Medicine®

Quality of postoperative recovery after upper-arm vascular surgery for hemodialysis in patients with end-stage renal disease: A prospective comparison of cervical epidural anesthesia vs general anesthesia

Hobum Cho, MD[a], Hyerim Kwon, MD[a], Sanghoon Song, MD[a], Jaehwa Yoo, MD[a], Mungyu Kim, MD, PhD[a], Sunyoung Park, MD, PhD[a], Jiwon Chung, MD, PhD[a], Sangho Kim, MD, PhD[a], Suyeon Park, MS[b], Siyoung Ok, MD, PhD[a],*

Abstract

Cervical epidural anesthesia (CEA) is generally not used during upper-arm vascular surgery for hemodialysis in end-stage renal disease (ESRD) patients, despite its advantages. The Quality of Recovery-40 questionnaire (QOR-40) has been validated as a tool for assessing the degree of recovery after surgery. We hypothesized that CEA could provide a better outcome on the QOR-40 than general anesthesia after upper-arm vascular surgery for hemodialysis in ESRD patients.

We divided anesthetic methods into general anesthesia and CEA. The QOR-40 was administered to 70 patients on the night before surgery and at 24 hours after surgery. Additional data, including consumption of opioid analgesics, occurrence of postoperative nausea and vomiting, and scores on a numeric rating scale (NRS) were collected.

The total QOR-40 scores of the two groups differed significantly ($P = .024$) on postoperative day 1. Opioid consumption ($P = .005$) and occurrence of postoperative nausea ($P = .019$) in the post-anesthesia care unit (PACU) were significantly lower in the CEA group, whose NRS scores were significantly lower in the PACU ($P < .001$) and at postoperative day 1 ($P = .016$).

Assessment of postoperative quality of recovery after upper-arm vascular surgery in ESRD patients showed that the CEA group had significantly better total QOR-40 and NRS scores. CEA could be used as an alternative anesthetic technique for upper-arm vascular surgery for hemodialysis in ESRD patients to improve the quality of recovery.

Abbreviations: CEA = cervical epidural anesthesia, ESRD = end-stage renal disease, NRS = numeric rating scale, PACU = post-anesthesia care unit, PCA = patient-controlled analgesia, POD = postoperative day, PONV = postoperative nausea and vomiting, QOR-40 = Quality of Recovery-40 questionnaire.

Keywords: cervical epidural anesthesia, quality of recovery, upper arm surgery

1. Introduction

Cervical epidural anesthesia (CEA) is conventionally performed for pain control in the head and neck or upper arm. Nevertheless, it is not commonly used for regional anesthesia. Epidural anesthesia is associated with several potential complications (local anesthetic administration into the subarachnoid space, bleeding with subsequent epidural hematoma formation, infection [epidural abscess], and severe central nervous system complications).[1–3] Whereas, CEA offers a simple procedure, improved safety, increased hemodynamic stability, and low postoperative morbidity during carotid artery and breast surgery.[4–6]

In end-stage renal disease (ESRD) patients, general anesthesia carries a high risk for post-anesthesia complications because of concomitant diseases such as coronary artery disease, diabetes mellitus, and hypertension.[7] Therefore, regional anesthesia, especially using brachial plexus block, may be a preferred alternative for vascular access surgery in ESRD patients, compared to general anesthesia.[8–10] However, the use of CEA for regional anesthesia in upper-arm vascular surgery for hemodialysis in ESRD patients has not been well-described.

As the development of anesthesia and surgical techniques has improved, assessment of the quality of recovery has become an important outcome, in addition to post-anesthesia complications. The Quality of Recovery-40 questionnaire (QOR-40) has been validated as a tool for assessing the degree of recovery after several different surgical and anesthetic techniques.[11] We hypothesized that CEA would have an improved QOR-40 outcome, compared to general anesthesia, after upper-arm vascular surgery for hemodialysis in ESRD patients.

In this study, we compared the quality of recovery outcomes between general anesthesia and CEA, using the QOR-40. The primary outcome of this study was a comparison of the QOR-40 scores of 2 anesthetic techniques (general anesthesia and CEA) at postoperative day (POD) 1. Secondary outcomes in this study were differences in consumption of opioid analgesics, occurrence of postoperative nausea and vomiting (PONV), and scores on the numeric rating scale (NRS) between the two groups.

2. Methods

To compare the effects of CEA vs general anesthesia on postoperative quality of recovery, a prospective data collection was performed from October 2016–April 2017 at Soonchunhyang University Hospital, Seoul, Republic of Korea. The study was approved by the Soonchunhyang University Hospital Institutional Review Board (IRB number: SCHUH2016–05–005). Written informed consent was obtained from all participants.

2.1. Study population

The inclusion criteria were as follows: age 32 to 65 years, American Society of Anesthesiologists physical status III, and decision to undergo elective upper-arm vascular surgery for hemodialysis. Exclusion criteria included history of alcohol or drug dependence, psychiatric disturbance, chronic pain requiring opioid treatment, blindness or difficulty reading the questionnaire, and allergies to any study medications.

2.2. Study design

In this study, the patients were divided into two groups, CEA and general anesthesia. The patients underwent general anesthesia due to coagulopathy or the use of anticoagulation medications, difficulties with epidural anesthesia, spinal diseases, and/or refusal of CEA. Other patients were anesthetized using CEA. Patients who discontinued anticoagulation medications in accordance with the American Society of Regional Anesthesia guidelines were assigned to the CEA group.[12]

2.3. Procedure and intervention

When departing for the operating theater, all patients were premedicated with 0.1 mg glycopyrrolate intramuscularly. Upon arrival in the operating theater, standard monitoring devices were applied, including electrocardiography, pulse oximetry, and an oscillometric noninvasive blood-pressure cuff. Bispectral index monitoring (BIS system, Aspect Medical Systems, Newton, MA) was performed for all participants.

In the general-anesthesia group, induction was performed using intravenous lidocaine 40 mg, fentanyl 0.5 μg/kg, propofol 1 to 1.5 mg/kg, and rocuronium 0.6 mg/kg for neuromuscular blockade.

Endotracheal intubation was performed using an endotracheal tube with internal diameter 6.5 to 8 mm (Mallinckrodt, Covidien, Ireland) using a curved laryngoscope (Macintosh blade); the insertion depth was 20 to 24 cm from the upper incisors. Anesthesia was maintained with oxygen, medical air, and 1 minimum alveolar concentration of desflurane under monitoring with a bispectral index of 40 to 60. Mechanical ventilation was maintained to an end-tidal carbon dioxide concentration of 35 to 40 mmHg. At skin closure, neuromuscular blockade was reversed with 0.2 mg/kg pyridostigmine and 5 μg/kg glycopyrrolate. At the end of the surgical procedure before tracheal extubation, patients received 0.5 to 1 μg/kg intravenous fentanyl.

In the CEA group, all procedures were performed by the attending anesthesiologist with the patient fully awake and cooperative. All patients were placed in the sitting position. After the cervical region had been prepared and draped aseptically, local anesthetic was infiltrated into the skin. An 18-gauge Tuohy needle was inserted into the C7-T1 interspace via the midline approach. The epidural needle was guided by loss of resistance with 1.5 to 2 mL air. After identifying the epidural space, an 18G epidural catheter (Portex, Smith Medical, Czech) was inserted approximately 5 cm within the epidural space; 0.375% ropivacaine 10 to 15 mL was injected through the epidural catheter based on the patient's characteristics. Fifteen minutes later, sensory (pinprick) and motor (Bromage score) measurements were performed, in combination with vital-sign monitoring, to ensure the block was in effect. Sedation was necessary to prevent movement during vascular surgery. Using 6 L/minute oxygen supply through a simple mask, 2% propofol was administered with a target-controlled infusion system using a target-controlled infusion pump (Orchestra, Fresenius-Vial, France). The target concentration of propofol was adjusted to maintain a bispectral index of 60 to 70. A nasal airway was inserted to maintain the airway, if necessary. An additional 4 mL 0.375% ropivacaine bolus injection was performed at 2 hours after the first injection. When surgery was completed, the epidural catheter was removed before the patient was transferred to the post-anesthesia care unit (PACU).

All patients received intravenous ephedrine 4 mg for blood pressure values below 20% of baseline.

2.4. Data collection

The perioperative data collected included patients' sex, age, height, weight, use of patient-controlled analgesia (PCA), surgery and anesthetic duration, postoperative pain scores using NRS, PONV occurrence, and opioid consumption in the PACU and until 24 hours postoperatively in the ward. Opioids administered in the operating room were not included. In the PACU and ward, patients received opioid or anti-emetics on demand.

The QOR-40 questionnaire assesses five dimensions of recovery: physical comfort (12 questions), physical independence (5 questions), emotional state (9 questions), psychological support (7 questions), and pain (7 questions). Each question is graded on a five-point Likert scale, and total scores range from 40 (extremely poor) to 200 (excellent). The QOR-40 was completed by patients on the night before surgery and at 24 hours after surgery.

2.5. Statistical analyses

The primary outcome was the total QOR-40 score 24 hours after surgery. Sample-size calculations were based on the assumption that the total QOR-40 mean difference was 13 at POD 1, and the

standard deviations of each group were 17 and 22.[13] Twenty-eight patients per group were necessary to achieve a power of 80% (beta of 0.2) with an alpha of 0.5 using a 2-sided test. Considering a drop-out rate of up to 20%, we enrolled 35 patients per group.

The Shapiro-Wilk test was used to test the hypothesis of normal distribution for continuous variables. All continuous variables were reported as means ± standard deviations and all categorical variables were reported as n (proportion, %). We performed the Mann–Whitney U test, chi-square test, Fisher exact test, and Wilcoxon rank-sum test, as appropriate, for intergroup comparisons of QOR-40 scores and other clinical variables. To identify the relationships between QOR-40 and NRS scores, we used the Spearman correlation coefficient analyses. SPSS version 25 (SPSS, Inc., Chicago, IL, USA) were used for all statistical analyses; a P value $<.05$ was considered statistically significant.

3. Results

3.1. Study population

The QOR-40 questionnaire was completed by a total of 70 patients (general anesthesia = 35, CEA = 35). Seven omitted an answer in the questionnaire, 4 refused to answer the secondary POD 1 questionnaire, 2 changed their anesthetic method from CEA to general because of incomplete block, 1 had difficulty with conversation in the PACU. Therefore, we collected and analyzed data from 56 patients. The baseline characteristics of patients, durations of surgery and anesthesia, and use of PCA are presented in Table 1. Types of surgeries were basilic vein to brachial artery arteriovenous fistula (17.86%), cephalic vein bypass (21.43%), jump or interposition of upper-arm graft (21.43%), reduction of aneurysm (19.64%), and upper-arm arteriovenous bridge graft (19.64%).

The technical failure rate due to incomplete block was 5.7% (2 of 35 patients). Patients who exhibited failed CEA were changed to general anesthesia. No major complications were observed.

3.2. Comparison of QOR-40 scores between CEA and general anesthesia on POD #1

Preoperative and POD 1 QOR-40 scores in the general anesthesia and CEA groups are presented in Table 2. The baseline scores did

Table 1

Baseline patient characteristics, use of patient-controlled analgesia, anesthetic and surgery duration.

	General anesthesia (n = 28)	CEA (n = 28)	P value
Sex	15 (53.6%):	11 (39.3%):	†.284
(male: female)	13 (46.4%)	17 (60.7%)	
Age (years)	49.46 ± 9.87	52.27 ± 7.37	.72
Height (cm)	168.38 ± 6.78	155.53 ± 5.99	.76
Weight (kg)	65.46 ± 11.96	56.37 ± 10.09	.48
BMI (kg·m^{-2})	23.07 ± 3.37	23.34 ± 3.76	.89
Patient-controlled analgesia	10 (35.7%)	7 (25.0%)	†.383
Anesthetic duration (min)	148.19 ± 51.47	145.3 ± 36.23	.63
Surgery duration (min)	107.62 ± 45.12	99.77 ± 32.20	.12

All continuous variables are reported as mean ± SD and all categorical variables as n (proportion, %). Data were analyzed using Mann–Whitney U test and †chi-squared test.
BMI = body mass index, CEA = cervical epidural anesthesia.

Table 2

Total and dimensional QOR-40 scores between CEA and general anesthesia.

	General anesthesia (n = 28)	CEA (n = 28)	P value
Preoperative			
Emotional status	31.5 ± 7.4	31.4 ± 6.8	.915
Physical comfort	46.1 ± 8.6	43.3 ± 10.1	.325
Psychological support	29.5 ± 4.2	29.0 ± 4.8	.805
Physical independence	20.1 ± 5.4	20.0 ± 4.6	.609
Pain	27.3 ± 5.8	27.0 ± 6.7	.948
Total	154.9 ± 24.2	150.6 ± 27.7	.623
POD 1			
Emotional status	33.7 ± 8.2	36.8 ± 6.1	.186
Physical comfort	43.1 ± 11.2	48.0 ± 9.3	.093
Psychological support	28.8 ± 5.6	31.3 ± 3.6	.102
Physical independence	18.5 ± 5.4	21.7 ± 3.2	.006
Pain	24.3 ± 6.3	27.9 ± 5.7	.027
Total	148.4 ± 30.3	165.7 ± 22.8	.024

All continuous variables are reported as mean ± SD. Data were analyzed using Mann-Whitney U test.
CEA = cervical epidural anesthesia, POD = postoperative day, QOR-40 = quality of recovery-40 questionnaire.

not differ between the two groups ($P = .623$). However, a significantly higher total QOR-40 score was noted at POD 1 in the CEA group ($P = .024$). When dimensional QOR-40 scores were compared between the two groups, physical independence ($P = .006$) and pain ($P = .027$) showed significant differences.

3.3. Comparisons of opioid consumption, PONV, and NRS

Table 3 presents opioid consumption and PONV occurrence in the PACU and at POD 1. In the PACU, opioid consumption was significantly lower in the CEA group ($P = .005$). At POD 1, there were no significant differences in opioid consumption, although consumption tended to be lower in the CEA group ($P = .051$).

The occurrence of nausea in the PACU was also significantly less frequent in the CEA group ($P = .019$) and no vomiting occurred in the CEA group (1 patient exhibited vomiting in the general anesthesia group). However, at POD 1, there were no significant differences in nausea or vomiting ($P = .131$ and $P = .252$, respectively).

NRS scores were significantly lower in the CEA group in the PACU ($P < .001$) and at POD 1 ($P = .016$).

4. Discussion

We found that CEA significantly improved the postoperative quality of recovery, compared to general anesthesia, after upper-arm vascular surgery in ESRD patients. Total QOR-40 scores at POD 1 were significantly higher in the CEA group than in the general anesthesia group. Opioid consumption and nausea in the PACU, and NRS scores in the PACU and at POD 1 were significantly lower in the CEA group.

CEA was a feasible regional anesthesia approach for vascular surgery for hemodialysis in ESRD patients, and it did not cause any major complications. Some previous studies have suggested that brachial plexus block is an effective and safe technique for regional anesthesia for upper-arm vascular surgery in ESRD patients.[8–10] However, the extent of surgery was sometimes unexpectedly extended to the axillary vein; in affected patients, brachial plexus block provided insufficient anesthesia. Furthermore, this

Table 3

Opioid consumption, PONV and NRS.

	General anesthesia (n = 28)	CEA (n = 28)	P value
At PACU			
Fentanyl use			
0	19 (67.9)	27 (96.4)	.005
1	9 (32.1)	1 (3.6)	
Presence of nausea			
0	19 (67.9)	26 (92.9)	.019
1	9 (32.1)	2 (7.1)	
Vomiting episode			
0	27 (96.4)	28 (100.0)	1.000
1	1 (3.6)	0 (0.0)	
NRS	5.43 ± 2.08	2.11 ± 2.1	‡ <.001
At POD 1			
Tridol use			
0	19 (67.9)	25 (89.3)	.051
1	9 (32.1)	3 (10.7)	
Presence of nausea			
0	18 (64.3)	23 (82.1)	.131
1	10 (35.7)	5 (17.9)	
Vomiting episode			
0	22 (78.6)	26 (92.9)	.252
1	4 (14.3)	2 (7.1)	
2	2 (7.1)	0 (0.0)	
NRS	3.25 ± 2.12	2.04 ± 1.64	‡ .016

All continuous variables are reported as mean ± SD and all categorical variables as n (proportion, %). Data were analyzed using chi-squared test and ‡Shapiro-Wilk test.
CEA = cervical epidural anesthesia, NRS = numeric rating scale, POD = postoperative day, PONV = postoperative nausea and vomiting.

procedure involves risks, including local anesthetic toxicity, peripheral nerve damage, and prolonged anesthesia duration.[14] Previously, Bonnet et al showed that CEA was safe and effective for carotid artery surgery and that it was a simple and easy technique for trained anesthesiologists to use in all circumstances.[4] Christopherson et al demonstrated that epidural anesthesia was associated with a lower incidence of reoperation for inadequate tissue perfusion for lower-extremity vascular surgery.[15] Similarly, the technical failure rate of CEA was only 5.7% in our study.

Effective pain control after surgery has a substantial effect on the recovery process and patient satisfaction with postoperative care.[16,17] In our study, pain scores on the QOR-40 at POD 1, as well as NRS scores in the PACU and at POD 1, were significantly lower after CEA. Furthermore, consumption of opioid analgesics was significantly lower in the PACU and tended to be lower at POD 1. These results suggest that CEA provided effective postoperative pain relief. Proper postoperative pain control can lead to earlier discharge from hospital and an improved overall quality of recovery.[18] Moreover, an opioid-sparing effect can contribute to reduced incidence of opioid-related side effects, such as PONV.[19]

4.1. Limitations of the study

There were some limitations to our study. First, we used the Korean written version of the QOR-40 questionnaire. Although several previous studies have reported reliable results using the Korean version of the QOR-40,[20,21] some bias caused by language translation could have been introduced. Second, we administered the QOR-40 only at POD 1. Because ESRD patients received hemodialysis on the day of surgery, they had difficulty in

responding to the questionnaire due to poor general condition on the day of surgery. In addition, patients were discharged at POD 2; therefore, we could not compare QOR-40 scores on subsequent days. Third, patients who refused CEA were assigned to the general-anesthesia group. Thus, a degree of selection bias could be present. However, patient characteristics and preoperative QOR-40 scores did not differ between the two groups. Finally, we enrolled a small number of patients based on the statistical power to compare total QOR-40 scores between the 2 groups. Therefore, comparisons of individual dimensions of QOR-40 may be insufficient, and future studies with more patients are warranted.

In conclusion, regarding the postoperative quality of recovery after upper-arm vascular surgery in ESRD patients, the CEA group showed significantly better total QOR-40 and NRS scores compared to the general anesthesia group at POD 1. Opioid consumption, nausea incidence, and NRS scores were significantly lower in the CEA group in the PACU. Therefore, to improve quality of recovery, CEA could be used as an alternative anesthetic technique for upper-arm vascular surgery for hemodialysis in ESRD patients.

Author contributions

Conceptualization: Ho Bum Cho, Mungyu Kim, Jiwon Chung, Sangho Kim, Siyoung Ok.
Data curation: Hyerim Kwon, Jaehwa Yoo, Suyeon Park.
Formal analysis: Sunyoung Park, Suyeon Park.
Investigation: Sangho Kim, Siyoung Ok.
Methodology: Sunyoung Park.
Supervision: Siyoung Ok.
Writing – original draft: Ho Bum Cho.
Writing – review & editing: Ho Bum Cho, Sanghoon Song, Mungyu Kim, Siyoung Ok.
Ho Bum Cho orcid: 0000-0001-9540-1525.

References

[1] Wulf H. Epidural anaesthesia and spinal haematoma. Can J Anaesth 1996;43:1260–71.
[2] Cameron CM, Scott DA, McDonald WM, et al. A Review of neuraxial epidural morbidity experience of more than 8,000 cases at a single teaching hospital. Anesthesiology 2007;106: 997–1002.
[3] Horlocker TT, Wedel DJ. Neurologic complications of spinal and epidural anesthesia. Reg Anesth Pain Med 2000;25:83–98.
[4] Bonnet F, Derosier JP, Pluskwa F, et al. Cervical epidural anaesthesia for carotid artery surgery. Can J Anaesth 1990;37:353.
[5] Singh A, Tewari M, Singh D, et al. Cervical epidural anesthesia: a safe alternative to general anesthesia for patients undergoing cancer breast surgery. World J Surg 2006;30:2043–7.
[6] Wenk M, Massoth C, Pöpping DM, et al. Feasibility of cervical epidural anesthesia for breast cancer surgery. Anesthesiol Res Pract 2017;2017:7024924.
[7] Mouquet C, Bitker M, Bailliart O, et al. Anesthesia for creation of a forearm fistula in patients with endstage renal failure. Anesthesiology 1989;70:909–14.
[8] Shemesh D, Raikhinstein Y, Orkin D, et al. Anesthesia for vascular access surgery. J Vasc Access 2014;15(7_suppl):38–44.
[9] Malinzak EB, Gan TJ. Regional anesthesia for vascular access surgery. Anesth Analg 2009;109:976–80.
[10] Hingorani AP, Ascher E, Gupta P, et al. Regional anesthesia: preferred technique for venodilatation in the creation of upper extremity arteriovenous fistulae. Vascular 2006;14:23–6.
[11] Myles P, Weitkamp B, Jones K, et al. Validity and reliability of a postoperative quality of recovery score: the QoR-40. Br J Anaesth 2000;84:11–5.

[12] Horlocker TT, Wedel DJ, Rowlingson JC, et al. Regional anesthesia in the patient receiving antithrombotic or thrombolytic therapy: American Society of Regional Anesthesia and Pain Medicine Evidence-Based Guidelines (Third Edition). Reg Anesth Pain Med 2010;35:64–101.

[13] Lee W-K, Kim M-S, Kang S-W, et al. Type of anaesthesia and patient quality of recovery: a randomized trial comparing propofol–remifentanil total iv anaesthesia with desflurane anaesthesia. Br J Anaesth 2015;114:663–8.

[14] Miller RD, Eriksson LI, Fleisher LA, et al. Miller's Anesthesia E-Book. Elsevier Health Sciences; 2014.

[15] Christopherson R, Beattie C, Frank SM, et al. Perioperative morbidity in patients randomized to epidural or general anesthesia for lower extremity vascular surgery. J Am Soc Anesthesiol 1993;79: 422–34.

[16] Beauregard L, Pomp A, Choinière M. Severity and impact of pain after day-surgery. Can J Anaesth 1998;45:304.

[17] Rawal N, Hylander J, Nydahl RA, et al. Survey of postoperative analgesia following ambulatory surgery. Acta Anaesthesiol Scand 1997; 41:1017–22.

[18] White PF, Issioui T, Skrivanek GD, et al. The use of a continuous popliteal sciatic nerve block after surgery involving the foot and ankle: does it improve the quality of recovery? Anesth Analg 2003;97:1303–9.

[19] Roberts GW, Bekker TB, Carlsen HH, et al. Postoperative nausea and vomiting are strongly influenced by postoperative opioid use in a dose-related manner. Anesth Analg 2005;101:1343–8.

[20] Kim S, Oh Y, Park B, et al. Effects of single-dose dexmedetomidine on the quality of recovery after modified radical mastectomy: a randomised controlled trial. Minerva Anestesiol 2013;79:1248–58.

[21] Kim MH, Kim MS, Lee JH, et al. Can quality of recovery be enhanced by premedication with midazolam?: A prospective, randomized, double-blind study in females undergoing breast surgery. Medicine (Baltimore) 2017;96:e6107.