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COMPARATIVE BIOMECHANICAL ASSESSMENT OF THE FUNCTIONAL OUTCOMES OF TREATMENT IN PATIENTS WITH PELVIC BONE FRACTURES

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Abstract: The purpose of the study is to objectivize the reconstruction of locomotor functions in statics and gait after the treatment of unstable pelvis fractures at the follow-up for three months. Quantitative evaluation of the limbs support function, chronometrical, dynamic, kinematic and electromiographical indices of the locomotor system in 14 patients after transosseous osteosynthesis treatment and in 5 patients after conservative treatment has been studied. Changes of functional position and inclination of pelvic ring in patients with conservative treatment were revealed. Normalized indices of hip motion, support reactions, sagittal oscillations of body segments from 50% to 80% have been found out in walking, independently of a treatment method. However, 100% dysfunction of *musculus gluteus* in patients after conservative treatment is considering as a consequence of long akinesia, attended by this treatment methods as compared to whole muscle recovery after transosseous osteosynthesis.

Key words: pelvis fractures, transosseous osteosynthesis, conservative treatment methods, walking biomechanics

Treatment of patients with pelvic bone fractures is one of the most urgent and unsolved problems of the present-day traumatology.

The severity of pelvic ring injuries and their diversity, unsatisfactory results of routine conservative and operative methods urge on further profound studying of the treatment methods and anatomicofunctional outcomes [1].

Clinical and X-ray assessments of treatment of the patients suffering from pelvic ring lesions are made while considering the consolidation degree of fractures, residual deformations, hip joint degenerative changes associated with disorders of the locomotor system activity, short extremity, diuretic disturbance, circulatory and neurological disorders, spine and leg joints dysfunction.

However, the using of the clinical and X-ray data only proved to be insufficient very often for getting the objective evaluation of recent outcomes of clinical and rehabilitation prognoses of the unstable and multiform pelvic lesions [2-6].

To complete the insufficient evaluation of functional outcomes we considered the staticokinematic indices of the locomotor system. For this purpose the complex of biomechanical and electromyographical studies including the determination of static load in sagittal and coronal planes, podography, goniography, feet standing reaction, oscillography of coronal and sagittal angle deviations of shoulder and hip girdles, electromyography at phase of gait were carried out. Indices of each method were determined while considering the step length and the walking speed [8].

Functional outcomes within 3 months were analyzed in 14 patients with severe unstable pelvis fractures and in 5 patients after conservative treatment of multiple pelvic ring fractures with saved stability.

Quantitative evaluations of the locomotor system function were obtained while using 2 principle criteria: asymmetry coefficient between the right and left indices of the same name and absolute quantitative normalized indices of the locomotor system. All the indices were processed by using method of little selection with determination of the Student's criterion with principal probability 95% as it is usually applied in biology and medicine. Data processing was performed by means of hardware program complex based on PC Pentium.

Data are based on 3770 quantitative indices suitable to the estimation of transosseous osteosynthesis (Group 1) and on 1350 indices suitable to the estimation of conservative treatment (Group 2). These two criteria for assessing different parameters in statics and walking is designated by percents relatively to the whole number of studies in each group of patients.

Comparative analysis of functional outcomes revealed non-equivalence of staticokinematic disturbances. So, the indices of the balanced distribution of body weight on legs testifying normalized static weight-bearing capacity formed 71% in Group 1 and only 40% in Group 2 (Tabl. 1), whereas normal feet load bearing capacity had been found out in the lesser number of cases that is in 14% and 20%, respectively. Predominance of an overload of anterior parts of feet is a sign of anterior displacement of a centre of mass and preparatory mechanism to walking start.

This standing setting (functional position) was characterized by pelvic ring inclination (14% of patients in Group 1 and 20% in Group 2) and inclination of shoulder girdle (21% and 40%).

There was observed the increasing of pelvic inclination angle to anterior in 21% and 40% of cases, and shoulder girdle inclination angle in 71% and 40%, respectively, as well.

Thus, static indices of disturbances predominated while evaluating the conservative treatment as compared with the transosseous osteosynthesis.

All patients' walking was characterized by slow speed and short step.

Normal speed index formed only 12% in Group 1 and 13.3% in Group 2, but step lengths were observed only in 31% and 40%; asymmetry absence formed only 93% and 40% (Tabl. 2).

Table 1. The static indices of the locomotor system within three months after surgical and conservative treatment of pelvic bone fractures.

Parameters			**Percentages of total number of investigations**			
			Normal		**Incorrect**	
			I	**II**	**I**	**II**
Static Load Asymmetric Ratio: Frontal Plane			71.0	40.0	29.0	60.0
Static Load Asymmetric Ratio: Sagittal Plane			14.0	20.0	86.0	80.0
Position of Body Segments	Frontal Plane	Pelvis	86.0	80.0	14.0	20.0
		Shoulders	79.0	60.0	21.0	40.0
	Sagittal Plane	Pelvis	79.0	60.0	21.0	40.0
		Shoulders	29.0	60.0	71.0	40.0

I – patients after transosseous osteosynthesis; II – patients after conservative treatment

Table 2. The optimal kinematic indices of the locomotor system. Within three months after surgical and conservative treatment of pelvic bones fractures.

Parameters				Percentages of total number of investigations			
				Normal		Non-asymmetrical	
				I	II	I	II
Step Length				31.0	40.0	93.0	40.0
Walk Speed				12.0	13.3	–	–
One-Support Step Period				18.0	40.0	100.0	80.0
General Support Step Period				37.0	23.3	100.0	100.0
Double Step Duration				21.0	40.0	100.0	100.0
Movement Amplitude in Joints			Hip	88.0	100.0	50.0	20.0
			Knee	57.0	50.0	57.0	0.0
Back Push				44.0	50.0	93.0	100.0
Front Push				56.0	63.3	93.0	100.0
Load in One-Support Step Period				40.0	53.3	100.0	100.0
Angle Deviations of Body Segments	Frontal Plane		Pelvis	52.0	60.0	21.0	0.0
			Shoulders	26.0	30.0	29.0	20.0
	Sagittal Plane	Pelvis	One-Support Step Period	12.0	53.3	64.0	20.0
			Two-Support Step Period	58.0	43.3	43.0	0.0
		Shoulders	One-Support Step Period	19.0	46.7	29.0	0.0
			Two-support Step Period	55.0	30.0	21.0	20.0
Integrated Bioelectrical Muscle Activity			Sacrum	24.0	50.0	14.0	0.0
			Middle Buttock	45.0	0.0	46.0	0.0
			Two-headed	21.0	40.0	23.0	0.0
			Four-headed	14.0	50.0	44.0	0.0
			Calves	17.0	0.0	36.0	50.0
			Shin-bone	17.0	25.0	27.0	50.0

I – patients after transsosseous osteosynthesis
II – patients after conservative treatment

These indices witnessed the spared walking stereotype that involved increasing main phases length of the gait, and without asymmetry of indices of the same name. So, normal indices of single support period of gait, obtained while assessing static bearing capacity of limb in waking, predominated in patients after conservative methods (40%) as compared with patients of Group 1 (18%). At the same time normal indices of the total support period describing a compensatory mechanism, on the contrary, predominated in patients after transosseous osteosynthesis (37% and 23%), but indices of the same name of these phases were similar in all the patients, and absence of asymmetry formed 100 %. It meant that period

of weight-bearing of each limb was identical in all the patients. Indices of double gait (the principal criteria of the gait cycle) underwent analogue changes.

Therefore, in the shortest time biomechanical expediency revealed itself, first of all, in even load distribution of the both limbs and partial normalization of the main phases of gait with slow spared walking stereotype in all the patients.

Hip and knee joints functions had the most marked tendency of movement amplitude towards normalization: 88-57% (according to the joints) in Group I and 100-50% in Group II. However, the tendency was often of unilateral character, so the asymmetry of the same name indices was revealed in half the cases in Group I and almost in all the cases in Group II.

There was no considerable difference in dynamic factors of gate that control the body movement: hinder push, load in standing on one leg and anterior push if compared in both patients groups. So, almost in half the cases the normalization (40 - 63%) without asymmetry of indices of the same name was observed.

Indices of angle deviations of body segments in coronal and sagittal planes were not identical in all the patients. There was optimal quantity of normalized indices (in more than half the cases) in coronal and sagittal pelvic oscillation in both patients groups, but the asymmetry of the same name indices proved to be more strongly marked in comparison with other parameters of complex investigation. Maximum quantity of indices without asymmetry (64%) in period in patients of Group I were revealed only in sagittal pelvic oscillations.

Functioning lower limb muscles while walking was characterized as not identical with results in Group I. Maximum quantity of normalized indices was determined by the bioelectrical activity of *musculus gluteus medius* (45%) and absence of asymmetry often occurred in activity of *musculus gluteus medius* (46%) and *musculus quadriceps* (44%). Identical indices in the rest muscles on the right and left sides did not exceed 36%. In Group II normalized indices of bioelectrical activity of *musculus sacrospinalis* and *musculus quadriceps* formed 50%, and of *musculus biceps* did 40%. However, asymmetry of muscles indices of the same name was observed in all the tested muscles, that is more marked than in Group I, except *musculus gastrocnemius* and *musculus tibialis*, but absence of asymmetry in these muscles was attended by disturbance of phase activity from two sides, that is muscles were functioning almost without interruption.

Therefore, comparative biomechanical evaluation of functional outcomes by different treatment methods allowed to establish that biomechanical status, in three months after the treatment, was characterized not only by low asymmetry indices, but by their normalization. Nevertheless, optimal indices of complex biomechanical research without asymmetry predominated in assessment of functional outcomes after transosseous osteosynthesis in comparison with one after pelvic fractures treatment while using conservative methods.

Results of multi-criterion biomechanical study of the locomotor system in statics and walking are the basis of expedient employment of transosseous osteosynthesis in patients with severe unstable pelvis fractures.

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СРАВНИТЕЛЬНАЯ БИОМЕХАНИЧЕСКАЯ ОЦЕНКА ФУНКЦИОНАЛЬНЫХ ИСХОДОВ В ЛЕЧЕНИИ ПЕРЕЛОМОВ КОСТЕЙ ТАЗА

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Изучение функциональных исходов после лечения переломов костей таза – одна из наиболее актуальных проблем современной травматологии. Трудности изучения обусловлены тем, что клинико-рентгенологические показатели, наиболее полно характеризующие анатомические особенности, совершенно недостаточны для оценки функционального состояния опорно-двигательной системы, обусловленного остаточной несостоятельностью таза как одного из кинематических звеньев.

Цель исследования: разработать биомеханические критерии для объективной оценки ранних функциональных исходов после различных методов лечения переломов костей таза.

С этой целью нами применено многокритериальное комплексное биомеханическое и электромиографическое исследование, включающее определение статической нагрузки в сагиттальной и фронтальной плоскостях, подографию, гониографию, опорные реакции стоп, осциллографию фронтальных и сагиттальных угловых отклонений плечевого пояса и таза, электромиографию мышц в различных фазах шага. Синхронная запись показателей каждой методики проводилась с учетом длины шага и скорости ходьбы.

Функциональные исходы в сроки до трех месяцев изучены у 14 больных после чрескостного остеосинтеза тяжелых нестабильных переломов таза и у 5 больных после консервативного лечения при множественных переломах тазового кольца с сохранением стабильности.

Количественная оценка функции опорно-двигательной системы производилась с помощью двух основных критериев: величин коэффициентов асимметрии между одноименными правосторонними и левосторонними параметрами статики и ходьбы и с помощью нормализовавшихся абсолютных количественных показателей, выраженных в процентах относительно общего количества измерений по каждому параметру. Все

показатели статистически обработаны обычно применяемым методом в биологии и медицине при малой выборке с определением критерия Стьюдента при доверительной вероятности 95%. Обработка материала производилась с помощью программно-аппаратного комплекса на базе компьютера Pentium. Материал базируется на 3770 количественных показателях по оценке чрескостного остеосинтеза (I группа больных) и на 1350 показателях по оценке консервативного лечения (II группа больных).

Сравнительный анализ функциональных исходов выявил увеличенную позовую флексорную установку и перекос таза, наиболее выраженные у больных после консервативного лечения.

Нормализовавшиеся показатели ходьбы выявлены почти в равноценном количестве у больных обеих групп по амплитуде движений в тазобедренных суставах, опорным реакциям, фронтальным и сагиттальным колебаниям таза.

Отличительная особенность проявилась в нормализации фазной и интегрированной активности средних ягодичных мышц при ходьбе, выявленная в 45% случаев у больных после чрескостного остеосинтеза, при значительном снижении активности этой мышцы в 100% случаев после консервативного лечения, что обусловлено длительной акинезией в процессе лечения. Следовательно, оптимальные биомеханические показатели преобладают после чрескостного остеосинтеза.

Полученные результаты инструментального исследования функциональных исходов послужат обоснованием для целенаправленной реабилитации больных после лечения переломов костей таза. Библ. 8.

Ключевые слова: переломы таза, чрескостный остеосинтез, консервативное лечение, исходы, локомоции, биомеханический анализ

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