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JOURNAL	World Science
p-ISSN	2413-1032
e-ISSN	2414-6404
PUBLISHER	RS Global Sp. z O.O., Poland

ARTICLE TITLE	INFLUENCE OF VARIOUS FACTORS ON THE FREQUENCY OF COMPLICATIONS IN SKELETAL POLYTRAUMA AFTER INTERHOSPITAL TRANSPORT AND AT THE INTENSIVE CARE UNIT
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ARTICLE INFO	Potapchuk Yu. O. (2021) Influence of Various Factors on the Frequency of Complications in Skeletal Polytrauma After Interhospital Transport and at the Intensive Care Unit. World Science. 3(64). doi: 10.31435/rsglobal_ws/30032021/7506
DOI	https://doi.org/10.31435/rsglobal_ws/30032021/7506
RECEIVED	10 January 2021
ACCEPTED	04 March 2021
PUBLISHED	09 March 2021

INFLUENCE OF VARIOUS FACTORS ON THE FREQUENCY OF COMPLICATIONS IN SKELETAL POLYTRAUMA AFTER INTERHOSPITAL TRANSPORT AND AT THE INTENSIVE CARE UNIT

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DOI: https://doi.org/10.31435/rsglobal_ws/30032021/7506

ARTICLE INFO

Received: 10 January 2021
Accepted: 04 March 2021
Published: 09 March 2021

KEYWORDS

Polytrauma, complications, intensive care, medical errors.

ABSTRACT

The study involved 240 patients with skeletal polytrauma. The aim of the study was to improve the results of treatment of victims with skeletal polytrauma by substantiating methods for predicting and preventing various complications after interhospital transportation and in the intensive care unit. We found that after interhospital transportation of patients, the following complications were detected: fatty embolism (11.6%), anemic syndrome (51.7%), acute respiratory failure (20.3%), pneumonia (13.4%). The main defects at the hospital stage were: incomplete laboratory and instrumental studies (81.7%), untimely surgical osteosynthesis (49.2%), undiagnosed complications (31.2%), underestimation of the severity of the condition (30%), inadequate correction of hypovolemia, anemic syndrome, coagulopathy (51.7%, 81.7%, 63.3%, respectively), inadequate prevention of thromboembolic complications and fatty embolism (70%, 51.7%), inadequate correction of acid-base disorders and dyselectrolytemia (100%).

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Introduction. Mortality associated with polytrauma defined as severe multiple and combined injury with injuries ISS-based severity (Injury Severity Scale) ≥16 points, remains as high as 15-24% [1,5].

The estimation of skeletal injuries contribution to pathophysiology of polytrauma is promising for predicting of outcomes and complications and treatment optimization [1, 4]. In particular, it is important to state and clarify the indications for the application of the concept of staged treatment "Damage Control Orthopedics, to determine the optimal timing for surgery so that the operation would not become a "second blow" resulting in deterioration of immunological disorders and complications [1, 4, 5, 6]. The pathophysiological significance of skeletal injuries should be considered for prediction and prevention of complications, development of intensive care methods and optimization of surgical treatment tactics for polytrauma. Fractures of long tubular bones and pelvic bones with a severity ≥ 2 points (AIS damage scale) contribute to phenomenon of mutual burden of injuries associated with polytrauma [1].

The severity of injury often conceals the drawbacks of diagnosis and treatment, which in turn impacts the objective assessment of medical care [2, 3].

The most common drawback of medical care in patients with skeletal polytrauma is the lack of a transportation route patient and no clear protocol [2, 3].

All abovementioned factors contribute to relevance and necessity of Theses study, resulting in improvement of prediction, prevention and intensive care of embolic complications.

Study Objective – to improve the results of treatment of patients with skeletal polytrauma by substantiating of prognosis and prevention of various complications associated with inter-hospital transportation and at the intensive care unit.

Materials and Methods. The study involved patients with skeletal polytrauma who were treated at the Odessa Regional Clinical Hospital (third level of medical care) and medical institutions of Odessa region (2nd level of medical care).

The total number of patients was 240. Most were males - 135 (56.3%), and 105 (43.7%) patients were females. All patients were divided into two groups: control group (n = 120) - patients with skeletal polytrauma, who received medical care according to generally accepted recommendations and study group (n = 120) - patients with skeletal polytrauma, who received medical care in compliance with the proposed clinical route of patients, which can be used at the second and third tiers of medical care and medical protocol for inter-hospital transportation of patients with skeletal polytrauma (scheme 1-2).

Inclusion criteria: patients with skeletal polytrauma; age of patients - from 18 to 65 years; written informed consent for participation.

Exclusion criteria: refusal to participate in the study; age of patients over 65 years; no adequate contact with the patient (e.g., severe brain injury, cerebral circulation disorders, dementia, diabetic encephalopathy); individual intolerability of drugs used during the study; the history of blood clotting disorders (overdose of anticoagulants, vitamin K antagonists) or detection of such disorders during the study, administration of drugs that affect blood clotting.

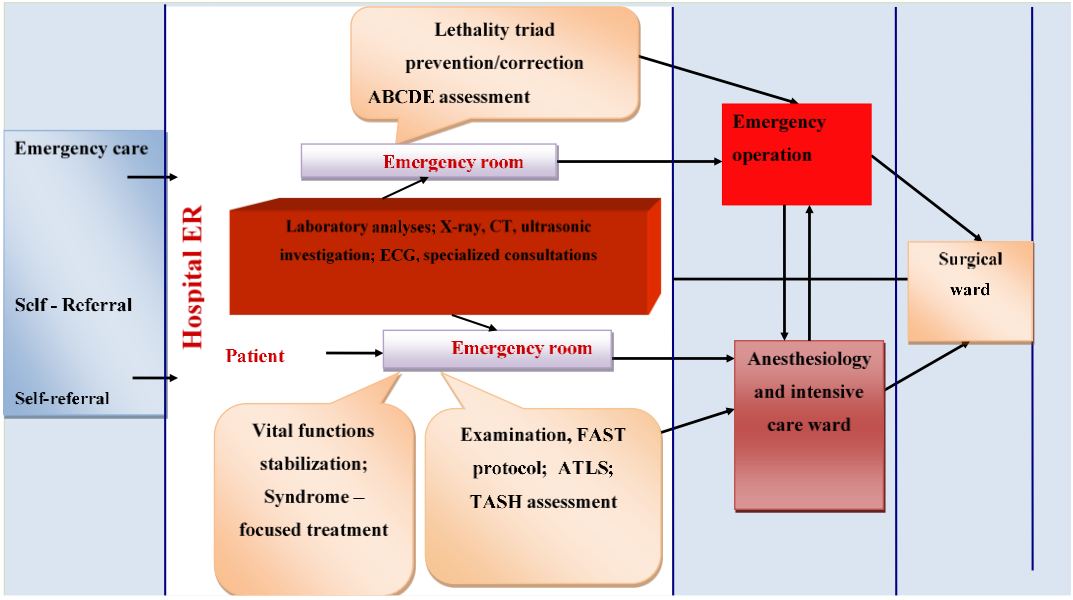

Fig.1. Skeletal trauma patient clinical route.

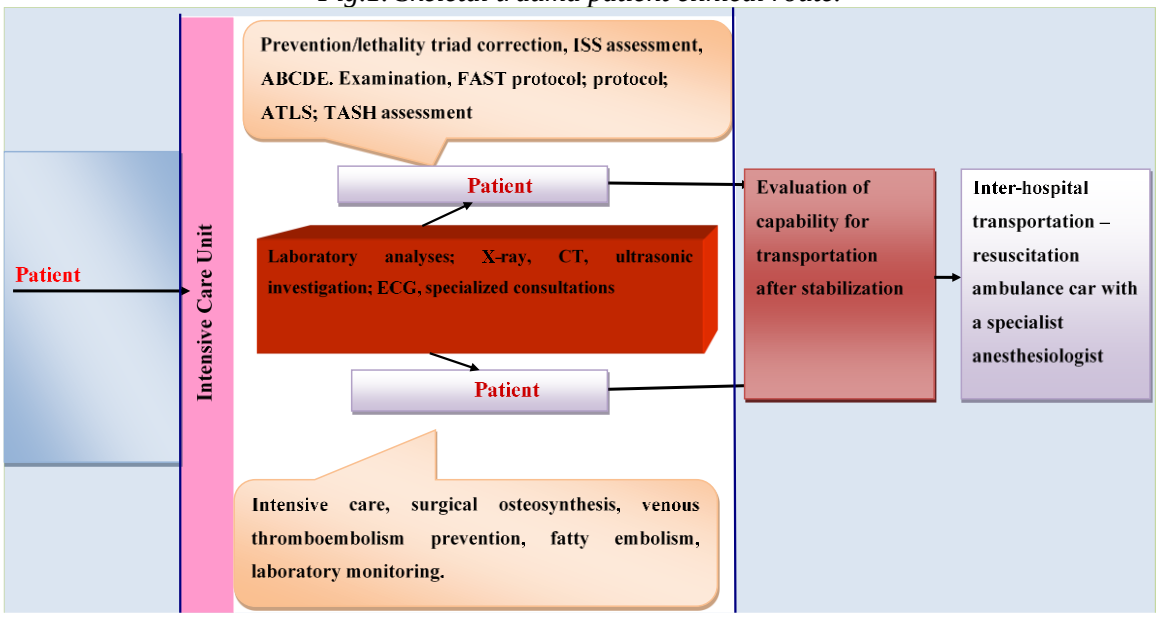

Fig.2. Medical care protocol: inter-hospital transportation for patients with skeletal polytrauma

Control and study groups were randomized according to the location of fractures and type of injury (Table 1).

Table 1. Total Traumas in patients from study and control groups

Fracture location; type of trauma	Groups		Total
	Control group, n	Study group, n	
Lower leg bones open fracture/ femoral bone open fracture	12	13	25
Lower leg bones closed fracture/ femoral bone closed fracture	45	44	89
Femoral bone closed fracture/ pelvic bones fracture	40	40	80
Multiple pelvic bones fracture	23	23	46
Total	120	120	240

Also, patients in both groups had similar severity of injuries (Table 2).

Table 2. Case severity in both groups based on different evaluation scales

Severity scale	Group	
	Control group, n (grades)	Study group, n (grades)
ISS (≥16)	19,26±3,1	20,98±3,0
AIS (≥3)	3,50±0,6	3,58±0,7
TS (≥8)	9,1±0,8	9,1±0,7
CRAMS (≤8)	6,78±0,8	7,03±0,9
PTS (≥9)	16,56±4,16	16,86±4,11

Different rating scales were used to evaluate the severity of patient's condition, including Trauma Score (TS), Circulation Respiration Abdomen Motor & Speech system (CRAMS), Abbreviated Injury Scale (AIS).

Medical care in patients with skeletal polytrauma was based on the following tactics: 1. Urgency of care (unacceptable delays or delays of specialist's assistance) 2. Constant monitoring; 3. Continuity of resuscitation care; 4. If necessary, involvement of specialists of any other profiles providing emergency care.

Basic concepts of polytrauma treatment were taken into account: the "golden hour" rule; surgical resuscitation and "damage control"; poly-organic failure; traumatic disease and orthopedic resuscitation. The following factors influencing the decision regarding early surgical control of bleeding were considered: 1) the mechanism of injury, 2) the severity of injury, determined by injury assessment systems (shock index; TASH-assessment (Trauma Associated Severe Hemorrhage) predicting the possibility of massive transfusion based on 7 parameters: systolic blood pressure, hemoglobin level, presence of intra-abdominal fluid, fractures of tubular bones or fractures of pelvic bones, heart rate, excessive acids or alkaline levels, and gender, 3) the physiological condition of patient and his response to resuscitation.

We carried out prevention and correction of the "deadly triad": acidosis, hypothermia, and coagulopathy. Also, we recommended the following clinical route of a patient with skeletal polytrauma, which can be used at the second and third tiers of medical care.

For the correction of hemorrhagic syndrome, we were using fresh frozen plasma, tranexamic acid, vitamin K, and – in case of prior treatment failure - a concentrate of prothrombin complex under the control of blood clotting and thromboelastography.

For prevention and treatment of fatty embolism (FE), we have recommended the following strategy: adequate immobilization using a vacuum mattress (pre-hospital stage), adequate analgesia (paracetamol, dexketoprofen, opioids, regional anesthesia), correction of traumatic/hypodynamic conditions), orthopedic resuscitation. Within the next few hours after admission, the fractures of long tubular bones and pelvic bones had to be fixed thus eliminating the foci of endotoxicosis, dissolution of demulsified fat (essential phospholipids - 15-20 mg/kg/day), albumin transfusion, corticosteroids, oxygenation, respiratory support, prevention of thromboembolic complications (administration of low molecular weight heparins).

All patients with skeletal polytrauma were receiving infusion therapy (solutions of balanced crystalloids and colloids) based on blood circulation volume deficiency (BCV), if necessary - at all stages of inpatient treatment. Infusions were performed through peripheral (size - G16-18) and central venous catheters.

Statistical processing was performed using the statistical program "STATSOFT STATISTICA 6.0". To assess the reliability of results of various indicators in patients, Pearson's criterion $\chi 2$ has been calculated. The probability of mean differences was assessed using 95% confidence interval (95% CI). The calculation of sensitivity and specificity was performed using a four-field table. Permission to conduct the study was obtained from the Bioethics Commission.

Results and discussion. Intensive care at the stage of preparation for transportation had its own specific features. Intensive care at the second stage of medical care in patients with skeletal polytrauma included the following stages: correction of hypovolemia and anemic syndrome, hemostatic therapy, oxygenation and respiratory support, antibacterial therapy, prophylaxis and treatment. Surgical osteosynthesis has been conducted if necessary.

We found that the later the patients with skeletal polytrauma were transferred to the 3rd tier of care, the higher were the frequency of embolic complications and mortality level. A close correlation was found ($r = 0.96$, $p < 0.05$) for the relationship between transport time and the incidence of embolic complications.

In the treatment of patients with skeletal polytrauma at the 2nd tier, we found that the frequency of diagnostic errors and embolic complications was 47% and 23%, respectively.

The main errors of medical care in patients with skeletal polytrauma were the following: undiagnosed dominant trauma (23.2%) and its complications (31.2%), underestimation of severity (30%), insufficient amount of medical care (39.2%).

We have conducted retro- and prospective search and identified the following errors in the provision of medical care in patients with skeletal polytrauma at the second tier of medical care (Table 3).

Table 3. Medical care errors at the pre-hospital stage – skeletal polytrauma patients

Medical care errors	Number (%)
Incomplete laboratory investigations/imaging	98 (81,7%)
Case severity underestimated	36 (30%)
Injury volume underestimated	10 (8,3%)
Polytrauma complications not detected	47 (31,2%)
Concomitant disease not detected	23 (19,2%)
No supporting monitoring by other specialists	47 (39,2%)
Patients treated outside BAIT ward	56 (46,7%)
No adequate treatment	47 (39,2%)
Untimely surgical osteosynthesis	59 (49,2%)
Patient’s transportation without prior intensive care	12 (10%)

As shown in Table 1, the main errors at the hospital stage were: incomplete laboratory and instrumental investigations (81.7%), untimely surgical osteosynthesis (49.2%), management of patients outside Department of Anesthesiology and Intensive Care (46.7%), lack of dynamic monitoring of by specialists (39.2%), lack of adequate therapy (39.2%), undiagnosed complications of polytrauma (31.2%), undiagnosed comorbidities (19.2%) and underestimation of the severity of the patient’s condition (30%).

In our opinion, this is a result of several factors, namely: low level of qualification of doctors, poor organization of medical care for patients with polytrauma, deontological issues, corporate relations, lack of objective internal and external audit and low level of logistics in some hospitals.

In our study, we analyzed the provision of medical care in patients with skeletal polytrauma in the resuscitation at the second tier of medical care and studied the structure of medical errors. We found that errors were related both to diagnostic and therapeutic issues (Table 4). Most errors are related to the lack of local protocol and clinical route for patients with polytrauma, poor assessment of severity of the patient’s condition (ISS, and AIS scales), disrupted water-and-electrolyte balance, lack of adequate prevention and poor diagnosis of venous thromboembolic and fatty embolism (Table 4).

Table 4. Structure of diagnostic errors at the Resuscitation Ward at the second tier medical care in patients with skeletal polytrauma

Errors	Number (%)
No local protocol or clinical route for polytrauma patients	18 (15%)
Severity underestimation based on ISS or AIS scales	68 (56,7%)
Peripheral microcirculation underestimated	58 (48,3%)
No central venous pressure control	46 (38,3%)
No coagulation status monitoring	120 (100%)
No electrolytes level control and acid/alkaline balance monitoring	120 (100%)
No regular imaging	88 (73,3%)
No hydration balance control	24 (20%)
No venous thromboembolism prognosis scale	88 (6,7%)
No fatty embolism prognosis scale	120 (100%)

At the third tier, there were no diagnostic errors that affected the outcome of treatment of patients with skeletal polytrauma (Table 5).

We found that the lack of adequate intensive care reduces patient's survival rate from 89% to 82%, with the 1.5 fold relative risk of death increase.

We have confirmed that the most common errors were the following: inadequate correction of hypovolemia and anemia (51.7%, and 81.7%, respectively), inadequate correction of coagulopathy (63.3%), inadequate prevention of thromboembolic complications (70%), untimely prevention and diagnosis of fatty embolism (51.7%), inadequate correction of water-and-electrolytes balance disorders (100%).

Table 5. Diagnostic errors in resuscitation ward at the third tier – skeletal polytrauma patients

Errors	Number (%)
No local protocol or clinical route for polytrauma patients	0 (0%)
Severity underestimation based on ISS or AIS scales	2 (56,7%)
Peripheral microcirculation underestimated	2 (48,3%)
No central venous pressure control	0 (0%)
No coagulation status monitoring	0 (0%)
No electrolytes level control and acid/alkaline balance monitoring	5 (%)
No regular imaging	0 (0%)
No hydration balance control	0 (0%)
No venous thromboembolism prognosis scale	0 (0%)
No fatty embolism prognosis scale	3 (%)

In the treatment of patients with skeletal polytrauma at the 2nd tier, we found that the frequency of diagnostic errors and embolic complications was 47% and 23%, respectively.

It was found that the later the patients with skeletal polytrauma were transferred to the 3rd tier of medical care, the higher was the frequency of embolic complications and mortality.

Thus, the main directions for reducing mortality in patients with skeletal polytrauma can be divided into organizational, diagnostic and therapeutic.

The proposed measures resulted in decrease of thromboembolism complications from 25.8% to 15% ($\chi 2 = 13.07$, $p = 0.001$) in the study group, similar reduction in fatty embolism rate was from 19.2% to 3.3%, $\chi 2 = 15.07$, $p = 0.001$).

Conclusions.

1. After inter-hospital transportation of patients with skeletal polytrauma, the following complications were detected: fatty embolism (11.6%), anemia (51.7%), acute respiratory failure (20.3%), pneumonia (13.4%), bedsores (3%).

2. The optimal terms of transportation to the hospital of the third tier are the first and second days after osteosynthesis of injured segments ($r = 0.96$, $p < 0.05$).

3. The main errors at the hospital stage (resuscitation ward, surgical department) in patients with skeletal polytrauma were: incomplete laboratory and instrumental investigations (81.7%), untimely

surgical osteosynthesis (49.2%), undiagnosed complications (31.2%), underestimation of the severity (30%), inadequate correction of hypovolemia, anemia, and coagulopathy (51.7%, 81.7%, and 63.3%, respectively), inadequate prevention of thromboembolic complications and fatty embolism (70%, and 51.7%), inadequate correction of water-and-electrolytes balance disorders and dyselectrolytemia (100%).

4. Based on the study results, a clinical route and algorithm for medical care in patients with skeletal polytrauma were developed and implemented, which allowed reduction of the incidence of venous thromboembolism from 25.8% to 15% ($\chi 2 = 13.07$, $p = 0.001$), and fatty embolism reduction from 19.2% to 3.3% ($\chi 2 = 15.07$, $p = 0.001$).

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