Clinical Interventions in Aging Dovepress

Open Access Full Text Article ORIGINAL RESEARCH

The Scalp Nerve Block Combined with Intercostal Nerve Block Improves Recovery After Deep Brain Stimulation in Patients with Parkinson's Disease: A Prospective, Randomized Controlled Trial

Wenbin Lu[1,*], Xinning Chang[1,*], Wei Wu[2–5], Peipei Jin[1], Shengwei Lin[1], Lize Xiong[2–5], Xiya Yu[2–5]

[1]Faculty of Anesthesiology, Changhai Hospital, Naval Medical University/Second Military Medical University, PLA, Shanghai, People's Republic of China; [2]Department of Anesthesiology and Perioperative Medicine, Shanghai Fourth People's Hospital, School of Medicine, Tongji University, Shanghai, People's Republic of China; [3]Shanghai Key Laboratory of Anesthesiology and Brain Functional Modulation, Shanghai Fourth People's Hospital, School of Medicine, Tongji University, Shanghai, People's Republic of China; [4]Translational Research Institute of Brain and Brain-Like Intelligence, Shanghai Fourth People's Hospital, School of Medicine, Tongji University, Shanghai, People's Republic of China; [5]Clinical Research Centre for Anesthesiology and Perioperative Medicine, Tongji University, Shanghai, People's Republic of China

*These authors contributed equally to this work

Correspondence: Lize Xiong; Xiya Yu, Email mzkxlz@126.com; lizexiong@tongji.edu.cn; yuxiyash@163.com

Objective: To explore the effect of scalp nerve block (SNB) combined with intercostal nerve block (ICNB) on quality of recovery (QoR) after deep brain stimulation (DBS) in patients with Parkinson's disease (PD).

Methods: We conducted a prospective randomized controlled trial in which 88 patients with PD were randomly assigned to undergo SNB combined with ICNB (SNB group) or not (control group) before surgery. The primary outcome was the 15-item QoR (QoR-15) score 24 h after surgery. The secondary outcomes included QoR-15 scores at 72 h and 1 month after surgery, pain-related events, recovery events in post-anesthesia care unit (PACU), duration of anesthesia and surgery, and nerve block-related adverse events.

Results: The QoR-15 score at 24 h after surgery was significantly higher in SNB group than Control group: 122.0 ± 7.6 vs 113.5 ± 11.3 (P = 0.006). SNB combined with ICNB improved QoR-15 scores at 72 h (P = 0.004) but not at 1 month after surgery (P = 0.230). The SNB group was positively related to QoR-15 scores 24 h after surgery (β = 8.92; 95% CI = 4.52~13.32) after adjusting for confounding variables. The numeric rating scale pain scores at PACU discharge and at 24 h, intraoperative opioid consumption, rescue analgesic use, and the incidence of postoperative nausea and vomiting (PONV) in SNB group were significantly lower than Control group (P < 0.05).

Conclusion: Preoperative SNB combined with ICNB improved QoR and analgesia after surgery, and reduced intraoperative opioid consumption and the incidence of PONV in patients with PD who underwent DBS.

Keywords: deep brain stimulation, intercostal nerve block, Parkinson's disease, quality of recovery, scalp nerve block

Introduction

Parkinson's disease (PD) is a progressive neurodegenerative disorder characterized by motor symptoms, such as tremors, rigidity, and bradykinesia.[1,2] More than 6.1 million people globally experience multisystem symptoms of PD.[3] Deep brain stimulation (DBS) has emerged as an effective treatment modality for managing advanced PD, providing significant symptomatic relief, and improving the quality of life of patients.[4–6] Despite improvements in surgery and anesthesia, pain affects postoperative recovery in patients undergoing such surgeries due to altered pain processing and sensitization to opioids.[7] Therefore, appropriate analgesia strategies should be adopted to PD patients scheduled for DBS surgery, which may improve the postoperative quality of recovery (QoR), shorten hospital stays, and decrease potential complications after surgery.[8,9]

Received: 11 April 2024
Accepted: 23 September 2024
Published: 8 November 2024

Multiple clinical studies have adopted peripheral nerve blocks instead of opioids to treat acute pain after surgery.[10,11] Previous studies have shown that a scalp nerve block (SNB) with ropivacaine can provide perioperative analgesia and reduce pain-related complications after craniotomy.[12,13] In addition, the intercostal nerve block (ICNB) has been reported to alleviate acute pain and reduce opioid consumption after thoracotomy.[14] Therefore, SNB combined with ICNB may reduce pain and pain-related adverse events after DBS surgery because the incision sites are innervated by the scalp and intercostal nerves.

Postoperative pain and pain-related complications are important components of the 15-item QoR (QoR-15) score after surgery, which is a validated questionnaire used to assess multidimensional postoperative recovery.[15] Previous studies have shown that peripheral nerve blocks improve QoR after craniotomy.[16] However, few studies have explored the efficacy of SNB combined with ICNB in improving QoR after DBS surgery.

We conducted this prospective randomized controlled trial to examine the hypothesis that SNB combined with ICNB would enhance the quality of recovery after DBS surgery in patients with PD, aimed to provide suitable analgesic strategies to patients undergoing DBS surgery, and to propose a new insight for the improvement of recovery.

Materials and Methods

This single-center, prospective, double-blinded, randomized trial was performed at Changhai Hospital, Naval Medical University, Shanghai, China, from April 2022 to March 2023. Protocol[17] was approved by the ethics committee of Shanghai Changhai Hospital (CHEC2022-042) on March 22, 2022, and was registered at clinicaltrials.gov (NCT05353764) on April 19, 2022. All enrolled patients provided written informed consent before surgery.

Participants

We enrolled patients with PD aged ≥18 years who underwent elective subthalamic nucleus DBS surgery, had an American Society of Anesthesiologists (ASA) physical status of I–III, and were able to communicate normally. We excluded patients who had (1) an allergy to local anesthetics, (2) pre-existing infection at the block site, (3) severe coagulopathy, (4) preoperative neuropathic pain, and (5) a history of DBS surgery.

Randomization and Blinding

Patients were randomly assigned to the SNB and control groups at a ratio of 1:1 using computer-generated random number tables by an anesthesia nurse who was not involved in the study. The anesthesia nurse typed the group assignment on separate papers, folded them up, and placed them inside sequentially numbered sealed opaque envelopes. On the day of surgery, the anesthesia nurse opened the envelopes and prepared the study drug. Anesthesia induction and blockade were performed by the same attending anesthesiologist on our study team. The attending anesthesiologist performing the blockade and the anesthesia nurse were aware of the allocation. The patients were blinded to the group allocation because the blockade was performed when they were unconscious. In addition, group assignment was concealed from another anesthesiologist responsible for operation, investigators involved in the follow-up and collecting data, surgeons, and personnel in the post-anesthesia care unit (PACU).

Anesthetic and Analgesic Managements

Anesthesia induction and maintenance were conducted in accordance with a previous protocol[17] after providing standard care to the patients in the two groups. Briefly, anesthesia was induced with 8 mg of dexamethasone, sufentanil 0.3–0.5 μg kg^{-1}, propofol 2–3 mg kg^{-1}, and rocuronium 0.6 mg kg^{-1}. Anesthesia was maintained through continuous infusion of remifentanil (0.1–0.2 μg kg^{-1} min^{-1}), and propofol (6–8 mg kg^{-1} h^{-1}) was administered to maintain stable hemodynamics. Additionally, 10 μg of sufentanil was administered 30 min before the end of surgery, and propofol and remifentanil infusions were discontinued after surgery. After surgery, patients were transferred to the PACU without receiving patient-controlled analgesia. When the Aldrete score was ≥ 9, patients were transferred to the ward. Parecoxib sodium 40 mg was administered as rescue treatment for patients whose numeric rating scale (NRS) scores were higher than 4 in the PACU or ward. If patients experienced nausea or vomiting, they were administered 4 mg of ondansetron.

Interventions

Participants randomized to the SNB group underwent SNB and ICNB with 0.5% ropivacaine, which was performed exclusively by attending anesthesiologists after the induction of general anesthesia. A 25- gauge needle with a 10-mL syringe was used to perform landmark-guided SNB.[18] After negative aspiration, the scalp nerves, including the greater occipital, auriculotemporal, supratrochlear, and supraorbital nerves, were blocked by injecting 2–3 mL of 0.5% ropivacaine bilaterally around each of the 4 nerves. The total volume of the SNB did not exceed 10 mL.

Ultrasound-guided ICNB on the surgical side was performed at the plane of T4-T5 proximal to the anterior axillary line in the supine position after SNB. After determining the optimal image, including the pleura, internal intercostal muscles, rib, and innermost intercostal muscles, an echogenic needle was inserted to target the inferior margin of the rib, using the in-plane technique. After volume aspiration, 10–15 mL of 0.5% ropivacaine was injected into the intercostal spaces. ICNB was considered successful when downward displacement of the pleura was observed in the intercostal spaces.

The block efficacy for dermatomal sensory testing was not formally tested because the patients under general anesthesia were unconscious. After the nerve blockade, the attending anesthesiologists covered the dressing in the relevant areas to hide the allocation. The participants in the control group received the same care as those in the SNB group. However, only the dressing was covered for these participants at the same site in the SNB group, without SNB or ICNB. Patients in both the SNB and control groups did not undergo local infiltration of the anesthetic and did not receive scheduled nonsteroidal anti-inflammatory drugs after surgery.

Outcome Measures

The primary outcome was the QoR-15 score 24 h after surgery. The secondary outcomes included QoR-15 scores at 72 h and 1 month after surgery; NRS pain scores (overall pain at rest) before discharge from the PACU, and at 24 h, 72 h, and 1 month after surgery; intraoperative opioid consumption; rescue analgesic use 24 h after surgery; nausea and vomiting 24 h after surgery; emergence agitation; time to respiratory recovery; time to response; time to extubation;[17] duration of anesthesia and surgery; PACU length of stay; and nerve block-related adverse events.

The quality of recovery following surgery was assessed using the QoR-15 score, which includes five dimensions of recovery: pain, physical comfort, physical independence, psychological state, and emotional state.[15] The total score on the QoR-15 ranges from 0 (poorest QoR) to 150 (best QoR). At the 1-month assessment, the patients answered the QoR questionnaire before receiving an explanation of their condition at the outpatient clinic. The QoR-15 questionnaire was administered by qualified investigators trained in the manual.

Sample Size and Statistical Analysis

The sample size was calculated using the QoR-15 score. A QoR-15 score change of 8 points was considered clinical improvement.[19] According to our preliminary study, the QoR-15 score 24 h after DBS in PD patients without nerve block was 110 (10.1). We calculated the required number of patients using PASS 11 software with an alpha error of 0.05 and power of 95% for an 8 points difference in QoR-15 score, and determined that 35 patients would need to be included in each group. Considering the dropout rate of 20%, we defined a sample size of 88 participants.

Data analyses were primarily performed in the intention-to-treat population using R software packages and Free Statistics software, version 1.7.1. For subjects with missing data due to loss to follow-up for one month after surgery, we used available assessments. The normality of continuous variables was tested using the Shapiro–Wilk normality test. Continuous variables in normally distributed data, represented as mean ± standard deviation, were compared using the Student's *t*-test, while continuous variables in non-normal distribution data, reported as medians (quartiles), were compared using the Mann–Whitney *U*-test. Categorical variables, described as frequencies and percentages, were compared using $\chi 2$ test or Fisher's exact test.

Repeated measures of variables at different times in QoR-15 scores were analyzed using generalized estimating equation models adjusted for baseline characteristics (including age, sex, body mass index, ASA physical status, hypertension, diabetes, and preoperative QoR-15 scores). NRS pain scores between the two groups were compared using the Mann–Whitney *U*-test, which was used as an exploratory test. The association between the primary outcome

and intervention was adjusted for potential confounders using multivariable linear regression analysis in the post hoc analysis, including sufentanil consumption, remifentanil consumption, rescue analgesic use, nausea and vomiting, and NRS pain score at PACU discharge and 24 h after surgery. $P < 0.05$ was regarded as statistically significant.

Results

One hundred and forty patients were initially assessed for eligibility in this study; however, 20 did not meet the inclusion criteria, and 32 refused to participate. Therefore, 88 patients were randomly allocated to the study group. At the time of assessment 1 month after surgery, ten and six patients in the SNB and control groups, respectively, were lost to follow-up (Figure 1). The baseline characteristics of the subjects are depicted in Table 1. No significant differences were noted between the Control and SNB groups. In addition, there were no nerve block-related adverse events in this study.

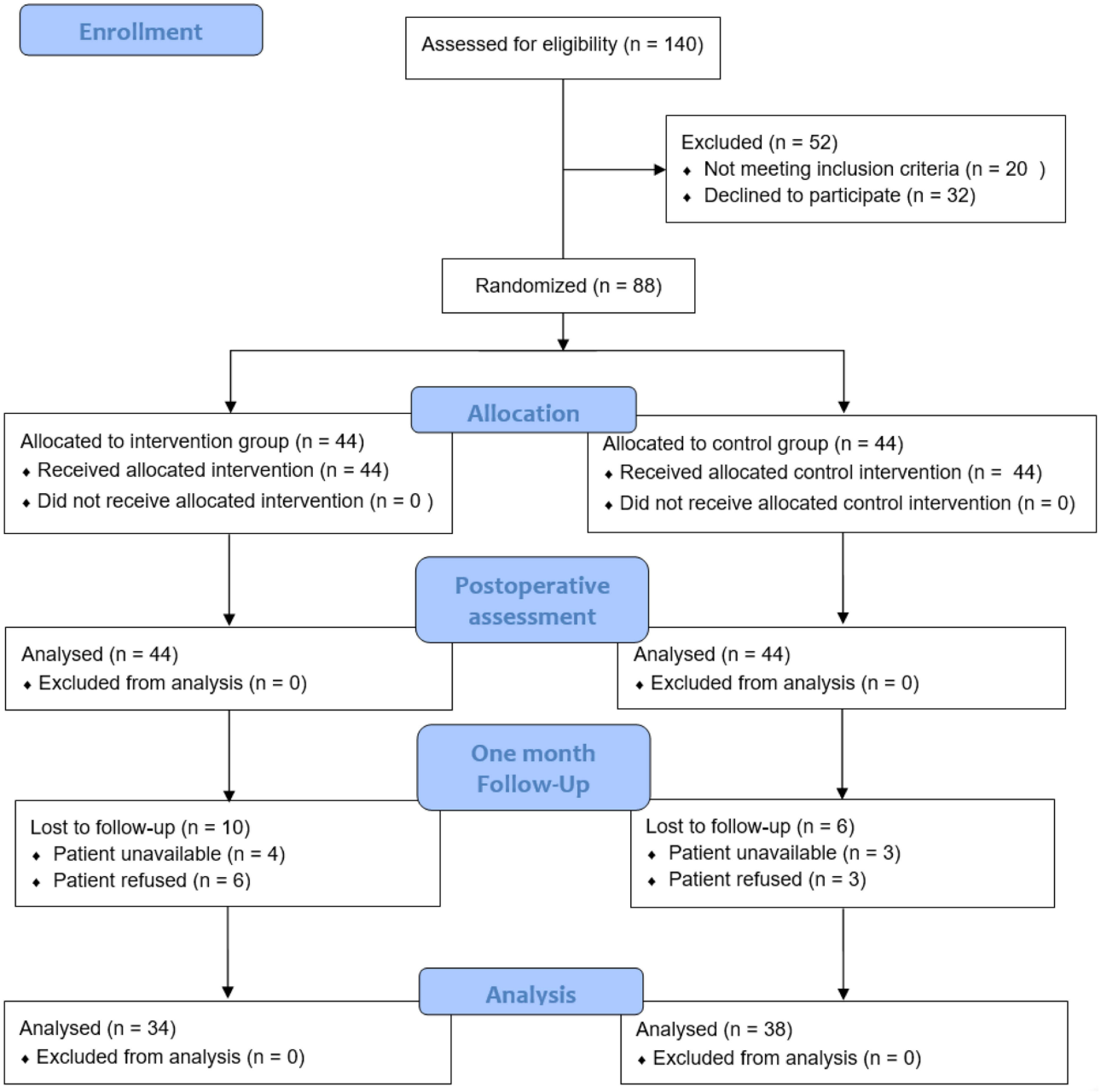

Figure 1 Flowchart of study population.

Table 1 Baseline Characteristics of the Participants

Patient Characteristics	Control Group (n = 44)	SNB Group (n = 44)	*P*
Age (year)	60.9 ± 7.5	60.2 ± 9.1	0.702
Sex			0.522
Female	23 (52.3)	20 (45.5)	
Male	21 (47.7)	24 (54.5)	
BMI (kg/m^2)	22.3 ± 3.4	23.6 ± 3.5	0.092
ASA physical status			I
II	38 (86.4)	38 (86.4)	
III	6 (13.6)	6 (13.6)	
Hypertension	11 (25)	10 (22.7)	0.803
Diabetes	4 (9.1)	6 (13.6)	0.502
Preoperative QoR-15 scores	116.5 ± 14.3	121.3 ± 10.2	0.073
Disease duration (year)	9.0 (7.0–12.2)	10.0 (7.0–12.0)	0.850
UPDRS scores	139.0 (113.5–172.0)	139.0 (126.5–154.5)	0.980
Dopamine dose equivalence (mg/d)	750.0 (581.2–940.6)	750.0 (643.7–881.2)	0.950
Preoperative MMSE scores	27.0 (25.0–29.0)	26.5 (25.0–28.0)	0.807

Notes: Data are reported as mean ± standard, medians (quartiles), and frequency (%).
Abbreviations: BMI, body mass index; ASA, American Society of Anesthesiologists; QoR, quality of recovery; UPDRS, unified Parkinson's disease rating scale; MMSE, Mini-mental State Examination; SNB, scalp nerve block.

Primary Outcome Data

The primary outcome, QoR-15 score 24 h after surgery, is shown in Table 2. The QoR-15 score (mean ± standard) at 24 h after surgery was significantly higher in the SNB group than that in Control group: 122.0 ± 7.6 vs 113.5 ± 11.3 (P = 0.006).

Secondary Outcome Data

Similar to the primary outcome, the QoR-15 score at 72 h after surgery was higher in the SNB group than in the control group (P = 0.004). However, there were no significant differences in long-term QoR between the SNB group (n = 34) and control group (n = 38) groups (P = 0.230) (Table 2).

The other secondary outcomes are presented in Table 3. Preoperative SNB combined with ICNB reduced the NRS pain scores at PACU discharge and 24 hours after surgery (all P < 0.05). However, there were no differences in NRS scores at 72 h (P = 0.603) and 1 month (P = 0.250) after surgery between the two groups. The intraoperative mean remifentanil consumption (1.5±0.2 mg vs 1.7±0.3 mg, P = 0.017), and mean sufentanil consumption (29.5±6.9 μg vs 34.1 ±4.9 μg, P < 0.001) in SNB group were significantly lower than those of Control group.

The number (%) of rescue analgesics required 24 h after surgery was lower in the SNB group (18.2%) than in the control group (45.5%) (P = 0.006). The incidence of postoperative nausea and vomiting (PONV) was lower in the SNB group (36.4%) than in the control group (61.4%) (P = 0.019). However, there were no significant differences between the two groups in the duration of anesthesia, duration of surgery, and PACU length of stay. The incidence of emergence agitation, time to respiratory recovery, time to response, and time to extubation were similar between the two groups.

Table 2 The QoR-15 Scores Compared Between Two Groups

QoR-15 Scores	Control Group (n=44)	SNB Group (n=44)	*P*
Postoperative 24 h	113.5 ± 11.3	122.0 ± 7.6	0.006
Postoperative 72 h	118.8 ± 9.6	126.9 ± 8.2	0.004
Postoperative 1 month*	123.6 ± 8.9	129.0 ± 8.3	0.230

Note: Data are reported as mean ± standard. *Data missing from six patients in the Control Group and ten in the SNB Group.
Abbreviations: QoR, quality of recovery; SNB, scalp nerve block.

Post Hoc Analyses

Because secondary outcomes may affect QoR-15 scores, we performed a post hoc analysis of the association between nerve block and QoR-15 scores 24 h after surgery. After adjusting for variables with $P < 0.05$, as shown in Table 3, nerve block was positively related to QoR-15 scores 24 h after surgery (β = 8.92; 95% CI = 4.52~13.32) (Table 4).

Discussion

This prospective randomized controlled trial aimed to investigate the effect of preoperative SNB combined with ICNB on the quality of recovery after DBS surgery in patients with Parkinson's disease. We found that patients who underwent preoperative SNB combined with ICNB reported higher QoR-15 scores than those in the control group at 24 and 72 h after surgery after adjusting for baseline characteristics. In addition, patients in the intervention group had reduced intraoperative opioid consumption, decreased postoperative rescue analgesic use, low incidence of PONV, and superior pain relief in the early postoperative period. No nerve block-related adverse events (eg, local anesthetic toxicity,

Table 3 Secondary Outcomes During the Study Period

	Control Group (n=44)	SNB Group (n=44)	*P*
Duration of surgery (min)	135.0 (123.8, 145.0)	140.0 (130.0, 150.0)	0.227
Duration of anesthesia (min)	170.0 (160.0, 185.0)	180.0 (165.0, 186.2)	0.226
Sufentanil consumption (μg)	34.1 ± 4.9	29.5 ± 6.9	< 0.001
Remifentanil consumption (mg)	1.7 ± 0.3	1.5 ± 0.2	0.017
Rescue analgesic use	20 (45.5)	8 (18.2)	0.006
Nausea and vomiting	27 (61.4)	16 (36.4)	0.019
Emergence agitation	3 (6.8)	0 (0)	0.241
PACU discharge time (min)	45.0 (40.0, 50.0)	40.0 (30.0, 50.0)	0.074
Time to respiratory recovery (min)	10.0 (5.0, 15.0)	10.0 (5.0, 15.0)	0.489
Time to response (min)	12.5 (8.8, 15.0)	10.0 (5.0, 15.0)	0.434
Time to extubation (min)	20.0 (15.0, 30.0)	15.0 (12.2, 25.5)	0.215
Postoperative pain (NRS) score			
PACU discharge	2.0 (1.0, 5.0)	1.0 (0.0, 3.0)	0.009
24 h	3.0 (1.0, 4.0)	2.0 (0.0, 3.0)	0.031
72 h	1.0 (1.0, 2.0)	1.0 (1.0, 2.0)	0.603
1 month *	0 (0, 0)	0 (0, 0)	0.250

Notes: Data are reported as mean ± standard, frequency (%), or median (inter-quartile range). *Data missing from six patients in the Control Group and ten in the SNB Group.
Abbreviations: PACU, postanesthesia care unit; NRS, numeric rating scale; SNB, scalp nerve block.

Table 4 Multivariable Linear Regression Analysis to Assess the Association Between Nerve Block and QoR-15 Scores at 24 h After Surgery

	β (95% CI)	P
Nerve block	8.92 (4.52~13.32)	<0.001
Sufentanil consumption	0.07 (−0.28~0.42)	0.707
Remifentanil consumption	4.80 (−3.28~12.88)	0.247
Nausea and vomiting	−0.89 (−8.33~6.55)	0.816
Rescue analgesic use	0.81 (−6.79~8.4)	0.836
NRS at PACU discharge	−0.6 (−1.7~0.51)	0.293
NRS at Postoperative 24 h	−1.27 (−2.54~0.01)	0.055

Abbreviations: QoR, quality of recovery; PACU, postanesthesia care unit; NRS, numeric rating scale; CI, confidence interval.

pneumothorax, bleeding, or infection) were observed. These findings indicate that preoperative SNB combined with ICNB may be an effective intervention to enhance recovery after DBS in patients with PD.

QoR-15 is an outcome questionnaire reported by patients that assesses the quality of recovery following surgery and anesthesia.[20] The QoR-15 score involves many areas beyond the scope of postoperative pain, which is consistent with Standardized Endpoints in Perioperative Medicine initiatives.[21] In addition, the QoR-15 questionnaire has the same psychometric properties, but is more feasible to use than the QoR-40.[22] Therefore, we chose the QoR-15 score 24 hours after surgery as the primary outcome.

Previous studies have demonstrated that peripheral nerve blocks alleviate pain and enhance the QoR after surgery.[23–25] In this study, we found that preoperative SNB combined with ICNB enhanced the short-term QoR-15 score after DBS surgery but not 1 month after surgery. However, QoR-15 scores may be affected by intraoperative variables. After adjusting for potential confounders, the intervention was associated with higher QoR-15 scores 24 hours after surgery. Therefore, our results indicate that preoperative SNB combined with ICNB led to significantly better postoperative short-term health status of patients after DBS surgery, which is consistent with previous studies.[16,26]

In addition to the improvement in the quality of recovery, our study also showed opioid-sparing properties and better analgesia with preoperative SNB combined with ICNB. We found that patients who received intervention before surgery had lower pain scores at PACU discharge and 24 hours after surgery than those in the control group. However, the statistical differences did not last longer than 24 hours, which may be attributed to the pharmacokinetic features of ropivacaine. Consistent with many studies,[27,28] preoperative SNB combined with ICNB also decreased the intraoperative opioid consumption. High opioid consumption results in numerous adverse events such as respiratory depression, nausea, vomiting, and bowel ileus.[29,30] Therefore, SNB combined with ICNB instead of opioids to prevent acute postoperative pain could be a promising component of a multimodal analgesic approach in DBS surgery.

In this study, we also showed that patients receiving SNB combined with ICNB had a lower incidence of PONV and rescue analgesic use 24 hours after surgery. Most likely, the prolonged time in which SNB combined with ICNB provided pain relief, lower pain scores, and decreased intraoperative opioid consumption may have reduced PONV and rescue analgesic use. Previous studies have also reported that peripheral nerve blocks are associated with a significantly lower risk of PONV and rescue analgesic use after surgery.[31,32] Moreover, no nerve blockade-related complications were observed in this study, which may occur due to superficial nerves and ultrasound guidance.

Several potential mechanisms may explain the observed benefits of preoperative SNB combined with ICNB in our study. SNB and ICNB interrupt the transmission of nociceptive signals from the incisions, providing analgesia and reducing central sensitization. This reduced intraoperative opioid consumption, opioid-related side effects, and rescue analgesic use. Moreover, improved analgesia may enhance postoperative sleep quality and lower anxiety and depression levels, leading to improved postoperative recovery.

This study has several limitations. First, a formal dermatomal evaluation of block efficacy was not conducted because of unconsciousness after anesthesia, which increased the risk of incomplete block. However, complete block of the superficial nerves for SNB and ultrasound guidance for ICNB are easy to obtain, which is consistent with the routine clinical practice. Second, the Chinese version of the QoR-15 questionnaire was used in the present study, which may have distorted the results because of this study due to language and cultural differences. Third, our study was conducted at a single center, which may have introduced a potential bias. Multicenter studies are needed to confirm the efficacy and safety of preoperative SNB combined with ICNB in patients with Parkinson's disease undergoing DBS surgery.

Conclusion

In conclusion, our study provides evidence that preoperative scalp nerve block combined with intercostal nerve block improves the quality of recovery, enhances analgesia, and reduces intraoperative opioid consumption and incidence of PONV in patients with Parkinson's disease undergoing DBS surgery.

Data Sharing Statement

Data supporting the findings of this study can be obtained from the corresponding author (Xiya Yu) upon reasonable request, and the corresponding author (s) can be directly contacted for further inquiry.

Ethics Statement

Studies involving human participants were reviewed and approved by the Ethics Committee of Shanghai Changhai Hospital (CHEC2022-042). The patients and participants provided written informed consent to participate in the study. This study conforms to the ethical guidelines of the Declaration of Helsinki.

Acknowledgments

We thank all those who supported and participated in the study, including our staff, the patients, and their family members.

Author Contributions

All authors made a significant contribution to the work reported, whether in the conception, study design, execution, acquisition of data, analysis, and interpretation, or in all these areas, took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This work was supported by the Major Program of the National Natural Science Foundation of China (82293640 and 82293643), the Research Initiation Foundation of Shanghai Fourth People's Hospital (sykyqd05901), the Discipline Boosting Program of Shanghai Fourth People's Hospital (SY-XKZT-2022-1003), and the Innovative Program of the First Affiliated Hospital of Naval Medical University (2020YXK013).

Disclosure

The authors declare that the study was conducted without any commercial or financial relationship or potential conflicts of interest.

References

1. Shkodina AD, Tan SC, Hasan MM, et al. Roles of clock genes in the pathogenesis of Parkinson's disease. *Ageing Res Rev*. 2022;74:101554. doi:10.1016/j.arr.2021.101554
2. Diederich NJ, Uchihara T, Grillner S, Goetz CG. The evolution-driven signature of Parkinson's disease. *Trends Neurosci*. 2020;43(7):475–492. doi:10.1016/j.tins.2020.05.001
3. Bloem BR, Okun MS, Klein C. Parkinson's disease. *Lancet*. 2021;397(10291):2284–2303. doi:10.1016/S0140-6736(21)00218-X
4. Meng F, Hu W, Wang S, et al. Utilization, surgical populations, centers, coverages, regional balance, and their influential factors of deep brain stimulation for Parkinson's disease: a large-scale multicenter cross-sectional study from 1997-2021. *Int J Surg*. 2023. doi:10.1097/JS9.0000000000000603
5. He S, Baig F, Merla A, et al. Beta-triggered adaptive deep brain stimulation during reaching movement in Parkinson's disease. *Brain*. 2023;146:5015–5030. doi:10.1093/brain/awad233
6. Okun MS. Deep-brain stimulation for Parkinson's disease. *New Engl J Med*. 2012;367(16):1529–1538. doi:10.1056/NEJMct1208070
7. Rukavina K, Leta V, Sportelli C, et al. Pain in Parkinson's disease: new concepts in pathogenesis and treatment. *Curr Opin Neurol*. 2019;32(4):579–588. doi:10.1097/WCO.0000000000000711
8. Yim RLH, Leung KMM, Poon CCM, Irwin MG. Peri-operative management of patients with Parkinson's disease. *Anaesthesia*. 2022;77(Suppl 1):123–133. doi:10.1111/anae.15617
9. Lenka A, Mittal SO, Lamotte G, Pagan FL. A pragmatic approach to the perioperative management of Parkinson's disease. *Can J Neurol Sci*. 2021;48(3):299–307. doi:10.1017/cjn.2020.211
10. Luo M, Zhao X, Deng M, et al. Scalp nerve block, local anesthetic infiltration, and postoperative pain after craniotomy: a systematic review and network meta-analysis of randomized trials. *J Neurosurg Anesth*. 2022. doi:10.1097/ANA.0000000000000868
11. Gupta R, Van de Ven T, Pyati S. Post-thoracotomy pain: current strategies for prevention and treatment. *Drugs*. 2020;80(16):1677–1684. doi:10.1007/s40265-020-01390-0
12. Yang Y, Ou M, Zhou H, et al. Effect of scalp nerve block with ropivacaine on postoperative pain in patients undergoing craniotomy: a randomized, double blinded study. *Sci Rep*. 2020;10(1):2529. doi:10.1038/s41598-020-59370-z
13. Ning L, Jiang L, Zhang Q, Luo M, Xu D, Peng Y. Effect of scalp nerve block with ropivacaine on postoperative pain in pediatric patients undergoing craniotomy: a randomized controlled trial. *Front Med*. 2022;9:952064. doi:10.3389/fmed.2022.952064
14. Guerra-Londono CE, Privorotskiy A, Cozowicz C, et al. Assessment of intercostal nerve block analgesia for thoracic surgery: a systematic review and meta-analysis. *JAMA Netw Open*. 2021;4(11):e2133394. doi:10.1001/jamanetworkopen.2021.33394
15. Kleif J, Waage J, Christensen KB, Gögenur I. Systematic review of the QoR-15 score, a patient- reported outcome measure measuring quality of recovery after surgery and anaesthesia. *Br J Anaesth*. 2018;120(1):28–36. doi:10.1016/j.bja.2017.11.013

16. Choi S, Choi YH, Lee HS, et al. Effects of scalp nerve block on the quality of recovery after minicraniotomy for clipping of unruptured intracranial aneurysms: a randomized controlled trial. *J Korean Neurosurg Soc*. 2023;66:652–663. doi:10.3340/jkns.2023.0010
17. Sheng Y, Wang H, Chang X, et al. Effect of scalp nerve block combined with intercostal nerve block on the quality of recovery in patients with Parkinson's disease after deep brain stimulation: protocol for a randomized controlled trial. *Brain Sci*. 2022;12(8):1007. doi:10.3390/brainsci12081007
18. Osborn I, Sebeo J. "Scalp block" during craniotomy: a classic technique revisited. *J Neurosurg Anesth*. 2010;22(3):187–194. doi:10.1097/ANA.0b013e3181d48846
19. Myles PS, Myles DB, Galagher W, Chew C, MacDonald N, Dennis A. Minimal clinically important difference for three quality of recovery scales. *Anesthesiology*. 2016;125(1):39–45. doi:10.1097/ALN.0000000000001158
20. Wessels E, Perrie H, Scribante J, Jooma Z. Quality of recovery in the perioperative setting: a narrative review. *J Clin Anesth*. 2022;78:110685. doi:10.1016/j.jclinane.2022.110685
21. Myles PS, Boney O, Botti M, et al. Systematic review and consensus definitions for the standardised endpoints in perioperative medicine (StEP) initiative: patient comfort. *Br J Anaesth*. 2018;120(4):705–711. doi:10.1016/j.bja.2017.12.037
22. Lee JH, Ki M, Choi S, et al. Validity and reliability of the Korean version of the quality of recovery-15 questionnaire. *Korean J Anaesth*. 2021;74(2):142–149. doi:10.4097/kja.20435
23. Hung KC, Ko CC, Hsu CW, Pang YL, Chen JY, Sun CK. Association of peripheral nerve blocks with patient-reported quality of recovery in female patients receiving breast cancer surgery: a systematic review and meta-analysis of randomized controlled studies. *Can J Anaesth*. 2022;69(10):1288–1299. doi:10.1007/s12630-022-02295-0
24. Wang Q, Yang Y, Yang Z, et al. Analgesic effects of ultrasound-guided iliohypogastric/ilioinguinal nerve block combined with lateral Femoral cutaneous nerve block in total hip arthroplasty via direct anterior approach: a retrospective cohort study. *Orthop Surg*. 2021;13(3):920–931. doi:10.1111/os.12795
25. Yao Y, Fu S, Dai S, et al. Impact of ultrasound-guided erector spinae plane block on postoperative quality of recovery in video-assisted thoracic surgery: a prospective, randomized, controlled trial. *J Clin Anesth*. 2020;63:109783. doi:10.1016/j.jclinane.2020.109783
26. He Y, Xu M, Li Z, Deng L, Kang Y, Zuo Y. Safety and feasibility of ultrasound-guided serratus anterior plane block and intercostal nerve block for management of post-sternotomy pain in pediatric cardiac patients: a prospective, randomized trial. *Anaesth Crit Care Pain Med*. 2023;42(6):101268. doi:10.1016/j.accpm.2023.101268
27. Prasad MK, Rani K, Jain P, Varshney RK, Jheetay GS, Bhadani UK. Peripheral nerve stimulator guided erector spinae plane block for post-operative analgesia after total abdominal hysterectomies: a feasibility study. *Indian J Anaesth*. 2021;65(Suppl 4):S149–s155. doi:10.4103/ija.IJA_69_21
28. Parthasarathy S, Krishnapriyanka KJ, Saravanan B. Effectiveness of pre-emptive nerve block on opioid consumption in patients undergoing nasal surgery under general anaesthesia: a double-blinded randomised controlled study. *Indian J Anaesth*. 2022;66(2):133–139. doi:10.4103/ija.ija_813_21
29. van Lemmen M, Florian J, Li Z, et al. Opioid overdose: limitations in naloxone reversal of respiratory depression and prevention of cardiac arrest. *Anesthesiology*. 2023;139:342–353. doi:10.1097/ALN.0000000000004622
30. Rajan N, Joshi GP. Management of postoperative nausea and vomiting in adults: current controversies. *Curr Opin Anaesthesiol*. 2021;34(6):695–702. doi:10.1097/ACO.0000000000001063
31. Demeulenaere M, Janssens GPL, van Beek N, Cannaerts N, Tengrootenhuysen MMF. Optimizing rapid recovery after anterior hip arthroplasty surgery: a comparative study of fascia iliaca compartment block and local infiltration analgesia. *J Arthroplasty*. 2022;37(7):1338–1347. doi:10.1016/j.arth.2022.03.040
32. Das S, Saha D, Sen C. Comparison among ultrasound-guided thoracic paravertebral block, erector spinae plane block and serratus anterior plane block for analgesia in thoracotomy for lung surgery. *J Cardiothorac Vasc Anesth*. 2022;36(12):4386–4392. doi:10.1053/j.jvca.2022.08.022