Journal of Anesthesia (2025) 39:366–371
https://doi.org/10.1007/s00540-025-03472-3

ORIGINAL ARTICLE

Skin cooling reduces pain associated with peripheral nerve block to the face

Katsuhide Masui[1] · Takashi Asai[1] · Masato Tachikawa[1] · Ryosuke Osawa[1] · Yasuhisa Okuda[1]

Received: 14 January 2025 / Accepted: 16 February 2025 / Published online: 28 February 2025

Abstract

Purpose Peripheral nerve blocks are frequently used to treat chronic pain, but nerve block in itself may cause pain. Cooling the skin may inhibit pain associated with needle puncture to a venous, artery to the muscles, but it is not known if skin cooling inhibits pain associated with peripheral nerve block for chronic pain.

Methods As a randomized crossover design, we studied 14 patients (after obtaining approval from the research ethics committee and written informed consent) in whom a supraorbital, infraorbital or jaw nerve block was indicated, to compare the degree of pain (assessed using the Numerical Rating Scale) during needle puncture and during injection of a local anesthetic (2 ml of 0.2% ropivacaine), with and without cooling of the skin (to 20 °C).

Results Pain was significantly less with skin cooling than without, during needle puncture ($P=0.002$; 95%CI for median difference: 3–3), and during injection of a local anesthetic ($P=0.0036$: 95%CI for median difference: 2–2). Injection of a local anesthetic was significantly more painful than needle puncture, both with skin cooling ($P=0.0039$) and without skin cooling ($P=0.015$). There was no significant difference in the effect of skin cooling in reducing pain between needle puncture and injection of a local anesthetic ($P=0.48$).

Conclusion In patients receiving peripheral nerve blocks to the face, cooling of the puncture site of the skin may effectively inhibit pain during needle puncture and during injection of a local anesthetic.

Clinical trial registration jRCT1031230725.

Keywords Pain · Pain clinic · Peripheral nerve block · Cryotherapy

Introduction

In the pain clinic, peripheral nerve blocks are frequently used to treat chronic pain. Nevertheless, nerve block (needle puncture and injection of a local anesthetic) in itself may cause pain. Intradermal injection of a local anesthetic, application of a patch containing a local anesthetic, and cooling of the skin may be effective in inhibiting pain associated with needle puncture to a peripheral vein or artery, or with intramuscular injection [1–6]. However, there have been no studies which evaluated the effectiveness of skin cooling in reducing pain associated with peripheral nerve block for chronic pain.

Compared with intradermal injection of a local anesthetic or application of a patch containing a local anesthetic, skin cooling costs less and is associated with little side effect. One possible problem with skin cooling is that cold thermal injury may occur if the skin is cooled too much, and pain may be felt when the temperature becomes too low [1, 7, 8]. One study reported that pain produced by skin cooling was similar to pain produced by intradermal injection of a local anesthetic [8]. Nevertheless, there have been no studies in which the skin temperature was measured during or after

✉ Takashi Asai
asaita@dokkyomed.ac.jp

Katsuhide Masui
k-masui@dokkyomed.ac.jp

Masato Tachikawa
tachi@dokkyomed.ac.jp

Ryosuke Osawa
r-oosawa@dokkyomed.ac.jp

Yasuhisa Okuda
y-okuda@dokkyomed.ac.jp

[1] Department of Anesthesiology, Dokkyo Medical University Saitama Medical Center, 2-1- 50 Minami-Koshigaya, Koshigaya, Saitama 343-8555, Japan

cooling the skin and adjusted the skin temperature not too cold.

The purpose of this study was to evaluate if cooling the skin to a predefined temperature was effective in reducing pain associated with peripheral nerve block for chronic pain in the face.

Methods

Research ethics committee of Dokkyo Medical University approved the study (approved number 23096), and written informed consent was obtained from all the patients. The study was registered to publicly accessible site, before the start of the study (jRCT1031230725 on 20, March, 2023).

We studied 14 patients (6 men, 8 women; mean age: 72 (range: 55–85) years old) in whom a peripheral nerve block to the face (supraorbital, infraorbital or jaw nerve block) was indicated at least three times on different days to treat chronic pain. Patients with cutaneous disease, allergic to local anesthetics, or hypersensitive to cold, were excluded. We also excluded the patient for data analysis, if the patient complained of neuropathic pain (or allodynia) when an ice was applied to the puncture site, or if we could not obtain the data on three occasions. The intensity of chronic pain was assessed using a 11-point (0–10) Numerical Rating Scale (NRS) shown on a 100 mm long line, after explaining that "no pain" at 0, and "the worst imaginable pain" at 10. Oral medications for pain management were recorded.

As a randomized crossover design, the degree of pain during needle puncture and during injection of a local anesthetic was compared with and without cooling of the skin. In all the procedures, a 25-gauge needle (0.5 × 25 mm; Terumo needle, TERUMO Japan, Tokyo, Japan) was used, and 2 ml of 0.2% ropivacaine was injected via the needle using a 2.5 ml syringe. Immediately after injection of the local anesthetic, we asked the patient to rate the intensity of pain during needle puncture and during injection of the local anesthetic, on the NRS.

Our preliminary observations indicated that the degree of pain during needle puncture and during injection of a local anesthetic (without skin cooling) would be similar between several peripheral nerve blocks performed on different days. We felt that it would be more ethical to provide the conventional treatment method (*i.e.,* a peripheral nerve block without cooling) on the first occasion to a patient at the first visited to our pain clinic. Therefore, a peripheral nerve block was always performed without cooling on the first occasion, with cooling on the second occasion, and without cooling on the third occasion, and then made a random order of either "cooling followed by non-cooling" or "non-cooling followed by cooling" (details of randomization are described below).

For cooling of the skin before the nerve block, the target temperature of skin was set at 20 °C, because it has been reported that pain may be felt when the temperature becomes less than 15 °C [9]. The skin surface at the injection site was cooled with a medical ice pack (cold/hot pack, 3 M, U.S.A) for 3 min, as our preliminary observations indicated that it would take approximately 3 min for the skin temperature to become 20 °C. The skin temperature was measured with a noncontact thermometer (Aimedata, Toamit, Japan). If it was 21 °C or above, the skin was cooled for another 1 min. If the patient claimed pain by cooling, cooling was terminated, and the patient was excluded from data analysis. When the skin temperature was around 20 °C, nerve block was performed. We asked the patient to score degree of pain using the NRS.

Statistical analysis

The primary outcome measure was the NRS during needle puncture and during injection of a local anesthetic.

We first assessed if there were significant differences in the NRS between two blocks performed without skin cooling (*i.e.,* blocks on the first and the third occasions). Two-way analysis of variance was used to compare the NRSs between the three occasions. If there was a significant difference, Wilcoxon signed rank sum test was used to compare NRSs during nerve blocks on the first and the third occasions. $P < 0.025$ was judged significant, as Bonferroni correction for two comparisons (*i.e.,* needle puncture and injection of a local anesthetic) indicated that the significant level to be 0.025 (0.05/ 2 = 0.025). 95%CI (confidence intervals) were calculated for the median difference in the NRS between blocks on the first and the third occasions, and if the 95%confidence interval was 1 or less, we judged that there was clinically no meaningful difference.

We then randomly chose one of the two NRSs for peripheral nerve blocks without skin cooling (*i.e*., nerve blocks on the first and the third occasions) to choose randomly the order of "cooling followed by non-cooling" or "non-cooling followed by cooling" in each patient. Random allocation was made using a block randomization (in block of 7), and each allocation was indicated in a card placed into a sealed opaque envelope.

Wilcoxon signed rank sum test was used to compare NRSs with and without skin cooling. 95%CI (confidence intervals) for the median difference in the NRS with and without cooling treatment were calculated. We judged that the difference was clinically meaningful, if the 95%CI (confidence intervals) for the median difference in the NRS was 2 or greater, as previous studies have indicated that the average differences in the intensity of pain of 10–18 mm (of 100 mm) in the visual analog scale

or 2 in the NRS would be regarded as the minimal clinically important difference [10–12].

To analyze secondary outcome measure, Wilcoxon signed rank sum test was used to compare NRSs during needle puncture and during injection of a local anesthetic, with and without skin cooling. 95%CI (confidence intervals) were also calculated for the median difference in the NRSs.

From preliminary observation, we estimated that the degree of pain would be less with skin cooling than without, in 95% of cases. To detect this difference, with a power of 0.8, and $P = 0.05$, 14 patients (7 patients for each group) would be required.

Results

We recruited 16 patients, from whom written informed consent was obtained. Two patients were excluded from data analysis, as one of these patients refused to receive skin cooling before a peripheral nerve block on the second occasion, and the other patient did not visit our pain clinic for the block on the third occasion (Fig. 1). The skin temperature was lowered to 20 °C by 3 min in 13 of 14 patients, and by 4 min in the remaining one patient. No patient claimed pain during skin cooling. Therefore, 14 patients (12 with postherpetic neuralgia and 2 with atypical facial pain) were included to the study (Fig. 1).

Five of 14 patients received no oral medication for pain management, whereas the remaining 9 patients were taking

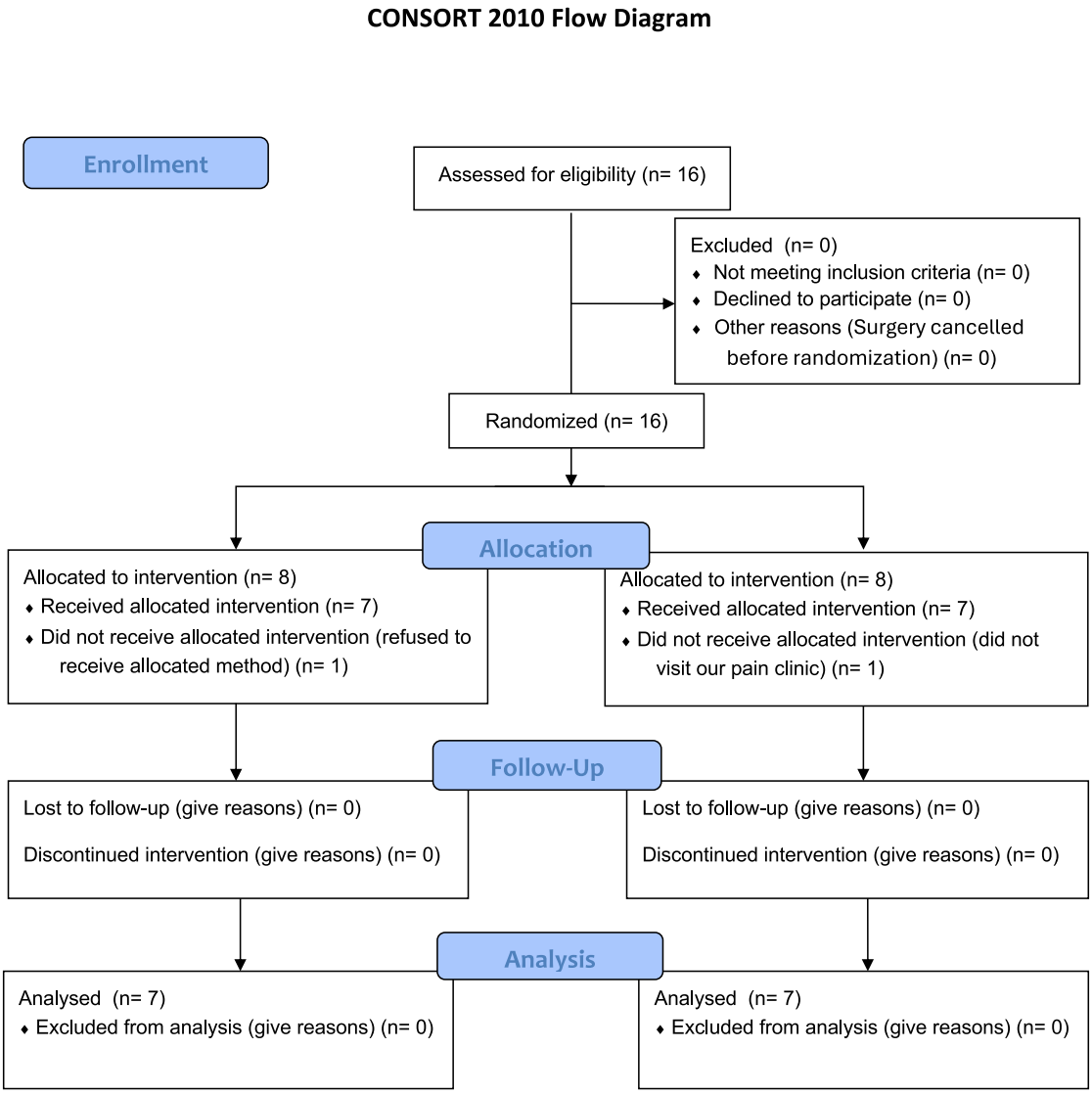

Fig. 1 CONSORT flowchart

one to three of the following oral medications for pain management: celecoxib in one patient (200 mg); duloxetine hydrochloride in one patient (20 mg); imipramine hydrochloride in one patient (10 mg); mecobalamin in 3 patients (0.5, 1.0, and 1.0 mg); mirogabalin besilate in 3 patients (2.5, 5.0, and 7.5 mg); neurotropin in 3 patients (4N.U.); pregabalin in 2 patients (75, 150 mg); and tramadol hydrochloride in one patient (50 mg). The intensity of chronic pain ranged from the NRS 3 to 7, with the median of 5.

There was a significant difference in the NRSs between the three occasions for needle puncture ($P < < 0.001$) and for injection of a local anesthetic ($P < < 0.001$). There was no significant difference between the two blocks without skin cooling (*i.e.*, blocks on the first and the third occasions) in the NRSs for needle puncture ($P = 0.75$; 95%CI for median difference: 0 to 0), and for injection of a local anesthetic ($P = 0.38$; 95%CI for median difference: 1 to 1) (Fig. 2).

With the random allocation, the order of "cooling followed by non-cooling" was used in 7 patients, and the order of "non-cooling followed by cooling" was used in the remaining 7 patients. Pain during needle puncture was less with skin cooling than without, in 13 of 14 patients; same with and without skin cooling in one patient; and in no patient was pain greater with skin cooling than without. Pain during needle puncture was significantly less with skin cooling than without ($P = 0.002$), and the difference was clinically meaningful (95%CI for difference in NRS: 3–3) (Fig. 3). Pain during injection of a local anesthetic was less with skin cooling than without, in 12 of the 14 patients; same with and without skin cooling in 2 patients; and in no patient was pain greater with skin cooling than without. Pain during injection of a local anesthetic was significantly less with skin cooling than without ($P = 0.0036$), and the difference was clinically meaningful (5%CI for difference: 2 to 2) (Fig. 3).

Injection of a local anesthetic was significantly more painful than needle puncture, both with skin cooling ($P = 0.0039$: 95%CI for median difference: 2–2) and without skin cooling ($P = 0.015$: 95%CI for median difference: 2–2), and the differences were clinically meaningful. There was no significant difference in the effect of skin cooling in reducing pain between needle puncture and injection of a local anesthetic ($P = 0.48$: 95%CI for median difference: −1–2).

Discussion

We have found that, during a peripheral nerve block to the face, injection of a local anesthetic was significantly more painful than needle puncture, and that cooling of the skin was effective in inhibiting pain both during needle puncture and during injection of a local anesthetic.

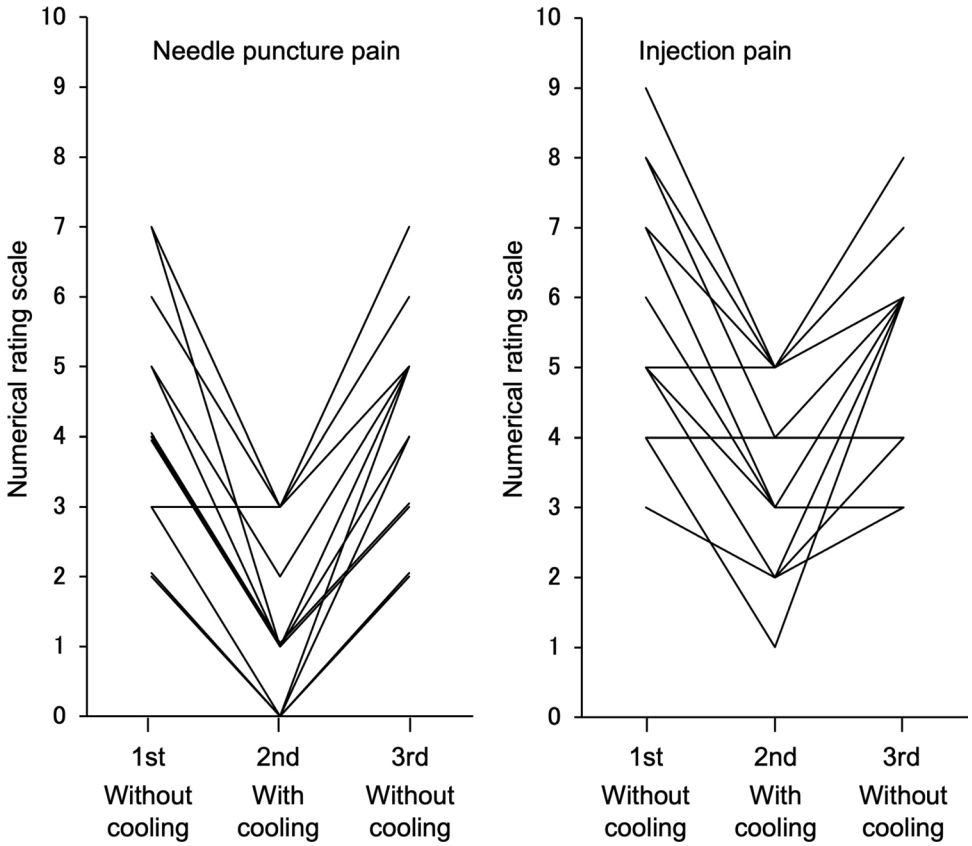

Fig. 2 Subject profile plots for the *NRS* Numerical Rating Scale for pain perceived during peripheral nerve blocks at three different occasions (left: needle puncture; right: injection of a local anesthetic)

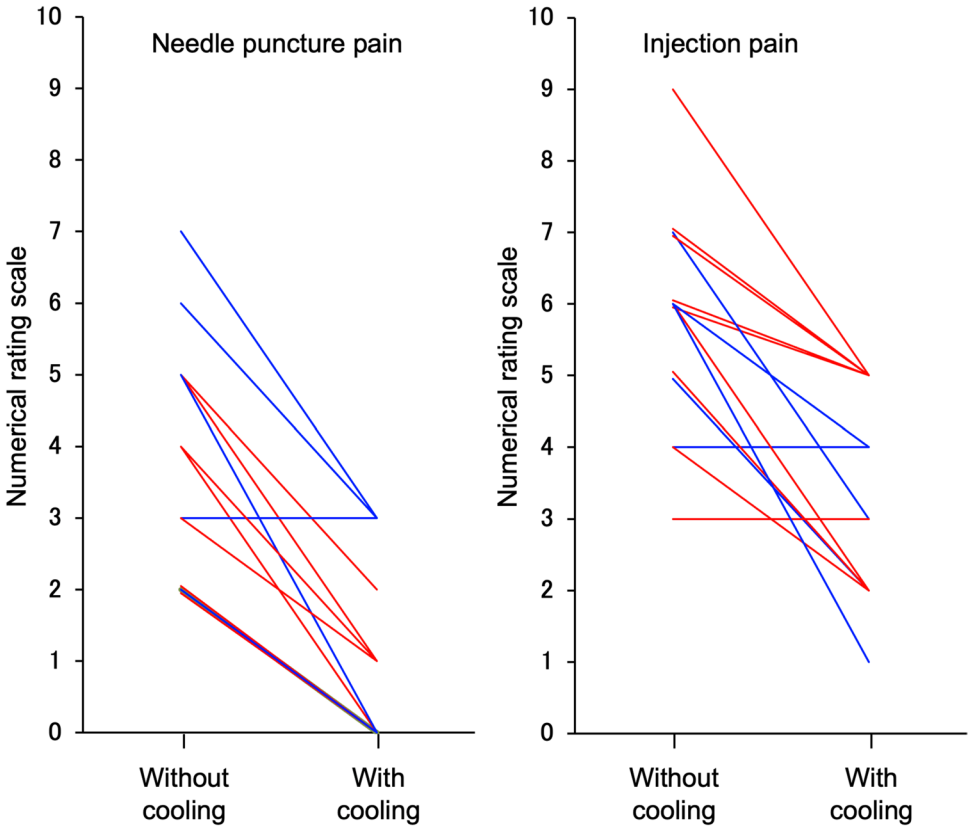

Fig. 3 Subject profile plots for the *NRS* Numerical Rating Scale for pain perceived during peripheral nerve block, with and without skin cooling (red lines in patients with oral medications and blue lines in patients without oral medications; left figure: needle puncture; right figure: injection of a local anesthetic)

Although there was no significant difference in the effect of skin cooling on reducing pain associated with needle puncture and with injection of a local anesthetic, injection of a local anesthetic was significantly more painful than needle puncture, even with skin cooling. The reason for this difference is not clean, but one possibility is insufficient cooling of the skin. The site where the local anesthetic is injected during nerve block is deeper than the epidermis. Therefore, even if the epidermis was sufficiently cooled, the site of local anesthetic injection might not have been sufficiently cooled. In addition, there was a slight time lag between needle puncture and injection of a local anesthetic, so that the area of the injection of the local anesthetic had been rewarmed by the patient's body temperature.

No patient claimed pain during skin cooling in our study, whereas in some previous studies, cooling skin produced a mild or moderate pain [1, 7, 8]. The exact reason for this difference is not clear, but it is likely that the skin was cooled excessively in those previous studies. In some studies [1, 7, 8], vapocoolant (*e.g.,* ethyl chloride or a mixture of propane, butane, and pentane) was sprayed to the skin to achieve skin blanching, so that the skin temperature would have been less than 15 °C [9]. In another studies, ice was applied for 5 to 6 min [3, 4]. In our study, we have confirmed that the skin temperature can usually be lowered to 20 °C by 3 min. Therefore, it is advisable to monitor the skin temperature during cooling, and avoid reducing the skin temperature excessively.

Advantages of cooling the skin over the use of a local anesthetic patch include that skin cooling would have a faster inhibitory effect on pain associated with the nerve block. In addition, the cost is less, and there is no possibility of anaphylaxis reaction. It has also been suggested [3] that skin cooling decreases capillary blood flow, so that accidental injection of local anesthetics into blood vessels may be reduced.

Disadvantages of skin cooling may include that it may decrease the clearance of local anesthetics and thus may unintentionally enhance the effects of a peripheral nerve block. In addition, as indicated in Fig. 3, skin cooling may not have a clinically meaningful inhibitory effect on pain in some patients, particularly in patients who would feel relatively low pain (*e.g.,* NRS 5 or less) without cooling. Furthermore, as stated above, cold stimulation may cause pain sensation in patients with chronic pain, and may not be suitable for patients with cold hypersensitivity.

Limitations of the study include that we did not compare the inhibitory effects of skin cooling and other methods, such as intradermal injection of a local anesthetic, or application of an anesthetic patch. In addition, neither the patient nor the practitioner was blind to the allocation. Therefore, there might have been a bias toward cooling treatment. This

could have been minimized using a placebo, but we rejected the use of a placebo (a non-iced ice pack), as the patient (as well as the practitioner who would touch the injection site) would easily tell if an iced or a non-iced pack was used. A systematic review on the inhibitory effect of cooling on pain by venous cannulation [1] has indicated that cooling spray has a significant and clinically meaningful analgesic effect, when compared with either placebo or with no treatment. Therefore, it is likely that cooling by ice was effective in inhibiting pain associated with peripheral nerve block for chronic pain in our study.

The cause of chronic pain, the baseline severity of chronic pain, and the type and dosage of oral medications for pain management may influence the degree of sensation of pain during needle puncture and during injection of local anesthetic. For example, in a patient with allodynia, pain by needle puncture and injection of a local anesthetic would be stronger, and cooling itself may evoke pain. In contrast, in a patient with chronic pain, pain by needle puncture might be more tolerated. We could not formally analyze these factors mainly because of a limited number of patients studied, but it appears from Fig. 3, there seem no marked differences in the inhibitory effect of cooling on pain between patients with and without oral medications.

We assessed the effect of skin cooling only once, so that it is not clear if the cooling method would be the same when the peripheral nerve blocks are repeated on different occasions. We only assessed the inhibitory effect of skin cooling during blocks to the face. Because epidermal pain threshold may be considerably different between different needle puncture sites [13], it is not clear if pain associated with a peripheral nerve block to the sites located other than the face would also be effectively inhibited by skin cooling.

In conclusion, we believe that, in patients receiving peripheral nerve blocks to the face, cooling of the puncture site of the skin may frequently inhibit pain during needle puncture and during injection of a local anesthetic.

Author contributions KM: This author made the study conception and design, proposal writing, data management, interpretation, as well as drafting and approving the final version of the manuscript. TA: This author made the study conception and design, proposal writing, data management, analysis and interpretation, as well as drafting and approving the final version of the manuscript. MT: This author helped in the study design, data collection, as well as approving the final version of the manuscript. RO: This author helped in the study design, data collection, as well as approving the final version of the manuscript. YO: This author helped in the study design, select patients for the study, data collection, as well as approving the final version of the manuscript.

Funding None.

Data availability Data are available from the authors.

Declarations

Conflict of interest TA is an Associate Editor-in-Chief of the *Journal of Anesthesia*. The other authors have no conflicts to declare.

References

1. Griffith RJ, Jordan V, Herd D, Reed PW, Dalziel SR. Vapocoolants (cold spray) for pain treatment during intravenous cannulation. Cochrane Database Syst Rev. 2016;4:CD009484.
2. Majidinejad S, Heidari F, Famil CA. Skin cooling to reduce the pain associated with local anesthetic injection; a randomized controlled trial. Archiv Acad Emerg Medi. 2022;10:e20.
3. Mahshidfar B, Cheraghi Shevi S, Abbasi M, Kasnavieh MH, Rezai M, Zavereh M, Mosaddegh R. Ice reduces needle-stick pain associated with local anesthetic injection. Anesth Pain Med. 2016;6:e38293.
4. Pagnucci N, Pagliaro S, Maccheroni C, Sichi M, Scateni M, Tolotti A. Reducing pain during emergency arterial sampling using three anesthetic methods: a randomized controlled clinical trial. J Emerg Med. 2020;58:857–63.
5. Jamalinik M, Hasheminik M, Paivar B, Khaleghipour M, Khorashadizadeh F, Bordbar R, Lakziyan R, Siavoshi M, Shafigh N. Comparative study of the effect of lidocaine spray and ice spray on the pain intensity during intramuscular injection: a randomized clinical trial. Pain Manag Nurs. 2023;24:229–34.
6. Rasooli F, Sotoodehnia M, Nejati A, Payandemehr P. The assessment of ice pack effect in pain reduction during digital nerve block: a randomized clinical study. Turk J Emerg Med. 2020;20:81–5.
7. Hijazi R, Taylor D, Richardson J. Effect of topical alkane vapocoolant spray on pain with intravenous cannulation in patients in emergency departments: randomised double blind placebo controlled trial. BMJ. 2009;338: b215.
8. Armstrong P, Young C, McKeown D. Ethyl chloride and venepuncture pain: a comparison with intradermal lidocaine. Can J Anaesth. 1990;37:656–8.
9. Tominaga M, Caterina MJ. Thermosensation and pain. J Neurobiol. 2004;61:3–12.
10. Myles PS, Myles DB, Galagher W, Boyd D, Chew C, MacDonald N, Dennis A. Measuring acute postoperative pain using the visual analog scale: the minimal clinically important difference and patient acceptable symptom state. Br J Anaesth. 2017;118:424–9.
11. Laigaard J, Pedersen C, Rønsbo TN, Mathiesen O, Karlsen APH. Minimal clinically important differences in randomised clinical trials on pain management after total hip and knee arthroplasty: a systematic review. Br J Anaesth. 2021;126:1029–37.
12. Salaffi F, Stancati A, Silvestri CA, Ciapetti A, Grassi W. Minimal clinically important changes in chronic musculoskeletal pain intensity measured on a numerical rating scale. Eur J Pain. 2004;8:283–91.
13. Masui K, Asai T. Differences in the epidermal pain threshold between different needle puncture sites. J Anesth. 2024;38:496–9.