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Etiopathogenical criteria in the early diagnosis of Compartmental Syndrome (CS) of the shank

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ABSTRACT

Through the evaluation of some etiopathogenic risk factors one can anticipate the evaluation of some fractures towards Compartmental Syndrome (CS) and then their diagnosis in early stage, when the symptomatology is still unconvincing and the treatment reduces the risk of ischemia lesions. Based both on some prospective observations, using a group of shank fractures, and also on the clinical facts of constituted CS, there were made correlations, statistically reported in the case of some etiopathogenic risk factors represented by the fracture localization and its characteristics, traumatic mechanisms, soft tissue quality and polytraumatism, having an objective common denominator, the compartmental pressure level measured directly. The authors propose an etiopathogenic risk score of CS for the fractures reaching the pressure level of 20-30mmHg, recommending the pressional and clinical monitoring for a score of minimum 10 points. These fractures have a certain risk of CS.

Keywords: Compartmental syndrome, shank, criteria, pressure level

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Introduction

The shank has ideal anatomical conditions to develop a pressional conflict in his compartments, being the region with the most frequent localization of CS. The compartmental spaces, with physiological value in normal conditions, become hurtful for the anatomical structures contented, due to a characteristic microcirculatory unbalance characteristic for CS [1,2].

The clinical and experimental research sustains the complex character of the CS physiopathology which is the same with the microcirculatory physiopathology in the phase of the decompensation of the changes between vessels and tissues. The complex implication of the enzymatic, metabolism and biochemical factors which cannot be measured as quality and quantity in emergency conditions, make to be difficult to find the risk or the precocious diagnosis using classical labor methods.

The clinical experience demonstrated that CS cannot be explained as a complication, logical to traumatism, although it appears secondary to a trauma, but it is known, there is also a nontraumatic etiology. The traumatic etiopathogeny can be a risk factor, but it has not an absolute value, direct as cause and effect to develop a CS [3].

After a start of CS with an incomplete clinical presentation or with unconvincing symptomatology, the early diagnosis can be difficult to establish, which delay the surgical treatment, as result progressive ischemical lesions [4].

The paper propose to evaluate some etiopathogenic criteria under pressional report, phisiopathological and clinical and to establish a risk score useful to have a precocious diagnosis through continuous clinical and pressional monitorisation.

Figure 2 - Stryker technique

Material and Methods

1. Prospective pressional study upon 268 shank fractures (2012-2014).

2. Clinical study upon 64 cases of CS (2008-2014).

3. Direct compartmental pressional measurement – Whiteside technique [5], Stryker technique (Figure 1 & 2).

4. The evaluation of some etiopathogenic risk factors upon pressional periods:

- fracture localization;
- traumatic mechanism;
- fracture characteristics;
- soft tissue quality;
- politraumatic associations;
- pressional dynamics.

Figure1 - Whiteside technique

Results

In relation with the period of time from the accident to the first measurement, taking as working place the antero-external compartment, the structure of casuistry in relation with the localization of fracture was the following (Table I):

Table I - Fracture prospective group 2012-2014

Frequency of fractures in relation with the period of time when the initial manometry was made

Localization	Total	Time accident – first manometry (hours)			
		1-6	6-12	12-24 hours	24-72 hours
1. Epiphyseal fractures					
Proximal tibia, peroneus	48	27	14	5	2
2. Diaphyseal fractures					
1/3proximal	63	29	23	11	
1/3medium	98	34	29	17	18
1/3medium- 1/3distal	41	14	18	5	4
1/3distal	18	2	8	5	3
TOTAL	268	79	78	38	25

Traumatic mechanism evaluated anamnestic, clinical, radiological and anatomopathological is considered to be direct (high energy) in 155 cases and indirect (low energy) 113 cases. This systematization is referred to the type of predominant mechanism, in reality being the

Table II - Pressure interval 15 - 20 mmHg
Basic characteristics of the fractures that evolved to CS

No	Localization	Time to first manom.	Time to diagnosis	Mechanism	Fracture type	Soft tissue quality	Politrauma
	Diaphysis						
1.	First 1/3	3 hours	27 hours	Direct	Comminuted	Open III A	Yes
2.	First 1/3	6 hours	30 hours	Direct	Comminuted	Open III A	No
3.	First 1/3	2 hours	26 hours	Indirect	Comminuted	Closed	Yes
4.	Second 1/3	2 hours	26 hours	Direct	Comminuted	Closed	No
5.	Second 1/3	1 hour	49 hours	Indirect	Comminuted	Closed	No
6.	Third 1/3	2 hours	50 hours	Direct	Simple	Closed	No

association of the both mechanisms.

Characteristics of the fracture site:

- simple fractures - 140 cases
- comminuted fractures - 128 cases

Soft tissue quality:

- closed fractures - 162 cases
- open fractures - 110 cases (Gustilo I, II, IIIA,B)

It was made an analysis of the etiopathogenic factors with risk value for the pressional criterion (first manometry) and the time periods from the accident.

1. Pressure interval 15-20mmHg - 41.4% (111 cases) of which 40.5% (45) reached this level in the first 6 hours from the accident, 39.6% (44) between 6-12 hours, and the rest of the cases over 12-24 hours and even 72 hours. From this interval, 5.4% (6) turned to CS presenting the following base characteristics (Table II):

2. Pressure interval 21-25mmHg - 38.4% (103 cases) of which 45.6% (47) reached this level in the first 6 hours. Turned to CS 4.8% (5) presenting the

following base characteristics (Table III):

3. Pressure interval 26-30mmHg - 11.9% (32 cases) of which 28.1% (9) reached this level in the first 6 hours. Turned to CS 15.6% (5) presenting the following base characteristics (Table IV):

4. Pressure interval 31-40mmHg - 5.2% (14 cases) of which 14.2% (2) reached this level in the first 6 hours and turned to CS 7.1% (1) presenting the following base characteristics (Table V):

5. Pressure interval 41-100mmHg - 2.9% (8 cases) was diagnosed with CS (Table VI):

Table III - Pressure interval 21 -25 mmHg
Basic characteristics of the fractures that evolved to CS

No	Localization	Time to first manom.	Time to diagnosis	Mechanism	Fracture type	Soft tissue quality	Politrauma
	Epiphysis						
1.	Schatzker V type	1 hour	13 hours	Direct	Simple	Closed	Yes
2.	Schatzker IV type	1 hour	5 hours	Indirect	Simple	Closed	Yes
	Diaphysis						
3.	First 1/3	2 hours	50 hours	Direct	Comminuted	Open III A	Yes
4.	First 1/3	3 hours	50 hours	Indirect	Simple	Closed	No
5.	Second 1/3	2 hours	50 hours	Indirect	Simple	Closed	No

*Table IV - Pressure interval 26 - 30 mmHg
Basic characteristics of the fractures that evolved to CS*

No	Localization	Time to first manom.	Time to diagnosis	Mechanism	Fracture type	Soft tissue quality	Politrauma
	Epiphysis						
1.	Schatzker V type	2 hours	26 hours	Direct	Comminuted	Closed	Yes
	Diaphysis						
2.	Second 1/3	7 hours	15 hours	Direct	Simple	Open I	No
3.	Second 1/3	7 hours	9 hours	Direct	Simple	Closed	No
4.	Second 1/3	3 hours	11 hours	Direct	Comminuted	Open II	Yes
5.	Second 1/3	3 hours	11 hours	Direct	Simple	Closed	Yes

*Table V - Pressure interval 31 - 40mmHg
Basic characteristics of the fractures that evolved to CS*

No	Localization	Time to first manom.	Time to diagnosis	Mechanism	Fracture type	Soft tissue quality	Politrauma
	Diaphysis						
1.	First 1/3	11 hours	11 hours	Direct	Comminuted	Open II	No

*Table VI - Pressure interval 41 - 100 mmHg
Basic characteristics of the fractures that evolved to CS*

No	Localization	Time to diagnosis	Fracture type	Soft tissue quality	Politrauma
	Epiphysis				
1.	Schatzker IV type	3 hours	Comminuted	Closed	No
2.	Schatzker V type	6 hours	Simple	Closed	No
3.	Schatzker V type	6 hours	Simple	Closed	Yes
4.	Schatzker V type	7 hours	Comminuted	Closed	Yes
5.	Schatzker IV type	3 hours	Simple	Open II	No
	Diaphysis				
6.	First 1/3	24 hours	Comminuted	Open II	No
7.	Second 1/3	10 hours	Simple	Open I	No
8.	Distal 1/3	18 hours	Simple	Open II	No

Table VII - CS risk in relation with pressure interval and fracture localization

Pressure interval	Casuistry CS	Fracture localization				
		Epiphysis	Entire diaphysis	First 1/3	Second 1/3	Distal 1/3
15 - 20 mmHg	111 (41.4%)	1 (0.4%)	23 (8.6%)	38 (14.2%)	36 (9.7%)	13 (4.8%)
	6 (5.4%)		3 (13%)	1 (2.6%)	2 (5.5%)	
21 - 25 mmHg	103 (38.4%)	24 (9.0%)	23 (8.6%)	48 (18%)	3 (1.12%)	5 (1.9%)
	5 (4.8%)	2 (8.3 %)	2 (8.6%)		1 (33%)	
26 - 30 mmHg	32 (11.9%)	10 (3.7%)	14 (15.22%)	8 (3%)		
	5 (15.6 %)	1 (10%)		4 (50%)		
31 - 40 mmHg	14 (5.2%)	8 (57%)	2 (14.2%)	3 (21%)	1 (7.1%)	
	1 (7.1%)	1 (12.5%)				
44 - 100 mmHg	8	5	1	1	1	
Total	CS=25					

The risk probability of CS, in relation with the pressure interval, localization of fracture and the time period from the accident are presented in tables VII to IX:

Table VIII - Prospective group - Probability of CS risk in relation with fracture localization and interval between accident and first manometry (at admittance)

Fracture localization	No	CS	% CS	Interval from accident
Epiphysis	27	7		1 - 6 hours
Diaphysis	80	11	25.9%	
* First 1/3	30	5		
* Second 1/3	34	3	16.6%	
* Second 1/3 - Distal 1/3	11	3	8.8%	
* Distal 1/3	5		27.0%	
Epiphysis	14	1	7.1%	6 - 12 hours
Diaphysis	77	4		
* First 1/3	22		4.5%	
* Second 1/3	32	1		
* Second 1/3 - Distal 1/3	18	3	9.3%	
* Distal 1/3	5			
Epiphysis	7			12 - 24 hours
Diaphysis	63	2		
* First 1/3	10	1	10.2%	
* Second 1/3	35			
* Second 1/3 - Distal 1/3	10	1	10.1%	
* Distal 1/3	8			
Total	268	25		

Discussions

The CS incidence in the prospective casuistry was 9.3%. Proximal epiphyseal fracture localizations (tibia and peroneus) have a major risk (16%) and can

develop CS in the first 6 hours from the accident [6].

The high diaphyseal fractures (first 1/3) have a risk of 11.6%, value which decrease in second 1/3 to 9% and even 6%. For the fractures in the second 1/3, the evolution interval to CS can be 12 hours and even 24-48 hours which impose pressure monitorisation to the whole interval.

The direct traumatic mechanism presents a major risk (72%), and the gravity of CS is given by the association of crush lesions with pressional ischemia. The ischemic pressional effect is extended on tissular structures which are situated at the border line of viability. This situation characterizes the traumatism with high and medium energy.

The fracture characteristics as the number of fragments is not concluding when are analyzed separately, being no correlation with the risk of CS. A comminuted fracture can slow down the beginning of CS, but cannot stop it.

The integrity of the tegument are very important for the develop of CS in a short period of time. The presence of CS in case of open fractures (36%) show their risk, but the period of time needed to develop can be longer as 10 hours to 48 hours, with incomplete and unconvincing clinical manifestations. Politrauma was associated in 43% of cases, being a risk factor due to hemodynamic implications [7].

The pressional interval of 20-30mmHg represents an alarm interval due to microcirculatory hemodynamic instability. The fractures situated in that pressional interval can develop in double sense

Table IX - Prospective group 2012-2014

*- evaluation of the etiopathogenical factor risks in relation with the pressional intervals
- statistical aspects of the casuistry and of the cases that evolved to CS*

Pressure interval		Mechanism		Aspects		Soft tissue		Politrauma.
		Direct	Indirect	Comminuted	Simple	Closed fracture	Open	
15-20 mmHg	group	46.9%	53.1%	47.7%	52.2%	53.9%	46%	
	CS	7.7%	3.3%	9.4%	16.6%	6.7%	3.8%	33.3%
21-25 mmHg	group	63.1%	36.8%	38.8%	61.1%	62.1%	37.8%	12.6%
	CS	3%	7.8%	2.5%	6.3%	6.25%	2.5%	60%
26-30 mmHg	group	71.8%	28.1%	65.7%	34.3%	75%	25%	25%
	CS	21.7%		9.5%	27%	12.5%	25%	60%
31-40 mmHg	group	35.7%	64.2%	50%	50%	85.7%	14.2%	14.2%
	CS	1 S.C.		1 S.C.			1 S.C.	
41-100 mmHg	group							
	CS	5 S.C.	3 S.C.	3 S.C.	5 S.C.	4 S.C.	4 S.C.	50%

(normalization or worsening), in time period of 3-24 hours [8].

We propose a consultative evaluation score of the etiopathogenic risk which can be applied for the pressional interval of 20-30mmHg.

1. Fracture localization
 - tibia – 1 point
 - peroneus – 0
 - both – 2
2. Localization
 - epiphyseal proximal – 3
 - epiphyso-diaphyseal – 3
 - diaphyseal first 1/3 – 2
 - diaphyseal second 1/3 – 2
 - diaphyseal distal 1/3 – 0
3. Traumatic mechanism
 - direct – 3
 - not direct – 1
4. Time interval from accident to first manometry
 - 1-6 hours – 3
 - 6-12 hours – 2
 - 12-24 hours – 1
5. Soft tissue quality
 - closed fractures – 2
 - open fractures type I Gustilo – 2
 - open fractures type II and IIIA – 1
6. Polytrauma association – 1
7. Age
 - > 50 years - 0
 - <50 years – 1
8. Associated circulatory disease as high blood pressure or peripheral circulatory deficiency (relative value)
 - present – 1
 - absent - 0

The unpredicted character of the evolution of some tibia fractures imposes pressional monitoring of the cases that have a minimum score of 10 points. The secondary decreasing of pressional level in the compartment can exclude the risk of CS.

Conclusions

The compartmental pressure with ischemic effect on the compartmental anatomical structures is generated by a tissular edema with extended evolution, resulted as a malfunction of the liquid exchange in capillary, a deficit of lymphatic drainage and a pathologic increase of the capillary permeability.

Ischemia will have a progressive evolution and will affect all the structures of the compartment through a vicious circle edema-ischemia-high pressure.

CS represents an unpredicted state of the beginning, of evolution and the lesional determinism.

The principal risk factors selected are: fracture localization, fracture characteristics, type of traumatic mechanism, soft tissue quality, tegument quality, polytrauma, age, pressional level.

The analyzed etiopathogenic criterions must be correlated with the dynamic of the pressional levels. The increase of the pressional level over 20mmHg can be evaluated as the beginning of a microcirculatory hemodynamic imbalance with possible risk of CS. The pressional interval of 20-30mmHg can be correlated with the etiopathogenic factors using the risk score we described.

The presence of a pressional level between 25-30mmHg after 3-6 hours from the accident, with a risk score over 8 points represent an indicator of high importance of evolution to CS.

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