Zagazig University Medical Journal
www.zumj.journals.ekb.eg
https://doi.org/10.21608/zumj.2024.273198.3209 Volume 30, Issue 9, December. 2024
Manuscript id: ZUMJ-2402-3209
Doi: 10.21608/zumj.2024.273198.3209
REVIEW ARTICLES

Effects of Dexmedetomidine and Fentanyl on Post-Operative Cognitive Function

Doaa Mohamed Farid[1], Osama Abo Elfotouh Ismael Hassan[1], Ahmed M. Fahmy[1], Kareem Alaa Eldin Taha[1*]
[1] Anesthesia, Intensive Care and Pain Management Department, Faculty of Medicine, Zagazig University, Egypt

***Corresponding author:**
Kareem Alaa Eldin Taha

Email:
Kareemmousa854@gmail.com

Submit Date: 27-02-2024
Accept Date: 14-03-2024

ABSTRACT

Background: Total intravenous anesthesia (TIVA) has progressed thanks to the pharmacokinetic and pharmacodynamics of well-known intravenous medicines like propofol as well as newer, shorter-acting agents like remifentanil, as well as the advancements in pharmacokinetic models and infusion pump technology. TIVA is now simple, safe, and accurate thanks to the depth of anesthesia monitors and target-controlled infusion (TCI) pumps. Common infusion pumps can also be used for TIVA, therefore it's not always necessary to have access to more advanced equipment. We aimed to provide an outline of the effects of dexmedetomidine and fentanyl on post-operative cognitive functions.

Conclusion: The locus coeruleus in the brain stem, where the greatest number of α2 adrenoceptors are located, is where dexmedetomidine exerts its effects. In addition to originating noradrenergic routes from the medulla oblongata to the spinal cord, the locus coeruleus plays an essential role in coordinating waking and sleeping by controlling neurotransmitter release. Fentanyl has been studied for its effects on cognitive function and its potential influence on the occurrence of postoperative cognitive dysfunction. However, it's important to note that the available evidence is limited, and the specific impact of fentanyl on cognitive function and POCD is still an area of ongoing research.

Keywords: Dexmedetomidine, Fentanyl, Post-Operative Cognitive Function, Total Intravenous Anesthesia

INTRODUCTION

The physiology of cognitive function encompasses the biological processes and mechanisms that enable the brain to perform various cognitive tasks. It involves the intricate interplay of numerous structures, systems, and cellular processes within the brain. Understanding the physiology of cognitive function is crucial for unraveling the complexities of human cognition and elucidating the underlying mechanisms of cognitive disorders. A neuron is a basic unit of the nervous system that is essential for normal brain function. Information is received, processed, and transmitted by these specialized cells by chemical and electrical impulses. Neuronal communication occurs through the synapses allowing the transmission of signals. The precise coordination and integration of neuronal activity across different brain regions are essential for cognitive processes [1].

Neurotransmitters are chemical messengers that facilitate communication between neurons. They are involved in regulating various cognitive functions, including attention, memory, learning, and emotion. Acetylcholine, for instance, plays an essential role in cognition and memory formation, whereas dopamine is linked to drive, incentive, and locomotion. Cognitive diseases like schizophrenia, Alzheimer's disease, and Parkinson's disease may be influenced by imbalances or malfunctions in neurotransmitter systems. There is a critical role for brain areas and networks in cognitive function [2]. Certain mental operations are handled by distinct regions of the brain. An example of an executive function is the hippocampus's role in memory creation and retrieval, whereas the prefrontal cortex is engaged in planning

and decision-making. The complex networks formed by these areas of the brain allow for the integration and processing of information [3].

Structural and functional connectivity within the brain are crucial for cognitive function. Structural connectivity refers to the physical connections between brain regions, primarily through white matter tracts. These connections allow for the transmission of information between distant brain areas. Conversely, functional connectivity describes how different parts of the brain are correlated in terms of neural activity throughout time. When performing cognitive tasks, it mirrors the coordinated action of networks both inside and between them. The brain's remarkable capacity to rewire itself in reaction to novel stimuli and altered internal states is known as neuroplasticity. It encompasses processes such as synaptic plasticity, neurogenesis, and changes in neuronal connectivity. Neuroplasticity underlies learning, memory formation, and recovery from brain injuries. It enables the brain to modify its structure and function to optimize cognitive processes [4].

Blood flow and metabolism are closely linked to cognitive function. The brain requires a constant supply of oxygen and nutrients to sustain its high energy demands. Cerebral blood flow ensures the delivery of oxygen and glucose to active brain regions. Neurovascular coupling is the mechanism that regulates blood flow based on neuronal activity. Disruptions in neurovascular coupling can impact cognitive function and have been observed in conditions such as stroke and neurodegenerative diseases [5].

In the time immediately following surgery or anesthesia, a disorder known as postoperative cognitive dysfunction (POCD) can set in. The condition can emerge at any time between the immediate postoperative period and six months later when at least one anomaly in a specific area of mental state, such as memory, consciousness, or attention, according to the International Society of Postoperative Cognitive Dysfunction (ISPOCD). While most people recover within a few days to a few weeks after surgery, memory loss and intellectual incapacity typically don't appear until weeks or months later. When preoperative and postoperative psychometric testing yields different findings, it might be used to detect postoperative cognitive dysfunction (POCD). The latest global agreement among scientists and medics was published in 2018 in the British Journal of Anesthesia. The goal of introducing a more precise description of POCD was to make research and educational initiatives easier: (1) postoperative neurocognitive dysfunction and (2) delayed neurocognitive recovery (within 30 days after surgery) (between 30 days and 12 months postoperatively) [6].

A reduction in general health, a rise in the 1-year post-surgical mortality rate, a lengthier hospital stay, and a longer recovery time after surgery are all factors that contribute to postoperative complications and death. In order to avoid postoperative complications (POCD), it is necessary for several medical fields to work together before, during, and after surgery. Preventing POCD before it happens is the greatest way to fight it. In order to improve patients' postoperative recovery and quality of life, as well as to prevent postoperative complications (POCD), it is critical that medical workers have a comprehensive grasp of POCD [7].

A neurocognitive evaluation will include both objective measures, such as standardized neuropsychological testing (NPT), and subjective measures, such as questions asked of the patient or their close family, and an evaluation of the patient's capacity to carry out ADLs (ADL). When compared to the prior suggestion, which relied solely on an objective test, this new method yields a more precise POCD diagnosis. A recent study detailed the use of RUDAS, a Thai version, to screen for postoperative complications using a live video feed from a mobile phone during the 5th to 9th day after surgery. Even though the exam took nearly 30 minutes for each patient, which is more time than the typical in-person evaluation, this strategy promoted the utilization of telemedicine in older patients, particularly those who did not adhere to clinical follow-up as recommended [8].

Management

Disorders that are similar to POCD can be used as a basis for treatment; (e.g., myocardial infarction, septic shock, medication or toxic-substance abuse, electrolyte imbalance, a hypo- or hyperglycemic state, endocrine or liver dysfunction, and neurological deficits). A glucose solution administered intravenously can treat hypoglycemia. If Wernicke encephalopathy is suspected, the correct course of treatment is thiamine. Patients with postoperative chronic diarrhea can also benefit from the standard procedures used to care for surgical patients. Ensuring proper breathing and oxygenation, providing hemodynamic support, and effectively controlling postoperative pain are all crucial ways. Adequate patient counseling is necessary for pain control. For a faster recovery, it's recommended to

keep an eye on your vitals, electrolytes, and the health of your heart and lungs. Even after POCD has resolved, patients may find it stressful to remember details from their episodes. So, doctors and nurses must provide patients with sound guidance and support [6].

Total Intravenous Anesthesia

The development of pharmacokinetic models, advancements in infusion pump technology, and the pharmacodynamics of intravenous medicines such as propofol and remifentanil have all played a role in the evolution of total intravenous anesthesia (TIVA). The use of depth of anesthesia monitors and target-controlled infusion (TCI) pumps has greatly simplified, improved, and standardized TIVA. Regular infusion pumps can also be used to do TIVA, thus it's not always necessary to have access to more advanced equipment [9]. Endotracheal tubes, supraglottic airway devices, nasal or oral airways, or oxygen alone are all viable options for TIVA administration. To begin with, TIVA was used in neurosurgery, day care surgery, as an adjunct to regional or local anesthesia, and for diagnostic and treatments requiring sedation or analgesia. Oncosurgery, pediatric and geriatric surgery, heart surgery, and non-operating room anesthesia have all recently found their use to be advantageous [10].

Drugs/combinations in total intravenous anesthesia

Ideal TIVA drugs have a quick onset of action, quick recovery, high potency, solubility in lipids, and solubility in solution; furthermore, they should not extravasate and cause perivascular sloughing. To reduce solvent toxicity, it should be water-soluble; plastic shouldn't absorb it; it shouldn't have any negative side effects; it should be inexpensive; and, most importantly, it should be compatible with other agents so mixing them isn't a problem [11].

In order to decrease the risk of intraoperative and postoperative problems, TIVA makes use of several adjuncts. Postoperative nausea and vomiting in propofol-based TIVA can be reduced by 30 percent with a single 8 mg dosage of the anti-inflammatory medication dexamethasone, and patients experience satisfactory recovery and discharge outcomes [12]. In the maintenance phase, the TIVA dose can be reduced by 10–20% with lidocaine administered as a bolus dose of 1-1.5 mg/kg followed by an infusion of 1.5 mg/kg/h. When used as an adjuvant to TIVA, magnesium sulphate decreases the need for propofol, dexmedetomidine, atracurium, and other opioids in the postoperative period. Postoperative analgesia is improved when used at bolus doses of 30-50 mg/kg followed by maintenance doses of 10 mg/kg/h. Plus points include its ability to reduce blood pressure, open airways, prevent irregular heartbeats, calm tremors, and stop seizures. During preoxygenation, a bolus of 1 mg/kg esmolol can be administered over 60 seconds, resulting in an 18.5% reduction in the overall induction dose. Research has demonstrated that using esmolol intravenously during surgery can lessen the need for both anesthesia and pain medication, and A distinctive sedative with analgesic, sympatholytic, and respiratory-preserving qualities is dexmedetomidine, a powerful and extremely selective α-2 adrenoceptor agonist. The United States Food and Drug Administration has given its approval for the following uses: providing short-term sedation (< 24 h) to adult patients in the intensive care unit (ICU) who were initially intubated or mechanically ventilated, and sedating non-intubated patients during surgical and other procedures. Due to numerous beneficial physiologic effects, dexmedetomidine's clinical uses have substantially increased in recent decades, despite its widespread usage for the aforementioned reasons in the intensive care unit and operating room experienced pain following a surgical procedure [13,14].

Anesthesia practitioners also frequently utilize dexmedetomidine. Procedure sedation for various surgeries is its primary usage. It is also commonly used to sedate patients during awake intubation procedures. Given these considerations, it is a perfect fit for this indication. During general anesthesia, dexmedetomidine is also infused as an adjuvant. Evidence suggests that dexmedetomidine reduces nausea, postoperative opioid use, and pain after surgery. Even when administered as a sedative with spinal anesthesia, this effect has been demonstrated to occur with dexmedetomidine. A recent study, however, casts doubt on this opioid-sparing effect for a group of patients having extensive spinal surgery [15].

For the purpose of preventing postoperative cognitive impairment, delirium, and emerging agitation, dexmedetomidine has attracted some attention as an adjuvant. Both adults and children can benefit from measures that reduce emerging agitation. A recent randomized trial failed to demonstrate a statistically significant benefit in this postoperative population when administering an intraoperative infusion of dexmedetomidine for postoperative delirium. This was expected due to the optimism surrounding dexmedetomidine's potential use in ICU sedation and its apparent

prevention/treatment of delirium. To extend the duration of analgesia, dexmedetomidine has also been utilized in peripheral nerve blocks. According to the available research, dexmedetomidine has the potential to prolong a peripheral nerve block for about three hours [16].

The impact of dexmedetomidine on intracranial pressure (ICP) is still unclear, however, it decreases cerebral blood flow and the metabolic need for oxygen in the brain. In addition to its sedative, analgesic, and anxiolytic effects via the α2-AR, dexmedetomidine improves cognitive performance via modulating spatial working memory. Its neuroprotective effects begin with a decrease in catecholamine levels in the blood and the brain, which equalizes the supply of oxygen to the brain, lessens excitotoxicity, and improves perfusion in the ischemic penumbra. In cases of subarachnoid hemorrhage in particular, it lowers glutamate levels, which are responsible for cellular brain harm. Its morphologic and functional effects following focal and global ischemia and traumatic brain injuries have been demonstrated to be limited [17].

Effect of Dexmedetomidine on Cognitive Function and POCD

The locus coeruleus in the brain stem, where the greatest number of α2 adrenoceptors are located, is where dexmedetomidine exerts its effects. In addition to originating noradrenergic routes from the medulla oblongata to the spinal cord, the locus coeruleus plays an essential role in coordinating waking and sleeping by controlling neurotransmitter release. Dexmedetomidine blocks the effects of sympathetic nervous system activity by activating α2 adrenoceptors in the brain and spinal cord, which in turn decrease neuronal discharge [18].

Dexmedetomidine, aside from its sedative-hypnotic effects, has broad modulatory effects on neuroinflammation. It protects against brain injury and reduces inflammation by inhibiting inflammatory cytokines and promoting the production of anti-apoptotic proteins. Its anti-inflammatory effects are dependent on the cholinergic anti-inflammatory pathway and involve the suppression of microglia-mediated release of pro-inflammatory factors. Dexmedetomidine also enhances prefrontal cortex activity, which is important for attention and behavior regulation [19]. Additionally, reports have linked POCD to the inflammatory response. One of the key pathways in the development of POCD is inflammation, which a nonspecific inflammatory inhibitor has the potential to alleviate. Trauma from surgery triggers an immunological cascade and the production of inflammatory mediators, which can lead to postoperative complications (POCD). One possible explanation for dexmedetomidine's anti-inflammatory effects and its effect on POCD incidence is that it decreases inflammation [20].

Patients using dexmedetomidine had a considerable improvement in their postoperative MMSE score and a marked decrease in the occurrence of early POCD. Significant stress-relieving (cortisol-reducing) effects and a marked decrease in proinflammatory cytokines have been linked to intraoperative dexmedetomidine. Treatment with dexmedetomidine was also linked to markedly improved neurocognitive function in patients older than 60 years. In the aged, both impacts may have a greater positive impact. This study's findings about the efficacy of dexmedetomidine in older individuals should be further investigated using bigger datasets [21].

Adverse Effects

Hypotension, bradycardia, and hypertension are the most prevalent side effects of dexmedetomidine. The activation of certain receptor subtypes in the smooth muscles lining blood vessels can lead to hypertension. Slow delivery or skipping the loading dose can usually prevent hypertension, which typically does not necessitate therapy. In addition to a reduction in central sympathetic outflow, hypotension, and bradycardia are brought about by the activation of presynaptic alpha receptors, which causes a decrease in norepinephrine release. It makes no difference which way the administration handles these matters [22].

Fentanyl

Like morphine, the powerful synthetic opioid fentanyl has analgesic effects, but to a larger degree. This powerful pharmacologic substance is usually fifty to one hundred times stronger than morphine. One hundred micrograms is all it takes to get the analgesic effects of about ten milligrams of morphine. However, fentanyl's pharmacokinetics and characteristics are quite different. Due to its largely hepatic clearance, it is most commonly used as a sedative in intubated patients and for severe pain in patients with renal failure [23].

When treating patients with chronic pain who have established a tolerance to opiates, physicians may occasionally resort to using fentanyl. The most popular method of administering it as a sedative is by a drip because of its adaptability in titration circumstances. When used as a sedative to individuals who need mechanical breathing, high

doses may be necessary. Fentanyl is also an option perioperatively as a pre-medication for procedures, especially those that are expected to cause discomfort. As a last point, fentanyl can be used to treat epilepsy. To clarify, therapeutic neuroleptanalgesia involves the use of this drug in conjunction with specific neuroleptic medicines [24]. The most common methods of administering fentanyl include intravenous (IV), intramuscular (IM), transdermal (TD) patches applied to the skin, intranasal (IN) volatile nasal spray, and intrathecally (IT). Like the sublingual pills, it is also available as a thin film that dissolves in the mouth, called buccal soluble. Synthetic opiate forms, such as oral pills or powders, are less common than other opiates. The new drug selectively acts on the gastrointestinal mu-opioid receptors, which means it can help with constipation and pain relief—a problem that was previously treated off-label in some hospitals by taking a mixture of naloxone and ice water orally—to address the GI side effects without counteracting the drug's main analgesic aims. One option for chronic pain treatment is the transdermal patch [25].

Fentanyl and Cognitive Function

Researchers have looked at fentanyl's impact on cognition and whether or not it increases the risk of postoperative cognitive impairment. Nevertheless, it should be mentioned that the current evidence is somewhat limited, and researchers are presently actively studying the exact effects of fentanyl on cognitive function and POCD. Acute impacts on cognitive function, especially at larger doses, can be produced by fentanyl. Sedation, disorientation, lethargy, and diminished focus are some of the possible side effects. It should be noted, though, that these side effects are usually just temporary and go away after the medicine is broken down and removed from the body [26].

Fentanyl is a common component of anesthetic used to alleviate pain and make patients more comfortable during surgery. The analgesic effects of fentanyl during surgery have the potential to mitigate the stress reaction, which in turn may help to maintain cognitive abilities. Reducing the secretion of stress hormones and inflammatory mediators is one goal of effective pain treatment, which may lead to a decreased likelihood of postoperative chronic pain (POCD). It is unclear, however, how fentanyl alone affects long-term cognitive outcomes like POCD. The inflammatory response in the body, including the brain, can be triggered by surgery and anesthesia, and neuroinflammation has been linked to the development of postoperative cognitive dysfunction (POCD). Fentanyl and other opioids have been the subject of research that suggests they may modify the brain's inflammatory response and even have anti-inflammatory effects. Fentanyl may have a neuroprotective impact by lowering neuroinflammation, which could lower the risk of POCD. The connection between fentanyl, neuroinflammation, and cognitive performance remains unclear, though, and requires additional research [27].

Adverse Effects

Fentanyl's side effects are similar to those of heroin, which produce euphoria, confusion, respiratory depression (which, if extensive and untreated, may lead to arrest), drowsiness, nausea, visual disturbances, dyskinesia, hallucinations, delirium, a subset of the latter known as "narcotic delirium," analgesia, constipation, narcotic ileus, muscle rigidity, constipation, addiction, loss of consciousness, hypotension, coma, and even death. Alcohol and other drugs (i.e., cocaine, and heroin) can synergistically exacerbate fentanyl's side effects, creating multi-layered clinical scenarios that can be complex to manage. These substances, taken together, generate undesirable conditions that complicate the patient's prognosis [28].

Like heroin, fentanyl can cause a variety of unpleasant side effects, including but not limited to euphoria, confusion, respiratory depression (which, if left untreated, can cause arrest), lethargy, nausea, visual disturbances, dyskinesia, hallucinations, delirium (including a type of delirium called "narcotic delirium"), analgesia, constipation, narcotic ileus, muscles rigidity, constipation, addiction, loss of consciousness, hypotension, coma, and death. In addition to amplifying fentanyl's negative effects, alcohol and other substances (such as heroin and cocaine) can have a multiplicative effect, leading to complicated and multi-faceted clinical situations. The patient's prognosis is worsened when these chemicals are combined and cause unpleasant situations.

CONCLUSION

In the brain stem, where the highest concentration of α2 adrenoceptors is found, dexmedetomidine exerts its effects in the locus coeruleus. In addition to originating noradrenergic routes from the medulla oblongata to the spinal cord, the locus coeruleus plays an essential role in coordinating waking and sleeping by controlling neurotransmitter release. Fentanyl has been studied for its effects on cognitive function and its potential influence on the occurrence of postoperative cognitive dysfunction. However, it's

important to note that the available evidence is limited, and the specific impact of fentanyl on cognitive function and POCD is still an area of ongoing research.

Conflict of interest: None.

Funding sources: None.

REFERENCES

1. Bayne T, Brainard D, Byrne RW, Chittka L, Clayton N, Heyes C, et al. What is cognition?. Curr Biol. 2019;29(13):608-15.
2. Lin X, Chen Y, Zhang P, Chen G, Zhou Y, Yu X. The potential mechanism of postoperative cognitive dysfunction in older people. Exp Gerontol. 2020;130:110791.
3. Pulvermüller F, Tomasello R, Henningsen-Schomers MR, Wennekers T. Biological constraints on neural network models of cognitive function. Nat Rev Neurosci. 2021;22(8):488-502.
4. Lyon P, Keijzer F, Arendt D, Levin M. Reframing cognition: getting down to biological basics. Philos Trans R Soc Lond B Biol Sci. 2021;376(1820):20190750.
5. Bechtel W, Bich L. Grounding cognition: heterarchical control mechanisms in biology. Philos Trans R Soc Lond B Biol Sci. 2021;376(1820):20190751.
6. Suenghataiphorn T, Songwisit S, Tornsatitkul S, Somnuke P. An Overview on Postoperative Cognitive Dysfunction; Pathophysiology, Risk Factors, Prevention and Treatment. Siriraj Medical Journal,2022, 74(10), 705-13.
7. Brodier EA, Cibelli M. Postoperative cognitive dysfunction in clinical practice. BJA Educ. 2021;21(2):75-82.
8. Suesat H, Srinonpraser V, Limpawattana P, Nakyos S, Poontananggul J, Jiraphorncharas C, et al. Detection of Postoperative Cognitive Dysfunction by Telemedicine Among Octogenarian Patients Who Underwent Minor Elective Surgery; Prospective Cohort Study. Siriraj Med J,2022, 74(2), 126-33.
9. Wong SSC, Choi SW, Lee Y, Irwin MG, Cheung CW. The analgesic effects of intraoperative total intravenous anesthesia (TIVA) with propofol versus sevoflurane after colorectal surgery. Medicine (Baltimore). 2018;97(31):e11615.
10. Kapoor P. M,Chokshi T. Utility of TIVA in COVID-19 Era. *JCCC TSS*,2021, *5*(01), 1-4.
11. Wiener-Kronish J. P, Cohen N. H, Leslie K, Gropper M. A, Eriksson L. I, Fleisher, L. A. Miller's anesthesia, 2-volume set E-book. Elsevier Health Sciences,2019.
12. Gupta B. Role of dexamethasone in peri-operative anesthesia management: a review of literature. Anesthesiol. Res. Pract. —Open Journal,2017, 2(2), 33-9.
13. Kong H, Li M, Deng CM, Wu YJ, He ST, Mu DL. A comprehensive overview of clinical research on dexmedetomidine in the past 2 decades: A bibliometric analysis. Front Pharmacol. 2023;14:1043956.
14. Paula-Garcia WN, Oliveira-Paula GH, de Boer HD, Garcia LV. Lidocaine combined with magnesium sulfate preserved hemodynamic stability during general anesthesia without prolonging neuromuscular blockade: a randomized, double-blind, controlled trial. BMC Anesthesiol. 2021;21(1):91.
15. Goucher Miranda H, Krystal AD, Fierro MA. Nocturnal Dexmedetomidine in Nonintubated, Critically Ill Patients: Sleep or Sedation?. Anesthesiology. 2017;127(2):397-8.
16. Deiner S, Luo X, Lin HM, Sessler DI, Saager L, Sieber FE, et al. Intraoperative Infusion of Dexmedetomidine for Prevention of Postoperative Delirium and Cognitive Dysfunction in Elderly Patients Undergoing Major Elective Noncardiac Surgery: A Randomized Clinical Trial. JAMA Surg. 2017;152(8):e171505.
17. Bao N, Tang B. Organ-Protective Effects and the Underlying Mechanism of Dexmedetomidine. Mediators Inflamm. 2020;2020:6136105.
18. Cheon SY, Kim JM, Kam EH, Ho CC, Kim EJ, Chung S, et al. Cell-penetrating interactomic inhibition of nuclear factor-kappa B in a mouse model of postoperative cognitive dysfunction. Sci Rep. 2017;7(1):13482.
19. Qiu Z, Lu P, Wang K, Zhao X, Li Q, Wen J, et al. Dexmedetomidine Inhibits Neuroinflammation by Altering Microglial M1/M2 Polarization Through MAPK/ERK Pathway. Neurochem Res. 2020;45(2):345-53.
20. Tan XX, Qiu LL, Sun J. Research Progress on the Role of Inflammatory Mechanisms in the Development of Postoperative Cognitive Dysfunction. Biomed Res Int. 2021;2021:3883204.
21. Ran J, Bai X, Wang R, Li X. Role of Dexmedetomidine in Early POCD in Patients Undergoing Thoracic Surgery. Biomed Res Int. 2021;2021:8652028.
22. Lee S. Dexmedetomidine: present and future directions. Korean J Anesthesiol. 2019;72(4):323-30.
23. Glick JL, Christensen T, Park JN, McKenzie M, Green TC, Sherman SG. Stakeholder perspectives on implementing fentanyl drug checking: Results from

a multi-site study. Drug Alcohol Depend. 2019;194:527-32.
24. Wakeman SE, Chang Y, Regan S, Yu L, Flood J, Metlay J, et al. Impact of Fentanyl Use on Buprenorphine Treatment Retention and Opioid Abstinence. J Addict Med. 2019;13(4):253-7.
25. Nagelhout, J. J. Opioid and Nonopioid Analgesics. Nurse Anesthesia-E-Book, 138.
26. Thompson R, Seck V, Riordan S, Wong S. Comparison of the Effects of Midazolam/Fentanyl, Midazolam/Propofol, and Midazolam/Fentanyl/Propofol on Cognitive Function After Gastrointestinal Endoscopy. Surg Laparosc Endosc Percutan Tech. 2019;29(6):441-6.
27. De Cosmo G, Sessa F, Fiorini F, Congedo E. Effect of remifentanil and fentanyl on postoperative cognitive function and cytokines level in elderly patients undergoing major abdominal surgery. J Clin Anesth. 2016;35:40-6.
28. Mars SG, Rosenblum D, Ciccarone D. Illicit fentanyls in the opioid street market: desired or imposed?. Addiction. 2019;114(5):774-80.

Citation

Farid, D., Hassan, O., Fahmy, A., Taha, K. Effects of Dexmedetomidine and Fentanyl on Post-Operative Cognitive Function. *Zagazig University Medical Journal*, 2024; (4748-4754): -. doi: 10.21608/zumj.2024.273198.3209