MODERN NEUROSURGICAL STRATEGIES AND OUTCOMES IN THE TREATMENT OF CHIARI MALFORMATION TYPE I AND ASSOCIATED SYRINGOMYELIA

Mukhammadov Nuriddin Askarovich

Samarkand State Medical University, Department of Neurosurgery

Abstract. *Chiari malformation type I (CM-I) and syringomyelia represent complex congenital anomalies of the craniovertebral junction that can lead to significant neurological impairment. Surgical treatment is indicated only for patients with progressive clinical symptoms or deteriorating quality of life. The primary goals of neurosurgical intervention include restoration of cerebrospinal fluid (CSF) circulation, decompression of the posterior cranial fossa, and prevention of brainstem compression. This article reviews modern approaches, including various techniques of suboccipital craniectomy, C1 laminectomy, dura mater plasty, and management of associated hydrocephalus. Comparative analysis of surgical outcomes demonstrates that adequate CSF restoration significantly improves long-term results, while complications such as CSF leakage, aseptic meningitis, and craniovertebral instability remain relevant. The study emphasizes the importance of individualized selection of decompression techniques and intraoperative CSF dynamics monitoring for optimal prognosis.*

Key words: *Chiari malformation type I, syringomyelia, posterior cranial fossa decompression, cerebrospinal fluid circulation, dura mater plasty, neurosurgical outcomes.*

Introduction. The presence of chiari anomaly and syringomyelia without neurological symptoms and clinical picture is not an indication for surgery [11, 60]. In controversial cases, cine-MRI and evaluation of cerebrospinal fluid dynamics are necessary. Surgery is indicated only for those patients who have clinical symptoms associated with chiari anomaly and significantly worsen the quality of life, and (or) progression of symptoms [61, 62]. The main goals of neurosurgical intervention are restoration of normal circulation of cerebrospinal fluid, creation of a large occipital cistern and stopping the progression of compression of the brainstem [48, 63, 64]. Elimination of syringomyelia is possible only with restoration of circulation of cerebrospinal fluid at the craniovertebral level [14]. This leads to a gradual increase in the pressure of the cerebrospinal fluid in the subarachnoid space of the spinal cord, displacement of stagnant cerebrospinal fluid from the central canal into the natural cerebrospinal fluid pathways and normalization of the oncotic gradient on both sides of the spinal cord. All operations are performed with patients in a semi-sitting, prone or lateral position [59, 65]. The prone position (concorde) almost completely eliminates the risk of developing air-venous embolism, in addition, it takes less time to position the patient than the sitting and semi-sitting positions. The semi-sitting position of the patient, according to some neurosurgeons, is preferable to the prone position, since it provides a better view and orientation in the wound if revision of the foramen of Magendie is necessary, and is also associated with less blood loss. The range of surgical treatment methods for patients with chiari anomaly is represented by more than 20 types of surgical techniques [6, 13]. For posterior approaches, various intervention options and their combinations are used. Craniectomy performance varies from economical (2x2 cm) to wide decompression (from the middle of the occipital bone with lateral expansion). The need for a laminectomy of the C1 vertebra is widely debated. When dissecting the dura mater, the neurosurgeon is faced with a choice between a linear and a Y-shaped incision. A vertical linear incision of the dura mater does not provide the necessary increase in the useful area of the dura mater defect, while a Y-shaped incision is technically somewhat more difficult to perform (Fig. 3). The next step in decision-making is the arachnoid membrane. The current concept assumes preservation of the integrity of the arachnoid membrane; however, the presence of adhesions in the subarachnoid space can cause disturbances in the flow of cerebrospinal fluid. In the presence of adhesions or the impossibility of visual assessment of the subarachnoid space, some neurosurgeons propose performing a linear incision of the arachnoid membrane followed by exploration of the subarachnoid space [17].After opening the arachnoid membrane, it becomes possible to examine and revise the foramen of Magendie in order to restore the circulation of cerebrospinal fluid at the level of the cisterna magna [15], which can be confirmed by introducing dyes into the cisterna magna and by the fact of transposition of the contrast into the perivascular and perineural spaces of the upper cervical roots [54]. In some patients, due to the dilation of the fourth ventricle, implantation of ventriculo-subarachnoid shunts is possible at this stage. After decompression, a hermetically sealed dura mater is performed in order to prevent cerebrospinal fluid leakage in the postoperative period, the risk of which is higher in these patients due to the impaired circulation of cerebrospinal fluid. For dura mater plastic surgery, autogenous tissue (fascia lata – Fig. 4, fragment of occipital aponeurosis) or artificial membranes (xenodura, Reperen, Dura Soft, Dura Armor, Lioplast, duramatrix, neodura, etc.) Are used [9, 66]. To reduce the risk of developing postoperative graft adhesion, pronounced cicatricial-adhesive process and impaired cerebrospinal fluid circulation, some authors recommend avoiding autogenous tissue plastic surgery [27]. In addition to the described decompression technique, a number of neurosurgeons propose resection of the cerebellar tonsils to a level of 5–10 mm above the BZO by coagulation or subpial excision to eliminate compression of the medulla oblongata, nerve roots and cervical region of the spinal cord [15, 64, 65]. Subpial resection of the cerebellar tonsils is justified when they descend to the level of the C2 vertebra and below [17]. In some patients with a large bone defect, plastic surgery of the skull defect is performed with an implant (CONMET, Medbiotech, Reperen, etc.) (Fig. 5). This helps to reduce the adhesion process outside the dura mater and eliminate the factor of compression of the arachnoid space by edematous muscles [9]. Some neurosurgeons describe a treatment option for type I chiari anomaly without dura mater plastic surgery to reduce the risk of postoperative complications, considering it sufficient to achieve the goal of the operation [67]. They suggest performing only bone decompression on patients with type I chiari anomaly: suboccipital craniectomy for wide decompression of the cerebellar hemispheres, brainstem and midline structures; C1 laminectomy for cervical spinal decompression (Fig. 6). This position is justified by the fact that hydrocephalus is extremely rare in type I Chiari malformation, meaning that cerebrospinal fluid flow through the foramen of Magendie is preserved, despite the descent of the cerebellar tonsils and their fusion with the medulla oblongata. The appearance of clear pulsation of the dura mater has been proposed as a criterion for restoring cerebrospinal fluid flow; however, a single criterion cannot provide the required reliability.To obtain additional information, neurophysiological monitoring of somatosensory evoked potentials, non-invasive study of craniovertebral volume ratios, cerebrospinal fluid dynamics and blood flow velocity in the straight sinus by intraoperative ultrasound Dopplerography can be used. This method provides sufficient information on the possible postoperative regression of symptoms [66]. American neurosurgeons propose to perform ventriculodrainage surgery as the main method of treating the combined pathology of chiari malformation and hydrocephalus [34, 54]. Despite the fact that endoscopic triventriculostomy has displaced other treatment options for occlusive hydrocephalus, this type of surgery is not an option of choice for chiari malformation, since there are no data on the treatment of patients with concomitant syringomyelia with this method. Other types of neurosurgical interventions are also distinguished: transoral decompression and craniovertebral decompression with occipitospondylodesis [66]. The transoral decompression technique in patients with chiari malformation should be resorted to in cases of severe anterior compression and the presence of basilar invagination. According to the majority of researchers, in patients with a combination of anterior and posterior compression, given the traumatic nature of this method, it is advisable to resort to standard craniovertebral decompression with a simultaneous stabilization operation as the first stage of surgical treatment. Simultaneous performance of craniovertebral decompression and stabilization surgery is indicated for a relatively small group of patients with chiari malformation with atlantoaxial dislocation and a high risk of developing cervical spine instability, identified during the preoperative examination. The provoking factors for the development of cervical instability in patients with chiari anomaly type I are disorders of innervation of the neck muscles in the presence of a syringomyelia cyst at the upper cervical level of the spinal cord, fibrous changes in the muscles, and repetitive contractions and stretches of the muscles [66, 68]. An example of treatment of a patient with chiari anomaly is shown in Fig. 7. Remote treatment results. X. Deng et al. Studied remote postoperative outcomes based on 152 performed decompressions of the posterior cranial fossa and concluded that the presence of paresis in the limbs, signs of compression of the cerebral trunk and basilar invagination are predictors of unfavorable clinical prognosis. Repeated surgeries and severe arachnopathy also negatively affect remote results. Complications after decompression of the posterior cranial fossa are observed in 3–40% of patients [69] and include cerebrospinal fluid leakage, aseptic meningitis, wound infection, hydrocephalus, dysphagia, and instability in the craniovertebral junction. In a study [70] analyzing 1946 operations for chiari anomaly type I, it was found that the development of complications does not depend on the patient’s age. A number of authors point out that,that performing surgery without dura mater plastic surgery results in complications in 6% of cases (3 out of 55 patients), while when choosing a more "aggressive" neurosurgical method, including dura mater plastic surgery, the incidence of complications increases to 12.4% (28 out of 226 patients) [71]. The most common complication in all study series was postoperative wound cerebrospinal fluid leak (in 5.9–9.5% of patients) [71]. To prevent the development of cerebrospinal fluid leak, high-quality dura mater plastic surgery and the use of modern sealing agents (Cryophyte, Neosulfacrylate, Silacrylate, bioglue, Evicel, Tachocomb, LAMBA, etc.) Are recommended. The second most common complication is aseptic meningitis (in 3.7–4.8% of patients) [69]. According to some authors, its development is associated with the material used for dura mater plasty. When using allografts, the incidence of this complication is higher [69]. Surgical intervention does not stop the process of cerebellar tonsil descent into the spinal canal. A comparative assessment of the depth of tonsil descent in the pre- and postoperative periods showed that cerebellar tonsil descent of varying degrees in the postoperative period was observed in 53%, and no changes in the location of the tonsils were observed in 41% [29, 23].

Conclusion. The management of Chiari malformation type I and associated syringomyelia remains one of the most debated areas in modern neurosurgery.

Surgical intervention should be strictly reserved for patients with pronounced or progressive neurological symptoms, radiologically confirmed cerebrospinal fluid (CSF) flow obstruction, or deterioration in quality of life. The principal objective of surgical treatment is to restore normal CSF dynamics at the level of the craniovertebral junction, decompress the posterior cranial fossa, and alleviate compression of the brainstem and spinal cord structures.

Among the variety of available surgical techniques, the combination of suboccipital craniectomy, C1 laminectomy, and adequate dura mater plasty remains the gold standard, providing optimal decompression and CSF circulation restoration. The choice between linear and Y-shaped dural incisions, as well as the decision to preserve or open the arachnoid membrane, should be individualized based on intraoperative findings. The use of modern sealing materials and biocompatible dural substitutes significantly reduces the risk of postoperative CSF leakage and infectious complications.

Long-term results demonstrate that proper restoration of CSF circulation correlates with favorable neurological recovery and decreased progression of syringomyelia. However, postoperative complications such as CSF leak, aseptic meningitis, and craniovertebral instability remain clinically relevant and require careful preventive measures. The integration of intraoperative ultrasound, neurophysiological monitoring, and advanced imaging plays an essential role in predicting outcomes and minimizing risks.

Ultimately, successful treatment of Chiari malformation type I depends on a comprehensive, patient-specific approach that combines precise diagnostic evaluation, careful surgical planning, and modern neurosurgical technologies.

References:

1. Pattisapu, J. V., Ackerman, L. L., Infinger, L. K., et al. (2023). Congress of Neurological Surgeons systematic review and evidence-based guidelines for patients with Chiari malformation: surgical interventions. *Neurosurgery, 93*(6), 731–735. [EN]

2. Guo, F., et al. (2022). Precise Management of Chiari Malformation Type I. *Frontiers in Surgery, 9*, 850879. [EN]

3. Nishikawa, M., et al. (2022). Surgical Management of Chiari Malformation Type I with Associated Syringomyelia. *Journal of Clinical Medicine, 11*(15), 4556. [EN]

4. Pan, D. S., et al. (2025). A new concept and surgical approach for Chiari I malformation. *Scientific Reports*. [EN]

5. Prasad, A. S., et al. (2025). Efficacy of neurosurgical intervention in syrinx resolution in CM-I with syringomyelia: Systematic review and meta-analysis. *Neurosurgery*. [EN]

6. Arnautovic, A., Splavski, B., Boop, F. A., & Arnautovic, K. I. (2015). Pediatric and adult CM-I surgical series 1965–2013: Review. *Journal of Neurosurgery: Pediatrics*, *15*(2), 161–177. [EN]

7. Tam, S. K. P., Brodbelt, A., Bolognese, P. A., & Foroughi, M. (2020). PFDD in CM-I: Systematic review and meta-analysis. *Acta Neurochirurgica, 163*(1), 229–238. [EN]

8. Gallo, P., Copley, P. C., McAllister, S., & Kaliaperumal, C. (2021). Impact of neurosurgical technique on outcomes in adult CM-I. *Clinical Neurology and Neurosurgery, 200*, 106380. [EN]

9. Kular, S., & Cascella, M. (2020). *Chiari I Malformation*. StatPearls. [EN]

10. Chotai, S., Kshettry, V., et al. (2015). Surgical outcomes using wide suboccipital decompression for adult CM-I with/without syringomyelia. *World Neurosurgery*. [EN]

11. Toader, C., et al. (2023). Decoding Chiari Malformation and Syringomyelia. *Brain Sciences, 13*(12), 1658. [EN]

12. Akakın, A., et al. (2015). Syringomyelia secondary to Chiari: treatment options. *Journal of Korean Neurosurgical Society, 58*(4), 303–310. [EN]

13. Яриков, А. В. (2022). Мальформация Арнольда–Киари: этиология, патогенез, диагностика и хирургическое лечение. *Журнал «Врач» / Идеи и инновации в медицине*. [RU]

14. Ларионов, С. Н., Сороковиков, В. А., & Потапов, В. Э. (2013). МК-I: современные аспекты диагностики и лечения. *Бюллетень ВСНЦ СО РАМН, 5*(93), 181–186. [RU]

15. Слынько, Е. И., и соавт. (2010). Патогенетическая связь между аномалией Киари и сирингомиелией. *Украинский нейрохирургический журн.* [RU]

16. Файзутдинова, А. Т., и соавт. (2017). Беременность при мальформации Киари и сирингомиелии: междисциплинарные вопросы. *Казанский мед. журнал.* [RU]

17. Евзиков, Г. Ю. (2016). Острое развитие поперечного поражения спинного мозга при МК-I. *Российский журнал неврологии и психиатрии.* [RU]

18. Каххаров, Р. А., и соавт. Опыт вариантов пластики ТМО при МК-I/II. *Нейрохирургия (РФ).* [RU]

19. Ларионов, С. Н., и соавт. (2013). МК-I: диагностика и лечение (обзор). *Acta Biomedica Scientifica (Иркутск).* [RU]

20. Евзиков, Г. Ю. (2013). Аномалия Киари и сирингомиелия (лекция). [RU]

21. «Аномалия Арнольда–Киари, сирингомиелия» (клинические рекомендации/обзор, НПЦ). [RU]

22. МК-II у детей (обзор литературы). *Неврология (РФ).* [RU]

23. Авдей, Г. М. (2020). Сирингомиелия: обзор, клиника, лечение. *Медицинский журнал (РБ).* [RU]

24. Мальформация Арнольда–Киари (памятка/обзор, ДГКБ). [RU]

25. Руководство: «Хирургическое лечение мальформации Киари у взрослых» (перевод). [RU]

26. Nurmatov, A. A., Khazratkulov, R. B., & Boboev, Zh. I. (2025). Outcomes of microsurgical treatment of Chiari type I malformation. *USA Journals – Uzbekistan* (open access). [EN/UZ context]

27. Tadqiqot.uz (2024). Мальформация Арнольда–Киари I тип: клиника, диагностика, лечение (обзор). *Neurology section.* [RU; Uzbekistan platform]

28. Endomarkaz (РСНПМЦ нейрохирургии, Ташкент). Перечень операций: декомпрессия ЗЧЯ при МК-I (институциональный источник). [UZ/RU]

29. Neuro.uz (РССПМЦ Нейрохирургии, отделения; локальная экспертиза по КВ-зоне). [UZ/RU]

30. Apollo Hospitals Uzbekistan page. *Arnold Chiari malformatsiyasi: turlari, sabablari, belgilari va davolash*. [UZ]

31. Abduvoyitov, B. (2025). FARMAKOREZISTENT EPILEPSIYA BILAN OG'RIGAN BEMORLARNING JARROHLIK DAVOLASH NATIJALARI VA QONIQARSIZ JARROHLIK NATIJALARINI BASHORAT QILUVCHI OMILLAR. *Modern Science and Research*, *4*(2), 91-92.

32. Abduvoyitov, B. (2025). POLIMIKROGIRIYALI FARMAKOREZISTENT EPILEPSIYANI DAVOLASH NATIJALARI. *Modern Science and Research*, *4*(2), 117-121.

33. Abduvoyitov, B. (2025). FARMAKOREZISTENT EPILEPSIYADA STEROIDLARNING AHAMIYATI. *Medical Research Journal*, *1*(1), 244-250.

34. Abduvoyitov, B. (2025). MRT ASOSIDA FARMAKO REZITENT EPILEPSIYANI TASHXISLASH VA NATIJALARNI PROGNOZ QILISH: ZAMONAVIY YONDASHUVLAR. *Medical Research Journal*, *1*(1), 215-219.

35. Мамадалиев, А. М., Алиев, М. А., Абдувойитов, Б. Б. У., Хайритдинов, Б. Б., Фарухова, М. Ф., Гаппарова, О. И., ... & Бурхонов, А. Ш. (2022). Клинический случай риносинусогенного абсцесса головного мозга и обзор литературы. *Uzbek journal of case reports*, *2*(2), 7-11.

36. Bahodirovich A. B. et al. Approaches to intestinal decompression during different appendicular peritonitis in children //Достижения науки и образования. – 2018. – №. 18 (40). – С. 92-95.

37. Djalolov D. A. et al. Features of microflora in the etiological structure of diffuse appendicular peritonitis //Вопросы науки и образования. – 2018. – Т. 8. – №. 2. – С. 116.

38. Abduvoyitov Bobur Bahodirovich, Djalolov Davlatshokh Abduvokhidovich, Khasanov Aziz Batirovich, Abbasov Khojimuhammad Khabibullayevich The effect

of ozone on the course and development of complications of peritonitis in children // Вопросы науки и образования. 2018. №29 (41).

39. Abduvoyitov B. B. et al. The effect of ozone on the course and development of complications of peritonitis in children //Вопросы науки и образования. – 2018. – Т. 29. – С. 110-113.

40. Bahodirovich A. B. et al. Immunological feature of the body in children with diffused appendicular peritonitis //Вопросы науки и образования. – 2019. – №. 2 (45). – С. 115-122