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# ALGORITHM OF MEDICAL CARE FOR CHILDREN WITH POLYTRAUMA

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**Background.** Polytrauma is the main reason for incapacitation and death in children of all ages. The appropriate timing of specialized medical care plays a crucial role for the outcomes of the polytrauma.
**Aim.** The aim of the study is to analyze the results of the treatment of musculoskeletal injuries with the use of a decision-making algorithm in pediatric patients with polytrauma.
**Materials and methods.** This is a prospective, observational, controlled, single-center study. The research included 130 children who were divided into two groups. In the main group, the children were provided with specialized medical care by a multidisciplinary team. After stabilization, the patients were transferred to a specialized center for final surgical treatment by minimally invasive fracture osteosynthesis. After the elimination of existing life-threatening conditions and the fitting of skeletal traction, the patients in the control group received surgical treatment only after transferal to a specialized center.
**Results.** In the main group, pain regressed significantly earlier (1.7 ± 0.6 vs 3.2 ± 0.4, $p < 0.05$), and the duration of the postoperative ICU stay was significantly reduced (1.5 ± 0.9 vs 2.4 ± 1.4 days, $p < 0.05$). The optimization of the surgical treatment of injuries facilitated a reduction in the duration of the ICU stay of patients in the main group (5.6 ± 0.3 vs 6.5 ± 0.4 days), in the surgical department (21.5 ± 0.7 vs 25 ± 0.9 days), and the overall hospital stay (up to 27.5 days).
**Conclusions.** This study developed a decision-making algorithm for administering medical care to children with polytrauma based on the principle of stabilization of the condition and early low-trauma surgery in the hours following injury.

**Keywords:** polytrauma; children; medical care; algorithm.

# АЛГОРИТМ ОКАЗАНИЯ ПОМОЩИ ДЕТЯМ С СОЧЕТАННОЙ ТРАВМОЙ

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**Обоснование.** Сочетанная травма является основной причиной инвалидизации и летальных исходов у детей всех возрастных групп, при этом сроки оказания специализированной помощи играют решающую роль в исходе сочетанной травмы.
**Цель** — анализ результатов лечения повреждений опорно-двигательного аппарата в структуре политравмы на основе алгоритма принятия тактического решения.
**Материалы и методы.** Дизайн исследования — проспективное обсервационное контролируемое одноцентровое. Обследовано 130 детей, которые были разделены на две группы. Детям основной группы была оказана специализированная медицинская помощь силами мультидисциплинарной выездной бригады, и после стабилизации состояния пациенты были переведены в специализированный центр для хирургического лечения путем малоинвазивного остеосинтеза переломов. Пациентам, составившим группу сравнения, устраняли жиз-

неугрожающие состояния и устанавливали скелетное вытяжение, хирургическое лечение выполняли после перевода в специализированный центр.

**Результаты.** В основной группе боль регрессировала значительно раньше (1,7 ± 0,6 vs 3,2 ± 0,4; $p < 0,05$), существенно сократилась длительность пребывания пациентов в отделении реанимации и интенсивной терапии в послеоперационном периоде (1,5 ± 0,9 vs 2,4 ± 1,4; $p < 0,05$). Оптимизация тактики хирургического лечения повреждений позволила снизить длительность пребывания пациентов основной группы в отделении реанимации и интенсивной терапии (5,6 ± 0,3 vs 6,5 ± 0,4 сут), в профильном отделении (21,5 ± 0,7 vs 25 ± 0,9 сут) и стационаре (до 27,5 сут).

**Заключение.** Предложен алгоритм принятия тактического решения при оказании помощи детям с сочетанной травмой, заключающийся в стабилизации состояния и проведении ранних малотравматичных операций в ближайшие часы после травмы.

**Ключевые слова:** сочетанная травма; дети; медицинская помощь; алгоритм.

Timeliness and adequacy of therapeutic and diagnostic measures in assisting victims with severe concomitant injury are a prerequisite for improving treatment outcomes [1–4]. Following the existing system of medical care, the victim should be taken immediately from the scene to a specialized multidisciplinary medical institution (the "golden hour" concept) [5–7]. However, pediatric patients with concomitant injuries, affected in rural areas, are usually hospitalized in the nearest general inpatient facility, where the possibilities for providing specialized care to pediatric patients are extremely limited. This indicates the presence of several unresolved organizational and medical problems [7, 8–12].

An adequate and timely primary tactical decision determines not only the volume and sequence of medical and diagnostic measures but also the outcome of the injury itself. The concept of immediate surgical treatment of all injuries in place is currently debatable. Reducing the duration of the victim's stay in the general hospital and the earliest possible transfer to a specialized center significantly improve the outcome of the patient's treatment [8, 12–16]. Poor functional outcomes of the treatment of concomitant injuries in children also indicate the need to improve anesthesiology, resuscitation, and surgical treatment at all stages of care [12, 17–20].

**This study aimed** to analyze the results of the treatment of injuries of the musculoskeletal system (MSS) in the structure of the concomitant injury based on the tactical decision-making algorithm.

## Materials and methods

### Study design

This is a prospective observational controlled, nonrandomized, and single-center study. Children with concomitant trauma, aged 1 to 15 years, were examined. The main group was formed after the introduction of the tactical decision-making algorithm with the departure of a specialized resuscitation and traumatology team.

### Criteria

*Inclusion criteria* were concomitant injury to the pediatric patient and hospitalization in the hospital within the first 6 h from the moment of injury.

*Exclusion criteria* were the death of the patient within the first 24 h after the injury (fatal injury) and a less than 60 km distance to the specialized trauma center.

### Conditions

The study was conducted in the Department of Anesthesiology, Intensive Care, and the Traumatology Department of the Republican Children's Clinical Hospital of the Ministry of Health of the Republic of Bashkortostan.

### Duration of the study

A group of patients was formed from 2006 to 2015.

### Description of medical intervention

The treatment outcomes of concomitant trauma in pediatric patients were evaluated depending on the provision of specialized anesthesiological-resuscitation and traumatological care in the immediate hours after the trauma.

### Primary outcome of the study

Mortality, duration of inpatient treatment, and duration of treatment in the intensive care unit (ICU) were determined.

### Additional study outcomes

Functional condition of the damaged limb.

### Subgroup analysis

Of pediatric patients, 130 with concomitant trauma from the age of 1 to 15 years met the study criteria. All the patients were divided into two groups: the main group and the comparison group. The main group included 64 pediatric patients, who immediately after admission to the general hospital, were provided with specialized medical care by the mobile team of a specialized hospital, which included pediatric anesthetists, resuscitators, orthopedic traumatologists, and other experts. After fixing the damaged segments of the MSS with rod devices and stabilizing the condition, the patients were transferred to a specialized center for surgical treatment using minimally invasive plate osteosynthesis (MIPO).

The comparison group consisted of 66 pediatric patients who did not receive specialized medical care upon admission to the general hospital. The primary fixation of the MSS damaged segments was performed by skeletal traction or plaster immobilization. Specialized surgical treatment was performed after the patient was transferred to the children's traumatology center.

All the victims were initially admitted to the surgical departments of the municipal medical institutions of the Republic of Bashkortostan. Of patients, 109 (83.8%) were delivered within the first hour after the injury and 21 (16.2%) within 3 h from the moment of injury. The maximum number of victims was recorded in the summer and autumn months (73%), whereas the number of injuries was significantly lower (27%) during the winter and spring period. As a rule, the main causes of concomitant injuries were autotrauma and catatrauma. In all age groups, autotrauma prevailed, which caused severe injuries in 103 (79.2%) pediatric patients. Traumatic shock at admission developed in 88 (67.7%) victims. There were no differences between the main and control groups by age and gender.

All 130 (100%) pediatric patients suffered MSS trauma, and traumatic brain injuries (TBIs) of various severity were diagnosed in 126 (96.9%) patients, and damage to internal organs was observed in 40 (30.7%) patients. Most often, the MSS trauma was combined with a TBI (90 pediatric patients, 69%), and the combination of MSS injuries, internal organs, and a TBI was recorded less often (36 patients, 28%), as well as damage to MSS and internal organs (4 patients, 3%). All pediatric patients included in the study had 194 fractures (79.2%) with displacement and 51 (20.8%) fractures without displacement of fragments. Open fractures were diagnosed in 37 (19.1%) pediatric patients. Bone fractures of the lower extremity were observed in 137 (76.1%) patients. Fractures of the femur and lower leg were revealed in 97 (53.9%) and 40 (22.2%) pediatric patients, respectively. Traumatic injuries of the upper extremities were three times less common and accounted for only 23.9%. Injuries to the humerus and forearm bones were diagnosed in 28 (15.6%) and 15 (8.3%) patients, respectively. The total number of injuries was 497, with 243 injuries recorded in the main group and 254 in the control group, which exceed significantly

*Table 1*

Injury severity assessment according to ISS

| Patient's condition (points) | Main group, $n = 64$ | Control group, $n = 66$ | $\chi^2$ | $p$* |
|---|---|---|---|---|
| Stable (less than 17) | 9 (14.1%) | 11 (16.6%) | 0.028 | 0.433 |
| Borderline (17–25) | 34 (53.1%) | 32 (48.5%) | 0.125 | 0.362 |
| Unstable (26–40) | 19 (29.7%) | 19 (28.8%) | 0.006 | 0.468 |
| Critical (over 40) | 2 (3.1%) | 4 (6.1%) | 0.144 | 0.352 |

*Note.* *No statistically significant differences were found. The groups were homogeneous, $\chi^2$ test.

*Table 2*

Distribution of patients by severity of injury and condition

| Scale for assessing the injury severity | Main group, $n = 64$ | | | | Control group, $n = 66$ | | | | $p$* |
|---|---|---|---|---|---|---|---|---|---|
| | $M \pm \delta$ | Me | 25% | 75% | $M \pm \delta$ | Me | 25% | 75% | |
| PTS, points | 5.9 ± 2.0 | 6 | 4.75 | 7 | 6.2 ± 2.1 | 6 | 5 | 7 | 0.287 |
| ISS, points | 22.9 ± 7.3 | 20 | 18 | 29 | 22.6 ± 8.4 | 18.5 | 17.25 | 27 | 0.741 |
| GCS, points | 12.8 ± 2.7 | 14 | 12 | 15 | 12.8 ± 2.6 | 14 | 12 | 15 | 0.819 |
| PELOD, points | 10.1 ± 8.5 | 11 | 1 | 14 | 9.2 ± 8.7 | 10 | 0 | 14 | 0.113 |

*Note.* *There were no statistically significant differences in the groups by $\chi^2$, $p > 0.05$, and Mann–Whitney test. $M \pm \delta$; Me, median; 25%, 25$^{th}$ percentile; 75%, 75$^{th}$ percentile.

*Table 3*

Characterization of surgeries and manipulations

| Indicator | Main group | Control group |
|---|---|---|
| Total number of surgeries | 172 | 109 |
| Number of surgeries in a general hospital | 66 | 21 |
| Number of surgeries in a specialized hospital | 106 | 88 |
| Number of surgeries in the intensive care unit of the general hospital | 66 | 21 |
| Number of surgeries in a specialized department of a specialized hospital | 106 | 88 |
| *Surgeries and manipulations in a general hospital* | | |
| Plaster immobilization | 48 | 51 |
| Skeletal traction | 31 | 34 |
| Surgical treatment of wounds | 32 | 36 |
| Craniotomy | 4 | 3 |
| Laparotomy | 8 | 4 |
| Laparocentesis | 5 | 2 |
| Bulau drainage of the pleural cavity | 1 | 1 |
| Puncture of the pleural cavity и | 1 | 1 |
| External fixation device | 35 | 0 |
| Open reduction, osteosynthesis with Kirschner wires | 2 | 2 |
| Closed fracture reposition | 6 | 4 |
| Splint of the lower jaw | 1 | 0 |
| Blockade by Shkolnikov-Selivanov | 3 | 4 |

the number of victims. When categorizing pediatric patients according to the severity of damage (Table 1) and condition (Table 2), no intergroup differences were found.

Surgical interventions were performed in 130 patients, and a total of 281 surgeries and 232 manipulations were performed (Table 3).

During the stay of pediatric patients in ICU, 87 surgeries were performed, and 194 surgical interventions were done during treatment in the specialized department of a specialized hospital. Sequential osteosynthesis was performed in 11 patients and simultaneous osteosynthesis in 26.

**Outcome registration methods**

The severity of the patient's condition was determined using the scales of PTS, ISS, CGS, and PELOD. The anatomical and functional conditions after the surgery were evaluated according to the Mattis–Luboszitz–Schwarzberg scale.

**Statistical analysis**

*Principles for calculating the sample size.* The sample size was not previously calculated; all pediatric patients with concomitant trauma who were treated during the study at the Republican Children's Clinical Hospital of the Ministry of Health of the Republic of Bashkortostan were included in the study.

*Methods of statistical data analysis.* Statistical analysis was performed using the BioStat program. Qualitative and threshold indicators were analyzed using the Pearson $\chi^2$ criterion. Differences in quantitative variables between groups were evaluated using the Mann–Whitney test.

**Objects (participants) of the study**

The objects of the study were represented by medical records of inpatients and formalized study records.

## Results

Sixty-eight (52.3%) pediatric patients were registered with the intensive care and advisory center (ICAC) of the Republican Children's Clinical Hospital of the Ministry of Health of the Republic of Bashkortostan in the first 3 h from the moment of injury. There were 26 (20.0%) reported complaints from 3 to 12 h and 19 (14.6%) complaints from 12 to 24 h. Seventeen (13.1%) pediatric patients were registered 1 day after the injury. Also, 58 pediatric patients required remote counseling; ICAC specialized teams visited 72 injured, and 64 pediatric patients underwent surgical interventions with the participation of specialists from the pediatric trauma center.

The departure time of the ICAC team from the moment of injury is indicated in Table 4.

Specialized on-site anesthesiology, resuscitation, and trauma care were provided on the first day after injuries in more than 80% of cases. After diagnostic measures and preoperative preparation, emergency surgical interventions were performed and aimed at eliminating life-threatening complications and stabilizing the patient's condition. The time from the moment of injury to the start of surgery was 3.3 ± 0.5 h in the main group and 4.9 ± 1.2 h in the control group, and the differences between the groups were statistically significant.

Immediately after completion of surgeries aimed at eliminating life-threatening conditions, fixation of fractures of the tubular bones of the extremities and the pelvic ring in case of its unstable injuries was performed (Table 3). In 24 pediatric patients, 35 rod apparatuses were applied, whereas in 11 patients, rod osteosynthesis was performed on several segments at once.

Most often, the primary fixation of fractures upon admission of the victim to a general hospital was performed by plaster immobilization. In total, 99 (60%) plaster casts were applied. Four (2%) patients underwent closed reposition of fragments with subsequent plaster immobilization. Skeletal traction for fixing fractures of the lower extremities was used in 65 (50%) pediatric patients.

The external fixation apparatus (EFA) was used in 17 patients on day 1 after the injury and seven patients on day 2. In total, EFA was used in 35 patients with fractures of the lower extremities with displacement of fragments and unstable damage to the pelvic bones.

In 14 pediatric patients, EFA was used for open fractures of the femur, lower leg, and pelvis. According to the Gustilo-Anderson classification (1984), open type I fractures were diagnosed in 2 pediatric patients, type II fractures in 10, and type IIIA fractures in 2. In 18 cases, MSS trauma was combined with a closed TBI, and six pediatric patients had a blunt abdominal trauma with damage to the internal organs of the abdominal cavity. The distribution of patients, depending on the distance and time of transportation, is presented in Table 5.

More than 72% of the victims were transferred from medical organizations located 200 km from the pediatric trauma center, and the transportation time was 2.13 ± 0.48 h.

With an increase in the patient's age, the duration of treatment of the victim in a general hospital was significantly increased ($\chi^2 = 0.249$; $p = 0.028$). In particular, the duration of treatment in the primary hospital did not exceed 3 days in pediatric patients up to 6 years old, and in patients aged 7–10 years and 11–15 years, it was no more than 4 and 5 days, respectively.

*Table 4*

Departure time of the specialized brigade of the intensive care and advisory center from the moment of injury

| Departure time (h) | Main group, $n = 64$ | | Control group, $n = 66$ | | $\chi^2$ | $p$* |
|---|---|---|---|---|---|---|
| | $n$ | % | $n$ | % | | |
| Up to 12 h | 13 | 43.3 | 29 | 69.0 | 3.762 | 0.026 |
| 12–24 h | 8 | 26.7 | 9 | 21.5 | 0.055 | 0.407 |
| Over 24 h | 9 | 30.0 | 4 | 9.5 | 3.672 | 0.028 |
| Total | 30 | 100 | 42 | 100 | | |

*Note.* *The differences are significant (at $p < 0.05$) relative to the corresponding indicators of the control group, according to the $\chi^2$ criterion.

*Table 5*

Distance and duration of patient transportation

| Distance, km | Number of patients, $n = 130$ | | Duration of transportation, ч |
|---|---|---|---|
| | $n$ | % | ($M \pm \delta$) |
| Up to 100 | 54 | 42.2 | 1.31 ± 0.45 |
| 101–200 | 39 | 30.5 | 2.96 ± 0.57 |
| 201–300 | 26 | 20.3 | 3.44 ± 0.62 |
| 301–400 | 3 | 2.3 | 5.72 ± 1.14 |
| 401–500 | 4 | 3.1 | 7.21 ± 1.25 |
| Over 500* | 2 | 1.6 | 2.2 |

*Note.* *Transportation of the patient by air ambulance.

*Table 6*

Damage treatment in a specialized department

| Method of treatment by type of fracture | Main group, $n$ = 64 | | Control group, $n$ = 66 | | Total | |
|---|---|---|---|---|---|---|
| | $n$ | % | $n$ | % | $n$ | % |
| Epimetaphyseal fractures | | | | | | |
| Reposition + plaster | 2 | 1.9 | 2 | 2.3 | 4 | 2.1 |
| Kirschner wire | 27 | 25.5 | 30 | 34.1 | 57 | 29.4 |
| Screws | 6 | 5.7 | 5 | 5.7 | 11 | 5.7 |
| Diaphyseal fractures | | | | | | |
| Skeletal traction | – | | 8* | 9.1 | 8 | 4.1 |
| Bone osteosynthesis | 10 | 9.4 | 40* | 45.5 | 50 | 25.8 |
| TEN | 35* | 33.0 | – | – | 35 | 18.0 |
| MIPO | 10* | 9.4 | – | – | 10 | 5.2 |
| External fixation apparatus | 16* | 15.1 | 3 | 3.4 | 19 | 9.8 |
| Total | 106 | 100 | 88 | 100 | 194 | 100 |

*Note.* * Differences in groups are significant at $p < 0.05$. TEN, titanium elastic nail — intramedullary osteosynthesis using rods; MIPO, minimally invasive plate osteosynthesis.

In a specialized department, 106 surgeries were performed for patients in the main and 88 surgeries in the control groups (Table 6). The final osteosynthesis in patients in a stable state was performed on day 6.4 ± 1.2 in both groups. In case of an unstable condition, fractures were fixed on days 14.8 ± 1.2 and 19.2 ± 1.3 in the main and control groups, respectively.

The main methods of treating fractures of the lower extremities in the main group were titanium elastic nail (TEN, intramedullary osteosynthesis using rods) in 35 cases (33%), MIPO in 10 cases (9.4%), and EFA in 16 cases (15.1%). Extramedullary plate osteosynthesis was used in 10 (9.4%) pediatric patients in the presence of multi-fragmented fractures. In the control group, open extramedullary osteosynthesis was used most often (40 cases, 45.5%); skeletal traction was used in 8 cases (9.1%), and the Ilizarov apparatus was used in 3 cases (3.4%). Sequential osteosynthesis was performed in three and eight cases in the main and control groups, respectively. Simultaneous surgeries were performed in 19 and 7 patients in the main and control groups, respectively. Most often, delayed interventions were performed in the case of osteosynthesis of bones of the lower extremities, namely, in 75.4% cases in the main and 69.3% cases in the control groups.

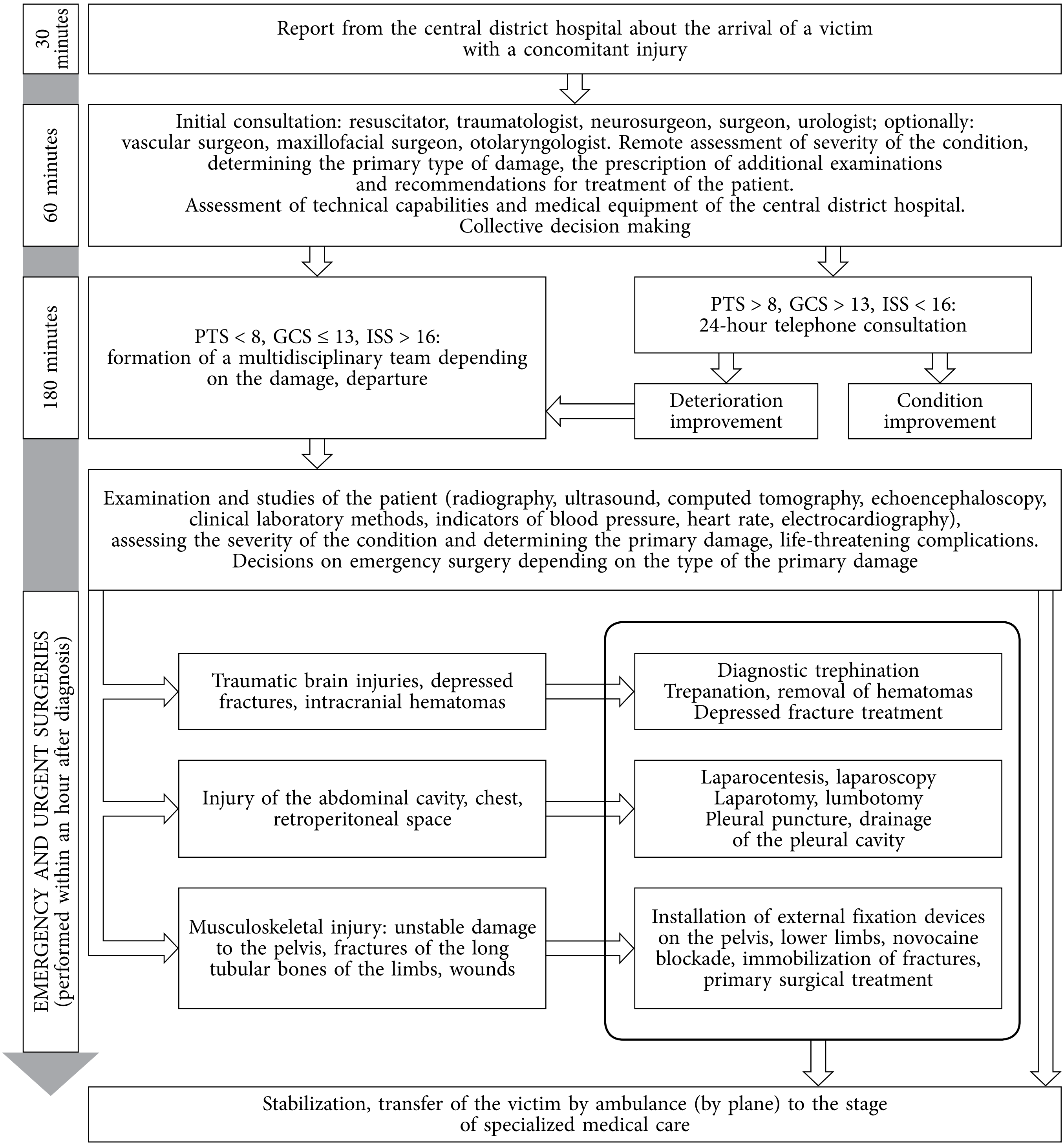
For the final fixation of epimetaphyseal fractures of the bones of the upper and lower extremities, Kirschner wires and screws were used in 33 (31.2%) cases of pediatric patients in the main group and 35 (39.8%) cases in the control group.

The most common method for treating diaphyseal fractures of the lower extremities in the main group was TEN (35 cases, 33%); EFA was used in 16 cases (15.1%) and MIPO in 10 cases (9.4%). The technique of plate extra-cortical osteosynthesis was applied in 10 (9.4%) pediatric patients with multi-fragmented fractures. The main methods for fixing fractures of the lower extremities in the control group were open bone osteosynthesis in 40 cases (45.5%), skeletal traction in 8 cases (9.1%), and EFA in 3 cases (3.4%).

The data obtained helped develop a tactical decision-making algorithm for combined trauma in pediatric patients (Figure).

The application of the algorithm, which is based on the principle of primary stabilization of the condition and early low-traumatic surgeries in the first hours after the injury, helped achieve faster stabilization of the condition and contributed to the earliest possible transfer of patients to a specialized center. The average treatment time for patients in general medical organizations before being transferred to a specialized center was 5.89 ± 1.44 days from 2006 to 2010 and 4.31 ± 1.31 days from 2011 to 2015 ($p < 0.001$).

Of pediatric patients, 128 were transferred to specialized departments for further treatment. When analyzing the immediate results of therapy, it was found that in the main group, the early postoperative period was more favorable, and the pain completely regressed by day 1.7 ± 0.6. Meanwhile, in the control group, this was achieved




The algorithm of therapeutic management for concomitant trauma in pediatric patients: PTS, GCS, and ISS are scales for assessing the severity of injury (points)

*Table 7*

Description of complications of the postoperative period

| Complications | Main group, $n$ = 64 | | Control group, $n$ = 66 | | $p$* |
|---|---|---|---|---|---|
| | $n$ | % | $n$ | % | |
| Infection | 1 | 1.6 | 4 | 7.8 | 0.126 |
| Trophic disorders | 3 | 4.8 | 11 | 21.5 | 0.008 |
| Paresis of a nerve | – | – | 2 | 3.9 | 0.171 |
| Secondary displacement of fragments | – | – | 2 | 3.9 | 0.171 |
| Total | 4 | 6.4 | 19 | 32.3 | 0.0007 |

*Note.* * The differences are significant at $p < 0.05$, $\chi^2$ test.

on day 3.2 ± 0.4 ($p < 0.05$). For the main group, active movements of the limbs were restored much faster on day 2.1 ± 1.6. For the control group, active movements recovered only on day 5.3 ± 2.8, which was statistically significant compared with the main group ($p < 0.001$). Also, the duration of stay of patients in the ICU in the postoperative period was significantly reduced (1.5 ± 0.9 vs. 2.4 ± 1.4; $p < 0.05$). The number of complications in the early postoperative period in pediatric patients of the main group was also significantly less (Table 7). There were no fatal outcomes in either the main or the control groups.

Optimization of the approach of surgical treatment of injuries helped reduce the duration of stay of patients in the main group in both the ICU (5.6 ± 0.3 vs. 6.5 ± 0.4 days) and the specialized department (21.5 ± 0.7 vs. 25 ± 0.9 days), which led to the reduction in the duration of inpatient treatment from 32.5 ± 10.1 to 27.5 ± 9.5 days ($p < 0.05$).

The terms of restoration of lower limb support ability were 32.6 ± 8.9 days in the main group and 57.0 ± 7.8 days in the control group.

Full load on the limb after bridge osteosynthesis 4 weeks after the surgery was allowed in 10 pediatric patients. The final consolidation of fractures was diagnosed 6–8 months after the injury. The rods were removed 9–12 months and 8–10 months after surgery in cases of femur damage and tibia injuries, respectively.

Long-term results were studied in 52 patients of the main and 49 of the control groups within 4 years after surgery. The functional state of the limbs was evaluated according to the Mattis–Luboszitz–Schwarzberg scale (Table 8). In the control group, cicatricial changes in soft tissues, accompanied by discomfort, but not limiting the limb function, were noted 2.5 times more often than in the control group, with statistically significant differences (22 vs. 9; $p < 0.001$).

When assessing the range of movement in the joints of a damaged limb, normal mobility of pediatric patients in the main group was noted 2.8 times more often than in the control group. A decrease in range of motion within the range of 50–95% of the norm was found in the control group three times more often (22 vs. 7; $p < 0.001$); trophic changes in the soft tissues of the injured limb and hypotrophy were detected three times more often (39 vs. 11).

Excellent fracture treatment results were achieved in 51.9% of the patients in the main group and 20.4% cases in the control group. Good results were observed in 34.6% and 42.9% of cases in the main and control groups, respectively. The average score was less than 80 points in more than 36.7% of cases in pediatric patients of this group, whereas the results of surgical treatment were found to be unsatisfactory in three (6.1%) patients.

In the control group, 36.7% of patients had a rating on a scale of less than 80 points, whereas in 6.1% of pediatric patients, the results of surgical treatment were found to be unsatisfactory.

After analyzing the functional results of the treatment of traumatic injuries, we found a statistically significant increase in excellent and good results (by 23.2%) and a significant decrease in satisfactory (by 17.1%) and unsatisfactory (by 6.1%) results. Earlier, a number of researchers have noted that a reasonable formalization of medical care for polytrauma in pediatric patients helps improve treatment outcomes [2, 6, 8, 10, 20].

*Table 8*

Functional results of fracture treatment according to the Mattis–Luboszitz–Schwarzberg scale

| Results (points) | | Main group, *n* = 52 | Control group, *n* = 49 | Total |
|---|---|---|---|---|
| Poor (<60) | *n* | 0 | 3 | 3 |
| | % | 0.0 | 6.1 | 3.0 |
| Satisfactory (60–79) | *n* | 7 | 15 | 22 |
| | % | 13.5 | 30.6 | 21.8 |
| Satisfactory (80–90) | *n* | 18 | 21 | 39 |
| | % | 34.6 | 42.9 | 38.6 |
| Excellent (>90) | *n* | 27 | 10 | 37 |
| | % | 51.9 | 20.4 | 36.6 |
| Total | *n* | 52 | 49 | 101 |
| | % | 100.0 | 100.0 | 100.0 |
| $\chi^2 = 13.874$ ($p = 0.003$) | | | | |

Thus, the scoring of the severity of traumatic injuries and the condition of pediatric patients with polytrauma, the early departure of an ICAC specialized multidisciplinary team, and the use of rod EFAs in the immediate hours after the injury and minimally invasive methods for fixing diaphyseal fractures of the lower extremities after stabilization of the patient's condition have significantly improved the quality of care for patients and anatomical and functional long-term outcomes of surgical treatment.

## Discussion

The provision of specialized anesthesiological-resuscitation and trauma care during the first 4 h after the injury helps to stabilize the condition as quickly as possible and transfer the child to a specialized hospital for further treatment, which is especially important for preschool pediatric patients; the treatment of which requires special training. In pediatric patients of the main group, pain regressed faster; active movements in the extremities were restored much earlier, and the duration of patients' stay in the ICU in the postoperative period was reduced. An algorithm for making a tactical decision is proposed, which significantly improved the results of treatment.

Assisting pediatric patients with polytrauma is one of the most important problems of pediatric intensive care. This is due to several factors, namely, lack of time to assess the severity of the condition and identify the primary traumatic injury immediately after the injury, the presence of life-threatening or critical conditions that require immediate action at the prehospital stage, lack of necessary healthcare resources, and long-time transportation to a specialized hospital in some cases [21, 22].

It should be noted that medical care, even provided on time, is far from always being sufficient and highly qualified, as linear ambulance teams do not carry out basic therapeutic measures that aim to eliminate pain and acute blood loss and immobilize damaged segments of MSS and prosthetics of vital functions. This is true not only for various regions of the Russian Federation but also for foreign states, which indicates the undoubted relevance of the problem under consideration [23, 24].

As early as several decades ago, the famous surgeon R.A. Cowley introduced the concept of "golden hour," which is widely used in modern traumatology in helping patients and victims in a critical condition [25]. First of all, this, of course, refers to conditions when a fatal outcome can occur within a few minutes; however, the presence of multiple lesions of the MSS can also play a negative role and cause the development of multiple organ failure syndrome.

Special attention should be given to patients with severe head injury in the structure of polytrauma and young pediatric patients who are most vulnerable. The lack of adequate intensive care measures and specialized neurosurgical and comprehensive trauma care can cause secondary brain damage and nonreversible severe neurological deficiency [26, 27]. That is why the initiation of the whole range of medical and diagnostic measures as soon as possible after an injury significantly improves the treatment outcome of polytrauma in pediatric patients. The proposed algorithm helps make a rational personified and pathogenetically substantiated tactical decision, which determines the outcome of polytrauma in a particular patient. The results obtained are confirmed by the works of other Russian and international authors [22, 26, 27].

In several studies, it was found that if care is provided within the next 10 min after the injury, the life of 90% of victims with concomitant trauma can be saved, and the patient's survival rate is only 15% after 20 min [22].

According to Semenova et al. [11], early admission of pediatric patients with severe concomitant trauma (up to 24 h) to a specialized hospital has a mortality rate of 23%, and it increased to 31% at a later date. Locke et al. [27] found that pediatric patients with severe trauma transferred from other hospitals spend a longer time in specialized trauma centers, although the frequency of complications does not differ.

The most common reason for providing inadequate or delayed specialized care for pediatric patients with polytrauma is organizational aspects, which include a violation of routing principles and lack of conditions and equipment for high-tech diagnostic examinations, manipulations, and surgical interventions. It should also be noted that the doctors of hospitals with a general profile do not have the necessary experience in helping pediatric patients with polytrauma.

In particular, Coakes et al. (2011) demonstrated that for an ICU general practitioner, there are only three to thirteen pediatric cases per year, and the number of patients requiring intubation is from one to six cases per year, on average, three cases per doctor per year. This does not allow the medical staff to maintain the necessary level of qualification and knowledge of emergency manipulation techniques.

It is the timing of the provision of specialized anesthesiological-resuscitation and traumatological care aimed at eliminating acute massive blood loss and life-threatening traumatic injuries, which are the main factors determining the outcome of polytrauma in pediatric patients [28, 29].

The main limitation of the study was the small sample size and observational single-center nature of the study.

## Conclusion

The treatment and diagnostic algorithm of care for pediatric patients with concomitant trauma in general hospitals can significantly improve treatment results by providing highly qualified care as early as possible.

The early provision of specialized care for pediatric patients with concomitant trauma shortens the term from the moment of injury to surgery and reduces the duration of stay in general hospitals.

The use of minimally invasive osteosynthesis technologies in the treatment of lower limb fractures in pediatric patients with concomitant trauma helps to reduce the duration of hospital treatment from 32.5 to 27.5 days and results in more effective restoration of limb function, whereas the share of excellent and good results increases from 63.3 to 86.5%.

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**Contribution of authors**

*DI. Yunusov, P.I. Mironov* created the study concept and design, performed material processing, and wrote the article.

*V.Yu. Aleksandrovich* performed statistical analysis of primary data, translated the articles, prepared an article for publication.

*K.V. Pshenisnov* performed analysis of the literature, wrote the article.

*G.E. Ulrich, N.K. Pastukhova, S.N. Nezabudkin, D.D. Kupatadze* performed literature analysis and the article editing.

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

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