Efficacy and Safety of Neurolytic Splanchnic Nerve Block via Transintervertebral Disc Approach to Retrocrural Space: A Multicenter Retrospective Study

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ABSTRACT

Introduction: Celiac plexus block is effective for treating intractable cancer pain and has been the focus of many studies. Several guiding techniques such as fluoroscopy, computed tomography, and endoscopy have been devised, and the target of the block has varied in previous studies as both the celiac plexus and splanchnic nerve, which is the main origin of the celiac plexus, have been targeted. At our affiliated institution, fluoroscopy-guided splanchnic nerve block with a single needle via transintervertebral disc approach is the first choice. However, there have been few reports on the use of this technique. This study investigated the efficacy and safety of this technique. Methods: This multicenter retrospective observational study reviewed the medical records of patients who underwent neurolytic splanchnic nerve block (NSNB) via transintervertebral disc approach for intractable cancer pain at five tertiary hospitals in Japan from April 2005 to October 2020. The primary outcome was the
Clinical success ratio of NSNB, and the secondary outcome was the incidence ratio of NSNB-related adverse events.

**Results:** In total, 103 patients were included in the analysis. Of these, 77 patients met the definition of clinical success, with a ratio of 74.8%. The incidence ratio of NSNB-related adverse events was 40.8% (hypotension, 21.4%; alcohol intoxication, 13.6%; diarrhea, 11.7%; and vascular puncture, 3.9%; duplicates were present). All adverse events improved with observation and symptomatic treatment only. No patient had infection or serious adverse events such as organ or nerve damage.

**Conclusions:** The clinical success ratio of this technique was 74.8%. Although the incidence of adverse events was 40.8%, all events were mild and no serious adverse events were observed. The findings demonstrate the efficacy and safety of our NSNB in patients with intractable cancer pain.

**PLAIN LANGUAGE SUMMARY**

In patients with intractable pain from abdominal cancer, fluoroscopy-guided neurolytic splanchnic nerve block via transintervertebral disc approach is an effective and safe procedure. It can be completed with a single needle puncture, and is anatomically less likely to cause organ or nerve damage compared with other approaches. The analgesia produced by this technique, along with conventional pharmacotherapy for cancer pain, may reduce opioid dose and its side effects and improve patients’ quality of life.

**Keywords:** Cancer pain; Fluoroscopically guided; Neurolytic splanchnic nerve block; Retrocrural space; Single needle; Transintervertebral disc approach technique

**INTRODUCTION**

Pain management in patients with cancer is important since pain is associated with insomnia, anxiety, depression, and decreased quality of life (QOL) [1, 2]. Pharmacotherapy is the primary treatment for cancer pain with opioids being commonly used [3]. High-dose opioids may be required for intractable cancer pain, such as with pancreatic cancer; however, they may cause grave side effects including somnolence, confusion, nausea and constipation,
dependence, and addiction resulting in decreased QOL of the patients [4, 5].

Celiac plexus nerve block relieves intractable cancer pain arising from the pancreas or other organs in close proximity. Its analgesic effect may reduce opioid dose and its resultant side effects, thereby improving patients’ QOL [4, 6]. Celiac plexus block has a long history, and numerous studies have reported the treatment of cancer pain caused by malignant abdominal tumors since the 1950s [7]. Initially, this block was performed with blind techniques; however, with advancements in technology, various needle tip guiding methods have been devised, including radiographic fluoroscopy, computed tomography (CT)-guided, and endoscopic methods, with improved safety and effectiveness [4, 8–10].

Celiac plexus block targets the celiac plexus located in front of the aorta, while splanchnic nerve block targets the splanchnic nerves within a compartment surrounded by the crura of the diaphragm, vertebral bodies, and aorta (retrocrural space; Fig. 1i). Clinically, the two techniques are considered to produce similar analgesia [11–13]. Conversely, when the splanchnic nerve block was additionally performed in 34 patients with pancreatic cancer with poor analgesia from the celiac plexus block, the efficacy ratio after 2 weeks was 76.5%, and it was reported that the splanchnic nerve block produced analgesia even when the celiac plexus block was ineffective [6]. Similarly, the celiac plexus block has been performed in a variety of methods, depending on the facilities available at each institution and the preference and experience of the practitioners [9, 14].

At our affiliated institution, fluoroscopy-guided splanchnic nerve block (Fig. 1) with a single needle using absolute alcohol (transintervertebral disc approach) is the first choice for performing the celiac plexus block. Compared with the anterior approach or paravertebral approach, the advantages of this technique include the requirement of only one fluoroscopy system, it can be completed with a single needle puncture, and anatomically it is less likely to cause organ/nerve damage [10, 12, 13, 15]. Specifically, it is technically simple and less invasive. Additionally, neurolytic splanchnic nerve block (NSNB) via the transintervertebral disc approach under fluoroscopic guidance is a relatively easy procedure for pain that can be administered by clinicians who are accustomed to fluoroscopic nerve blocks. However, reports on the efficacy and safety of this technique are scarce.

The purpose of this study was to investigate the clinical success ratio and the adverse events ratio of NSNB via the transintervertebral disc approach under fluoroscopic guidance, and to evaluate its efficacy and safety in patients with intractable cancer pain.

METHODS

Ethics Compliance

This study was approved by the ethics committees of the Yokohama City University Medical Center (approval no. B220400040; April 18, 2022), Yokohama City University Hospital (approval no. B220300073; April 18, 2022), Yokohama Municipal Citizen’s Hospital (approval no. 21-03-03; March 9, 2021), Kanagawa Cancer Center (approval no. 2021-39; July 12, 2021), and NTT Medical Center Tokyo (approval no. 21-146; March 2, 2022), Japan. The requirement for written informed consent was waived by the ethics committee because of the retrospective study design. The opportunity to withdraw consent was provided on the institutional websites. This study was conducted in accordance with the Declaration of Helsinki and good clinical practice guidelines and complied with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [16].

Study Design, Setting, and Patients

This was a multicenter retrospective observational study that analyzed the medical records of patients with cancer who underwent fluoroscopy-guided NSNB via the transintervertebral disc approach. The participants were selected from five institutions—Yokohama City University Medical Center, Yokohama City
University Hospital, Yokohama Municipal Citizen’s Hospital, Kanagawa Cancer Center, or NTT Medical Center Tokyo—between April 2005 and October 2020. The inclusion criteria were as follows: age 20 years or older, and patients with cancer who had undergone NSNB via the transintervertebral disc approach. Patients who underwent NSNB via approaches...
other the transintervertebral disc approach were excluded.

**Neurolytic Splanchnic Nerve Block: Transintervertebral Disc Approach to the Retrocrural Space Using a Single Needle**

In this study, patients indicated for NSNB were those who consulted the anesthesiologists at each institution for control of cancer pain. The patients were evaluated by anesthesiologists with expertise in interventional treatment, and deemed suitable for undergoing NSNB on the basis of their pain and imaging findings.

All procedures were performed by anesthesiologists specialized in pain intervention. All participants received NSNB using a standardized, fluoroscopically guided, transintervertebral disc approach technique to the retrocrural space with a single needle. The blocks were performed with patients in the prone position; a mild oblique or side lying position was adopted if the supine position was difficult because of pain. The patients were prepared by placing a sterile draping over their backs (Fig. 1i). Subsequently, the intervertebral discs ranging from T11 to L2 were observed under fluoroscopy and local anesthesia was delivered at the needle insertion sites (2.5–6.5 cm from the midline at the level of intervertebral discs T11–T12, T12–L1, or L1–L2). When we performed NSNB, left-sided puncture was our first choice. This is because the descending aorta is often located on the left side, and a left-sided puncture allows us to avoid the aorta from the direction of the needle (Fig. 1v is an example). Under fluoroscopic guidance, a 21-gauge, 15-cm needle was inserted through the predetermined site toward the intervertebral disc in a predetermined direction. When the tip of the needle encountered the disc, it was advanced until it penetrated the disc (Fig. 1ii). Penetration was confirmed when the depth of the needle coincided with the predetermined depth and by the loss-of-resistance technique using a syringe containing sterile saline (Fig. 1iii, iv). After verification of the placement of the needle tip through radiography, 10–30 ml of local anesthesia and contrast mixture were injected. After administering the local anesthetic and contrast mixture, we carefully checked that the contrast spread remained within the vertebral body on the anteroposterior view (Fig. 1vi, ix) and in front of the vertebral body on the lateral view (Fig. 1vii), and that there was no injection into arteries or veins. On confirming satisfactory pain relief and adequate spread of the contrast medium (Fig. 1vi, vii, ix), we performed a motor and sensory examination of the lower extremities after 15–20 min. These processes were implemented to prevent major organ damage during or after alcohol injection. Subsequently, a neurolytic agent (10–30 ml of absolute alcohol) was injected through the needle. During the administration of the absolute alcohol, we also carefully checked for the appearance of any new neurological findings. Following NSNB, patients were kept in the prone or supine position for at least 120 min [12].

**Measurement**

We extracted patient data from electronic medical records that included the following baseline characteristics: age, sex, body mass index (BMI), primary tumor site, extent of disease, metastatic locations, history of anticancer treatment, and Eastern Cooperative Oncology Group (ECOG) Performance Status score. ECOG Performance Status score describes a patient's level of functioning in terms of their ability to care for themself, daily activity, and physical ability (walking, working, etc.). Score 1—restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature, e.g., light housework, office work. Score 2—ambulatory and capable of all selfcare but unable to carry out any work activities; up and about more than 50% of the waking hours. Score 3—capable of only limited selfcare but unable to carry out any work activities; up and about more than 50% of the waking hours. Score 4—completely disabled; cannot carry out any selfcare; totally confined to a bed or chair [17]. Data on the following pain characteristics were retrieved from the records: pre-block numerical rating.
scale (NRS) scores, pain duration, pain therapy, opioid use duration, opioid dose (equivalent oral morphine dose), post-block NRS scores (lowest scores within 14 days after block), post-block pain therapy, post-block opioid dose (lowest equivalent oral morphine dose within 14 days after block). We defined clinical success as at least 50% reduction in NRS score without opioid escalation within 14 days after block. We investigated the clinical success ratio of NSNB, absolute alcohol, neurolytic agent, dose, and the ratio of NSNB-related adverse events. Baseline and pain characteristics were compared between clinically successful and unsuccessful groups.

**Outcome**

The primary outcome was the efficacy of NSNB via transintervertebral disc approach technique (ratio of patients with at least 50% reduction in NRS score without opioid escalation within 14 days after block).

The secondary outcome was the safety of NSNB via transintervertebral disc approach technique (incidence ratio of NSNB-related adverse events such as hypotension, alcohol intoxication, diarrhea, and vascular puncture).

**Statistical Analysis**

All statistical analyses were performed using JMP version 15 (SAS Institute Inc., Cary, NC, USA). Categorical and numerical data were analyzed using the chi-squared and Mann–Whitney U tests, respectively. Statistical significance was set at $P < 0.05$. We did not perform a sample size calculation because of the descriptive epidemiological nature of the study.

**RESULTS**

In total, 107 patients underwent fluoroscopy-guided NSNB at the five institutions. Four patients were excluded because of paravertebral approach from the beginning as a result of anatomical reasons that made transintervertebral disc approach difficult. Finally, 103 patients who underwent fluoroscopy-guided NSNB via transintervertebral disc approach were included. Of these, 77 patients met the definition of clinical success while in 26 patients, the block was clinically unsuccessful (Fig. 2).

The baseline characteristics of the 103 patients are presented in Table 1. The median age was 64 years (interquartile range [IQR], 52–72 years), and 60 patients (58.3%) were men.
The most common primary tumor site was the pancreas (60.2%). Metastatic disease was present in all patients (100.0%), with the most frequent locations being the lymph nodes (94.2%). Chemotherapy and/or biological therapy was the most frequently used (85.4%), followed by surgery, or radiation therapy. No anticancer treatment was received by 6.8%. The ECOG Performance Status scores were 2 and 3 in 50 (48.5%) and 29 patients (28.2%), respectively.

The pain characteristics of the 103 patients are shown in Table 2. Before the block, the median NRS score was 6 (IQR 5–8). All patients experienced pain; 10 (9.7%) had mild pain (NRS score 1–3), and 93 (90.3%) had moderate or severe pain (NRS score ≥ 4). The median pain duration was 158 days (IQR 72–310). Ninety-six patients (93.2%) were prescribed opioids, and seven patients (6.8%) were prescribed only non-opioids. The median equivalent oral morphine dose was 75 mg (IQR 30–160 mg). After the block, the median NRS score was 1 (IQR 0–3); 29 patients (28.1%) had no pain, 59 (57.3%) had mild pain (NRS score 1–3), and 15 (14.6%) had moderate to severe pain (NRS score ≥ 4). Ninety-two patients (89.3%) were prescribed opioids, and 11 patients (6.8%) were prescribed only non-opioids. The median equivalent oral morphine dose was 75 mg (IQR 24–150 mg).

Data of the 103 included patients are shown in Table 3. The clinical success ratio was 74.8%. The median absolute alcohol dose was 15 ml (IQR 10–16). The ratio of NSNB-related adverse events was 40.8%; 21.4% had hypotension, 13.6% had alcohol intoxication, 11.7% had diarrhea, and 3.9% had vascular puncture (duplicates were present). No patient had infection.
or serious adverse events such as organ damage or nerve damage (not shown in the table).

A comparison of clinically successful and unsuccessful groups is shown in Table 4. The median age was higher in the clinically successful group than in the clinically unsuccessful group (median age 64 vs. 53 years; \( P = 0.032 \)). Other variables, including the primary tumor site, were not statistically significantly different between the two groups. The median post-block NRS score and the median daily equivalent oral morphine dose post-block were lower in the clinically successful group than in the clinically unsuccessful group (median NRS 1 vs. 3.5, \( P < 0.001 \); median daily equivalent oral morphine dose post-block, 60 vs. 120 mg, \( P = 0.002 \)). The absolute alcohol dose and NSNB-related adverse events were also not statistically significantly different between the two groups.

### DISCUSSION

In this multicenter retrospective observational study, 77 of the 103 (74.8%) included patients with cancer showed clinical success after NSNB. The incidence of adverse events was 40.8%; however, none of the patients had any serious adverse events such as organ or nerve damage. To the best of our knowledge, this is the first multicenter retrospective study on the efficacy and safety of single-needle fluoroscopy-guided NSNB via transintervertebral disc approach using absolute alcohol.

At our affiliated institutions, fluoroscopic splanchnic nerve block [12, 13, 15] via transintervertebral disc approach with a single needle using absolute alcohol is the first choice for celiac plexus block (Fig. 1). Although the celiac plexus block may be performed in a variety of ways [8–10], there are three main advantages of the present technique. First, it can be performed using a fluoroscopy system alone. Although a CT image of the puncture level is necessary for

### Table 2 Pain characteristics of the patients

|                          | Pre-block data, number | Percentage | Post-block data, number | Percentage |
|--------------------------|------------------------|------------|-------------------------|------------|
| **NRS**                  |                        |            |                         |            |
| Median (IQR)             | 6 (5–8)                |            | 1 (0–3)                 |            |
| NRS 0                    | 0                      | 0.0        | 29                      | 28.1       |
| NRS 1–3                  | 10                     | 9.7        | 59                      | 57.3       |
| NRS ≥ 4                  | 93                     | 90.3       | 15                      | 14.6       |
| **Pain therapy**         |                        |            |                         |            |
| Opioids                  | 96                     | 93.2       | 92                      | 89.3       |
| Only non-opioids         | 7                      | 6.8        | 11                      | 10.7       |
| **Equivalent oral morphine dose, mg** |                  |            |                         |            |
| Median (IQR)             | 75 (30–160)            |            | 75 (24–150)             |            |
| **Pain duration, days**  |                        |            |                         |            |
| Median (IQR)             | 158 (72–310)           |            | –                       |            |
| **Opioid-use duration, days** |                    |            |                         |            |
| Median (IQR)             | 65 (29–169)            |            | –                       |            |

NRS numerical rating scale, IQR interquartile range
pre-block puncture planning [12], the NSNB itself can be performed with a fluoroscopy system alone without CT guidance [15]. Second, it can be completed with a single needle puncture. Requirement of fewer punctures may reduce the associated complications and the time required to perform the procedure [15, 18], thereby reducing patient burden. Third, anatomically, it is less likely to cause organ or nerve damage than the anterior approach or paravertebral approach [12, 13, 15]. We compared our approach (NSNB via transintervertebral disc approach) with other approaches, and the results are presented in Table 5. The paravertebral approach requires the needle to be at the widest insertion angle from the sagittal plane so that the needle often encounters the surrounding organs (liver, kidney, etc.), and this approach usually requires bilateral puncture. On the other hand, fewer important organs exist in the block route of transintervertebral disc approach, and a single puncture completes the splanchnic nerve block in many cases. Although the transaortic or anterior approach can be performed with only a single needle, aortic puncture and intra-abdominal organ injuries are inevitable. Therefore, this approach is technically simple and less invasive than other approaches [13, 15].

In this study, the efficacy of NSNB was comparable to that of previous studies, and the adverse events comparable or less. The definition of clinical success of NSNB in this study was set as at least 50% reduction in NRS score after the block without opioid escalation [5]. The definition of clinical success varied in previous studies. With the cutoff value of at least 50% reduction in NRS score after the block [19], 91 patients out of 103 patients in the present study fulfilled the condition, and the success ratio was 88.3% (data not shown). Similarly, previous studies have shown that the efficacy of this technique is comparable to that of fluoroscopy-guided celiac plexus block, which showed 70–90% success [9]. Furthermore, the ratio of NSNB-related adverse events (40.8%) was comparable to or lower than those of previous studies [4, 12, 19, 20]; all adverse events improved with observation and symptomatic treatment only. For example, temporary facial flushing and nausea, which were clinical symptoms of alcohol intoxication, could be treated only with IV fluids and antiemetic administration. In patients with suspected alcohol intolerance, the dose of absolute alcohol was limited to 10 ml. No patient had infection or serious adverse events such as organ damage or nerve damage (data not shown). Therefore, the safety of this technique has also been demonstrated. NSNB is an invasive procedure compared to pharmacotherapy. All cases in which NSNB was performed in non-opioid or opioid low-dose patients were cases in which NSNB was requested by the attending physician because of severe opioid side effects such as nausea, somnolence, and constipation, difficulty in increasing the opioid dose, opioid discontinuation, and poor pain control. In this study, NSNB was performed only on patients with cancer who understood the invasive procedure and wanted the block. Additionally, on comparing the pre-block data between clinically successful and unsuccessful groups, only age showed statistically significant difference. Good ECOG Performance Status score and low oral morphine equivalent before the block are reportedly predictors of a successful block [5]; however, the present results are different. The reason is unclear, and may be because younger

| Table 3 Data of the patients analyzed |
|-----------------|-----------------|
| Clinical success, n (%) | 77 | 74.8 |
| Absolute alcohol (neurolytic agent), ml |
| Median (IQR) | 15 (10–16) |
| NSNB-related adverse events* | 42 | 40.8 |
| Hypotension | 22 | 21.4 |
| Alcohol intoxication | 14 | 13.6 |
| Diarrhea | 12 | 11.7 |
| Vascular puncture | 4 | 3.9 |

NSNB neurolytic splanchnic nerve block, IQR interquartile range
*Duplicates were present
Table 4 Comparison between the clinically successful and unsuccessful groups

|                                | Clinically unsuccessful N = 26 | Clinically successful N = 77 | P value |
|--------------------------------|--------------------------------|------------------------------|---------|
| Age, years                     |                                |                              |         |
| Median (IQR)                   | 53 (46–69.8)                   | 64 (55.5–73)                 | 0.032   |
| Sex                            |                                |                              |         |
| Male (%)                       | 16 (61.5%)                     | 44 (57.1%)                   | 0.694   |
| BMI, kg/m²                     |                                |                              |         |
| Median (IQR)                   | 19.4 (17.6–21.5)               | 19.8 (17.4–21.0)             | 0.421   |
| Primary tumor site             |                                |                              |         |
| Pancreas (%)                   | 13 (50.0%)                     | 49 (63.6%)                   | 0.222   |
| Stomach (%)                    | 2 (7.7%)                       | 8 (10.4%)                    | 0.681   |
| Bile duct (%)                  | 0 (0%)                         | 6 (7.8%)                     | 0.142   |
| Gallbladder (%)                | 2 (7.7%)                       | 3 (3.9%)                     | 0.458   |
| Esophagus (%)                  | 2 (7.7%)                       | 1 (1.3%)                     | 0.125   |
| Liver (%)                      | 0 (0%)                         | 1 (1.3%)                     | 0.559   |
| Metastatic locations           |                                |                              |         |
| Lymph node (%)                 | 25 (96.2%)                     | 72 (93.5%)                   | 0.603   |
| Liver (%)                      | 11 (42.3%)                     | 42 (54.5%)                   | 0.280   |
| Lung (%)                       | 4 (15.4%)                      | 23 (29.9%)                   | 0.131   |
| Peritoneal (%)                 | 5 (19.2%)                      | 12 (15.6%)                   | 0.669   |
| Bone (%)                       | 1 (3.8%)                       | 5 (6.5%)                     | 0.603   |
| History of anticancer treatment|                                |                              |         |
| Chemotherapy and/or biological therapy (%) | 23 (88.5%) | 65 (84.4%) | 0.606 |
| Surgery (%)                    | 11 (42.3%)                     | 28 (36.4%)                   | 0.591   |
| Radiotherapy (%)               | 4 (15.4%)                      | 8 (10.4%)                    | 0.504   |
| None (%)                       | 1 (3.8%)                       | 6 (7.8%)                     | 0.465   |
| ECOG Performance Status Scale  |                                |                              |         |
| Median (IQR)                   | 2 (2–3)                        | 2 (2–3)                      | 0.546   |
| Pre-block data                 |                                |                              |         |
| NRS                            |                                |                              |         |
| NRS median (IQR)               | 6 (5–8.3)                      | 7 (5–8)                      | 0.917   |
| Pain duration, days            |                                |                              |         |
| Median (IQR)                   | 145.5 (48–310)                 | 164 (78–343)                 | 0.347   |

△ Adis
patients might have a lower threshold for pain. On the other hand, the post-block data between clinically successful and unsuccessful groups showed that the median post-block NRS score and the median daily equivalent oral morphine dose post-block were lower in the clinically successful group than in the clinically unsuccessful group.

There are two disadvantages of the transintervertebral approach to the retrocrural space. First, there is a risk of discitis, disc degeneration, or disc herniation because the puncture is made via the disc [12]. Flanagan and Chung reported that diagnostic discography did not initiate degenerative changes in the previously normal disc during a 10–20-year follow-up period [21]. Johnson et al. also found no evidence that diagnostic discography of the normal disc produced a herniation of nuclear material [22]. Since there were no reports of complications related to disc puncture in previous studies [12, 13, 15], and none in the present study, we consider that this is hardly a clinical issue. Second, the transintervertebral disc approach may be difficult because of bone or disc degeneration due to aging, or it may be difficult to inject the drug into the compartment because of tumor extension into the retrocrural space. In such patients, it is necessary to utilize a paravertebral approach or switch the target of the needle to the celiac plexus itself. In the present study, in four patients who were excluded from the analysis, the transintervertebral disc approach was considered difficult by preliminary CT evaluation, and paravertebral approach was utilized from the start (Fig. 2). Our basic stance on NSNB was to perform NSNB to a safe and reasonable extent rather than to complete the block. Therefore, we did not perform additional punctures in most cases if we found the contrast

### Table 4 continued

|                         | Clinically unsuccessful | Clinically successful | P value |
|-------------------------|-------------------------|-----------------------|---------|
| Median (IQR)            | 48.5 (18.5–138.5)       | 70 (34–208)           | 0.097   |
| Equivalent oral morphine dose, mg |                         |                       |         |
| Median (IQR)            | 90 (60–180)             | 75 (30–160)           | 0.158   |
| Post-block data NRS     |                         |                       |         |
| NRS median (IQR)        | 3.5 (1.8–6)             | 1 (0–2)               | < 0.001 |
| Equivalent oral morphine dose, mg |                         |                       |         |
| Median (IQR)            | 120 (60–180)            | 60 (15–120)           | 0.002   |
| Absolute alcohol (neurolytic agent), ml |                 |                       |         |
| Median (IQR)            | 15 (10–20)              | 15 (10–16)            | 0.959   |
| NSNB-related adverse events |                         |                       |         |
| Hypotension (%)         | 6 (23.1%)               | 16 (20.8%)            | 0.806   |
| Alcohol intoxication (%)| 3 (11.5%)               | 11 (14.3%)            | 0.724   |
| Diarrhea (%)            | 3 (11.5%)               | 9 (11.7%)             | 0.984   |
| Vascular puncture (%)   | 2 (7.7%)                | 2 (2.6%)              | 0.278   |

BMI body mass index, ECOG Eastern Cooperative Oncology Group, IQR interquartile range, NRS numerical rating scale, NSNB neurolytic splanchnic nerve block
covering only one side in our NSNB using a single needle. Even in cases where only one side was contrasted, our policy was not to force additional punctures but to ask the attending physician to control the residual pain with pharmacotherapy. Only in a few cases where the patient’s desire for additional blocks was strong, NSNB was performed again at a later date (data not shown).

The strengths of this study are uniformity in the techniques and drugs administered for splanchnic nerve block and the lack of intercenter variability. All NSNB procedures in this study involved the same fluoroscopic technique and neurolytic agent (absolute alcohol). They were performed by anesthesiologists who were trained in the same program and were similarly skilled in performing nerve blocks. Therefore, we consider the quality of the NSNBs in this study to be homogenous. In the future, it is hoped that this study will be used as a baseline before a randomized controlled trial of this approach is conducted.

This study had several limitations. First, the short-term results were obtained within 2 weeks after block administration; long-term outcome data were unavailable. Second, the decision to administer the NSNB was left to the discretion of individual clinicians. Third, all hospitals included in this study were tertiary hospitals, which may have resulted in a selection bias in patient backgrounds. Prospective studies are needed in the future.

CONCLUSIONS

The clinical success ratio of single-needle NSNB via the transintervertebral disc approach for cancer pain was 74.8%. Although the incidence of adverse events was 40.8%, all events were mild, and no serious adverse events were observed. The efficacy and safety of NSNB via the transintervertebral disc approach for patients with intractable cancer pain were demonstrated.
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**Authorship.** All named authors meet the International Committee of Medical Journal Editors (ICMJE) criteria for authorship for this article, take responsibility for the integrity of the work, and have given their approval for this version to be published.

**Author Contributions.** Ryota Yanaizumi contributed to study design. Ryota Yanaizumi, Yusuke Nagamine, Shinsuke Harada, Tomoko Kuramochi, Shuhei Ota, Yoichiro Abe, Masayuki Nakagawa, Kenya Kaminuma, Maya Hayashi, Toshiharu Tazawa, Kenichi Ogawa, and Takahisa Goto were responsible for data collection. Ryota Yanaizumi, and Yusuke Nagamine were involved in data analysis. All authors contributed to drafting and critically reviewing the manuscript. Ryota Yanaizumi, and Yusuke Nagamine were responsible for the preparation of the tables.

**Disclosures.** Ryota Yanaizumi, Yusuke Nagamine, Shinsuke Harada, Tomoko Kuramochi, Shuhei Ota, Yoichiro Abe, Masayuki Nakagawa, Kenya Kaminuma, Maya Hayashi, Toshiharu Tazawa, Kenichi Ogawa, and Takahisa Goto declare that they have nothing to disclose.

**Compliance with Ethics Guidelines.** This clinical study was conducted in accordance with the Declaration of Helsinki and the good clinical practice guidelines. Our observational study complied with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement. This retrospective observational study was approved by the ethics committees of the Yokohama City University Medical Center (B220400040; April 18, 2022), Yokohama City University Hospital (approval no. B220300073; April 18, 2022), Yokohama Municipal Citizen’s Hospital (approval no. B220300073; March 9, 2021), Kanagawa Cancer Center (approval no. 2021-39; July 12, 2021), and NTT Medical Center Tokyo (approval no. B220300073; March 2, 2022), Japan. The requirement for written informed consent was waived by the ethics committee because of the retrospective nature of the study. The opportunity to withdraw consent was provided on the institutional websites.

**Data Availability.** The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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