addition, in our study, the duration of mechanical ventilation (6.93 vs. 7.98 hours) was found to be significantly lower in patients who underwent SAPB. This effect may be due to the reduction of opioid consumption and the associated sedative effect, and the reduction of pain during inspiration and the improvement of the patient's respiratory effort by providing appropriate analgesia of the thoracic tube drainage site.

Pain is most severe in the first 24 hours after cardiac surgery and decreases in the following days (24). In parallel, the greatest demand for analgesics will be in the first 24 hours, during which the incidence of side effects associated with high doses of opioids will increase. In our study, it was observed that opioid consumption was significantly higher in the control group in the first 24 hours, the requirement of opioids decreased by more than 50% in the second 24-hour period in both groups. Postoperative nausea-vomiting (PONV), one of the side effects associated with high opioid use, affects 20% to 67% of all patients in cardiac surgery, and this increases adrenergic stimulation, limits mobilization and oral intake, and can be distressing for patients (25).

In a randomized controlled study, the total dose of morphine and tramadol required in the SAPB group in patients who underwent elective thoracoscopy and the incidence of postoperative vomiting were found to be significantly lower than in patients who underwent conventional pain control (26). However, in a study of patients undergoing video-assisted thoracic surgery, opioid consumption with SAPB was significantly lower than in the control group. Although the incidence of PONV was low in the SAPB group, no statistically significant difference was found (27). In that study, although opioid consumption decreased in the first 24 hours in the SAPB group, the mean opioid consumption was 41.8 mg (OME), which was higher than in our SAPB group (31.51 mg, OME). In addition, factors affecting PONV, such as female gender, history of motion sickness, non-smoking, and young age, may have caused the differences among the studies.

However, regardless of the type of opioid, it is known that opioids increase the risk of dose-dependent PONV and this effect continues as long as they are used in the postoperative period (28). In our study, nausea scores were significantly higher in the non-blocking group and the proportion of patients with vomiting was also higher (21.4% vs. 9.3%),

which may reflect the opioid-reducing effect of the block. The extubation time of the patients in the conventional group was one hour longer, which may also be the reason for their later initiation of oral intake. Considering all outcomes, earlier extubation of the pain-free patient, lower use of opioids, and reduced incidence of nausea and vomiting will contribute not only to associated morbidities but also to lower overall care costs.

There is no randomization and no blindness due to the retrospective design, which is the major limitation. The results of this study clearly limit its potential generalizability in excluded patient groups. Similarly, due to the retrospective design, sternal retraction time, number of chest tubes, localization of the chest tubes, block effectivity, post-extubation sensory block distribution and pain localization could not be recorded.

CONCLUSION

In conclusion, our study showed that superficial serratus anterior plane block can play an important role in pain management in patients who underwent CABG with median sternotomy, by reducing both pain scores and opioid consumption in the first 24 hours postoperatively. The addition of SAPB to analgesia management can reduce nausea and vomiting, and patients' oral intake initiation time. Therefore, superficial SAPB may be part of opioid-sparing multimodal analgesia in cardiac surgery.

AUTHOR CONTRIBUTIONS

Conception or design of the work: AA, ZAD
Data collection: AA, NS
Data analysis and interpretation: AA
Drafting the article: AA, ZAD
Critical revision of the article: NS, ZAD
Other (study supervision, fundings, materials, etc): AA, NS, ZAD
All authors (AA, NS, ZAD) reviewed the results and approved the final version of the manuscript.

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