TREATMENT OF PEDIATRIC PATIENTS WITH CRANIOFACIAL INJURIES IN THE TRAUMA DEPARTMENT OF A MUNICIPAL HOSPITAL

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Aim: To improve treatment outcomes for children with combined craniofacial injuries

Materials and Methods: This study involved a retrospective analysis of treatment outcomes from 43 children with combined craniofacial trauma who were admitted to Rauhfus Children’s City Hospital No. 19 from 2012 to 2015. Analysis involved the age and gender of patients along with the mechanism of injury, areas sustaining injury, and methods of examination and treatment.

Results: All patients underwent full surgical treatment in the early stages.

Conclusions: Managing patients with concomitant craniofacial trauma requires a multidisciplinary approach. Treatment inevitably requires surgery, which needs to be performed as early as possible to avoid posttraumatic deformities and optimize functional and esthetic outcome.

Keywords: children, craniofacial trauma, face injury, early surgical treatment.

Introduction

Treatment of injuries associated with the maxillofacial area of the skull and the neurocranium is one of the most difficult and urgent problems in traumatology. The modern approach to the comprehensive treatment of adults includes full surgical measures taken as early as possible to stabilize all bones, create conditions for morphological and functional recovery of the maxillofacial area (e.g., functions of mastication and nasal respiration), and restore facial aesthetics during the postoperative period [1, 2]. Additionally, issues involving diagnostics and decision making regarding the sequence and choice of methods of comprehensive treatment in multi-specialty hospitals require further study and discussion among medical specialists.

Post-traumatic deformities of the maxillofacial region are frequently a consequence of late diagnosis, hospitalization in a general hospital, and delayed or improper treatment of injuries. These deformities may cause the restriction of lower jaw movements, impaired mastication, malocclusion, impaired visual function due to eyeball displacement, changes in nose shape and function, impaired respiration, and bad facial aesthetics [3, 4].

Injuries to the maxillofacial area constitute 6%–7% of all cranial and brain injuries in adults and up to 7% in children, according to Kharitonov [1]. The greatest number (between 10 and 16) of maxillofacial injuries in children occurs during their pre-teen and early teenage years, at an average age of 10.7 years [6]. The clinical picture of associated craniofacial injuries in children is different from that in adults because of the anatomical and physiological characteristics of children [7], and children require hospitalization in a specialized trauma hospital, in addition to targeted and coordinated diagnostic and treatment measures.

A considerable amount of research has been devoted to the study of causes and diagnosis of craniofacial injuries [8–10]. One urgent issue is the determination of the sequence, timing, and extent of specialized maxillofacial care and the selection of the best surgical treatment methods while considering the aggravating effects of associated injuries on the clinical course and outcome of trauma in the growing child. Even if the mechanisms of injury and types of fracture are similar, the treatment plan should take into account the anatomical and functional characteristics of children of different ages, including the facial-to-cranial skull ratio, size
and shape of jaw bones, different pneumaticity of paranasal sinuses, presence or absence of tooth rudiments, high level of elasticity, and regenerative ability of bone tissue in children, as well as the continuing and uneven growth of the facial bones [11].

In this study, we evaluated the timeline and extent of specialized maxillofacial and neurosurgical care provided in a trauma hospital with the goal of improving the results of treatment in children with associated craniofacial injuries.

Materials and methods

This study included 43 patients aged between 9 and 18 years who were treated for craniofacial trauma at the K.A. Rauhfus Children’s City Hospital no. 19 during 2012–2015. There were 36 male patients aged 9–17 years and 7 female patients aged 11–16 years. The most frequent mechanisms of injury were domestic trauma (violence), 27 patients; falls from height, 10 patients; and traffic accidents, 6 patients.

Fourteen patients had fractures of the mandible, 9 patients had zygomatic arch and orbital fractures, 8 patients had isolated fractures of the zygomatic arch, and 6 patients had fractures of the upper jaw. Nasoorbitoethmoid fractures were present in 4 patients, and very severe cases of mid- and upper-face fractures associated with brain trauma were present in 2 patients.

A comprehensive approach was used for establishing diagnosis and treatment planning. All injured patients had undergone thorough and detailed examinations, which included physical and neurological examinations, assessment of consciousness on the Glasgow Coma Scale on admission and during the course of traumatic disease. Spiral computed tomography (CT) and 3D image reconstruction were performed for all patients. The order and extent of diagnostic tests and treatment were determined according to the severity of condition, level of consciousness, stability of hemodynamics, and vital functions of the patient.

According to the severity of traumatic brain injury, the patients were divided as follows: 34 patients had concussions, and the causes were domestic injury (violence) in 63%, falling from height in 25%, and traffic accident in 13%; 3 patients had light contusions; 4 patients had moderate contusions; and 2 patients had severe brain contusions. Patients with severe and moderate brain trauma were injured in traffic accidents (44%), falls from heights (33%), and domestic trauma (violence; 22%). The clinical picture of associated craniofacial trauma was determined by the interactions of its components and the age of the patient. This trauma is manifested as an additive effect when 2 concomitant, separately induced, non-shock traumas together significantly aggravate the condition of the patient and result in traumatic shock. We encountered this problem in 7% of patients; these patients had severe traumatic brain injuries and needed emergency neurosurgical and intensive care in the ICU where they received infusions and antishock, hemostatic, edema-reducing therapy. After the life-threatening conditions were controlled, consciousness was regained, and indications for use of ventilator were resolved, the patients were transferred to a specialized department for surgical treatment. In the remaining 93% of patients, the present brain injury was not a contraindication for early specialized surgery, and the patients were operated on the second day after hospitalization.

Methods of surgical treatment were based on general principles established by the International Association of Oral and Maxillofacial Surgeons and included open reduction and extramedullary fixation of bone fragments with titanium or biodegradable mini- and microplates and screws, closed reduction, and maxillomandibular (interdental) fixation using standard wire ligatures, arch bars, or intraosseous microimplant techniques with the creation of elastic connections. The choice of surgical access in the treatment of skull fractures was based on localization of the fracture, possibility of free manipulation, and visual control in the surgical zone.

For treatment of mandibular fractures in all 14 patients, titanium miniplates (2.0 mm) with screws were used for fragment fixation. For surgical access, intraoral incisions were used in 60% of the patients, percutaneous incisions were used in 27%, and a combination of both was used in 13%. In 6 patients, in addition to osteosynthesis, maxillomandibular immobilization with implants was performed for a 2-week period. Use of titanium plates and their rigid fixation allowed early functional loading. In children <14 years of age, the miniplates and screws were removed 3–4 months after surgery because of the child’s bone growth, necessity of correct structure
development of facial architecture, or to prevent post-traumatic deformities. In older children, the miniplates were rarely removed. Biodegradable plates, and screws were used only in patients with mid-face fractures.

Open reduction and osteosynthesis of infraorbital edge surgery was performed in all 9 cases of zygomatic region fractures. Titanium miniplates (Conmet, Russia and were used in 5 cases, and biodegradable Sythes, Switzerland) (h = 1.2) miniplates were used in 4 cases. In patients with orbital bone defects with soft tissue prolapse (2 cases), plastic reconstruction of the orbital floor was performed, and the bone defect was replaced with an Ecoflon polytetrafluoroethylene implant (manufactured in Russia). In one patient with a small-fragment comminuted fracture, a custom titanium mesh implant was made to replace the infraorbital edge and orbital floor.

For treatment of isolated zygomatic fractures (8 patients) titanium and biodegradable microplates for the stabilization of the infraorbital edge and zygomaticofrontal suture were used.

Titanium plates in these patients were removed within 2 months after surgery, on average.

The use of biodegradable extramedullary plates for fragment fixation in the mid-face area was optimal for children because it prevented the need for a second surgery for plate removal. In patients with maxilla fractures, maxillomandibular fixation with titanium microplates (h = 1.5) was performed.

Only 2 patients with fractures in the zygomatic region and severe contusion of an eyeball had postoperative complications in the form of decreased visual acuity. Patients with other craniofacial injuries did not have any complications on the day of discharge from the hospital. The average duration of hospitalization was 10 days. In addition to neurological treatment, patients with jaw bone injuries were referred to an orthodontist for further treatment. Patients with mid- and upper-face injuries were referred to a neurologist, an ophthalmologist, and an ear, nose, and throat specialist according to individual indications. All patients were examined by their surgeon at 3, 6, and 12 months after surgery. During this period of observation, there were no post-traumatic mid-face deformities, dysfunction, or occlusion problems.

Case Studies

Patient B, was a 16-year-old male who was transferred to K.A. Rauhfus Children’s Hospital on 06.15.2015 from Central Regional Hospital (CRH), city of Priozersk. The patient had been at the CRH for 3 days with the following diagnosis: concomitant injury; open brain injury; severe brain contusion with hemorrhagic lesions of the frontal lobes; acute epidural hematoma of the right frontal region; multiple fractures of the roof and base of the skull and facial region; multiple fractures of the paranasal sinus accompanied by hematoma; severe right eye contusion (hyposphagma, injury, corneal erosion, multiple petechial hemorrhages), moderate left eye contusion (hyposphagma, retinal edema); and fractures of the lower lateral orbital walls on both sides and medial orbital wall on the left. Complications included pneumocephalus, cerebrospinal fluid rhinorrhea, lung contusion, and type 1 respiratory failure. During the patient’s hospitalization at CRH, the following measures were taken: decompressive craniectomy of the frontal–parietal–temporal areas on both sides, front and rear nasal tamponade, and tracheostomy (Figs. 1, 2).

It was necessary to stabilize the bones of the mid-face area because of multiple facial bone fractures with significant displacement of fragments involving mobility of fragments of the zygoma on the left, of the right maxilla, and lower orbital edge on both sides; enophthalmos on the right; and malocclusion. The patient had surgery on the second day after transfer to the K.A. Rauhfus Children’s Hospital. The next operations were performed through combined access (transconjunctival with canthopexy, and intraoral): reduction and osteosynthesis of the left zygomatic bone, examination and reduction of the right orbit floor fragments, and reduction and osteosynthesis of the right maxilla with titanium microplates and screws.

As a result of the surgery, all facial bone fragments were stabilized, which allowed restoration of mastication, prevention of diplopia, and achievement of a good aesthetic result (Figs. 3, 4). For further treatment, the patient was transferred to the Neurological Department of the City Children’s Hospital no. 22. Six months after surgery, a plan for reconstructive operation was developed by using computer modeling, and the surgery was performed; the bone defect of the skull was replaced with a custom-made porous hydroxyapatite implant (Figs. 5–8).
In this case, a good outcome from complex treatment of associated craniofacial injuries was achieved as a result of 2 stages of reconstructive surgery of the facial and cranial skull by using modern techniques of computer simulation and creation of an individual endoprosthesis.

**Patient Z.** was a 15-year-old male who was transferred to K.A. Rauhfus hospital on 09.14.2015 after a 2-day hospitalization in City Children’s Hospital no. 5 with a diagnosis of concomitant injury; open brain injury; moderate brain contusion; contusion-related hemorrhagic lesion of the right frontal lobe; subarachnoid hemorrhage; pneumocephalus; fractures of the facial region, Le Fort type II–III; squama frontalis fracture; fracture of the anterior walls of the

**Figure 1.** Patient B., a 16-year-old a male, before surgery

**Figure 2.** Patient B, spiral CT before surgery

**Figure 3.** Patient B, after surgery

**Figure 4.** Patient B, spiral CT after surgery

**Figure 5.** Patient B, measurement of the skull defect

**Figure 6.** Patient B, computer simulation of the skull defect and upper part of face compensation
maxillary sinuses and ethmoid bone; hematoma of all sinuses; periorbital hematoma on both sides; closed fracture of the spinous process of C2; compression-comminuted fracture of the Th1 vertebra without displacement; Th1 vertebra retrolisthesis; multiple soft tissue injuries of the face, trunk, and extremities; and acute peroral ethanol intoxication.

Osteosynthesis of damaged facial bones was necessary to eliminate mobility of maxillary and zygomatic bone fragments and of fragments in the metopic suture region as well as to prevent formation of the occlusion strain, post-traumatic sinusitis, nasal breathing problems, and disharmony of the face (Figs. 9, 10).
Because of his critical condition, the patient was in the ICU on the first 2 days after admission. The surgery was performed on the third day. Combined access (bitemporal and intraoral) allowed a full visual review of the middle and upper facial regions. The surgical treatment included reduction and osteosynthesis of the anterior wall of the frontal sinus, of the left zygomaticofrontal suture by using titanium plates and screws, of the maxilla on both sides by using titanium microplates and screws, and reduction of nasal bones (Figs. 11, 12).

As a result of early and complete surgical reduction and osteosynthesis of facial bones, it was possible to restore nasal breathing and mastication functions and facial aesthetics in this patient. Facial aesthetic results were achieved through the use of bitemporal and intraoral surgical access, which prevented formation of postoperative scars on the face.

For further specialized treatment of the vertebral fracture, the patient was transferred to the G.I. Turner Scientific and Research Institute for Children's Orthopedics.

Results and discussion

The largest number of craniofacial injuries in children occurs between the ages of 9 and 18. The most severe associated traumas of this region are the result of traffic accidents and falling from a height (77%). The most severe brain injuries (severe brain contusions) are typically combined with multiple fractures of the mid- and upper-face areas of the facial region of the skull; the cause of these injuries were traffic accidents. The additive effects of concomitant cranial, brain, and maxillofacial injuries aggravate the condition of the patient and determine specialized treatment tactics. In such cases, maxillofacial surgery for reduction and immobilization of facial bones is postponed by several days to allow stabilization and emergency neurosurgical treatment of the patient. However, in the majority of patients (93%), the degree of severity of neurotrauma was not a contraindication for specialized maxillofacial care 2 days after hospitalization.

The goal of this surgery was stabilization of fractured facial bones and to provide primary treatment of soft tissue for rapid recovery of important body functions, including mastication, breathing, and restoration of socially significant facial areas (speech and facial esthetics). The choice of surgical access (percutaneous, intraoral, transconjunctival, transcranial, or combined) was determined by fracture location and by the convenience of the field of view and manipulation in the wound. Intraoral access was used for mandible osteosynthesis in 60% of the cases; in the rest of the cases, percutaneous access was used. In patients with maxilla fractures and in some patients with mid- and upper-face fractures, it is preferable to use bitemporal (transcranial) combined with intraoral access to the fracture site (this approach was used in 5% of cases). Such operations do not result in scar formation on the face, which provides better aesthetic outcome. In the remaining patients, surgery was performed through skin incision, oral mucous membrane incision, or through conjunctiva in the patients with orbit fracture. We used the following methods of surgical treatment: open reduction and extramedullary fixation of bone fragments with titanium or biodegradable mini- and microplates and screws; closed reduction and maxillomandibular (interdental) fixation using standard wire ligatures, arch bars, or intraosseous microimplant techniques with the creation of an elastic connection. For mandible osteosynthesis in all 14 patients, we used extramedullary titanium miniplates with screws because only this method provides reliable immobilization of the fracture and enables early functional loading on the jaw. To create a more rigid immobilization, in 6 cases after osteosynthesis, additional intraosseous screw implants were used with elastic maxillomandibular traction. In all cases of mid- and upper-face bone fractures, metal plate osteosynthesis was used, which provided reliable stabilization of bones after fracture reduction in this area. On average, 2 (mid-face area cases) or 3–4 months (mandible fracture cases) after surgery, metal constructions were removed in patients with continued skull growth (under 14 years of age). In 6 patients with zygomatic–orbital region fractures and isolated fractures of the zygoma, biodegradable miniplates were used because these miniplates do not require a second surgery to remove them.

Biodegradable materials may be used successfully in children in areas where there is no large functional load, such as zygomatic bone, orbital bones, and the cranium. For orbital bottom defect filling, we used

Biodegradable materials may be used successfully in children in areas where there is no large functional load, such as zygomatic bone, orbital bones, and the cranium. For orbital bottom defect filling, we used
endoprostheses made of titanium mesh and custom-made polytetrafluoroethylene (Ecoflon) implants in 2 patients.

Postoperatively, minor complications, such as reduced visual acuity, were observed in 2 patients with fractures in the zygomatic–orbital region and contusions of the eyeball. During hospitalization (10 days on average) and the period of follow-up observation (12 months), the patients of the main group (93%) who were without severe brain contusion and/or neurological symptoms associated with craniofacial injury did not have complications in either the maxillofacial area or brain. There were no post-traumatic dental–maxillofacial deformities, occlusion pathology, disruptions of mastication and respiratory functions, or face disharmony.

We think that during treatment of brain and cranial injuries in children, diagnostic and therapeutic measures, including surgery, should be performed consecutively and consistently because the main goal is not only stabilization of the general and neurological condition of the patient but also early restoration of the dental–maxillary apparatus and other bone structures (nose and paranasal sinuses and orbits) and functions of the facial region of the skull. Achievement of early stabilization of facial bones after injury and restoration of mastication, breathing, and socially important functions (speech, facial harmony), is a measure of successful medical rehabilitation after trauma. These achievements also decrease the risk of post-traumatic deformities and other functional complications in the maxillofacial region.

Conclusions

Treatment of patients with craniofacial injuries requires a multidisciplinary approach. Early specialized neurological (neurosurgical) and maxillofacial surgical care should be directed at rapid and complete restoration of functions in the patient. Stabilization of facial bone fractures by using metal or biodegradable plates or other fixating constructions according to indications is fundamental in providing maxillofacial care.

Administration of specialized care by maxillofacial surgeons early and to the full extent can prevent complications during the postoperative period, prevent formation of post-traumatic deformities, and provide full medical rehabilitation of children with associated craniofacial injuries.

References


ОСОБЕННОСТИ ЛЕЧЕНИЯ ДЕТЕЙ С СОЧЕТАННОЙ ЧЕРЕПНО-ЛИЦЕВОЙ ТРАВМОЙ В УСЛОВИЯХ ГОРОДСКОЙ БОЛЬНИЦЫ СКОРОЙ ПОМОЩИ

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Цель исследования. Улучшение результатов лечения детей с сочетанной черепно-лицевой травмой. Материалы и методы. Проведен ретроспективный анализ результатов лечения 43 детей с сочетанной краниофациальной травмой, поступивших в ДГБ №19 им. К.А. Раухфуса г. Санкт-Петербурга в период с 2012 по 2015 год. Рассмотрены пол и возраст пациентов, локализация переломов на лицевом отделе черепа, методы обследования и лечения. Результаты. Всем пациентам было проведено оперативное лечение в ранние сроки в полном объеме с использованием различных методов остеосинтеза. Выводы. При ведении пациентов с сочетанной краниофациальной травмой требуется мультидисциплинарный подход, основным методом лечения является оперативный, сроки проведения операций должны быть ранними, лечение должно быть осуществлено в полном объеме. Это позволяет достичь оптимального функционального и эстетического результата лечения и избежать посттравматических деформаций в челюсто-лицевой области. Ключевые слова: дети, краниофациальная травма, повреждение костей лицевого отдела черепа, раннее оперативное лечение.

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