DOI: https://doi.org/10.17816/PTORS79988

Review

Algorithm for torticollis diagnosis in children of younger age groups

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BACKGROUND: Torticollis is a common term for abnormal head or neck positions. Torticollis can be due to a wide variety of pathological processes, from relatively benign to life-threatening. This syndrome is of particular relevance in pediatric practice and is often underestimated at the primary care level.

AIM: To analyze the data of domestic and foreign literature on the etiopathogenesis and clinical features of various types of torticollis in children and develop algorithms for the differential diagnosis of torticollis in children of younger age groups.

MATERIALS AND METHODS: A literature search was conducted in the open information databases of eLIBRARY and Pubmed using the keywords and phrases: "torticollis," "congenital muscular torticollis," "non-muscular torticollis," "acquired torticollis," and "neurogenic torticollis," without limiting the depth of retrospection.

RESULTS: Based on the literature data generalization, the classification of torticollis and the key directions of its differential diagnosis are systematized in tabular form. The range of differential diagnosis of torticollis is quite wide and has its characteristics in newborns and children of the first years of life, contrary to older children. The most common is congenital muscular torticollis. Concurrently, non-muscular forms of torticollis in the aggregate are not uncommon, more often with a more serious etiology, and require careful examination. Based on the analyzed literature, differential algorithms for torticollis diagnosis in children of younger age groups have been compiled.

CONCLUSIONS: Increasing the level of the knowledge of pediatric clinicians in the etiopathogenesis of torticollis syndrome will improve the efficiency of early diagnosis of dangerous diseases that lead to pathological head and neck positions in children.

Keywords: torticollis; congenital muscular torticollis; non-muscular torticollis; acquired torticollis; neurogenic torticollis.

To cite this article:
Garkavenko YuE, Pozdeev AP, Kriukova IA. Algorithm for torticollis diagnosis in children of younger age groups. *Pediatric Traumatology, Orthopaedics and Reconstructive Surgery.* 2021;9(4):477–490. DOI: https://doi.org/10.17816/PTORS79988

Received: 12.09.2021 **Accepted:** 22.11.2021 **Published:** 28.12.2021

ECO•VECTOR

УДК 616.743.1-009.12-053.37-07
DOI: https://doi.org/10.17816/PTORS79988

Научный обзор

Алгоритм диагностики кривошеи у детей младших возрастных групп

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Обоснование. Кривошея (torticollis) — общепринятый термин для обозначения порочного положения головы и шеи. Кривошея может быть следствием самых разных патологических процессов — от относительно доброкачественных до опасных для жизни. Особую актуальность этот синдром имеет в педиатрической практике и часто бывает недооценен на уровне первичного звена медицинской помощи.

Цель — проанализировать данные отечественной и зарубежной литературы, отражающие этиопатогенез и клинические особенности различных видов кривошеи у детей и разработать алгоритмы ее дифференциальной диагностики у пациентов младших возрастных групп.

Материалы и методы. Поиск литературы осуществляли в открытых информационных базах eLIBRARY и Pubmed по ключевым словам и словосочетаниям: «кривошея», «врожденная мышечная кривошея», «немышечная кривошея», «приобретенная кривошея», «нейрогенная кривошея» (torticollis, congenital muscular torticollis, nonmuscular torticollis, acquired torticollis, neurogenic torticollis) без ограничения глубины ретроспекции.

Результаты. На основании данных литературы в табличной форме приведены классификация кривошеи и ключевые направления ее дифференциальной диагностики. Спектр дифференциальной диагностики кривошеи достаточно широк и у детей первых лет жизни имеет свои особенности в отличие от детей более старшего возраста. Наиболее часто встречается врожденная мышечная кривошея. В то же время немышечные формы кривошеи не редкость, чаще характеризуются более серьезной этиологией, в таких случаях необходимо более тщательное обследование. Составлены алгоритмы дифференциальной диагностики кривошеи у детей младших возрастных групп.

Заключение. Повышение уровня знаний клиницистов педиатрического профиля в вопросах этиопатогенеза синдрома кривошеи улучшит эффективность ранней диагностики опасных заболеваний, приводящих к патологической установке головы и шеи у детей.

Ключевые слова: кривошея; врожденная мышечная кривошея; немышечная кривошея; приобретенная кривошея; нейрогенная кривошея.

Как цитировать:
Гаркавенко Ю.Е., Поздеев А.П., Крюкова И.А. Алгоритм диагностики кривошеи у детей младших возрастных групп // Ортопедия, травматология и восстановительная хирургия детского возраста. 2021. Т. 9. № 4. С. 477–490. DOI: https://doi.org/10.17816/PTORS79988

Рукопись получена: 12.09.2021 **Рукопись одобрена:** 22.11.2021 **Опубликована:** 28.12.2021

BACKGROUND

Torticollis (in Latin *tortus*: twisted, crooked + *collum*: neck) is a nonspecific polyetiological syndrome that is characterized by an abnormal head and neck position [1, 2]. Torticollis can manifest in various congenital and acquired diseases, from relatively benign to life-threatening [3–7]. The range of differential diagnostics of torticollis is very wide, with its characteristics in children of the first years of life, unlike older children [4, 8, 9].

Physiological lateralization of the head is typical for newborns and children of the first months of life, who were in utero in head presentation, [10] is not accompanied by pathological changes in the sternocleidomastoid muscle (SCMM), disappears by months 3–4 of life, and does not require any treatment.

Torticollis is most often represented by congenital muscular torticollis, which is noted in 3.9% of pediatric patients and ranks third in frequency after congenital dislocation of the hip and clubfoot among congenital pathologies of the musculoskeletal system [1, 11, 12]. Congenital muscular torticollis is usually detected during the first months of life, and in the classical course, without difficulties in diagnostics [8, 13]. The gold standard for diagnosing congenital muscular torticollis is ultrasound examination (US) of the SCMM in a questionable clinical presentation [13, 14]. If the diagnosis of congenital muscular torticollis is beyond doubt, further studies are not required. Concurrently, every child with a pathological head position in the absence of classic signs of congenital muscular torticollis should be carefully examined using clinical, laboratory, and imaging methods [7, 14, 15].

This study aimed to analyze the data of Russian and international literature, which present the etiopathogenesis and clinical characteristics of various types of torticollis in pediatric patients, and develop algorithms for its differential diagnostics in patients of younger age groups.

MATERIALS AND METHODS

The literature search was performed in the open information databases of eLIBRARY and Pubmed using keywords and phrases, such as “torticollis,” “congenital muscular torticollis,” “nonmuscular torticollis,” “acquired torticollis,” and “neurogenic torticollis” without limiting the depth of retrospection. The selection of sources was mainly limited to 1990–2021 (131 publications). According to the request criteria, 42 publications in the Russian (20), English (19), German (2), and French (1) languages were finally selected. Works published before 1990 were included in the review if they contained fundamentally important data.

RESULTS AND DISCUSSION

A change in the head and neck position in children can be the result of a variety of pathological processes [4–6, 16]. There can be congenital and acquired, muscular and nonmuscular, and paroxysmal and non-paroxysmal forms of torticollis. The most common in pediatric patients is congenital muscular torticollis. Concurrently, nonmuscular causes are not uncommon; many studies are focused on them [4, 5, 17].

R.T. Ballok and K.M. Song [17] analyzed 288 patients with torticollis, of whom 53 (18.4%) had nonmuscular torticollis (Klippel-Feil anomaly in 16 pediatric patients [30%], oculomotor disorders in 12 [23%], brachial plexus injury in 9 [17%] cases, and central nervous system disorders in 6 [11%] patients).

U Jain et al. [18] describe a case of torticollis in a 1-year-old boy with a recent upper respiratory tract infection. According to computed and magnetic resonance imaging (CT and MRI) of the cervical spine (CS) (erosions in the odontoid process, pannus), juvenile idiopathic arthritis was suggested as the cause of torticollis. In the treatment course according to MRI, inflammation decreased. The peculiarity of the case is that the CS lesion is rarely the initial sign of the disease.

Many authors emphasize that clinicians should be aware of the possibility of a tumor of the posterior cranial fossa (PCF) or CS, even if torticollis is the only symptom. Thus, K.B. Matuev et al. [19] provided a comparative analysis of the aspects of brain tumor clinical manifestations in infants, when torticollis occurred in 40% of cases with PCF tumors. A study by V.C. Extremera et al. [20] revealed torticollis in 23% of pediatric patients aged 2 to 8 years among patients with PCF tumors. A. Fafara-Les et al. [21] described 54 cases of tumors of the cervical spinal cord and PCF, and torticollis was the first sign of the tumor and preceded other neurological symptoms in 12 cases (22%).

Literature data are systematized and the classification of torticollis and key areas of its differential diagnostics in pediatric patients are presented in tabular form [1–42]. Herein, we do not deal in detail with the issues of acute torticollis with pain syndrome, which is described in detail by A.V. Gubin [3].

Table 1 presents the etiological classification of congenital and acquired forms of torticollis [1–42].

Table 2 lists the aspects of history taking and clinical examination in young children with torticollis, as well as the main methods of instrumental examination [1–42].

S. Haque et al. [14] recommended, in case of acquired torticollis and suspected traumatic genesis, radiography of the CS in the lateral and frontal projections as a first-line method and CT of the CS in case of non-traumatic genesis.

Table 1. Classification of torticollis

Torticollis	Causes
	Congenital
Physiological	• Physiological lateralization of the head in newborns and infants during the first months of life
Muscular	• Idiopathic muscular torticollis. • Aplasia of the SCMM. • Abnormalities of the trapezius muscle, the elevator muscle of the scapula
Bone	• CM in the craniocervical region (abnormalities in C_0–C_1–C_2, a fusion of the vertebrae, hemivertebrae, etc.)
Cutaneous	• Congenital alar folds of the neck
Other causes	• Skull deformities. • CM of the shoulder girdle (Sprengel's deformity). • Cervical ribs. • Syndrome of contractures and deformities (seven/eight syndrome)
	Acquired
Muscular	• Chronic inflammatory processes in SCMM
CS injury	• Birth/postnatal CS injury
Other injuries	• Injury of the shoulder girdle (clavicle fracture, etc.). • Brachial plexus injury
Manifestation of CS CM	• Manifestation of CS CM in the presence of injury. • Acute torticollis against the C_2–C_3 tropism abnormalities
Tumors of the CS and neck	• Bone tumors (eosinophilic granuloma, osteochondroma, osteoid osteoma, etc.). • Tumors of the soft tissues and organs of the neck
Infection	• Spondylitis: specific granulomatous (tuberculosis, mycosis, syphilis, etc.), nonspecific purulent (*Staphylococcus* spp. and *E. coli*), post-manipulation. • Discitis, epidural abscess. • Infection of the soft tissues of the neck (cervical lymphadenitis, etc.). • Infectious and inflammatory diseases of the ENT organs
Inflammation	• Grisel's torticollis. • Juvenile idiopathic arthritis
Benign acute torticollis	• Uncovertebral wedge syndrome of C_2–C_3, C_3–C_4
Hyperelasticity of the ligamentous apparatus of CS	• Down's syndrome, hereditary connective tissue disorders (Marfan's syndrome, Ehlers-Danlos syndrome, and osteogenesis imperfecta), mucopolysaccharidoses
Dermato-desmogenic	• Cicatricial changes in the skin and soft tissues of the neck (post-burn, post-traumatic, post-inflammatory, and post-operative)
Dystonic	• Hereditary dystonia (spastic torticollis, etc.). • Secondary dystonia
Neurogenic	• Damage to the central or peripheral nervous system of various origins, mainly at the level of the PCF and the craniocervical region (cerebellar tumors, cysts, etc.)
Ophthalmic	• Strabismus, nystagmus, Duane syndrome, and Brown syndrome. • *Spasmus nutans*
Vestibulocochlear	• Conductive/sensoneural bradyacuasia
Sandifer syndrome	• Gastroesophageal reflux
Benign movement disorders of childhood	• Benign paroxysmal infantile torticollis

Note. SCMM: sternocleidomastoid muscle; CM: congenital malformation; CS: cervical spine; PCF: posterior cranial fossa.

DOI: https://doi.org/10.17816/PTORS79988

Table 2. Characteristics of the examination in pediatric patients with torticollis

Stage	Characteristics
Medical history	• Age of onset of torticollis. • Pain (yes/no), constant/intermittent. • Recent events: injury (mechanism and prescription), awkward position, head and neck surgery, infectious symptoms (fever and sore throat). • Taking medications (e.g. metoclopramide). • Associated complaints (hyperthermia, signs of infection, headache, strabismus, vomiting, gait disorders, balance problems, etc.)
Anamnesis vitae	• The course of pregnancy (uterine abnormalities, intrauterine position of the fetus, oligohydramnios). • A traumatic course of childbirth. • Concomitant diseases
Clinical examination	• Head position (shoulder tilt, rotation, etc.). • Head and face (facial asymmetry and plagiocephaly). • Amplitude/pain of active and passive movements in the CS (in the absence of a recent injury). • Palpation of the neck (general, SCMM, and CS) (pathological formations, pain, and lymph nodes.) • Craniocervical dysmorphias. • General pediatric examination. • Infectious symptoms (fever, sore throat, etc.) • Neurological symptoms (strabismus, ataxia, etc.) • Consultation of highly specialized doctors (according to indications): orthopedist, traumatologist, surgeon, vertebrologist, neurologist, ophthalmologist (with visual field assessment), otolaryngologist, infectious disease specialist, gastroenterologist, neurosurgeon, rheumatologist, geneticist, etc.
Examination methods (according to indications)	• Clinical/biochemical blood test. • US of the SCMM. • US of the cervical lymph nodes, soft tissues of the neck. • US of the brain: TTUS, TUS in pediatric patients with a closed fontanel. • CS US. • X-ray of the CS (without functional tests). • CT scan of the brain. • CS CT. • Brain MRI ± contrast. • CS MRI ± contrast. • Others: EEG, ECG (heart rate with head position change), ENMG.

Note. CS: cervical spine; SCMM: sternocleidomastoid muscle; US: ultrasound examination; TTUS: transcranial-transfontanellar ultrasonography; TUS: transcranial ultrasonography; CT: computed tomography; MRI: magnetic resonance imaging; EEG: electroencephalography; ECG: electrocardiography; ENMG: electroneuromyography.

With a negative CT scan, brain MRI and CS should be performed.

Considering the risks of using expert imaging methods in young children (CT with radiation exposure and MRI with the need for anesthesia), screening for structural changes in the brain and spinal cord at the level of the CS at stage 1, and conducting a quick, affordable, and safe ultrasound examination for all pediatric patients with isolated torticollis syndrome and the absence of classic signs of congenital muscular torticollis are considered necessary. Concurrently, polypositional techniques are important, which allow the most complete assessment of the intracranial space, namely transcranial-transfontanellar ultrasonography in pediatric patients with an open fontanel and transcranial ultrasonography in pediatric patients with a closed fontanel [22]. With transcranial ultrasonography, scanning through the Bregma point (in the area of the closed anterior fontanel) is mandatory to assess the condition of the cerebellar vermis and the fourth ventricle; through the occipital points to assess the cerebellar hemispheres. The permeability of these points for the US remains until school age [22].

Table 3 presents the main clinical manifestations and data from additional research methods for various types of torticollis in pediatric patients [1–42].

Given the various causes of torticollis, as well as certain diagnostic difficulties, we propose algorithms for the diagnostic measures in children of younger age groups (Fig. 1, 2), which, in our opinion, will improve the quality of medical care for pediatric patients with this pathology.

Table 3. Differential diagnostics of the main types of torticollis in pediatric patients

Type of torticollis	Characteristic
	Congenital forms
Physiological lateralization of the head [10]	• In healthy newborns up to the age of 2–5 months in the supine position in an unstimulated state, the head turn to one side (usually to the right) predominates. • The cause is the fixed head position in fetuses in cephalic presentation → uneven irritation of the hair cells of the inner ear when the mother walks → dominance of the left otolithic apparatus. • Fetuses in the breech presentation have great freedom movement of the head, with no head lateralization. • Turning the head in the opposite direction is not limited. • Palpation of the CS: no abnormalities. • US of the sternocleidomastoid muscles is normal. • US of the brain (TTUS) — no pathology. • CS US — no pathology
Congenital muscular torticollis (idiopathic) [8, 11, 12]	• Shortening, cicatricial changes in SCMM. • Unknown causes: intrauterine (malformation, inflammation, ischemia, prolonged tilted fetal head position, and increased degeneration of myoblasts with predominance of fibroblasts); genetic predisposition; intranatal (injury/ischemia of SCMM). • Head tilt in the direction of the affected SCMM and turn in the opposite direction, limited mobility in the CS, and face and skull asymmetry. • Early form (4.5–14 %): from the first days of life. • Late form: from the end of week 2 of life: an inclined head position and a dense thickening (pseudotumor) in the middle lower part of the SCMM (maximum dimensions by the week 4–6: hazelnut/walnut). • In the area of the affected muscle, the skin is intact, without signs of inflammation. • SCMM US: induration (pseudotumor) and fibrosis. • Outcome: complete regression during conservative treatment/spontaneously after 2–12 months (induration disappears and SCMM elasticity and extensibility are restored); in 11%–20% of cases, fibrous degeneration of the SCMM (increased density, tension, and thinning of the muscular pedicles, the skin over the tense muscle is raised in the form of a “backstage”), an increase in deformities of the face, skull, spine, shoulder girdle
Congenital muscular torticollis in aplasia of the SCMM [8, 11]	• Aplasia of the SCMM on one side → predominance of intact muscle tone. • The head is tilted and turned toward the healthy muscle, the chin is slightly raised. • On the unaffected side has the skull flattening, the corner of the eye and mouth is lower. • On the affected side, the contours of the SCMM are not defined, in its projection, with soft tissue retraction in the form of a gutter (from the mastoid process to the sternoclavicular joint), the shoulder girdle is lowered. • Active head tilt toward aplasia is limited; when trying to passively eliminate the malposition, the head is freely brought to the middle position
Congenital muscular torticollis with abnormalities of the trapezius muscle, the elevator muscle of scapula [8]	• Congenital underdevelopment and shortening of the muscles (mainly the anterior sections of the trapezius muscle). • The head is tilted toward the modified muscle, tilted backward, and turned in the opposite direction ± high position of the scapula
Bone torticollis in CS CM [3, 23, 24]	• Malformations of C_0–C_1–C_2, a fusion of the vertebrae, wedge-shaped vertebrae/hemivertebrae, etc. • The inclined position of the head from an early age, progressing with time, facial asymmetry, CS movement limitations. • ± craniocervical dysmorphias (short neck, low hairline, ear abnormalities, etc.). • Passive removal of the head in the middle physiological position and the position of hypercorrection is possible in young children. • Palpation of the SCMM: no abnormalities. • SCMM US: no pathology. • Neurological status: normal/bulbar syndrome, cervical myelopathy, headaches, dizziness, etc. • Radiography ± CT of CS
Cutaneous [1, 2]	• Congenital alar folds of the neck (pterygium coli). • Triangle-shaped skin folds, from the lateral surfaces of the head to the shoulder girdle, short neck ± CM of muscles

Continuation of the Table 3

Type of torticollis	Characteristic
Seven/eight syndrome [25–27]	• Syndrome of contractures and deformities. • Causes: fetal malposition due to the cramped intrauterine space (large fetus, oligohydramnios, and deformity of the mother's pelvis). • Syndrome of seven/seven contractures [26]: plagiocephaly, torticollis, thoracolumbar scoliosis, limited hip abduction (often on the left), pelvic deformity, and foot deformity. • Eight syndrome [27] + leg deformity
	Acquired forms
Torticollis in the birth injury of the CS [8, 23, 28]	• Musculoskeletal damage, articular apparatus (mainly motor segments of C_0–C_3), more often by the type of sprain, and rarely fractures. • Intranatal risk factors: cervical stiffness, labor induction accelerated labor, head malpositioning (asynclitic, occipital, and facial), breech presentation, large fetus, narrow pelvis, obstetric aids (pushing out, forceps, and vacuum extraction), emergency cesarean section, and others. • External signs of traumatic childbirth: pronounced head configuration, scalp injury (cephalohematoma, etc.), clavicle fracture, hemorrhages in the sclera, etc. • Pathological position of the head (tilt to the shoulder and tilting back), restriction of CS movements (an attempt to bring the head to the middle position with crying due to pain). • Pain in the CS: moderate/severe, maximal in 1 week of life, but may persist up to 6 months, on palpation, during head manipulations, and when trying to raise the head in the prone position. • The SCMM is painless. • The tension of the suboccipital and posterior cervical muscles. • Symptom of "short neck" and "raised shoulder girdle." • Neurological symptoms: no/cervical myelopathy, bulbar syndrome
CS injury [3, 23, 24]	• Young children: more often auto injury; schoolchildren: sports injury. • Ligament injury, dislocations/subluxations, and fractures. • Immediately after the injury: local neck pain, pain on palpation of the spinous processes, limited CS movements, the rigidity of the paravertebral muscles, torticollis (in case of damage to the craniovertebral region) ± neurological symptoms. • Pain is moderate or may be absent. • Lateral X-ray of the CS (in case of a serious injury in the complete absence of symptoms). • CS CT (in the absence of neurological symptoms). • CS MRI (with neurological symptoms).
Manifestation of CS CM [3, 23, 24]	• Minor injury (push in the back, somersault, and sharp turn of the head) in case of CM of CS → pain and limited CS movement, and torticollis ± neurological symptoms. • Blocking due to abnormalities is possible *Acute torticollis in case of C_2–C_3 tropism abnormalities* • Unilateral subluxation in the C_2–C_3 zygapophysial joint with minimal injury in case of an anomaly — a different plane position of the zygapophysial joints. • The impossibility of flexion-extensor movements and the forward position of the head. • In healthy children after a sharp forward bend (headstand and sharp nod). • Neurological status is normal. • CS X-ray (lateral projection): straightening of lordosis, overlapping of the articular space of zygapophysial joints of C_2–C_3 by the superior articular process of C_3. • CS CT: unilateral subluxation of C_2–C_3
Acute torticollis in the syndrome of "uncovertebral wedge" of C_2–C_3, C_3–C_4 [3, 25]	• Benign acute torticollis. • Compression of the periosteal-fascial tissue in the uncovertebral fissure against the head movements or prolonged lateral flexion of the neck during sleep → "wedge" of edematous tissues → irritation of the posterior longitudinal ligament → antalgic position of the head. • Age: more often schoolchildren (up to 80%). • No history of recent injury. • Seasonality: autumn-winter period. • More often spontaneous onset in the morning with absolute health. • Sudden severe unilateral pain in the middle of the neck, aggravated in an upright position (due to increased pressure on the intervertebral disc and in the uncovertebral "slit" itself). • Torticollis: the predominance of the lateral tilt of the head in the opposite direction from the pain.

Continuation of the Table 3

Type of torticollis	Characteristic
	• Movements in the CS are impossible in the direction of pain, but possible in the opposite direction; lateral tilts are predominantly limited, rotation is impaired to a lesser extent. • The duration of the pain syndrome is 3–5 days. • MRI of the CS in the first 1–3 days (fat suppression mode): on the side of pain, there is hyperintense triangular luminescence in the area of the uncovertebral joints at the outer edge of the disc of C_2–C_3, C_3–C_4, and the luminescence disappears after a few days. • Possible complication: atlas-axial rotational blockage (rotational positioning of the head, blockage of rotational movements, according to functional CT, no rotation of C_1 around tooth of C_2)
Tumors of the CS and neck [14, 15, 23, 24]	• Bones (eosinophilic granuloma, osteochondroma, osteoid osteoma, etc.). • Soft tissues and organs of the neck (lymphoma, etc.). • Nonspecific symptoms and their moderate severity: pain in the CS (including nocturnal), limited CS movements, torticollis, pain on palpation of the CS. • Radiography, CT, and MRI of the CS
Infection [24, 29–32]	*Nonspecific purulent spondylitis (osteomyelitis)* • *Staphylococcus* spp., *E. coli*, etc. • Cervical vertebrae of ≈5 % of cases, more often in C_3–C_7 and less often in C_2 body and C_1 lateral masses. • Acute (<2 months)/subacute (2–6 months)/chronic (>6 months). • Anamnesis: infections with febrile fever and prolonged antibiotic therapy, sepsis, surgeries, and manipulations. • Concomitant diseases with immunodeficiency. • Pain and restricted CS movements, local pain on palpation, forced head position, kyphosis, and febrile/subfebrile fever. • Infants of the first year of life have no characteristic symptoms until vertebral complications (sepsis → 3–12 months → kyphosis). • Blood: moderate leukocytosis, increased ESR and CRP level, and procalcitonin test. • Complications: meningitis, pathological fracture, paravertebral/epidural abscess, myelopathy, etc. • X-ray, CT of the CS are not informative in the early stages (the first 2–4 weeks). • CS MRI with contrast is the method of choice at an early stage (days 2–4) *Tuberculous spondylitis* • Cervical vertebrae are rarely affected. • Total/subtotal destruction of the bodies of several vertebrae. • Spinal deformity (kyphosis) is the first symptom, with moderate pain and myelopathy. • Loss of appetite, night sweats, and fever. • Blood: moderate leukocytosis, increased ESR and CRP levels. • Immunological tests (Mantoux, diaskintest, QuantiFERON test, etc.) have low diagnostic values. • CT and MRI. • Verification of the diagnosis: bacteriological confirmation on the material from the lesion focus *Neck soft tissue infection* • Cervical lymphadenitis, acute surgical pathology (abscess, festering neoplasm of the neck, and phlegmon). • Torticollis with pain syndrome, fever, local swelling, hyperemia, enlarged lymph nodes, leukocytosis, increased ESR and CRP level
Grisel's torticollis [8, 33]	• Inflammatory spondyloarthritis of the lateral atlas-axial joint on one side against/after infectious and inflammatory diseases of the ENT organs, soft tissues of the neck, teeth (tonsillitis, otitis media, mastoiditis, retropharyngeal abscess, etc.); after tonsillectomy or other interventions in the nasopharynx → spasm of the homolateral deep suboccipital muscles attached to the atlas → displacement and rotation of the atlas. • A predisposing factor is the weakness of the C_1–C_2 ligaments. • Torticollis with the tilt of the head in a healthy side, turn in the opposite direction, and toward the affected joint. • Palpation of the upper cervical vertebrae with tenderness and protruding spinous process of the C_2 vertebra. • On the side of head rotation, there is a tension of the SCMM and posterior neck muscles.

Continuation of the Table 3

Type of torticollis	Characteristic
	• Active movements in the CS are absent/difficult. • Upon examination, the pharynx has dense elevation along the posterior wall of the pharynx, which changes in size when turning the head (the atlas has shifted forward and upward). • Acute/subacute infection of ENT organs, soft tissues of the neck, and teeth. • CS X-ray (through the open mouth) shows rotational subluxation of the atlas. • CT and MRI of the CS
Inflammation [34–38]	*CS injury in juvenile idiopathic arthritis* • Arthritis of the atlas-occipital and atlas-axial joints. • Limited range of motion in the CS is the most common symptom, with pain in the neck, pain upon CS palpation, morning stiffness, and torticollis ± cervical myelopathy. • Possibly asymptomatic. • CS X-ray with low sensitivity in the early stages of arthritis. • CS MRI with contrast is the method of choice in the early stages of arthritis (image evaluation 5–10 min after contrast injection to differentiate between the thickened synovial membrane and the joint fluid). • Indications for CS MRI: clinical signs of CS lesions, arthritis of the temporomandibular and shoulder joints, and polyarticular arthritis. • Consequences: C_2–C_3 ankylosis; atlas-axial instability/dislocation → spinal stenosis (increased distance between the anterior C_1 arch and C_2 odontoid process of ⩾3–5 mm and decreased distance between C_2 odontoid process and C_1 posterior arch of <13 mm); atlas-axial rotation block
Hyperelasticity of the CS ligamentous apparatus [23, 24, 39]	• In systemic genetic diseases: Down syndrome, connective tissue disorders (Marfan, Ehlers-Danlos syndrome, and osteogenesis imperfecta), and mucopolysaccharidoses. • Weakness of the ligamentous apparatus of the atlas-axial joints → atlas-axial and atlas-occipital instability. • Minor impact on the neck → atlas-axial dislocation → spinal stenosis → myelopathy. • Probability of neurological symptom occurrence/aggravation during intubation
Neurogenic torticollis [7, 8, 14–17, 19–21, 40]	• Cause: damage to the central or peripheral nervous system of various origins. • Pathology of the PCF and craniocervical region: tumors (cerebellum, etc.), malformations (Chiari syndrome, Dandy-Walker syndrome, arachnoid cysts, etc.), syringomyelia, hemorrhage, abscess, and hydrocephalus, and less often, several neuromuscular diseases, a fixed spinal cord, etc. • Mechanisms of development: oculomotor compensation, liquor-dynamic disorders, compression/irritation of the nuclei of the bottom of the ventricle IV, cerebellum, vestibular nerve, accessory nerve, and posterior upper cervical roots, and stretching of the dura mater. • Incorrect head position at rest: tilt to the shoulder forward, backward, and turn to the side as permanent/inconstant. • Previously normal head position. • ± limitation of active and passive movements in the CS. • ± pain in the occiput and neck. • Palpation of the SCMM: no abnormalities. • Neurological status: normal/syndrome of intracranial hypertension/focal neurological symptoms. • US of the SCMM: normal. • Screening for intracranial pathology: TTUS/TUS. • Screening of spinal pathology: CS US. • Expert imaging: brain and CS MRI
Dystonic syndromes [2, 4–7]	• Hereditary primary dystonia: focal cervical dystonia (spastic torticollis), dystonia – whisper dysphonia ± torticollis (mutation in the TUBB4 gene), myoclonus dystonia, etc. • Dystonia in neurodegenerative diseases: Wilson's disease, etc. • Secondary dystonia: perinatal damage to the central nervous system, drug-induced dyskinesia (for example, antipsychotics, cerucal, and anticonvulsants), tumors in the subcortical nuclei, etc.
Ophtalmic [1, 2, 41]	• Strabismus, nystagmus, Duane, and Brown syndromes. • Double vision compensation and binocular vision preservation. • Consultation with an ophthalmologist and assessment of visual fields

The end of the Table 3

Type of torticollis	Characteristic
	Spasmus nutans (nodding spasm) • Benign idiopathic oculomotor disorder. • Onset at the age of 3–12 months, spontaneous regression at the age of 2–5 years. • The triad of symptoms: nystagmus, yes-yes/no-no head nodding, and torticollis. • Head nodding suppresses nystagmus through the vestibular-ocular reflex and helps to see better. • Psychomotor development is normal. • EEG is normal. • US of the brain and CS are normal. • Brain MRI and CS are normal
Torticollis in Sandifer's syndrome [42]	• Hiatus hernia + gastroesophageal reflux + paroxysmal torticollis. • Onset mostly in the first year of life. • Paroxysmal repetitive pathological postures of the head (torticollis), sometimes of the trunk and limbs. • Occur during wakefulness and disappear during sleep. • Frequency from rare to daily multiple. • Duration of a few seconds to tens of minutes. • Association with food intake during meals and within 30 min after eating. • Preservation of consciousness during attacks. • At the time of an attack, the following concomitant symptoms are possible: motor (sucking and swallowing), gastrointestinal (vomiting and salivation), ocular (tonic eye-opening), behavioral (anxiety and crying), and respiratory failure. • Palpation of the SCMM, CS, and suboccipital region shows no abnormalities. • Active and passive movements in the CS are in full and are painless. • Neuroimaging shows no pathology. • Differential diagnostics with epilepsy (no loss of consciousness, epiactivity on video-EEG monitoring during an attack). • Fibrogastroduodenoscopy
Benign paroxysmal infantile torticollis [42]	• A rare paroxysmal movement disorder in healthy infants of unspecified etiology. • Onset at the age of 2–8 months, spontaneous regression at the age of 3–5 years. • Perinatal history is not aggravated. • Family history is often aggravated by migraine. • Psychomotor development is normal. • Sudden involuntary (usually after sleep) episodes of pathological head position during wakefulness (tilt to the shoulder), during several minutes, hours, and days. • During attacks, consciousness is preserved, and the child can contact. • Palpation of the SCMM, CS, and suboccipital region shows no abnormalities. • Passive movements in the CS are not limited and are painless. • Possible concomitant symptoms at the time of the attack: vegetative-visceral (pallor, perioral cyanosis, lacrimation, vomiting, and sweating), ocular (tonic eyes, nystagmus, ptosis, and mydriasis), behavioral (anxiety, crying, bad mood, and drowsiness). • In the attack-free interval, the condition is restored. • US and MRI of the brain and CS show no pathology. • Differential diagnostics with epilepsy (absence of loss of consciousness, epiactivity during video-EEG during an attack). • The prognosis is favorable and treatment is not required. • Spontaneous regression by the age of 2–5 years, but migraines often develop by school age

Note. CS: cervical spine; US: ultrasound examination; TTUS: transcranial-transfontanellar ultrasonography; SCMM: sternocleidomastoid muscle; CT: computed tomography; CM: congenital malformation; MRI: magnetic resonance imaging; ESR: erythrocyte sedimentation rate; CRP: C-reactive protein; PCF: posterior cranial fossa; TUS: transcranial ultrasonography; EEG: electroencephalography.

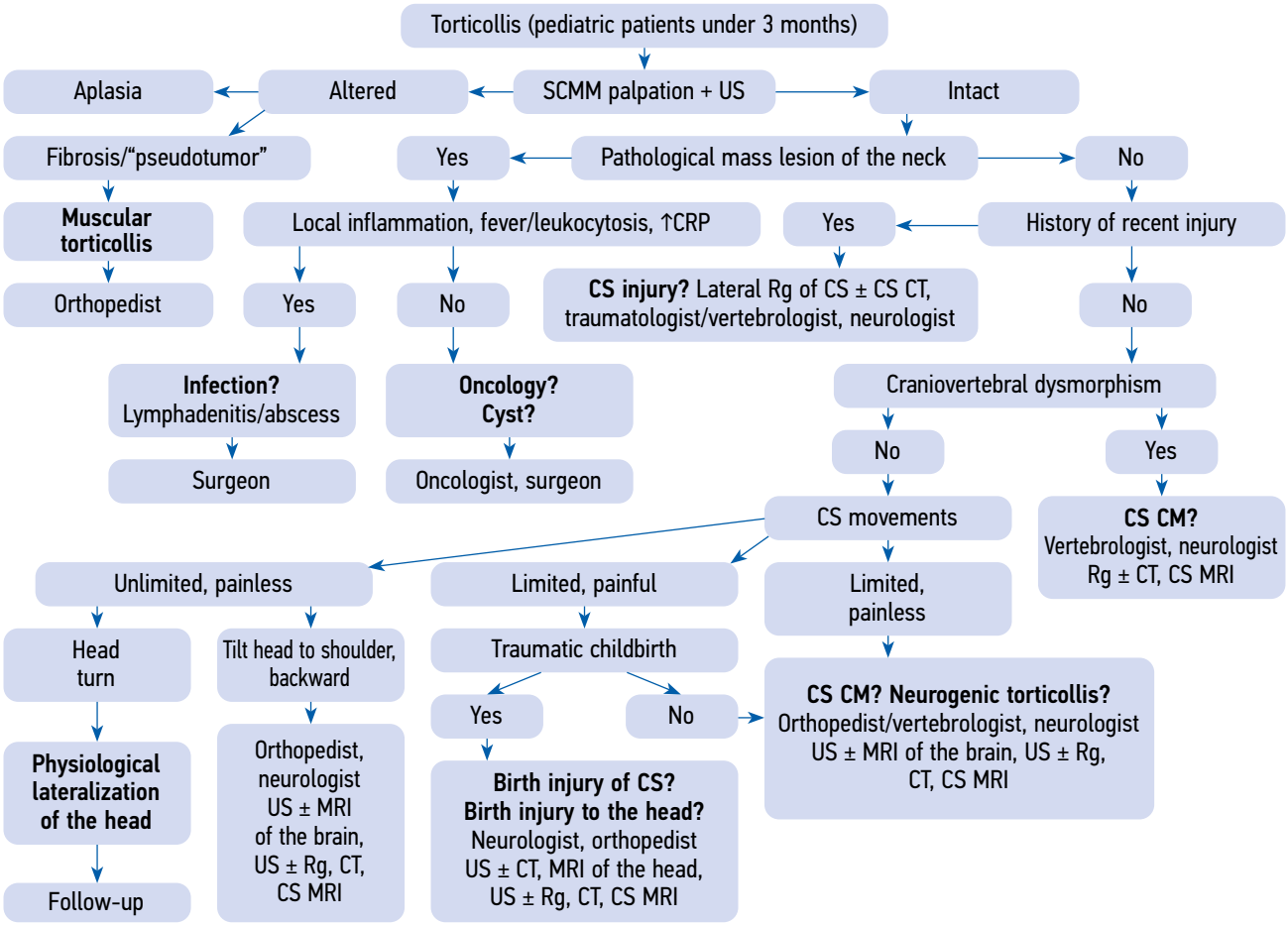

Fig. 1. Algorithm for the differential diagnostics of torticollis in newborns and pediatric patients under 3 months. SCMM: sternocleidomastoid muscle; CM: congenital malformation; CRP: C-reactive protein; CS: cervical spine; Rg: radiography

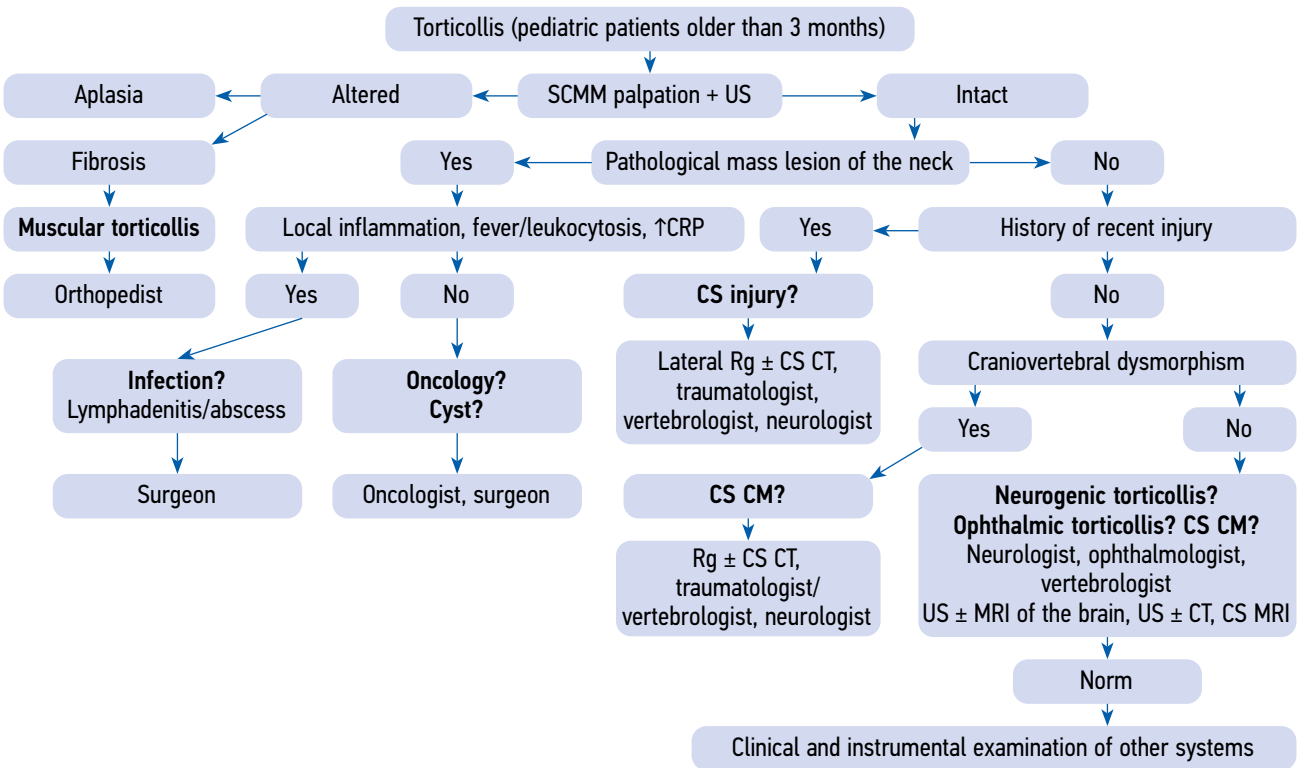

Fig. 2. Algorithm for the differential diagnostics of torticollis in pediatric patients of younger age groups. SCMM: sternocleidomastoid muscle; CM: congenital malformation; CRP: C-reactive protein; CS: cervical spine; Rg: radiography

CONCLUSION

We have considered pediatric issues of torticollis, presented the theoretical foundations, and developed algorithms for its differential diagnostics in pediatric patients of younger age groups. In most cases, diagnosing congenital muscular torticollis does not cause difficulties, thus additional examinations are not required. However, every child with an abnormal head position in the absence of classic signs of congenital muscular torticollis should be carefully examined using clinical, laboratory, and imaging techniques. The possibility of a mass lesion at the level of the PCF or cervical spinal canal should be considered, even if torticollis is the only symptom. Increasing the level of knowledge of pediatric clinicians about the etiopathogenesis of torticollis syndrome will improve the efficiency of early diagnostics of hazardous diseases that lead to pathological head and neck positions in children.

ADDITIONAL INFORMATION

Funding. The study had no external funding.

Conflict of interest. The authors declare no conflict of interest.

Author contributions. *Yu.E. Garkavenko* created the concept and design of the scientific work, collected information, processed the material, wrote the basic text, performed stage, and final editing. *A.P. Pozdeev* created the concept and design of the scientific work, collected information, processed the material, wrote the basic text, performed stage, and final editing. *I.A. Kryukova* collected information, processed the material, wrote the basic text.

All authors made a significant contribution to the study and preparation of the article, read and approved the final version before its publication.

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