POSTSURGICAL PAIN INTENSITY IN CHILDREN ON THE VAS AND FLACC SCALE ACROSS VARIOUS ANALGESIC TECHNIQUES. MATHEMATICAL PREDICTION AS A COMPONENT OF JUSTIFICATION

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Nowadays, in pediatric practice, the Visual Analogue Scale (VAS) and the Face, Legs, Activity, Cry, Consolability (FLACC) scale are effective for assessing postsurgical pain. The modern concept of pain management includes a multimodal approach, including regional analgesia techniques.

The aim *of the study was to present a mathematical model to assess the efficacy of regional analgesia techniques in managing postsurgical pain intensity on the VAS and FLACC scale up to the fifth day of the study and predict the behaviour of the experimental data function up to day 87 following surgery using the autoregressive probability model.*

Materials and Methods. *89 patients operated on the anterior abdominal wall were divided into 3 groups depending on the type of anesthesia. The assessment of pain management quality and the presence of acute pain was conducted using the VAS and FLACC scale on days 1, 2, 3, and 5 post-operatively in all children. The 'predict' function in PTC MathCad Prime 7.0. software was used to automate calculating predictions based on the Burg method.*

Results. *Studying the efficiency of the proposed treatment using regional analgesia techniques versus conventional analgesia enabled the prediction of varying postsurgical pain intensities on the VAS and FLACC scale based on their mathematical models, with coefficient of determination $R^2=0.9876$, $R^2=0,9827$, $R^2=0.9952$ for the FLACC scale and $R^2=0.9868$, $R^2=0,915$, $R^2=0.9774$ for the VAS.*

Conclusions. *The use of regional analgesia techniques in children undergoing anterior abdominal wall surgery has been confirmed to be associated with a significant reduction in postsurgical pain intensity to the fifth day of observation and predicted to remain so up to day 87*

Keywords: *local anesthetics, pain, regional analgesia, mathematical prediction*

1. Introduction

Myelination of peripheral nerves is completed at the moment of birth, therefore every newborn child, and later also infants, are able to feel pain and respond with motor reactions to unpleasant stimuli [1]. However, pain inhibition pathways are not yet developed, so younger children may experience stronger pain in response to a noxious stimulus of lower intensity [2, 3]. Tissue damage can lead to long-term structural and functional disruption of pain pathways, which in turn provokes chronic pain and increased sensitivity to pain stimuli in the future [4]. Physiological increases in heart rate, blood pressure, and oxygen demand in response to noxious stimuli can worsen postoperative outcomes [5], as well as provoke the development of psychological side effects such as fear, anxiety, and depression [6].

Postoperative treatment of pain in children in the world, and in our country in particular, is still far from ideal. As reported, only 25 % of children undergo surgical procedures without pain on the day of the intervention, and 13 % of children suffer from severe pain [7]. The principles of oligoanalgesia are used exclusively due to the lack of mandatory recommendations for pain assessment in each clinic in particular [8].

Currently, more than 40 multidimensional observation scales have been developed to assess pain intensity, some of them adapted and applied in different populations and clinical situations [9–11]. Self-assessment scales are the standard for assessing pain in children of different ages [12]. They can be verbal and non-verbal, but they always require a certain degree of knowledge and communication skills that depend on the child's development. For example, when working with younger children, facial expression scales are preferred [13]. The most frequently used self-assessment scales are FLACC (face, position of legs in bed, activity, crying, emotional state) and visual analogue scale (VAS). The VAS depicts a line 10 cm long on which the child must mark the point corresponding to his pain. These scales are often used in clinical practice, and their reliability and sensitivity have

been confirmed by research [14, 15]. The 2017 guidelines, based on the strongest evidence for the validity of specific pain scales, recommend using the VAS as the gold standard for pain assessment in children older than 6 years [16].

The FLACC scale was published in 1997 to assess postoperative pain in children and is currently one of the most used [17]. The FLACC scale contains 5 behavioural components, including facial expression, leg position in bed, activity, crying, and emotional state, and each is rated from 0 to 10. Compared to other pain scales in infants and children, the FLACC scale is more convenient and practical for diagnosing pain [18–20]. Also, according to Matsuishi et al. a high correlation between the FLACC and VAS scales was confirmed, which justifies their use in pediatric practice [21].

Postoperative pain can cause inflammatory, visceral, or somatic phenomena, which, in case of inadequate medical response, initiate the development of chronic pain. According to various data, the frequency of postoperative pain is diagnosed in 60 % of patients, and the efforts made by the world anesthesiological community are not yet able to fully solve this issue [22].

Opioids and non-steroidal anti-inflammatory drugs are used as components of analgesic therapy with their known side effects. The modern concept of pain treatment includes a multimodal approach and is mainly aimed at reducing the use of opioids to reduce the profile of side effects (postoperative respiratory depression, decreased intestinal peristaltic activity, length of hospital stay) [23].

Performance of advanced trunk blocks under regional anaesthesia (RA) in children (quadratus lumborum block 4, transversalis fascia plane block) today confirms its effectiveness in the treatment of acute postoperative pain and prevention of chronic pain in children [24–29].

The aim of the research was to present a mathematical model of the effectiveness of regional analgesia techniques on the intensity of postoperative pain according to the FLACC and VAS scales up to the fifth day of the study and to predict the behavior of the function of the experimental data up to the 87th day using the autoregressive probability model method.

2. Methods and materials of the research

The study was conducted based on the CNE "Ivano-Frankivsk Regional Children's Clinical Hospital IFRC" in the period from 2022 to 2023. 87 children (46 boys and 41 girls) aged from 7 to 18 years (average age of children – 11.96±0.12) participated in the study, who underwent surgery on the anterior abdominal wall with various options of anaesthesia. All patients were divided into 3 groups: the first group consisted of 33 children operated on the anterior abdominal wall under general anaesthesia with the use of morphine. The II group consisted of 27 children operated on the anterior abdominal wall under general anaesthesia with the use of a regional block of the transverse fascia of the abdomen (TFPB). Group III consisted of 27 children operated on the anterior abdominal wall, under general anaesthesia, using a regional block of the transverse fascia of the abdomen (TFPB), combined with a block of the quadratus lumborum muscle (QLB-4) from one injection. General anaes-

thesia was performed using sevoflurane (2–3 vol.%) or propofol infusion (1–2 mg/kg/h) and the opioid analgesic fentanyl (the dose varied depending on the type of anaesthesia). A 0.25% solution of bupivacaine at the rate of 0.2–0.3 ml/kg was used as a local anaesthetic.

The quality of analgesia and the presence of acute pain were assessed using the visual analogue scale (VAS), the FLACC scale (face, position of legs in bed, activity, crying, emotional state). Determination of VAS and FLACC indicators was carried out on 1, 2, 3 and 5 days, respectively, in all children.

All clinical and laboratory studies were conducted in accordance with the Declaration of Helsinki of the World Medical Association "Ethical Principles of Medical Research Involving Human Subjects". In accordance with current legislation, before the start of the study, each of its subjects (parents or adult guardians of the patient) signed a detailed form of informed consent for conducting the study. The article was passed by the commission on ethics based on the CNE "Ivano-Frankivsk Regional Children's Clinical Hospital IFRC", which is confirmed by an extract from the protocol of the commission No. 2 dated February 22, 2022.

To predict (extrapolate) the behavior of the function of the experimental data, the autoregression model method was used: the Berg method. Automation of forecasting calculations according to the Berg method was carried out using the **"predict" function** of RTS MathCad Prime 7.0. Linear, non-linear, and polynomial regression models were used to approximate the experimental data. The probability of the constructed mathematical model of a separate indicator was estimated using the coefficient of determination R^2, which shows what proportion of the total variation of the dependent variable is described by the selected set of independent variables. The value of R^2 varies from 0 to 1. The larger the value of the coefficient, the more accurate the constructed mathematical regression model is.

3. Research results

The mathematical model of the dynamics of the FLACC index in children who used traditional opioid analgesia during surgery on the anterior abdominal wall looks like: $y=a\cdot e^{bx}$, where $a=11,074$, $b=-0,486$ (coefficient of determination $R^2=0,9876$).

Fig. 1 shows the dynamics of the FLACC indicator in the studied group during five days of observation and 87 days of forecasting.

Thus, the level of pain according to the FLACC scale in the first five days after surgery was sufficiently high (≥ 4 points). Later, up to 10 days after surgery, a decrease in pain intensity is noted, but the pain is present at the level of two points. Mathematical forecasting until the 87th day after the operation confirms the slow decrease of the pain syndrome, which disappears only after the 82nd day.

For a group of children who received traditional opioid analgesia in combination with regional analgesia using transversum fascia plain block (TFPB) during surgery on the anterior abdominal wall, the mathematical model is represented by the formula:

$$y=a\cdot x^6+b\cdot x^5+c\cdot x^4+d\cdot x^3+k\cdot x^2+m\cdot x+n,$$

where $a=0,0003$, $b=-0,0117$, $c=0,1487$, $d=-0,8042$, $k=1,6611$, $m=1,3507$, $n=3,2732$ (coefficient of determination $R^2=0,9827$).
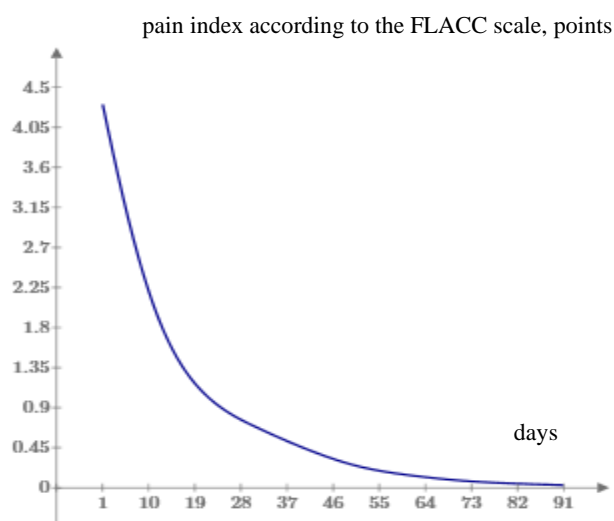

Fig. 1. The result of the five-day study and 87-day prediction of pain intensity according to the FLACC scale (points) in the group of patients receiving traditional opioid analgesia according to the mathematical model built in Mathcad Prime 7.0.0.0

Fig. 2 presents the dynamics of pain intensity in the study group during five days of observation and 87 days of prognosis.

An excellent dynamics of pain intensity according to the FLACC scale compared to patients in the opioid analgesia group is noted. The pain level on the fifth day was found to be 2.5 points, with a tendency to decrease until the 13th day after surgery. However, from the 28th day, the mathematical prediction shows an increase in pain intensity from negative numbers (-1.5 points) to a positive value on the 50th day (0.5 points) and a sharp decrease to the 87th day, acquiring normal values.
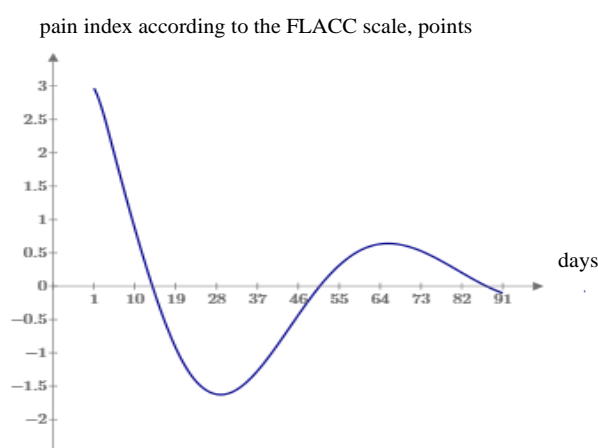

Fig. 2. The result of five days of research and 87 days of prediction of pain intensity according to the FLACC scale in a group of patients receiving traditional analgesia in combination with a regional block of TFPB according to the mathematical model built in Mathcad Prime 7.0.0.0

The dynamics of pain intensity in children who used traditional opioid analgesia in combination with regional analgesia using transversum fascia plain block (TFPB) and quadratus lumborum block (QLB) from one injection during surgery on the anterior abdominal wall is represented by a mathematical model:

$$y=a \cdot x^5 + b \cdot x^4 + c \cdot x^3 + d \cdot x^2 + k \cdot x + l,$$

where $a=0,0006$, $b=-0.02$, $c=0.2588$, $d=-1.4058$, $k=2.4191$, $l=1.5227$ (coefficient of determination $R^2=0.9952$).

Analysis of the curve shown in Fig. 3 indicates that the level of pain in children who used traditional opioid analgesia combined with regional analgesia using TFPB and QLB is the lowest, compared to other study groups. For comparison, the pain completely disappears up to 19 days after surgery, acquiring negative values up to 53 days. Mathematical modelling of pain intensity according to the FLACC scale in the studied group confirms the effectiveness of the proposed combination of regional blocks as an effective marker of postoperative analgesia.
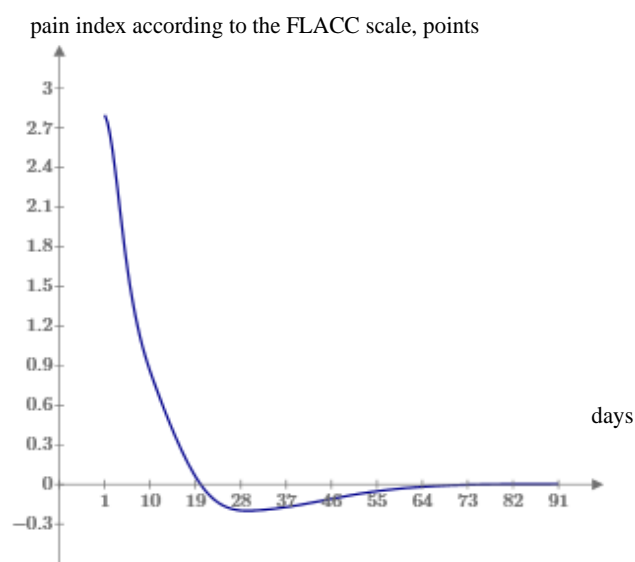

Fig. 3. The result of five days of research and 87 days of prediction of pain intensity according to the FLACC scale in the group of patients receiving traditional analgesia in combination with a regional TFPB+QLB block according to the mathematical model built in Mathcad Prime 7.0.0.0

Assessment of pain intensity using the visual analogue scale (VAS) established the following. The mathematical model of the dynamics of the VAS indicator in children who used traditional opioid analgesia during surgery on the anterior abdominal wall looks like:

$$y=a \cdot x^6 + b \cdot x^5 + c \cdot x^4 + d \cdot x^3 + k \cdot x^2 + m \cdot x + n,$$

where $a=0.0006$, $b=-0.022$, $c=0.2942$, $d=-1.7405$, $k=4.4482$, $m=-5.2919$, $n=6.8391$ (coefficient of determination $R^2=0.9868$).

Fig. 4 presents the dynamics of pain according to the VAS scale in the studied group during five days of observation and 87 days of prognosis.

Thus, the level of pain on the VAS scale in the first 20 days after surgery tends to decrease (from 4.5 points to 0 points). After 20 days, this indicator becomes negative (-3 points).

From the 35th day, an increase in the indicator is noted, and by the 65th day, it amounted to almost one and a half points. However, by the 87th day, the normalization of this indicator is noted.
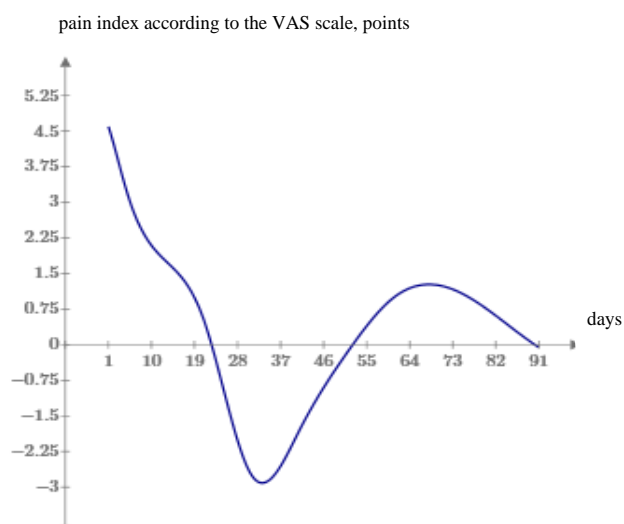

Fig. 4. The result of five days of research and 87 days of prediction of pain intensity according to the VAS scale (points) in the group of patients of traditional opioid analgesia according to the mathematical model built in Mathcad Prime 7.0.0.0

For a group of children who were treated with traditional opioid analgesia in combination with regional analgesia with the use of a regional TFPV block during surgery on the anterior abdominal wall, the mathematical model is represented by the formula:

$$y = a \cdot x^b + c,$$

where $a = -9.022 \cdot 10^5$, $b = 8.75 \cdot 10^{-7}$, $c = 9.022 \cdot 10^5$ (coefficient of determination $R^2 = 0.915$)

Fig. 5 shows the dynamics of pain intensity in the study group during 5 days of observation and 87 days of prognosis. Mathematical forecasting established that by the 19th day, an active reduction of the pain syndrome was noted with an initial value of 2.8 points. However, from the 30th day of mathematical forecasting, there is an inversion of the curve from a negative value (–0.8 points) to positive figures (0.3 points) with a further approach to 0 on the 87th day.

The dynamics of pain intensity in children who used traditional opioid analgesia in combination with regional analgesia using a regional block of TFPB and QLB from one injection during surgery on the anterior abdominal wall is presented by a mathematical model:

$$y = a \cdot x^6 + b \cdot x^5 + c \cdot x^4 + d \cdot x^3 + k \cdot x^2 + m \cdot x + n,$$

where $a = 0.0003$, $b = -0.0101$, $c = 0.123$, $d = -0.6135$, $k = 1.0447$, $m = -0.7468$, $n = 3.1055$ (coefficient of determination $R^2 = 0.9774$).
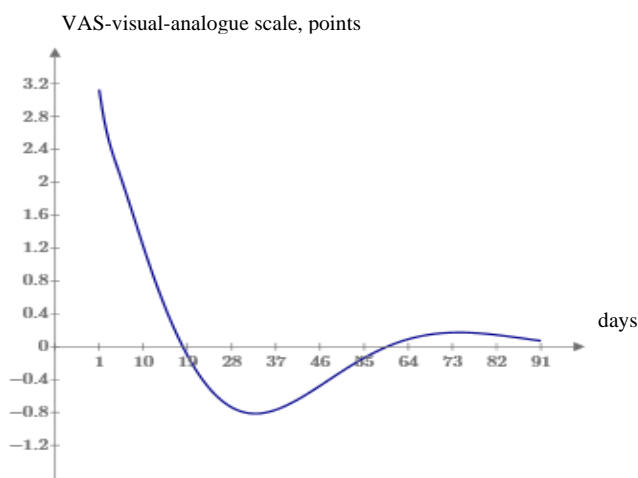

Fig. 5. The result of five days of research and 87 days of prediction of pain intensity according to the VAS scale in the group of patients of traditional anaesthesia in combination with a regional block of TFPB according to the mathematical model built in Mathcad Prime 7.0.0.0

The analysis of the curve shown in Fig. 6 indicates that the level of pain in children who used traditional opioid analgesia combined with regional analgesia using TFPB and QLB is the lowest, compared to other study groups. In comparison, pain completely disappears up to 10 days after surgery, acquiring negative values up to 87 days of mathematical prediction.
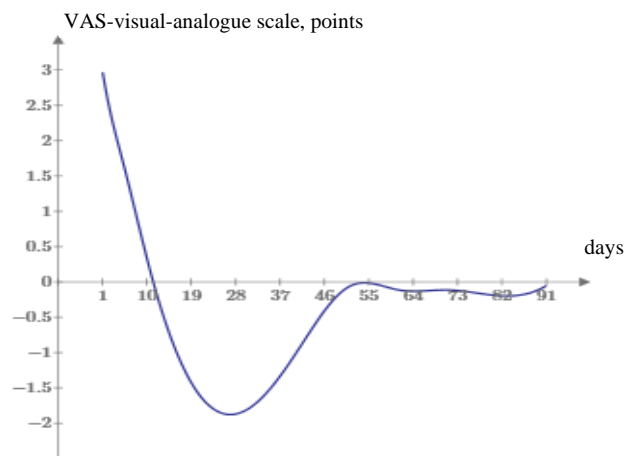

Fig. 6. The result of five days of research and 87 days of prediction of pain intensity according to the VAS scale in the group of patients of traditional analgesia in combination with a regional TFPB+QLB block according to the mathematical model built in Mathcad Prime 7.0.0.0

4. Discussion of research results

Local anesthetics (LA) are mainly used to reverse action potentials that generate impulse conduction along axons carrying sensory or motor signals. This occurs by blocking voltage-gated sodium channels. [30]. Acting as weak bases in their ionized form, LAs block the neural

conduction of Na⁺ in the channel when it is inactive, thus preventing the opening and flow of ions [31]. LAs can suppress the production of free radicals, thereby possessing anti-inflammatory properties [32]. To block impulse conduction, there is a minimum concentration of LA required for each nerve fiber according to its size and myelination. Unmyelinated fibers that control pain require lower concentrations of LA than myelinated fibers that control muscle contraction. Therefore, its lower concentrations can be used for analgesia, especially in children younger than 18 months, in whom myelination of the central nervous system has not yet been completed. LAs with continuous infusion have a longer duration of action than those administered according to the principle of single administration [33]. The effect of LA is influenced by pH, calcium concentration and nerve stimulation. Increasing the dose, concentration, and volume of LA can prolong the duration of the block by up to 50 %.

The proposed treatment using regional analgesia methods confirms its effectiveness by means of mathematical prediction, thanks to which the further average value of FLACC and VAS in children of the study groups is predicted according to their mathematical models according to the reliability of the approximation ($R^2=0.9876$, $R^2=0.9827$, $R^2=0.9952$ and $R^2=0.9868$, $R^2=0.915$, $R^2=0.9774$ respectively (Fig. 7, 8).

The clarity presented in Fig. 7 indicates that children with surgical interventions on the anterior abdominal wall using a combined TFPB+QLB regional block have the best dynamics of pain syndrome regression, and the absence of the appearance of pain in the process of mathematical forecasting is also confirmed.
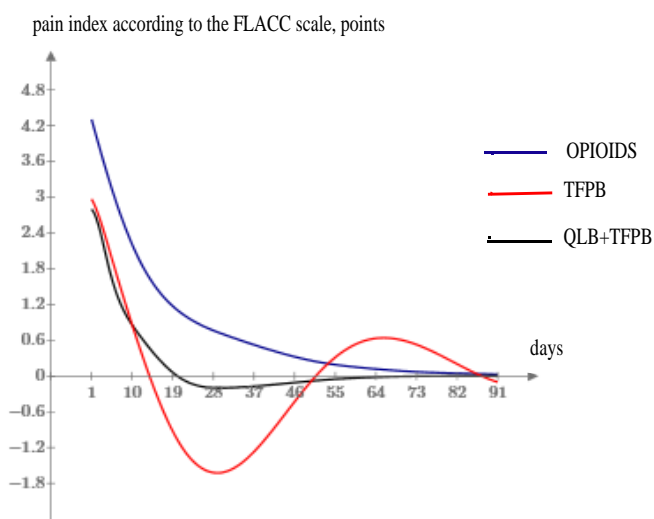

Fig. 7. The result of five days of research and 87 days of prediction of pain intensity according to the FLACC scale in the group of patients receiving traditional analgesia, in combination with a regional block of TFPB and a combination with a regional block of TFPB+QLB according to a mathematical model built in Mathcad Prime 7.0.0.0
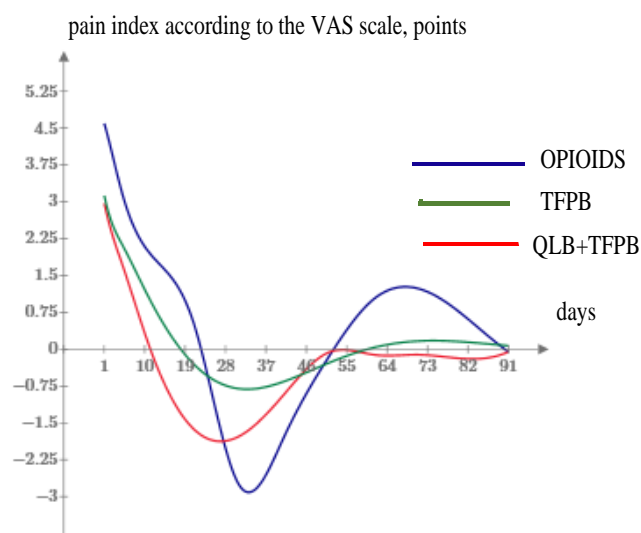

Fig. 8. The result of five days of research and 87 days of prediction of pain intensity according to the VAS scale in the group of patients receiving traditional analgesia, in combination with a regional block of TFPB and a combination with a regional block of TFPB+QLB according to a mathematical model built in Mathcad Prime 7.0.0.0

Study limitations. The study pays careful attention to the assessment of acute postoperative pain and the prediction of chronic pain syndrome depending on the choice of anaesthetic care. The application of the regional technique of analgesia of the quadratus lumborum muscle and plane of transverse lumbar fascia from one injection for the treatment of acute postoperative pain and the prevention of chronic pain syndrome is a limitation of this study.

The influence of martial law conditions. Full-scale invasion resulted in a significant limitation of the patient sample for the study.

Prospects for further research. It is planned to continue the study of the cause of the development of acute persistent postoperative pain, chronic pain syndrome, to improve the methods of regional analgesia using myofascial blocks under ultrasound guidance.

5. Conclusions

1. The use of methods of objective assessment of pain according to the FLACC and VAS scales allows timely medical response to the intensity of postoperative pain in children over six years of age.

2. It has been confirmed that the use of regional analgesia methods in children during operations on the anterior abdominal wall is accompanied by a significant decrease in the intensity of postoperative pain.

3. Pain intensity up to the fifth day of follow-up according to FLACC and VAS scales in children who used traditional analgesia in combination with regional analgesia using transversum fascia plain block and quadratus lumborum block is the lowest, compared to other study groups.

4. In the mathematical prediction of pain intensity up to 87 days, the best tendency to reduce pain is noted

when using a combined regional block from one injection compared to other study groups.

References

1. Gilhus, N. E., Deuschl, G. (2019). Neuroinflammation – a common thread in neurological disorders. Nature Reviews Neurology, 15 (8), 429–430. https://doi.org/10.1038/s41582-019-0227-8

2. Serhan, C. N., Gupta, S. K., Perretti, M., Godson, C., Brennan, E., Li, Y. et al. (2020). The Atlas of Inflammation Resolution (AIR). Molecular Aspects of Medicine, 74, 100894. https://doi.org/10.1016/j.mam.2020.100894

3. Semkovych, Ya., Dmytriiev, D., Dobrovanov, O., Vidiscak, M., Supinova, M. (2022). Acute and chronic pain in children. A modern view of the issue. Lekársky Obzor, 71 (9), 338–342.

4. Borsook, D., Youssef, A. M., Simons, L., Elman, I., Eccleston, C. (2018). When pain gets stuck: the evolution of pain chronification and treatment resistance. Pain, 159 (12), 2421–2436. https://doi.org/10.1097/j.pain.0000000000001401

5. Reust, C., Williams, A. (2016). Acute abdominal pain in children. American Family Physician, 93 (10), 830–836.

6. Linton, S. J., Shaw, W. S. (2011). Impact of Psychological Factors in the Experience of Pain. Physical Therapy, 91 (5), 700–711. https://doi.org/10.2522/ptj.20100330

7. Dmytriiev, D. (2018). Assessment and treatment of postoperative pain in children. Anaesthesia, Pain & Intensive Care, 22 (3), 392–400.

8. Semkovych, Ya., Dmytriiev, D., Rusak, P., Zaporozhan, S., Nazarchuk, O. (2022). Prevalence of chronic pain after herniorrhaphy, orchiopexy, and bernardi procedure in children. A retrospective-prospective study. Paediatric Surgery. Ukraine, 3 (76), 8–18. https://doi.org/10.15574/ps.2022.76.8

9. Hejr, H., Alizadeh, Z., Paymard, A., Khalili, A. (2017). A systematic review of pain assessment method in children. Annals of Tropical Medicine and Public Health, 10 (4), 847–849. https://doi.org/10.4103/atmph.atmph_155_17

10. Verstraete, J., Ramma, L., Jelsma, J. (2020). Validity and reliability testing of the Toddler and Infant (TANDI) Health Related Quality of Life instrument for very young children. Journal of Patient-Reported Outcomes, 4 (1). https://doi.org/10.1186/s41687-020-00251-4

11. Tamvaki, E., Efstratiou, F., Nteli, C., Matziou, V., Pavlopoulou, I., Myrianthefs, P. et al. (2020). Validation of the Greek Version of Comfort-B, FLACC, and BPS Scales in Critically Ill Children and Their Association with Clinical Severity. Pain Management Nursing, 21 (5), 468–475. https://doi.org/10.1016/j.pmn.2019.10.004

12. Birnie, K. A., Hundert, A. S., Lalloo, C., Nguyen, C., Stinson, J. N. (2018). Recommendations for selection of self-report pain intensity measures in children and adolescents: a systematic review and quality assessment of measurement properties. Pain, 160 (1), 5–18. https://doi.org/10.1097/j.pain.0000000000001377

13. Subramaniam, S. D., Doss, B., Chanderasekar, L. D., Madhavan, A., Rosary, A. M. (2018). Scope of physiological and behavioural pain assessment techniques in children – a review. Healthcare Technology Letters, 5 (4), 124–129. Portico. https://doi.org/10.1049/htl.2017.0108

14. de Tovar, C., von Baeyer, C. L., Wood, C., Alibeu, J.-P., Houfani, M., Arvieux, C. (2010). Postoperative Self-Report of Pain in Children: Interscale Agreement, Response to Analgesic, and Preference for a Faces Scale and a Visual Analogue Scale. Pain Research and Management, 15 (3), 163–168. https://doi.org/10.1155/2010/475907

15. Peng, T., Qu, S., Du, Z., Chen, Z., Xiao, T., Chen, R. (2023). A Systematic Review of the Measurement Properties of Face, Legs, Activity, Cry and Consolability Scale for Pediatric Pain Assessment. Journal of Pain Research, 16, 1185–1196. https://doi.org/10.2147/jpr.s397064

16. Beltramini, A., Milojevic, K., Pateron, D. (2017). Pain Assessment in Newborns, Infants, and Children. Pediatric Annals, 46 (10), 387–395. https://doi.org/10.3928/19382359-20170921-03

17. Merkel, S. I., Voepel-Lewis, T., Shayevitz, J. R., Malviya, S. (1997). The FLACC: a behavioral scale for scoring postoperative pain in young children. Pediatric Nursing, 23 (3), 293–297.

18. Crellin, D., Sullivan, T. P., Babl, F. E., O'sullivan, R., Hutchinson, A. (2007). Analysis of the validation of existing behavioral pain and distress scales for use in the procedural setting. Pediatric Anesthesia, 17 (8), 720–733. https://doi.org/10.1111/j.1460-9592.2007.02218.x

19. von Baeyer, C. L., Spagrud, L. J. (2007). Systematic review of observational (behavioral) measures of pain for children and adolescents aged 3 to 18 years. Pain, 127 (1), 140–150. https://doi.org/10.1016/j.pain.2006.08.014

20. Crellin, D. J., Harrison, D., Santamaria, N., Babl, F. E. (2015). Systematic review of the Face, Legs, Activity, Cry and Consolability scale for assessing pain in infants and children. Pain, 156 (11), 2132–2151. https://doi.org/10.1097/j.pain.0000000000000305

21. Matsuishi, Y., Hoshino, H., Shimojo, N., Enomoto, Y., Kido, T., Hoshino, T. et al. (2018). Verifying the validity and reliability of the Japanese version of the Face, Legs, Activity, Cry, Consolability (FLACC) Behavioral Scale. PLOS ONE, 13 (3), e0194094. https://doi.org/10.1371/journal.pone.0194094

22. Kehlet, H., Jensen, T. S., Woolf, C. J. (2006). Persistent postsurgical pain: risk factors and prevention. The Lancet, 367 (9522), 1618–1625. https://doi.org/10.1016/s0140-6736(06)68700-x

23. Semkovych, Y., Dmytriiev, D. (2023). Prevention of hyperalgesia in children when using various anesthesia techniques. Neonatology, Surgery and Perinatal Medicine, 13 (2 (48)), 71–77. https://doi.org/10.24061/2413-4260.xiii.2.48.2023.10

24. Merella, F., Canchi-Murali, N., Mossetti, V. (2019). General principles of regional anaesthesia in children. BJA Education, 19 (10), 342–348. https://doi.org/10.1016/j.bjae.2019.06.003

25. Blanco, R., Ansari, T., Riad, W., Shetty, N. (2016). Quadratus Lumborum Block Versus Transversus Abdominis Plane Block for Postoperative Pain After Cesarean Delivery: a randomized controlled trial. Regional Anesthesia and Pain Medicine, 41 (6), 757–762. https://doi.org/10.1097/aap.0000000000000495

26. Ishio, J., Komasawa, N., Kido, H., Minami, T. (2017). Evaluation of ultrasound-guided posterior quadratus lumborum block for postoperative analgesia after laparoscopic gynecologic surgery. Journal of Clinical Anesthesia, 41, 1–4. https://doi.org/10.1016/j.jclinane.2017.05.015

27. Semkovych, Y. (2023). Impact of the CD40-CD40L system on pain severity in children after anterior abdominal wall surgery using various anaesthesia techniques. Emergency Medicine, 19 (6), 414–418. https://doi.org/10.22141/2224-0586.19.6.2023.1621

28. Ahiskalioglu, A., Aydin, M. E., Doymus, O., Yayik, A. M., Celik, E. C. (2019). Ultrasound guided transversalis fascia plane block for lower abdominal surgery: First pediatric report. Journal of Clinical Anesthesia, 55, 130–131. https://doi.org/10.1016/j.jclinane.2018.12.046

29. El-Boghdadly, K., Elsharkawy, H., Short, A., Chin, K. J. (2016). Quadratus Lumborum Block Nomenclature and Anatomical Considerations. Regional Anesthesia and Pain Medicine, 41 (4), 548–549. https://doi.org/10.1097/aap.0000000000000411

30. Berde, C. (2004). Local anesthetics in infants and children: an update. Pediatric Anesthesia, 14 (5), 387–393. https://doi.org/10.1111/j.1460-9592.2004.01336.x

31. Yaster, M., Tobin, J. R., Fisher, Q. A., Maxwell, L. G. (1994). Local anesthetics in the management of acute pain in children. The Journal of Pediatrics, 124 (2), 165–176. https://doi.org/10.1016/s0022-3476(94)70300-0

32. Mazoit, J. (2011). Local anesthetics and their adjuncts. Pediatric Anesthesia, 22 (1), 31–38. https://doi.org/10.1111/j.1460-9592. 2011.03692.x

33. Suresh, S., Ecoffey, C., Bosenberg, A., Lonnqvist, P.-A., de Oliveira, G. S., de Leon Casasola, O. et al. (2018). The European Society of Regional Anaesthesia and Pain Therapy/American Society of Regional Anesthesia and Pain Medicine Recommendations on Local Anesthetics and Adjuvants Dosage in Pediatric Regional Anesthesia. Regional Anesthesia and Pain Medicine, 43 (2), 211–216. https://doi.org/10.1097/aap.0000000000000702

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