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The effect of the type of anesthesia on the quality of postoperative recovery after orthopedic forearm surgery

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Background: Although the quality of postoperative recovery may be affected by factors, there are few investigations whether the type of anesthesia also affects it. In this single-blinded, prospective, observational study, we compared the quality of postoperative recovery in patients undergoing orthopedic forearm surgery under general or regional anesthesia (brachial plexus block).

Methods: Ninety-seven subjects, aged 18–65 years and American Society of Anesthesiologists physical status I or II, undergoing orthopedic forearm surgery, were allocated to general or regional anesthesia group. The quality of postoperative recovery was assessed using a validated Korean version of Quality of Recovery-40 (QoR-40K) questionnaire. Patients were surveyed three times, the day before surgery (baseline) and 1st and 7th day after the surgery, and the scores of both groups were compared.

Results: We analyzed 47 and 50 patients in general and regional anesthesia, respectively. The global QoR-40K score and those of each of its five dimensions were not significantly different between the two groups at baseline, 1st and 7th day postoperatively. In two-way RM ANOVA, the global QoR-40K score at postoperative 1st day was significantly lower than that of baseline ($P < 0.001$) and postoperative 7th day ($P < 0.001$), respectively, in both general and regional anesthesia groups. However, there was no significant difference at each timepoint between the two groups.

Conclusions: The present study suggests that brachial plexus block with intravenous dexmedetomidine infusion does not improve the quality of postoperative recovery compared to sevoflurane inhalation anesthesia with remifentanyl infusion in patients undergoing orthopedic forearm surgery.

Keywords: General anesthesia; General surgery; Orthopedic surgery; Postoperative recovery; Quality; Regional anesthesia.

Introduction

Postoperative recovery is one of the major concerns for patients undergoing surgery. Most patients expect fast recovery of function following anesthesia and surgery, but in some instances, delayed postoperative recovery may cause a patient discomfort, a longer hospital stay, a delayed return-to-work, and increased health care costs. In the past, postoperative morbidity or mortality had been the major concerns associated with postoperative recovery outcomes. However, consistent with the current trends in the advanced health care system, the concept of patient-centered care has emerged as the primary approach for improving quality and safety of medical care services. In this context, patient-focused quality of postoperative recovery has been recognized as one of the most

important considerations in perioperative medicine.

Although the quality of postoperative recovery may be affected by several factors, such as the choice of anesthetic drugs [1,2], administration of a nerve block for postoperative analgesia [3–5], or several multimodal anesthetic or analgesic medications or interventions [6–9], there are few studies that have investigated whether the type of anesthesia (general vs. regional anesthesia) used affects the quality of postoperative recovery. The brachial plexus block is the most commonly used regional anesthesia method for upper extremity surgeries. The benefits of brachial plexus block are well known to reduce postoperative pain and opioid consumption and to improve intraoperative hemodynamic stability and patient satisfaction [10,11]. However, it is unknown whether a brachial plexus block positively affects the patient-focused quality of postoperative recovery or not.

In the present study, we hypothesized that the quality of postoperative recovery in patients undergoing orthopedic forearm surgeries would be better with brachial plexus block than with general anesthesia.

Materials and Methods

This study was approved by the Institutional Review Board of Chonbuk National University Hospital (CUH 2017-09-005) and registered at WHO International Clinical Trials Registry Platform (KCT0003503). After obtaining the written informed consent, 119 patients, aged 18–65 years and American Society of Anesthesiologists physical status I or II, who were undergoing orthopedic forearm surgeries during the period between November 2017 and April 2019 were enrolled in this single-blinded, prospective, observational study. Patients with a literacy problem, language difficulties, a history of psychotic disorder, allergic reactions to local anesthetics, or coagulation abnormalities were excluded from this study. The subjects were allocated to either the general or regional anesthesia group per anesthesiologist's decision based on each patient's medical condition and their preferred anesthesia method without randomization. The anesthetic regimen was standardized for both the general and regional anesthesia groups. On arrival in the operating room, standard anesthetic monitoring including electrocardiogram, pulse oximetry, and noninvasive blood pressure was employed in all subjects regardless of the allocated group. In addition, in the general anesthesia group, bispectral index (BIS) monitoring was employed in order to optimize the depth of anesthesia.

General anesthesia was induced with 1.5–2.5 mg/kg of propofol and 0.3–0.8 mg/kg of rocuronium, and effect-site concentration of 1–3 ng/ml remifentanyl was infused using a target-controlled

infusion pump (Orchestra® Base Primea, Fresenius Vial, France). Anesthesia was maintained with sevoflurane 1–4 vol% in 50% oxygen and remifentanyl 1–3 ng/ml in order to maintain non-invasive arterial pressure and heart rate within preanesthetic values. i-gel (i-gel™; Intersurgical Ltd., UK) or endotracheal tube was used for securing the airway during surgery. End-tidal carbon dioxide partial pressure and BIS value were maintained at 30–35 mmHg and 40–65, respectively. Once the surgery was completed, the administration of the anesthetics was stopped, and a residual neuromuscular block was antagonized with neostigmine 50 µg/kg and glycopyrrolate 10 µg/kg at the appearance of the second twitch response (T2) during the train-of-four count.

In the regional anesthesia group, the patients were premedicated with midazolam 1–2 mg intravenously. After the usual sterile preparation, the patients were scanned with a 13–6 MHz linear array transducer (EDGE® ultrasound machine, Sonosite Inc., USA) in order to identify the brachial plexus lying anterolateral to the subclavian artery in the supraclavicular fossa. Under the guidance of real-time ultrasonography, a 25-gauge, 5 cm short-bevel needle was inserted toward the brachial plexus using an in-plane technique and a lateral to medial direction. In the current study, as has been described in previous studies, half the volume of lidocaine 1.5% with epinephrine 5 µg/ml (16 ml) was injected into the main neural cluster, following which, the remaining half (16 ml) was injected into every single satellite neural cluster for a targeted intracluster injection [12,13]. All procedures were performed by a single skilled anesthesiologist (Dr. A.R. Doo) with experience of regional anesthesia for more than 5 years.

Subsequently, the extent of sensory blockade was evaluated via a pinprick test along the musculocutaneous, median, radial, and ulnar distribution every 5 min intervals until a successful blockade was confirmed, which was defined as complete loss of pinprick sensation. After successful blockade was confirmed, an intravenous dexmedetomidine infusion was started (loading 1 µg/kg over 10 min followed by 0.2–0.6 µg/kg/h), and 3 L/min of oxygen was supplied via a nasal cannula. During the operation, the target Modified Observer's Assessment of Alertness/Sedation scale (MOAA/S) 3–4, which presented moderate sedation, was maintained by titrating the dose of infusion (MOAA/S, 5 = responds readily to name spoken in normal tone, 4 = lethargic response to name spoken in normal tone, 3 = responds only after name is called loudly or repeatedly, 2 = responds only after mild prodding or shaking, 1 = responds only after painful trapezius squeeze, 0 = no response after painful trapezius squeeze).

In both groups, the hemodynamic parameters including the noninvasive blood pressure, heart rate, and peripheral oxygen saturation were recorded until the end of the surgery. The adverse

events including bradycardia (heart rate < 50 bpm) and hypotension (systolic blood pressure < 90 mmHg or a decrease more than 30% of baseline value) were recorded and treated with intravenous atropine 0.5 mg and ephedrine 5–10 mg, respectively. All the patients routinely received ketorolac 30 mg and nefopam 20 mg intravenously during the skin closure for postoperative pain management. During postoperative recovery in the postanesthesia care unit (PACU), pain (Numeric rating scale [NRS] ≥ 4 using 11-point scale, 0 = no pain, 10 = worst pain imaginable) was treated with fentanyl 1 $\mu\text{g}/\text{kg}$ increments every 5 min. The NRS score, total fentanyl consumption, and development of postoperative nausea and vomiting (PONV) were recorded. The patients were discharged to the ward when the modified Aldrete score was 9 or more.

Assessment of quality of postoperative recovery

The quality of postoperative recovery was assessed using a validated Korean version of Quality of Recovery-40 (QoR-40K) questionnaire [14]. QoR-40K is composed of 40-items of five dimensions including emotional state, physical comfort, psychological support, physical independence and pain [14,15]. Each item is rated on a 5-point Likert scale (1 = none of the time, 2 = some of the time, 3 = usually, 4 = most of the time, 5 = all of the time), and the global score ranges from 40 to 200. The patients were surveyed at three timepoints, the day before the surgery (baseline), 24 h after the surgery, and 7 d after the surgery (after discharge). The primary outcomes were the QoR-40K results. At the 24-h timepoint after the surgery, the patients were asked to fill the QoR-40K questionnaire similar to during the baseline evaluation that was conducted in the patient's ward. Meanwhile, on the 7th day after the surgery, QoR-40K was evaluated again via a telephone call between 4 and 6 pm by a single investigator, Dr. S.R. Kang who was blinded to the allocated groups.

Statistical analysis

The primary outcome was the global QoR-40K score evaluated on the 1st day postoperatively. For the two groups, a sample size of 51 subjects each was estimated to achieve 80% power to detect a 6.3-point difference in the QoR-40 score. A 6.3-point difference was identified by a previous study to be the minimal clinically important difference (MCID) in the QoR-40 score [16]. Considering the dropout rate of 20%, the sample size was enlarged to 123 patients. All the descriptive statistics are expressed as mean \pm standard deviation (SD), median (25th–75th percentile), percentage or the number of patients. Continuous variables including QoR-

40K scores were analyzed with Student's t-test or Mann-Whitney rank-sum test after a normality test, and categorical variables including opioid usage and incidence of PONV were analyzed using Chi-square test.

The QoR-40K scores of both groups were analyzed with two-way repeated measures analysis of variance (RM ANOVA) with spherical test, and the Bonferroni t-test was used for post-hoc analysis. All statistical analyses were performed using SigmaPlot version 12.5. (Systat Software Inc., USA), and P values < 0.05 were considered statistically significant.

Results

The details of subject flow are shown in Fig. 1. Among the 119 patients who were enrolled, 97 patients (47 in the general anesthesia group and 50 in the regional anesthesia group) completed the study, and their results were analyzed. Among the 22 patients excluded from the study in both group, two patients were excluded due to the incomplete motor and sensory block in the regional anesthesia group. Patients' demographics and clinical characteristics were not different between the two groups except anesthesia maintenance time (Table 1). Although there was no significant difference in both surgery time and anesthesia induction time between the two groups, the anesthesia maintenance time was significantly longer in the general anesthesia group compared to that in the regional anesthesia group ($P = 0.019$).

Postoperative quality of recovery was not significantly different between two groups. The global QoR-40K scores and each score of the five dimensions were not significantly different between the two groups at preoperative, postoperative 1st and 7th day (Table 2). In two-way RM ANOVA and Bonferroni post-hoc analysis, global QoR-40K score on the postoperative 1st day was significantly lower than that of preoperative baseline ($P < 0.001$) and postoperative 7th day ($P < 0.001$), respectively, in both general and regional anesthesia groups. However, there was no significant difference at each timepoint between the two groups (Fig. 2).

The regional anesthesia group exhibited better recovery profile in the PACU than the general anesthesia group (Table 3). Pain score and opioid consumption in the PACU were lower in the regional anesthesia group than in the general anesthesia group, respectively ($P < 0.001$ and $P < 0.001$). Additionally, the incidence of PONV was 10.6% in the general anesthesia group while none of the patients experienced PONV in the regional anesthesia group in PACU ($P = 0.024$). The duration of PACU stay was significantly shorter in the regional anesthesia group than in the general anesthesia group ($P = 0.018$).

The hemodynamic parameters including mean arterial pres-

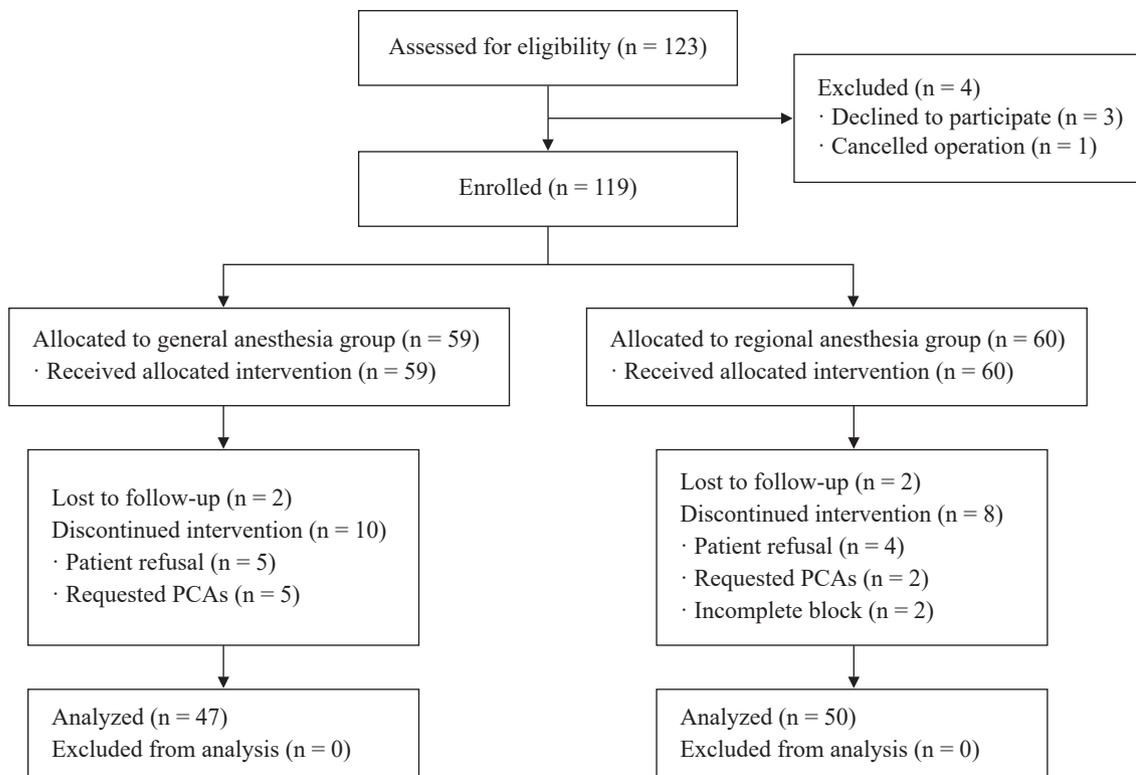


Fig. 1. Subject flow diagram.

Table 1. Patient Demographics and Clinical Characteristics

	General group (n = 47)	Regional group (n = 50)	P value
Sex (M/F)	26/21	29/21	0.951
ASA PS (I/II)	31/16	39/11	0.273
Age (yr)	44.0 (32.0–54.0)	41.5 (29.5–56.0)	0.860
BMI (kg/m ²)	24.8 ± 4.2	24.2 ± 3.6	0.486
Surgery time (min)	45.0 (25.0–70.0)	35.0 (24.5–61.3)	0.088
Anesthesia maintenance time (min)	90.0 (65.0–110.0)	65.0 (50.0–100.0)	0.019*
Anesthesia induction time (min)	25.0 (23.0–30.0)	27.0 (20.0–30.0)	0.802
Type of surgery			0.215
Fracture correction	2	3	
Hard ware removal	10	5	
Arthroscopic surgery	17	15	
Tendon/ligament repair	7	5	
Carpal tunnel release	5	3	
Mass excision	5	14	
Others	1	5	
Surgical side			
Dominant/non-dominant arm	28/19	30/20	0.869
Duration of hospital stay (days)	6.0 (5.0–8.0)	6.0 (5.0–8.0)	0.437

Values are presented as number of patients, mean ± SD or median (25th–75th percentile). ASA PS: American society of anesthesiology physical status; BMI: body mass index. Anesthesia maintenance time: time elapsed from the beginning to the end of anesthesia. Anesthesia induction time: time elapsed from the beginning of anesthesia induction to the beginning of the surgery.

Table 2. Quality of Postoperative Recovery by QoR-40K Scores

	Range	General group	Regional group	P value
Preoperative				
Global QoR-40K	40–200	177.0 (166.0–191.0)	182.5 (172.8–193.5)	0.201
Physical comfort	12–60	57.0 (52.0–59.0)	56.0 (53.0–59.3)	0.585
Emotional status	9–45	39.0 (37.0–43.0)	40.0 (38.0–43.0)	0.408
Physical independence	5–25	22.0 (20.0–25.0)	22.5 (19.0–25.0)	0.826
Psychological support	7–35	32.0 (27. –35.0)	33.0 (08.8–35.0)	0.764
Pain	7–35	31.0 (29.0–34.0)	33.0 (30.8–35.0)	0.067
Postoperative day 1				
Global QoR-40K	40–200	169.0 (143.0–185.0)	175.0 (158.0–186.5)	0.158
Physical comfort	12–60	52.0 (48.0–56.0)	55.0 (52.0–58.0)	0.059
Emotional status	9–45	39.0 (33.0–42.0)	41.0 (37.0–43.3)	0.068
Physical independence	5–25	18.0 (11.0–22.0)	17.5 (14.0–21.0)	0.685
Psychological support	7–35	31.0 (28.0–34.0)	33.0 (27.0–35.0)	0.572
Pain	7–35	30.0 (26.0–33.0)	31.5 (29.0–34.0)	0.140
Postoperative day 7				
Global QoR-40K	40–200	181.5 (171.3–196.0)	189.0 (182.8–196.4)	0.207
Physical comfort	12–60	57.0 (54.0–60.0)	58.0 (55.0–60.0)	0.507
Emotional status	9–45	41.0 (38.0–44.0)	42.5 (40.0–45.0)	0.101
Physical independence	5–25	21.0 (19.0–25.0)	22.0 (19.8–25.0)	0.834
Psychological support	7–35	33.3 (29.8–35.0)	35.0 (31.5–35.0)	0.463
Pain (7–35)	7–35	33.0 (31.0–34.0)	34.0 (31.8–35.0)	0.145

Values are presented as median (25th–75th percentile). QoR-40K Scores: Korean version of Quality of Recovery-40.

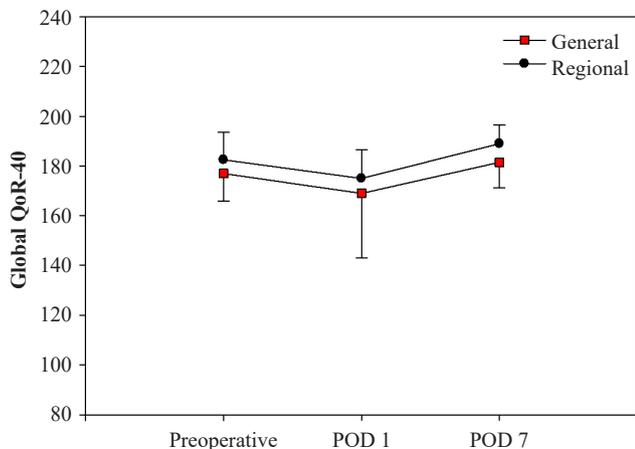


Fig. 2. Quality of Recovery-40 (QoR-40) scores between General and Regional anesthesia groups. There was no significant difference between the two groups at each time point by two-way RM ANOVA and Bonferroni post-hoc analysis. In General anesthesia group, global QoR-40 score at postoperative 1st day was significantly lower than that of preoperative baseline ($P < 0.001$) and postoperative 7th day ($P < 0.001$), respectively. In Regional anesthesia group, global QoR-40 score at postoperative 1st day was significantly lower than that of preoperative baseline ($P < 0.001$) and postoperative 7th day ($P < 0.001$), respectively.

ures and heart rates were remained stable during the operation and PACU stay although there were significant differences between two groups at certain timepoints of measurement. Mean arterial pressures and heart rates were significantly lower in the general anesthesia group compared to the regional anesthesia group at skin incision and 10 min after skin incision, respectively. And mean arterial pressures were significantly lower in the regional anesthesia group compared to the general anesthesia group at PACU admission and 30 min after PACU admission. However, in both group, there were no incidence of hypotension or bradycardia during the operation and PACU stay (Fig. 3).

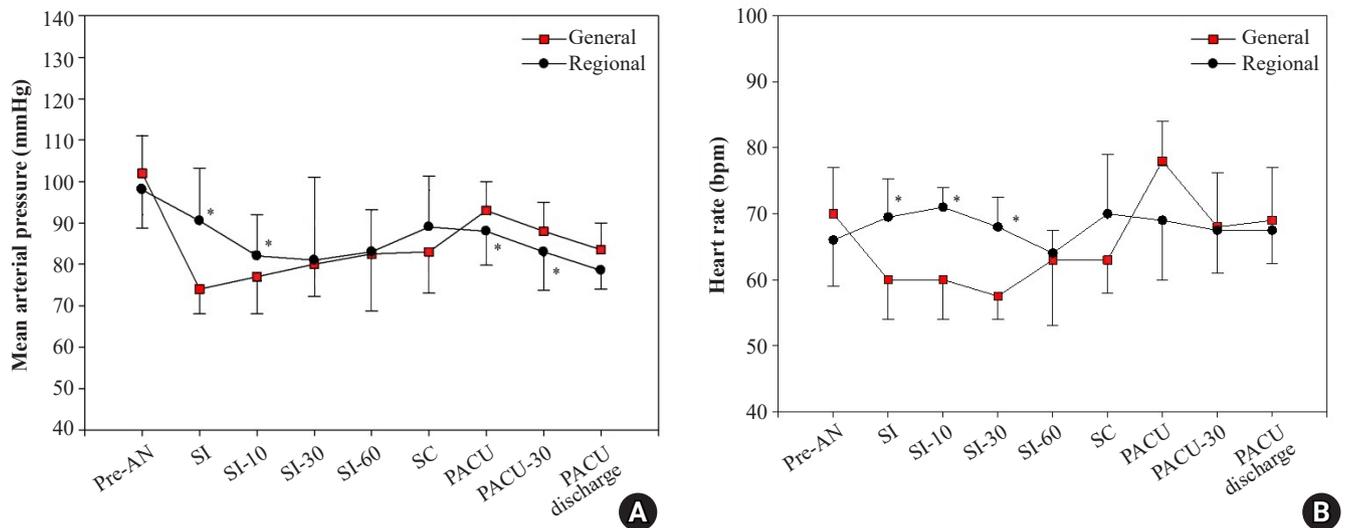
Discussion

The results of the present study suggest that the type of anesthesia (general vs. regional anesthesia) does not affect patient-focused quality of postoperative recovery in patients undergoing orthopedic forearm surgery. Generally, postoperative recovery involves an initial abrupt decline in function followed by progressive recovery toward the preoperative state or to a new equilibrium state. The time period required for complete postoperative recovery is extremely diverse and depends on the type of surgery, surgical invasiveness, patient’s medical condition, and other factors.

Table 3. Recovery Profile in Postanesthesia Care Unit

	General group (n = 47)	Regional group (n = 50)	P value
Pain score (NRS; 0-10)	3 (2-4)	0 (0-0)	< 0.001*
Opioid usage [n (%)]	14 (29.8)	0 (0)	< 0.001 [†]
Cumulative fentanyl consumption (μg)	0 (0-52)	0 (0-0)	< 0.001*
PONV [n (%)]	5 (10.6)	0 (0)	0.024 ^{††}
Duration of PACU stay (min)	65.0 (60.0-90.0)	60.0 (50.0-70.0)	0.018*

NRS: numeric rating scale, n: number of patients, PONV: postoperative nausea and vomiting, PACU: postanesthesia care unit. *by Rank-sum test, [†]by Chi-square test, ^{††}by Fisher's exact test.

**Fig. 3.** Hemodynamic parameters during surgery and in PACU. (A) Mean arterial pressures, (B) Heart rates.

*There were significant differences in mean arterial pressures and heart rates between two groups by two-way RM ANOVA and Bonferroni posthoc analysis. bpm; beats per minutes, Pre-AN: pre-anesthesia, SI: skin incision, SI-10: 10 minutes after skin incision, SI-30: 30 minutes after skin incision, SI-60: 60 minutes after skin incision, SC: skin closure, PACU: postanesthesia care unit admission, PACU-30: 30 minutes after PACU admission.

Although patient-focused quality of postoperative recovery is a complex outcome involving physiological, physical, functional, emotive, and nociceptive aspects, the authors assumed that the postoperative pain could potentially be the most important aspect involved in all of them during the early recovery stage. Several authors have reported that regional anesthesia provides significant benefits during the early recovery stage corresponding to the pain score, opioid consumption, opioid-related adverse effects, and length of hospital stay in comparison with general anesthesia [11,17]. Based on this, the authors hypothesized that patient-focused quality of postoperative recovery in patients undergoing orthopedic forearm surgery would be better with regional anesthesia than general anesthesia in the present study. However, the QoR-40K score was comparable between the general and regional anesthesia group during both the early recovery stage (postoperative 1st day) and late recovery stage (postoperative 7th day), even though the recovery profile including the pain score, opioid consumption and opioid-related complications in the PACU in the

regional anesthesia group was superior to that in the general anesthesia group. To the best of our knowledge, this is the first investigation that evaluates the effect of the type of anesthesia on patient-focused quality of postoperative recovery in patients undergoing orthopedic forearm surgery.

There has been a concept of enhancing the quality of medical care such as quality improvement program and Joint Commission International standards [18]. Traditionally, the quality of medical care has been based on providers-focused outcomes such as the survival rate, surgical mortality, or cost-effectiveness. However, patient-centered and patient-reported quality of medical care service has been a recent focus. For instance, the QoR-40 is a widely-used, patient-centered, self-rated questionnaire for assessing a patient's health status postoperatively, and several versions of this questionnaire in different languages have been validated [15,19-21]. QoR-40K, especially, has recently been demonstrated to be a valid, reliable and feasible tool that is used to evaluate Korean surgical patients [14]. QoR-40 is composed of 40-items of five di-

mensions including emotional state, physical comfort, psychological support, physical independence and pain. All the items are scored on a 5-point Likert scale, and consequently, the global score ranges from 40 to 200. Among the five dimensions, the items corresponding to physical independence may be influenced by the surgery of the dominant arm, because the inquiries include the ability to perform usual home activities such as brushing teeth or writing. Therefore, in the current study, we investigated whether the surgery was performed on the dominant forearm or not (Table 1).

Several studies including the current study simply compare the means of QoR-40 scores between the two groups [1–3]. However, a consensus on a statistical-analytical method that can be employed to assess a patient's recovery after surgery using QoR-40 scores has not been well established. Several statistical methods such as distribution-based statistics of an individual's change score or evaluation using predetermined threshold value or an estimated MCID has been recommended [16]. Furthermore, the timing of the recovery assessment differs amongst researches or tools. Most of the studies that assessed the QoR-40 scores limited their assessment to 24 h after the surgery. In the current study, in addition to assessing the QoR-40K scores at this timepoint, the authors assessed them at the one week timepoint after the surgery (after discharge) via telephone call in order to evaluate the restoration of functional activities in a daily living environment. Future studies should focus on the development of an accurate, reliable and valid methodology to assess postoperative recovery via the QoR-40 scoring system.

Meanwhile, one of the major concerns associated with regional anesthesia is how to shorten the duration of time that is required to perform the blocks while providing profound anesthesia and analgesia during surgery. As is well known, the application of ultrasound during a peripheral nerve block reduces the minimum effective analgesic volume, shortens the onset time, and increases the rate of successful blocks [22]. When compared with the axillary block, the supraclavicular approach has distinct advantages including faster onset, clear and simple sonoanatomy, and profound sensory and motor block with a lower volume of the local anesthetics via a single injection [12,23]. Furthermore, the ultrasound-guided targeted intracluster-injection method that was used in the current study has been reported to result in a quicker onset than other injection methods, such as the traditional corner pocket approach [13,24]. For these reasons, anesthesia induction time was not significantly different between the general and regional anesthesia groups in the present study.

Dexmedetomidine, a highly selective alpha-2 agonist, manifest sedative, sympatholytic, amnestic and analgesic properties. In our

standard clinical practice, dexmedetomidine is routinely administered intravenously for sedation during surgery under regional anesthesia, because it provides a reliable and predictable level of sedation and better analgesia without respiratory complications. Moreover, the efficacy of dexmedetomidine in regional anesthesia is well established that improves the quality of regional anesthesia and prolongs the duration of analgesia when administered either intravenously or perineurally. Lidocaine, which was used in the present study, is a frequently used local anesthetic drug for regional anesthesia practice because of its rapid onset of anesthesia and its safety; however, its limitation is a short duration of anesthesia. In the current study, even though the duration of postoperative analgesia was not evaluated, prolonged analgesia was expected due to the application of brachial plexus block and the additional administration of dexmedetomidine in the regional anesthesia group. Nevertheless, better recovery profile in PACU including lower pain score, reduced opioid consumption and lower incidence of PONV in the regional anesthesia group did not positively affect the quality of postoperative recovery during the early postoperative recovery phase when compared to in the general anesthesia group.

There are study limitations. First, the present study was a prospective observational study without randomization. The authors assumed that patient-focused quality of recovery could be heavily influenced by the patient's expectation or a previous experience associated with anesthesia. For example, if the patient received general anesthesia despite a strong preference for regional anesthesia, the patient satisfaction and patient-focused quality of recovery may be diminished. Second, as mentioned above, although lidocaine that was used in the present study is safe and brings on rapid onset of anesthesia, it yields a short duration of anesthesia. The use of long acting local anesthetics, which manifest long duration of analgesia, may affect the quality of postoperative recovery. Third, surgery-related outcomes including complication rates were not investigated in the present study. The effect of type of anesthesia on the surgical outcomes is still controversial. The overall provider- and patient-focused postoperative recovery outcome would be investigated in the future study. Fourth, the current study is limited by too small sample size to detect a difference of each scores of the five dimensions as well as the global QoR-40K score in both groups.

In conclusion, brachial plexus block with intravenous dexmedetomidine infusion does not appear to improve patient-focused quality of postoperative recovery compared to sevoflurane inhalation anesthesia with remifentanyl infusion in patients who are undergoing orthopedic forearm surgery.

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Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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