İstanbul Med J 2024; 25(3): 214-8
DOI: 10.4274/imj.galenos.2024.47417

Effect of Cerebral Dominance on Postoperative Pain

Mohammed Kado[1], Yeşim Çokay Abut[2], Veysel Erden[2]

[1]Cizre Dr. Selahattin Cizrelioğlu State Hospital, Clinic of Anesthesiologists, Şırnak, Turkey
[2]University of Health Sciences Turkey, İstanbul Training and Research Hospital, Clinic of Anesthesiology and Reanimation, İstanbul, Turkey

ABSTRACT

Introduction: In this study, we aimed to determine the functional dominance of the right and left hemispheres of the operated patients and the effectiveness of postoperative pain therapy when the patients underwent surgery on the same or different sides with the dominant hemisphere.

Methods: The patients were given a Miles test for the dominant eye in the preoperative period and were instructed while the key was in front of the patient to take the key and open the door to determine the dominant hand. For the dominant foot, the patient was given the command of "move your foot" in a calm environment and accepted as the foot that he carried the dominant foot. After routine spinal anesthesia and elective knee arthroplasty surgery, patients underwent Patient Controlled Analgesia device, 24th hour Numeric Rating Scale (NRS) scores, and the amount of total applied analgesic and additional analgesic were recorded.

Results: When the clinical characteristics of the patients were examined, there were 38 patients on the right side of the dominant eye, 34 on the left side, 67 on the right hand dominant side, 5 on the left side, 49 on the right foot dominant side, and 23 on the left side. The NRS score on the surgical side was compared with the dominant foot, dominant eye, and dominant hand. There was no statistically significant difference between the NRS pain scale and other variables except those opposed to the dominant eye ($p>0.05$). The NRS pain scale median (median: 3.0) was found to be significantly lower in patients who were operated on the same side as the dominant eye ($p=0.016$).

Conclusion: According to the results of our study, the NRS score was not changed in patients operated on the same side of the dominant foot and hand, whereas the NRS score was lower in patients operated on the same side with the dominant eye.

Keywords: Dominant hemisphere, postoperatif pain, cerebral lateralization

Introduction

Cerebral lateralization is described as anatomical and functional differentiation between the right and left hemispheres of the brain. The left hemisphere undertakes functions associated with verbal expression, such as reading, speaking, and using verbal symbols. The right hemisphere is associated with the acceptance and storage of visual data, visual and tactile recognition of shapes and forms, and orientation and perspective of the shapes (1).

One hemisphere is more dominant than the other is an anatomic lateralization and the hand-foot preference are considered functional lateralization. When we look at the laterality of pain neuroimaging studies of human pain have revealed a common "pain matrix" spreading into both hemispheres of the brain (2-5); however, specific findings suggest that the right hemisphere plays an important role in pain perception (6).

In this study, we performed hand, eye, and foot dominance tests on patients who underwent surgery and investigated whether there was an increase in postoperative pain on the dominant side according to the dominance of the right and left half of the body.

Methods

After approval of the University of Health Sciences Turkey, İstanbul Training and Research Hospital Ethics Committee (approval number: 1061, date: 04.08.2017, and informed consent of the patients, between August 2017 and February 2018, 80 patients were included in our prospective study evaluating the effect of dominant cerebral hemisphere on postoperative pain in knee arthroplasties. The sample was calculated using G*power 3.0 software, and the mean pain between the dominant and non-dominant side operations was 1.0±0.3 (3.5±1.5 and 4.5±1.8 respectively). The difference was estimated, and a total of 70 people were found to be sufficient with a 5% alpha error (type 1 error) and 80% power. Patients undergoing elective surgery with spinal anesthesia in the American Society of Anesthesiologists (ASA) classification 1-3 group were included in the study. Patients with dementia, diabetes mellitus, a history of cerebrovascular disease, degenerative nerve diseases, who cannot adapt to Patient Controlled Analgesia (PCA) machine, who do not want regional anesthesia or are under contraindication to regional anesthesia, who are given general anesthesia or have returned to general anesthesia, ASA4 and emergency patients, patients who could not use

Address for Correspondence: Yeşim Çokay Abut MD, University of Health Sciences Turkey, İstanbul Training and Research Hospital, Clinic of Anesthesiology and Reanimation, İstanbul, Turkey
Phone: +90 537 681 26 40 **E-mail:** yesimabut2000@yahoo.com **ORCID ID:** orcid.org/0000-0001-8763-605X

Cite this article as: Kado M, Çokay Abut Y, Erden V. Effect of Cerebral Dominance on Postoperative Pain. İstanbul Med J. 2024; 25(3): 214-8

Received: 21.02.2024
Accepted: 30.05.2024

PCA due to excessive nausea, or patients with device failure were excluded from the study.

Before surgery, the dominant hand, dominant eye, and dominant foot determination tests were performed. For that purpose of evaluating the dominant eye, the patients were asked to hold both arms forward, unite their hands at eye level, and look at an object 6 meters away from the triangle formed by bringing both the head and index fingers to the tip (modified Miles test) (7-9). To determine the dominant hand, instead of a questionnaire, inspired by Oldfield's Edinburgh Scale, the patient was asked to take the key from a box remaining in front of him and open the door with that key (10). In this test, the hand used to open the door was accepted as the dominant hand. The dominant foot was asked by male patients if they had played football. If the answer was "yes", then the participant was asked for foot preference. Other patients in the sitting position in a calm environment with eyes closed "Move toes" command was given to the foot and moving foot. Determined as dominant. Patients who played both feet at the same time, or asked "which" question to play, were asked to hit a ball placed on both feet with one foot while sitting. For the performance test, Coren and Porac (11) was inspired by the various works he has conducted since 1978. All patients were informed about Numeric Rating Scale (NRS), PCA and how to use the PCA device.

The NRS is a pain scaling system commonly used to evaluate pain severity. It is asked to the patient to describe her/his pain by giving a number between 010, with zero meaning "no pain" and 10 meaning "the worst pain imaginable" (12).

Routine, standard anesthesia monitoring (3-lead ECG, non-invasive arterial blood pressure, pulse oximetry) was provided to the patients, and after the vascular access was opened, a sitting position was provided, providing aseptic conditions, a 25-gauge spinal needle (Quincke 25-gauge Spinal, Egemen International) from the L3-4 intervertebral space was pushed forward to the subarachnoid space. By observing the free development of cerebrospinal fluid when the needle reached the subarachnoid space, spinal anesthesia was performed using 12.5 mg of bupivacaine (buvasin 0.5% spinal heavy VEM drug). Patients were then laid on the side for surgery, and the operation was started after the sensory and motor block levels were checked. At the end of the operation, patients were taken to the recovery room and intravenous PCA device was inserted and sent to the service. Tramadol was used at a concentration of 4 mg/mL during preparation of the intravenous PCA device. The device was programed with a bolus dose of 10 mg and continuous infusion of 10 mg/h for 20 min with a locking time of 20 min. Paracetamol (1 g) (parol intravenous 10 mg/mL 100 mL vial Atabay drug) and/or dexketoprofen (dexalgine 50 mg/2 mL Nobel drug) were administered as additional analgesics to patients with resting pain. During the first 24 hours after the operation NRS scores, total analgesic use, and additional analgesic need were recorded according to postoperative follow-up forms.

Statistical Analysis

The statistical analysis was performed using SPSS version 15.0 software. Parametric data were analyzed using Student's t-test, and non-parametric data were analyzed with Mann-Whitney U test. While descriptive analyses were presented, mean, standard deviation, median and minimum-maximum values were used. $P<0.05$ was considered statistically significant.

Results

Of the 80 patients who participated in the study, 6 had to have general anesthesia for various reasons and 2 patients were excluded because of PCA machine faults.

Of the 72 patients included in the study, 60 (83.3%) were female and 12 were male. The mean age was 63.1±4.3. The mean body mass index (BMI) was 31.9±2.5 years (Table 1).

Clinical characteristics of the patients participating in the study examined 40 people from the left knee, 32 people from the right knee, 38 people with right eye on the right side, 34 people on the left side, 67 people on the right hand side, 67 people on the right hand side, 5 people on the left side, 5 people on the left side 49 people with left side are 23 people (Table 1).

NRS 3-4, the targeted pain level, was reached in all patients. There was no statistically significant difference between the NRS pain scale scores and the other variables except those operated on the same side with the dominant eye ($p>0.05$). The median NRS pain scale score (median: 3.0) was significantly lower in patients who underwent surgery on the same side of the dominant eye than in the non-operative group (median: 4.0) ($p=0.016$) (Table 2).

Table 1. Demographic data and clinical characteristics of patients

		n/Mean ± SD*	%/(max.-min.)*
Gender	Female	60	83.3
	Male	12	16.7
Age*		63.1±4.3*	63 (54.0-73.0)*
BMI*		31.9±2.5*	32 (27.0-38.0)*
Operation side	Right/left	32/40	44.4/55.5
Eye dominance	Right/left	38/34	52.77/47.22
Hand dominance	Right/left	67/5	90.03/7.46
Foot dominance	Right/left	49/23	68.05/31.94

*In the measurement data, instead of n, mean ± standard deviation, instead of (%) median, minimum, and maximum values are given, BMI: Body mass index, SD: Standard deviation, max.: Maximum, min.: Minimum

Table 2. Comparison of NRS pain scale score and tramadol consumption in patients who operated on the same side with the dominant foot, dominant eye, and dominant hand

	NRS			p*	Consumption of tramadol (mg)		p*
	Mean ± SD		Median (min.-max.)		Mean ± SD	Median (min.-max.)	
Operation on the same side as the dominant foot	Yes	3.8±1.3	3.0 (3.0-8.0)	0.901	328±64.2	200-400	0.536
	No	4.0±1.6	3.0 (3.0-10.0)		318±66.1	131-400	
Operation on the same side as the dominant eye	Yes	3.6±1.5	3.0 (3.0-10)	**0.016**	314±65.2	131-400	0.353
	No	4.2±1.6	3.0 (3.0-8.0)		328±65.4	198-400	
Operation on the same side as the dominant hand	Yes	4.1±1.6	3.0 (3.0-8.0)	0.301	330±60.3	200-400	0.355
	No	3.8±1.5	3.0 (3.0-10)		315±68.8	131-400	

*Mann-Whitney U test, min.: Minimum, max.: Maksimum, SD: Standard deviation, NRS: Numeric Rating Scale

The amount of tramadol used by the patient-controlled analgesia device in 24 hours was compared with the amount used in the dominant foot, dominant eye, and dominant hand. Accordingly, there was no statistically significant difference in the total amount of tramadol (mg) used between the groups ($p>0.05$) (Table 2).

Discussion

The aim of our study was to evaluate the relationship between postoperative pain and eyes, hand, and foot dominance in patients who underwent arthroplasty under spinal anesthesia for knee osteoarthritis (OA).

Knee OA is the most common form of arthritis, and its prevalence is increasing., approximately 40% of the adult population over the age of 65 years has knee OA. Obesity and increased BMI are risk factors for OA (12,13).

The characteristics of the patients included in our study.

The mean age was 63. One year, and 83.3% of the patients were women. Our results regarding age and sex characteristics are consistent with the literature. The BMI was found to be 31.9±2.5 kg/m^2, and most patients were obese.

Pain is the most common symptom of knee OA. Macrotrauma or recurrence microtrauma may damage the articular cartilage. Chondrocytes react to this damage by releasing disintegrating enzymes and inducing a repair response. Thus, mechanical and nociceptive chronic pain occurs (14-16).

Neuropathic pain is also noted in individuals with long-lived symptoms duration. Surgical treatment is indicated for patients with advanced OA who do not respond to conservative treatment, and knee arthroplasty is performed (17).

Although knee arthroplasty is an effective and reliable surgical treatment, severe acute pain is observed in patients after surgery, and the incidence of chronicity is high if the acute pain is treated inadequately. In a previous study, showed that 35% of patients who underwent knee arthroplasty experienced continued pain complaint for 1 year postoperatively (18). Therefore, acute postoperative pain treatment after knee arthroplasties is provided by multimodal analgesia, including regional anesthesia techniques. Neuroaxial anesthesia (epidural, spinal anesthesia), which is an important component of multimodal analgesia, has a effects on mortality and morbidity in the perioperative period (19). With good pain control with multimodal analgesia, postoperative opioid consumption is reduced and rehabilitation. In our study, the NRS score was 3-4 in patients included in the study.

As distinct from the literature in our study, the relationship between cerebral laterality and pain after arthroplasty was evaluated.

One hemisphere is more dominant than the other is an anatomic lateralization and the hand-foot preference are considered functional lateralization.

Similar to hand preference, ie, the dominance of the foot, eye, and even the ear dominance is defined. In general, right eye dominance is observed in those who use the right hand was dominated more. Similarly, the right foot is dominant over the right handness (20,21).

In the examinations, it was understood that the preferences of the parents or educators changed the preferences of the hand and foot, which were contrary to the biological structure. However, eye preference does not change with education, social pressure, or other environmental factors. The choice of the eye preserves its natural nature (22).

When the clinical features of the patients who participated in the study were examined, 38 patients with right-sided eye dominance, 34 with left-sided eye dominance, 67 with right hand dominance, 5 with left-sided hand dominance, 49 with right foot dominance, and 23 with left foot dominance were found.

The left side is used negatively in many cultures and is interpreted as unfortunate. This makes it difficult to identify left foot and left hand dominance in social development. In particular, in our patients, motor activity at an advanced age was strengthened, and the functional difference between the two extremities decreased. The brain compensates for the decrease in the function of the limb, which it is conditioned not to use. Therefore, we thought that it would be difficult to evaluate the results of the questionnaire tests based on the patient queries, which are used in the literature, in all of our patients who were of advanced age. In addition, because our patients have orthopedic problems and have already experienced chronic pain and movement limitations for many years in both lower limbs, we have not been able to perform lower extremity tests on healthy volunteers. However, we were pleased to find that the results of our hand, eye, and foot dominance test were consistent with the dominance results in the abovementioned studies.

Functional magnetic resonance imaging studies by Symonds et al. (23) 5 of 9 brain regions associated with pain were activated in the right hemisphere during acute pain, demonstrating the dominance of the right hemisphere in the perception of pain.

Some studies have tried to explain the role of hemispheric activation in depression and pain (24). They hypothesized that the right hemisphere is specialized in activating and processing negative affective stimuli, and this specialization may play a role in the emergence of depression and pain. In order to evaluate the relationship between depression, experimental pain, and cerebral laterality, the researchers included 16 depressed and 16 normal girls who used their right hands in their studies. The suggestion that the right hemisphere mediates the coexistence of pain and depression is not supported; however, specific findings suggest that the right hemisphere plays an important role in pain perception.

Recent biochemical and behavioral data suggest that the right hemispheric lateralization of the amygdala during pain. Pain-related neuroplasticity in the laterocapsular division of the central nucleus of the amygdala in the right brain hemisphere has also been demonstrated. Ji and Neugebauer (25) evaluated electrophysiological pain perception before and after the induction of arthritis pain in rats using experimental models.

Short-term harmless and harmful test stimuli were applied to the peripheral, ipsilateral, and contralateral recording regions. A monoarthritis was created by intraarticular injection of kaolin and Irish moss into the rope or contralateral knee. Under normal conditions, neurons in the left amygdala were shown to have smaller recipient sites than those in the right amygdala; however, there was no difference in terms of pain perception. In another study, it was shown that right frontal brain hyperactivity can be used as a biological marker for increased pain sensitivity and has a negative effect (26). Merskey and Watson (27) showed that patients felt more pain on the left side of the body. They also pointed out that psychological pain was seen especially on the left side.

According to the results of our study, the NRS score was not changed in patients operated on the same side of the dominant foot and hand, whereas the NRS score was lower in patients operated on the same side with the dominant eye.

In a study of Lugo 328 right- and 22 left-handed patients, thermal noxious stimulus showed that while the majority of the cases used the right hand, the Visual Analogue Scale (VAS) score was significantly higher in the left hand (right hemisphere dominance). Previous studies reported high VAS scores on the left side (27-33). But the interesting thing is that 65% of the left side, irrespective of the dominance of the right or left hand, feels more painful on the left side. Researchers have suggested that the right hemisphere is predominantly involved in pain perception (34).

Our study was a clinical study that aimed to evaluate acute pain and chronic pain. Our study group consists of elderly patients with chronic pain instead of healthy volunteers; thus, our results may be different. The absence of functional imaging is an important limitation. Another limitation is that social pressures and beliefs affect hand and foot preferences. Extremity dominance may have disappeared in older people, such as our patients.

In this study, no significant correlation was found between the severity of perceived postoperative pain and the extremity dominance. Lower pain scores were observed only on the dominant eye side. In addition, there was no statistically significant difference between the tramadol use and operation sides. Although NRS is an effective method for pain assessment, it may have been insufficient in this study. It would be more accurate to assess the characteristics of the pain (type of pain, duration of intolerance, pain-related pain, behavior, anxiety score, etc.). In addition, OA is associated with chronic pain for a long time. When the pain becomes chronic, it can be accompanied by different problems, such as depression, anxiety, sleep disorders, attention, and memory changes (right hematologic dominance), which affect the threshold, perception, and severity of pain. In a review by Lithwick et al. (35), more common contralateral activation was observed in patients with chronic pain compared with acute pain in which the ipsilateral side was activated. Several studies have shown that chronic pain of psychological origin is especially on the left side (right hemisphere dominance) (33,36).

Study Limitations

This was a clinical study, and it was intended to evaluate acute pain in patients with chronic pain. Our study group consists of elderly patients with chronic pain instead of healthy volunteers; thus, our results may be different. The absence of functional imaging is an important limitation. Another limitation is that social pressures and beliefs affect hand and foot preferences. Extremity dominance may have disappeared in older people, such as our patients.

Conclusion

The postoperative pain scores of patients who underwent surgery on the same side with the dominant eye were low. We believe that our findings should be validated in studies in which similar clinical parameters and high validation scales are considered and functional imaging or electrophysiological evaluations are performed.

Ethics Committee Approval: The study was approved by the University of Health Sciences Turkey, İstanbul Training and Research Hospital Ethics Committee (approval number: 1061, date: 04.08.2017).

Informed Consent: It was obtained.

Authorship Contributions: Surgical and Medical Practices - M.K., Y.Ç.A.; Concept - Y.Ç.A.; Design - Y.Ç.A., V.E.; Data Collection or Processing - M.K.; Analysis or Interpretation - Y.Ç.A., V.E.; Literature Search - Y.Ç.A.; Writing - M.K., Y.Ç.A.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Nicholas P, La Mendola A. Peripheral and cerebral asymmetries in the rat. Science. 1997; 278: 31-4.
2. Casey KL. Forebrain mechanism of nociception and pain: analysis through imaging. Proc Natl Acad Sci USA. 1990; 96: 7668-74.
3. Davis KD. Pain imaging. Progress in Pain Research and Management, Volume 18. In: Casey KL, Bushnell MC (eds). International Association for the Study of Pain, Seattle, Washington, USA, 2000; p. 239.
4. Ingvar M. Pain and functional imaging. Philos Trans R Soc Lond B Biol Sci. 1999; 354: 1374-58.
5. Peyron R, Garcie-Larrea L, Gregoire M, Convers P, Richard A, Lavenne F, et al. Parietal and cingulate processes in central pain. A combined positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) study of an unusual case. Pain. 2000; 84: 77-87.
6. Symonds LL, Gordon NS, Bixby JC, Mande MM. Right-lateralized pain processing in the human cortex: an FMRI study. J Neurophysiol. 2006; 95: 3823-30.
7. Miles WR. Ocular dominance demonstrated by unconscious sighting. Journal of Experimental Psychology. 1929; 12: 113-26.
8. Miles WR Ocular dominance in human adults. Journal of General Psychology. 1930; 3: 412-29.
9. Valle-Inclan F, Blanco MJ, Soto D, Leiros L. A new method to assess eye dominance. Psicologica. 2008; 29: 55-64.
10. Oldfield RC. The assessment and analysis of handedness: The Edinburgh Inventory. Neuropsychologia. 1971; 9: 97-113.
11. Coren S, Porac C. The validity and reliability of self-report items fort the measurement of lateral preferance. BJ Psichology. 1978; 69: 207-11.
12. Breivik H, Borchgrevink PC, Allen SM, Rosseland LA, Romundstad L, Hals EK, et al. Assessment of pain. Br J Anaesth. 2008; 101: 17-24.
13. Tutun S, Altin F, Ozgonenel L, Cetin E. Demographic characteristics in patients with knee osteoarthritis and relationship with obesity, age, pain and gender. Istanbul Med J. 2010; 11: 109-12.
14. Ozcakır S. Diz Osteoartriti. İrdesel J, editör. Diz Ağrıları. 1. Baskı. Ankara: Türkiye Klinikleri; 2018: 32-8.
15. Neogi T. The epidemiology and impact of pain in osteoarthritis. Osteoarthritis Cartilage. 2013; 21: 1145-53.
16. Gunduz H. Pain pathogenesis in osteoarthritis. Turkiye Klinikleri J PM&R-Special Topics. 2008; 1: 28-32.
17. Polat CS, Doğan A, Ozcan DS, Köseoğlu BF, Akselim SK. Is there a possible neuropathic pain component in knee osteoartrhtritis? Arch Rheumatol. 2017; 32: 333-8.
18. Puolakka PAE, Rorarius MGF, Roviola M. Persistent pain following knee arthroplasty. Eur J Anaesthesiol. 2010; 27: 455-60.
19. Kehlet H, Dahl JB. The value of multimodal or balanced analgesia in postoperative pain treatment. Anesth Analg. 1993; 77: 1048-56.
20. Annett M. Left, right hand and brain:right shift theory. Lawrence Erlbaum; London, 1985.
21. Baykal O, Dane S, AkarS, Colak A, Pence S. Relationships between hand preference and eye dominance in normal human subjects. Turkish Journal of Medical Sciences. 1995; 24: 95-7.
22. Gündoğan NU. Hand Choice and Dominant Eye. Türkiye Klinikleri. 2005; 25: 327-28.
23. Symonds LL, Gordon NS, Bixby JC, Mande MM. Right-lateralized pain processing in the human cortex: an FMRI study. J Neurophysiol. 2006; 95: 3823-30.
24. Hecht D. Depression and the hyperactive right hemisphere. Neurosci Res. 2010; 68: 77-87.
25. Ji G, Neugebauer V. Hemispheric lateralization of pain processing by amygdala neurons. J Neurophysiol. 2009; 102: 2253-64.
26. Pauli P, Wiedemann G, Nickola M. Pain sensitivity, cerebral laterality, and negative affect. Pain. 1999; 80: 359-64.
27. Merskey H, Watson GD. The lateralization of pain. Pain. 1979; 7: 271-80.
28. Barroso J, Vigotsky AD, Branco P, Reis AM, Schnitzer TJ, Galhardo V, et al. Brain gray matter abnormalities in osteoarthritis pain: a cross sectional evaluation. Pain 2020; 161: 2167-78.
29. Burrowes SAB, Goloubeva O Keaser ML, Haythornthwaite JA, Seminowicz DA. Differences in gray matter volume in episodic migraine patients with and without prior diagnosis or clinical care. J Headache Pain. 2021; 22: 127.
30. Lin JC, Chu LF, Stringer EA, Baker KS, Sayyid ZN, Sun J, et al. One month of oral morphine decreases gray matter volume in the right amygdala of individuals with low back pain: Confirmation of previously reported magnetic resonance imaging results. Pain Med. 2016; 17: 1497-504.
31. Northon S, Deldar Z, Piche M. Spinal and cerebral integration of noxious inputs in left-handed individuals. Brain Topog. 2021; 34: 568-86.
32. Chandramouli R, Kanchan B, Ambadevi B. Right-left asymmetry in tonic pain perception and its modification by simultaneous contralateral noxious stimulation. Neuropsychologia 1993,31: 687-94.
33. Schiff BB, Gagliese L. The consequences of experimentally induced and chronic unilateral pain: reflections of hemispheric lateralization of emotion. Cortex. 1994; 30: 255-67.
34. Lugo M, Isturiz G, Lara C, Garcia N, Eblen-Zajjur A. Sensory lateralization in pain subjective perception for noxious heat stimulus. Somatosensory Motor Research. 2002; 19: 207-12.
35. Lithwick A, Lev S, Binshtock A. Chronic pain-related remodelling of cerebral cortex - 'pain memory': a possible target for treatment of chronic pain. Pain Management. 2013; 3: 35-45.
36. Yang S, Chang MC. Chronic pain:Structural and functional changes in brain structures and associated negative affective states. Int J Mol Sci. 2019; 20: 3130.