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ORIGINAL ARTICLE
Reconstructive

Surgery With Peripheral Nerve Block Under Dexmedetomidine Sedation for Foot Ulcer

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Background: Patients who require surgical treatment for diabetic foot ulcer (DFU) or chronic limb-threatening ischemia (CLTI) are often in generally poor condition and have complications. General anesthesia may be risky in surgery for such patients. Thus, the authors perform surgery using peripheral nerve block under dexmedetomidine sedation for patients with DFU and CLTI.

Methods: This study evaluated intraoperative stress, anxiety, and safety in 18 patients undergoing peripheral nerve block with dexmedetomidine. Sedation levels were assessed using the observer's assessment of alertness/sedation (OAA/S) score on a 5-point scale from 5 (awake) to 1 (deeply sedated). Postoperatively, a questionnaire was administered to assess intraoperative stress and memory. Intraoperative stress was assessed using a 6-point face scale (0 to 6: not at all to unbearably high), and intraoperative memory was rated on a 5-point numeric scale (1 to 5: no memory to everything).

Results: The intraoperative OAA/S score was 3–5, indicating that appropriate sedation was obtained. The mean intraoperative stress score was 0.72 (range: 0–3), and the mean intraoperative memory score was 2.44 (range: 1–4). One patient had bradycardia and 9 had hypoxemia. All of these cases were improved by decreasing the dose of dexmedetomidine and encouraging deep breathing on call.

Conclusions: These results suggest that this procedure is a useful method to reduce patient burden and alleviate stress and anxiety during surgery. However, dexmedetomidine may cause hypoxemia in patients with DFU or CLTI; thus, attention should be paid to hypoxemia and countermeasures should be taken against this adverse effect.
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INTRODUCTION

Patients who require surgical treatment for diabetic foot ulcer (DFU) or chronic limb-threatening ischemia (CLTI) are often in generally poor condition and have complications such as coronary artery disease, cerebrovascular disease, and renal dysfunction.[1,2] In surgery for such patients, general anesthesia may have a significant effect on the circulatory and respiratory systems and a high risk of complications.[3,4] Peripheral nerve block has the advantage that it can be used for patients who are at high risk for general anesthesia or are taking antithrombotic drugs that make epidural or spinal anesthesia difficult to perform. However, there is a concern that peripheral nerve block may cause high intraoperative stress and anxiety to the patient because the surgery is performed under conscious conditions.

Dexmedetomidine is an α2 adrenergic receptor agonist. Unlike with other sedatives, patients who receive dexmedetomidine are easily aroused by stimulation, can communicate even while appropriately sedated, and have less respiratory depression.[5,6] Therefore, appropriate sedation with dexmedetomidine may reduce patient stress and anxiety. From a global perspective, it is not uncommon for plastic surgeons to perform surgery under self-administered anesthesia, depending on the surgical field and regional characteristics.[7,8] However, there are few reports on the use of dexmedetomidine in patient populations with DFU and CLTI. The authors perform surgery using peripheral nerve block under dexmedetomidine

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sedation for patients with DFU and CLTI. In this study, the authors investigated intraoperative stress and memory in these patients using a postoperative questionnaire and examined the safety of this procedure. Given the high risk of complications in patients with DFU and CLTI undergoing surgery, exploring alternative sedation methods that minimize respiratory and circulatory risks is crucial. Thus, the authors' research provides valuable insights into a potentially safer and more effective sedation method for these high-risk patients. This study is targeted toward global health physicians who often work in environments where anesthesia providers are not readily available due to shortages of anesthesiologists, among other factors. It seeks to offer viable solutions for safe and effective sedation in such contexts.

Takeaways

Question: To clarify intraoperative stress, anxiety, and safety in patients with diabetic foot ulcer and chronic limb-threatening ischemia undergoing peripheral nerve block with dexmedetomidine.

Findings: This study suggests that peripheral nerve block under dexmedetomidine sedation reduces patient burden and intraoperative stress. Dexmedetomidine may cause upper airway obstruction, especially in high body mass index patients.

Meaning: Peripheral nerve block under dexmedetomidine sedation is a satisfactory approach. In patients with high body mass index, the risk of hypoxemia due to upper airway obstruction necessitates careful monitoring and countermeasures.

METHODS

This study is a single-center, retrospective observational study. The subjects were 18 patients in whom dexmedetomidine was used during peripheral nerve block surgery for DFU and CLTI. The peripheral nerve block administration, sedation with dexmedetomidine, and patient monitoring were performed by the plastic surgeon. Peripheral nerve block was performed using an echo-guided nerve block needle. The tip of the needle and the nerve fiber were identified by echo imaging, and anesthetic was injected circumferentially around the nerve. The anesthetic comprised 15–20 mL of an equal dilution of 0.75% ropivacaine hydrochloride (Anapain) and 1% lidocaine hydrochloride (Xylocaine) for femoral nerve block and sciatic nerve block.

Dexmedetomidine was administered at an initial loading dose of 6 μg/kg/h for 10 minutes, followed by a maintenance dose of 0.2–0.4 μg/kg/h. Sedation levels were assessed every 10 minutes using the observer's assessment of alertness/sedation (OAA/S) score on a 5-point scale from 5 (awake) to 1 (deeply sedated) (Table 1).[9] An OAA/S score of 3–4 represents a moderate level of sedation-analgesia and a score of 1–2 represents unconsciousness.

Postoperatively, a questionnaire was used to evaluate intraoperative stress and memory. Intraoperative stress was assessed on a 6-point face scale (0: not at all, 1: a little, 2: a little more, 3: much more, 4: very high, and 5: unbearably high). Intraoperative memory was rated on a 5-point numeric scale (1: not at all, 2: almost none, 3: a little, 4: partial, and 5: all). Postoperative symptoms (eg, discomfort, nausea/vomiting, palpitations, and dizziness) were also surveyed.

Statistical analysis was performed to identify patient factors associated with postoperative complications using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan). EZR is a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria, v. 4.1.2) that is a modified version of R commander (v. 2.7-1) with added functions frequently used in biostatistics.[10] Categorical variables were analyzed by the Fisher exact test, and continuous variables were evaluated by Mann-Whitney *U* test. All *P* values were 2-sided, and a *P* value of less than 0.05 was considered to be significant.

The study was performed in compliance with the Declaration of Helsinki and was approved by the research ethics committee of National Hospital Organization Takasaki General Medical Center (No. TGMC2024-028). Written informed consent was obtained from all subjects or their legal guardians.

RESULTS

The patients (15 men and 3 women) had a mean age of 66.1 years (range: 41–81 y) (Table 2). There were 6 cases with DFU alone, 3 with CLTI alone, and 9 with both conditions. Anesthesia methods included sciatic nerve block in 14 cases, combined sciatic and femoral nerve block in 2 cases, and combined sciatic nerve block and local anesthesia in 2 cases. Five patients underwent

Table 1. OAA/S Scale

Response	Speech	Facial Expression	Eyes	Score
Responds readily to name spoken in normal tone	Normal	Normal	Clear, no ptosis	5
Lethargic response to name spoken in normal tone	Mild slowing or thickening	Mild relaxation	Glazed or mild ptosis (less than half the eye)	4
Responds only after name is called loudly or repeatedly	Slurring or prominent slowing	Marked relaxation (slack jaw)	Glazed and marked ptosis (half the eye or more)	3
Responds only after mild prodding or shaking	Few recognizable words			2
Does not respond to mild prodding or shaking				1
Does not respond to noxious stimulus				0

Table 2. Data and Outcomes of Patients

Age (y)	Sex	BMI (kg/m^2)	Diagnosis	Basic Disease	Operation	Operation Time (min)	Anesthesia	OAA/S	HR	sBP	SpO_2	Adverse Event	Intraoperative Stress	Intraoperative Memory	Postoperative Symptoms
72	Male	21	DFU, CLTI	DM, CKD/HD, CHF	Below-knee amputation	104	Sciatic + femoral	4–5	70-92	87–120	98–99	—	2	3	—
69	Male	18.5	CLTI	HT	Below-knee amputation	116	Sciatic + femoral	3–5	49–78	110–148	94–98	Bradycardia	2	2	—
58	Male	24.7	DFU	DM, HT, DL	Toe amputation	51	Sciatic	3–4	56–76	168–196	95-96	-	0	2	—
64	Male	32.7	DFU, CLTI	DM, CKD/HD, CAD	Foot amputation	86	Sciatic	3–5	70–94	90–122	78–100	Hypoxemia	1	3	—
73	Female	23.7	DFU, CLTI	DM, CAD	Toe amputation	26	Sciatic	4–5	64–70	99–128	95–97	—	3	3	—
45	Male	24.8	DFU	DM	Foot amputation	134	Sciatic	3–5	112–124	140–171	88–98	Hypoxemia	0	1	—
61	Male	24.9	DFU, CLTI	DM, HT, CKD/HD, CAD	Foot amputation	85	Sciatic	4–5	71–75	114–133	82–98	Hypoxemia	0	4	—
81	Male	19.8	DFU, CLTI	DM,HT	Toe amputation	60	Sciatic	3–5	64–73	118–165	81–99	Hypoxemia	0	1	—
72	Male	20.8	CLTI	HT,CKD/HD	Foot amputation	80	Sciatic	4	65–85	86–155	86–99	Hypoxemia	1	3	—
81	Male	14.9	DFU	DM, HT	Toe amputation	77	Sciatic	4	80–84	106–133	92–98	—	0	3	—
65	Male	19	DFU, CLTI	DM, CAD.RA	Toe amputation	67	Sciatic	3–4	58–95	94–123	95–99	—	0	3	—
76	Female	21.8	CLTI	-	Foot amputation	60	Sciatic	4	65–103	67–134	85–93	Hypoxemia	0	1	—
69	Male	28	DFU, CLTI	DM, HT, CKD/HD	Split-thickness skin graft	76	Sciatic + local	4–5	73–79	150–197	87–99	Hypoxemia	1	2	—
48	Female	20.8	DFU, CLTI	DM, HT	Debridement	82	Sciatic	4	51–67	111–166	94–97	—	1	3	—
71	Male	22	DFU	DM	Full-thickness skin graft	58	Sciatic + local	3–4	78–94	116–154	92–99	—	0	3	—
67	Male	24.3	DFU, CLTI	DM, HT	Foot amputation	59	Sciatic	3–4	66–69	119–133	86–98	Hypoxemia	0	2	—
41	Male	28	DFU	DM	Foot amputation	93	Sciatic	3–4	64–73	108–131	88–98	Hypoxemia	0	2	—
76	Male	18.7	DFU	DM	Foot amputation	77	Sciatic	3–5	52–73	122–163	94–100	-	2	3	Nausea

CAD, coronary artery disease; CHF, chronic heart failure; CKD/HD, chronic kidney disease/hemodialysis; DL, dyslipidemia; DM, diabetes mellitus; HR, heart rate; HT, hypertension; RA, rheumatoid arthritis; SBP, systolic blood pressure; SpO2, saturation of percutaneous oxygen.

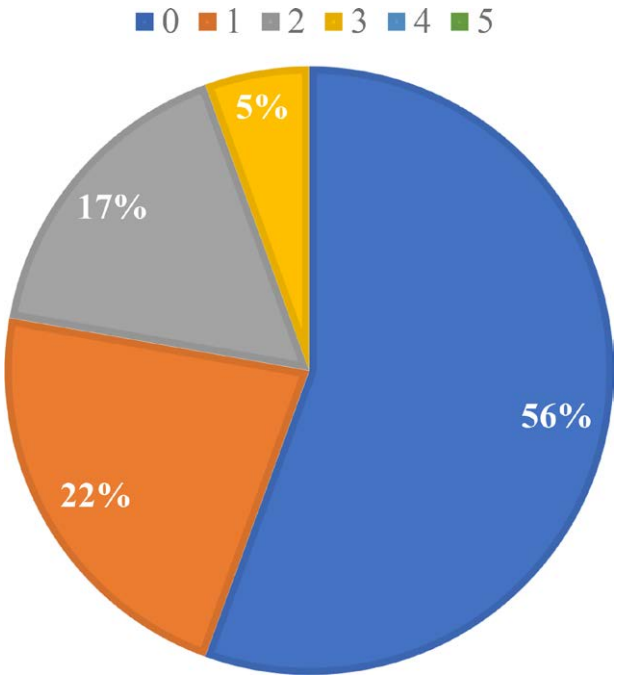

Fig. 1. Percentage of cases with different levels of intraoperative stress assessed on a 6-point face scale (0: not at all, 1: a little, 2: a little more, 3: much more, 4: very high, 5: unbearably high). No cases were in categories 4 or 5.

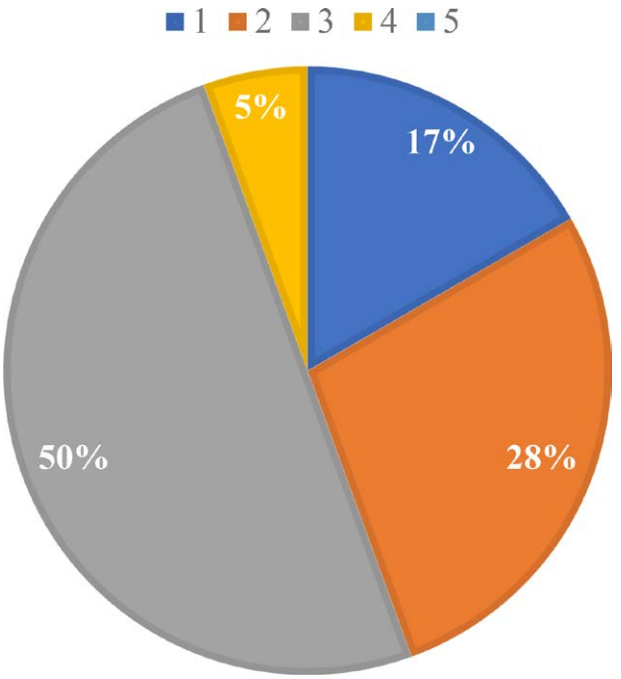

Fig. 2. Percentage of cases with different levels of intraoperative memory rated on a 5-point numeric scale (1: not at all, 2: almost none, 3: a little, 4: partial, and 5: all). No cases were in category 5.

toe amputation; 8 received foot amputation; 2 had below-knee amputation; and there was 1 case each of split-thickness skin graft, full-thickness skin graft, and debridement. The mean operative time was 78.9 minutes (range: 26–164 minutes).

Sedation levels ranged from OAA/S scores of 3 to 5, and no cases were oversedated. Intraoperative stress was 0: not at all (n = 10), 1: a little (n = 4), 2: a little more (n = 3), and 3: much more (n = 1). No cases had high intraoperative stress (4: very high or 5: unbearably high) (Fig. 1). Intraoperative memory was 1: not at all (n = 3), 2: almost none (n = 5), 3: a little (n = 9), and 4: partial (n = 1) (Fig. 2).

One patient complained of nausea as a postoperative symptom, but this improved with follow-up. Heart rate less than 50 bpm was considered to be bradycardia, and saturation of percutaneous oxygen less than 90% was defined as hypoxemia. Bradycardia occurred in 1 case but improved after adjusting the dexmedetomidine dosage. Hypoxemia occurred in 9 patients. Oxygenation was improved by adjusting the dexmedetomidine dose and encouraging deep breathing on call. In the statistical analysis, no correlations were found between specific comorbidities, types of surgery, or duration of surgery and adverse events. Only high body mass index (BMI) was significantly associated with hypoxemia ($P = 0.02$) (Table 3).

DISCUSSION

Surgery under general anesthesia for patients with DFU and CLTI, who often have various complications, is risky due to possible effects on the circulatory and respiratory systems.[3,4] Epidural or spinal anesthesia may also cause circulatory instability from effects on the sympathetic nervous system, and many of the patients are receiving antithrombotic therapy due to complications of the coronary artery and cerebrovascular disease, and are at risk for hematoma formation.[11] In contrast, peripheral nerve block does not involve the sympathetic nervous system and has less effect on the cardiovascular system. Chelly and Schilling[12] retrospectively evaluated a total of 6935 peripheral nerve blocks in 3588 patients who underwent hip or knee arthroplasty. The procedures included lumbar plexus, femoral, and sciatic nerve block, and none resulted in postoperative hematoma formation.[12] Echo-guided sciatic and femoral nerve blocks are relatively shallow nerve blocks that have a low risk of hematoma formation and are relatively easy to apply in patients with coagulation dysfunction or difficulty with antithrombotic drug withdrawal.

Dexmedetomidine is an α2 adrenergic receptor agonist. In the central nervous system, binding of an α2 agonist to α2 receptors on the presynaptic membrane of noradrenergic neurons inhibits release of noradrenaline from nerve terminals by negative feedback, thereby suppressing sympathetic nerve activity. At the same time, binding of the agonist to α2 receptors in the postsynaptic membrane suppresses excitation of the postsynaptic membrane, which is also thought to suppress sympathetic activity.[13] Compared with other sedatives, patients treated with dexmedetomidine are easily aroused by stimulation, can communicate while appropriately sedated, and have less respiratory depression.[5,6]

Table 3. Comparison of Characteristics of Patients With and Without Hypoxemia in Univariate Analysis

Variable	No Hypoxemia (n = 9)	Hypoxemia (n = 9)	*P*
Age (y)	68.1 ± 9.7	64.0 ± 13.0	0.48
Sex			
Male	7 (77.8%)	8 (88.9%)	1
Female	2 (22.2%)	1 (11.1%)	
Body mass index (kg/m^2)	20.4 ± 2.9	25.0 ± 4.0	0.02*
Diabetes mellitus	8 (88.9%)	7 (77.8%)	1
Chronic limb-threatening ischemia	5 (55.6%)	7 (77.8 %)	0.62
Chronic kidney disease/hemodialysis	1 (11.1%)	4 (44.4%)	0.29
Hypertension	4 (44.4%)	5(55.6%)	1
Dyslipidemia	1 (11.1%)	0 (0%)	1
Coronary artery disease	2 (22.2%)	2 (22.2%)	1
Chronic heart failure	1 (11.1%)	0 (0%)	1
Rheumatoid arthritis	1 (11.1%)	0 (0%)	1
Operation time (min)	73.1 ± 26.3	84.8 ± 31.3	0.48

Data are shown as mean ± SDs or number of patients (percentage).
*$P < 0.05$ for no hypoxemia vs. hypoxemia in univariate analysis.

Dexmedetomidine has also been reported to potentiate the effects and prolong the duration of action of local and peripheral nerve anesthesia.[14–16] Thus, analgesia with peripheral nerve block and sedation with dexmedetomidine may reduce the burden and stress on patients and contribute to safer surgery, and there have been several reports showing the usefulness of this combination.[7,8,17] Dexmedetomidine is used in many hospitals and medical facilities in both developed and developing countries. Although dexmedetomidine is generally more expensive than propofol and midazolam, studies have shown that its overall cost can be lower when considering factors such as reduced mechanical ventilation time and lower incidence of delirium.[18] Additionally, in cardiac surgery, high-dose dexmedetomidine has been associated with reduced costs primarily through decreased postoperative respiratory failure and shorter hospital stays.[19] Furthermore, in thoracoscopic surgery, dexmedetomidine as an adjuvant to ropivacaine provided better pain control and shorter hospital stays compared with dexamethasone.[20] These studies suggest that dexmedetomidine can be a cost-effective option in various perioperative scenarios.

In this study, the degree of sedation was assessed using the OAA/S, in which sedation levels are rated on a 5-point scale from 5 (awake) to 1 (deeply sedated). An OAA/S score of 3 to 4 indicates that the patient is not uncomfortable or distressed and is able to communicate adequately.[7] Dexmedetomidine was administered as an initial loading dose at 6 μg/kg/h for 10 minutes, followed by maintenance dosing at 0.2–0.4 μg/kg/h, which resulted in appropriate sedation levels with OAA/S scores of 3 to 5. The mean intraoperative stress score was 0.72 (0: not at all, 1: a little) (range: 0–3), and the mean intraoperative memory score was 2.44 (2: almost none, 3: a little) (range: 1–4). These results suggest that peripheral nerve block of the lower extremities under dexmedetomidine sedation reduces patient burden and alleviates stress and anxiety during surgery.

Common complications of dexmedetomidine include bradycardia, hypotension, hypertension, and (less frequently than other sedatives) respiratory depression.[21] When these side effects occur, dexmedetomidine should be reduced or discontinued, and the patient should be stimulated or administered an appropriate drug or oxygen. In this study, 1 patient showed bradycardia and 9 had hypoxemia. Dexmedetomidine causes less respiratory depression than other sedatives, but airway obstruction and apnea have been noted in some studies.[22,23] Lodenius et al[24] found that dexmedetomidine was not superior to propofol for upper airway obstruction. In the current study, high BMI was significantly associated with hypoxemia ($P = 0.02$) (Table 3). It is widely known that patients with a higher BMI have a higher risk of obstructive sleep apnea,[25] and those with a tendency for upper airway obstruction during sleep are also vulnerable during anesthesia and sedation.[26] Hypoxemia poses a risk of serious complications, making intraoperative monitoring extremely important. When a decrease in saturation of percutaneous oxygen is observed, the initial steps include awakening the patient through verbal stimulation and encouraging deep breathing. If necessary, oxygen administration via nasal cannula or mask should be considered. Additionally, reducing or discontinuing the dexmedetomidine dosage may be necessary. If upper airway obstruction due to tongue displacement is suspected, insertion of an oral or nasal airway should be considered. In addition to hypoxemia in patients with high BMI, older patients; those with cardiovascular disorders; and patients with reduced cardiac function, severe renal impairment, or hepatic dysfunction are also at higher risk of experiencing side effects. Therefore, it is necessary to consider measures such as reducing the initial loading dose and starting the maintenance dose at a lower level. Intraoperative monitoring should be conducted, and adjustments should be made as needed according to the patient's condition.

The limitations of this study include the single-center design and small number of subjects. Although our findings provide preliminary insights into the use of dexmedetomidine in patients with DFU and CLTI, we recognize

that further research with larger sample sizes is needed to validate these results and strengthen the conclusions. A large-scale, multicenter study is needed to validate the safety and examine complications of the surgical procedure.

CONCLUSIONS

Appropriate sedation levels were obtained by controlling the dexmedetomidine dose in 18 patients with DFU and CLTI who underwent surgery using peripheral nerve block of the lower extremities under sedation with dexmedetomidine. Complications included bradycardia in one case and hypoxemia in 9 cases, all of which were mild and easily resolved. These results suggest that dexmedetomidine sedation and peripheral nerve block can reduce patient burden and alleviate stress and anxiety during surgery. However, dexmedetomidine may cause upper airway obstruction, especially in patients with a high BMI, and awareness of and countermeasures against hypoxemia are particularly important in these patients.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

PATIENT CONSENT

Written informed consent was obtained from all subjects or their legal guardians. All data generated or analyzed during this study are included in this published article.

ETHICAL APPROVAL

All procedures involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. The study was performed in compliance with the Declaration of Helsinki and was approved by the research ethics committee of National Hospital Organization Takasaki General Medical Center (No. TGMC2024-028).

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