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Condition of bone tissue with chronic limb ischemia (obliterative atherosclerosis)

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Abstract
In this article represent method of quantitative analysis of bone mineral density that enables improved prognosis and postoperative rehabilitation period for patients in whom amputation can't turn away and, most importantly, allows you to fully assess the state of bone that under will more accurately determine the course of chronic ischemia stages lower extremities. This quantitative analysis improves the quality of objectification and diagnostic examinations of various organs and systems, and in this study results to fully correlate with dual energy X-ray densitometry of the bone in the femoral neck - medial third for patients with of chronic lower limb ischemia.

Keywords: Chronic limb ischemia, obliterative atherosclerosis, bone mineral density, osteoporosis, bone tissue, spiral computed tomography.

1. Introduction
The problem of study and treatment of chronic limb ischemia (CLI) and its complications are extremely important [1]. Obliterative arterial disease of the lower extremities is diagnosed in 0.4% of the population over the age of 30 years old, 1% - 40 years and older, 2-3% - 50 years and older and 5-7% - 60 years and older. Social importance of chronic critical limb ischemia caused by lack of tendency to reduce the frequency of its appearance [2]. Etiology, pathogenesis, morphogenesis and treatment of these diseases still remain an unresolved problem. Among chronic obliterating diseases of lower limb's arteries leading position is occupied by atherosclerosis and diabetic foot syndrome [3]. Limited number of work has been devoted to the study regards changes in the bone tissue with chronic limb ischemia. [5, 7]. The attention is drawn to the role of bone tissue during a rehabilitation period in patients with amputations in the context of wound healing in Ukrainian medical literature [4]. Important data are received on bone mineral density (BMD) of the lower extremities in patients suffering from diabetes [8] and on the possible high information content of densitometric analysis in practice reduce of the risk of fractures during CLI [6]. According to the scientific analysis, problems caused by involutional changes in bone (osteoporosis, osteopenia) will be important for the state, society and health care system [5].
The purpose of this research work was a comparison of the results of clinical and radiological examination to objectification status bone of the lower extremities in patients with chronic limb ischemia, caused by atherosclerosis.

2. Materials and Methods. Forty-four patients were examined (male) with a diagnosis of chronic limb ischemia, according to the etiological factor –atherosclerosis of the arteries. Pursuant to the classification by Fontaine, patients were divided into groups of eleven people: a) patients with stage II A, b) patients with stage II B, c) patients with stage III, d) patients with stage IV CLI. There were excluded patients with bone fractures of the lower limbs in anamnesis and diseases that could lead to changes in bone mineral density in accordance to the history of the disease. For control, data on bone mineral density of the lower extremities in 15 healthy people were used. There were clinical and laboratory examinations conducted for all patients after traumatic injuries. The condition of the vascular bed studied during angiography and duplex sonography. The average age of examined patients was 53 ± 8 years, the control group (C) 36 ± 4,5 years.
The determination of bone mineral density of the skeleton was performed on the dual energy X-ray densitometer (technology - DEXA) company CHALLENGER (France) (Fig. 1).

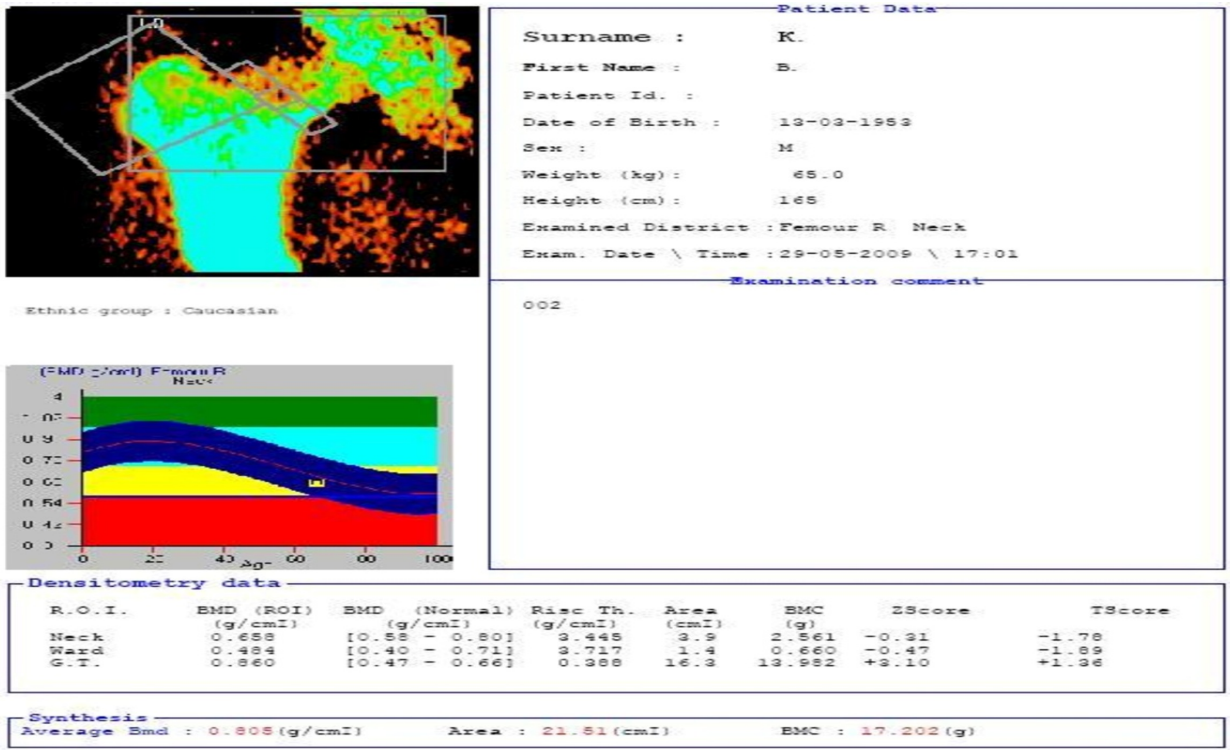

Fig 1: Protocol of densitometric examination on dual-energy X-ray densitometer company CHALLENGER. The patient has stage II A of CLI.

Processing of the results of mineral density was performed according to the guidelines of the International Society for Clinical Densitometry (ISCD - 2003, 2005, 2007) [8]. The determined T-score is the amount of standard deviations above or below the average for peak of bone mass. The value of this criterion complied with the percent reduction of mineral density. T-score fluctuations within the range 1,0 SD refers to norm. A decrease of BMD between -1 and -2,5 SD is diagnosed like osteopenia (pre-osteoporosis condition). If the decrease of BMD exceeds -2,5 SD of peak indices (T-score ≥-2,5 SD), results correspond to osteoporosis.

Mineral density of the calcaneus was determined by using spiral computed tomography (SCT) (Emotion Siemens). In determining the bone mineral density (BMD) with SCT there were used relative values, so-called Hounsfield units (HU), and an aperture of 2 cm ^{2} (Fig. 2).

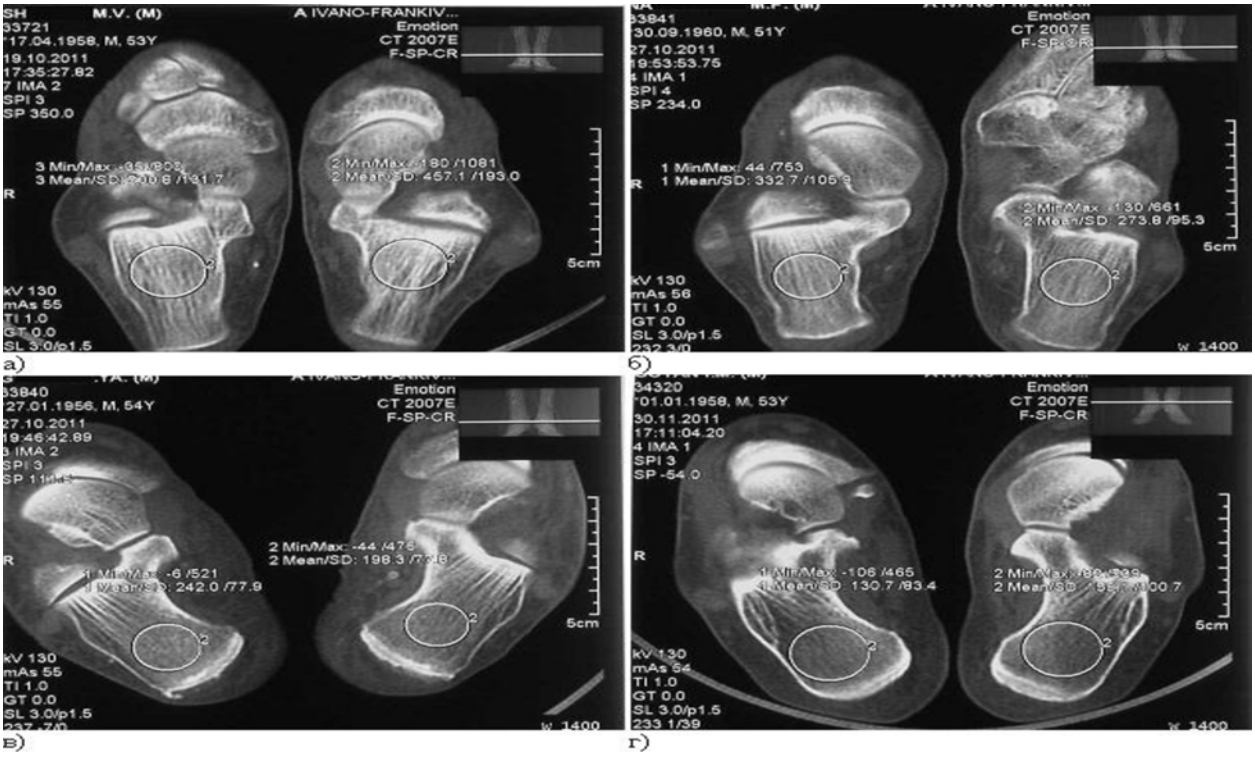

Fig 2: SCT calcaneus: а) IIa stage, б) IIb stage в) III stage, г) IV stage.

Statistical analysis were conducted by using data of application package «Statistica 6.0». The reliability of the results was provided by using standard diagnostic methods and definition the Student's t-test.

3. Results and Discussion. For patients in the control group (C) BMD of the calcaneus ranged from 620,9 ± 12,22 HU (M + m).

1. The first group - men, body length of 178 ± 2 cm, weight 79 ± 2 kg. According to clinical data they correspond IIa stage by Fontaine. The index T-score is -0.5, the average value mineral density is 0,895 ± 0,032 g / cm^2, M ± SD. Despite the World Health Organization (WHO) criteria for indicators of T-score at densitometric examination these data are within the range of normal fluctuations. For calcaneus BMD value (M + m) is makes 453,7 ± 10,24 HU.
2. The second group - male body length of 180 ± 2 cm, weight 78 ± 2 kg. According to clinical data they correspond stage IIb by Fontaine. T-score is at -1,3-1,5, the average value mineral density 0,689 ± 0,013 g / cm^2, M ± SD, corresponds to osteopenia. The value of BMD (M + m) for calcaneus is 344,9 ± 9,44 HU.
3. The third group - male, body length 167 ± 1,5sm, weighing 74 ± 2 kg. Third stage by Fontaine in accordance with the clinical data. T-score is definited for femoral neck at the middle third is -2.0. The value of mineral density is 0,647 ± 0,015 g / cm^2, M ± SD, corresponds osteopenia or preclinical osteoporosis according to WHO criteria. Calcaneus - BMD (M + m) equal to 247,9 ± 9,44 HU.
4. The fourth group - male, body length 175 ± 1,5sm, weighing 78 ± 2,5 kg.They are in the clinical group IV (4th stage according to the classification by Fontaine). Some patients in this group were prepared for further amputations of limbs in the clinic. T-score in this group was -2,3-2,5, that corresponded the level of osteoporosis. Bone mineral density of the femoral neck is 0,599 ± 0,017 g / cm^2, M ± SD, for calcaneus BMD was (M + m) equal to 136,0 ± 7,29 HU concordantly.

Summary data of clinical and radiological examination (BMD of femur) with the definition Student's t-test and the reliability of difference are shown in Table 1. The results (Fig. 2) correlate with BMD of the calcaneus (Table 2), where the levels of BMD decrease with the increasing of circulatory failure, according to the stages of the disease. For calcaneus BMD such decreasing that is expressed in HU is more notable compared to femoral BMD.

Table 1: The comparison of clinical and radiological examination with the definition Student's t-test and reliability difference (femur)

Group	Clinical stage	Amount of patients	Bone mineral density (absolute index), g/cm^2	Bone mineral density (M+SD), g/cm^2	Groups	Student's t-test	p (reliability)
1	2	3	4	5	6	7	8
1	IIa	1	0,933	0,895±0,032	1:2	5,96413	p<0,001
		2	0,997		1:3	7,01730	p<0,001
		3	0,805		1:4	8,16882	p<0,001
		4	1,002		2:3	2,11593	p<0,05
		5	0,905		2:4	4,20542	p<0,001
		6	0,705		3:4	2,11718	p<0,05
		7	0,721				
		8	0,947				
		9	0,885				
		10	0,932				
		11	1,010				
2	IIb	1	0,710	0,689±0,013			
		2	0,770				
		3	0,695				
		4	0,705				
		5	0,684				
		6	0,685				
		7	0,660				
		8	0,705				
		9	0,673				
		10	0,595				
		11	0,700				
3	III	1	0,645	0,647±0,015			
		2	0,650				
		3	0,620				
		4	0,656				
		5	0,581				
		6	0,655				
		7	0,634				
		8	0,650				
		9	0,781				
		10	0,655				

		11	0,585		
4	IV	1	0,609	0,599±0,017	
		2	0,505		
		3	0,525		
		4	0,675		
		5	0,685		
		6	0,585		
		7	0,577		
		8	0,562		
		9	0,666		
		10	0,595		
		11	0,605		

Table 2: The comparison of clinical and radiological examination with the definition Student's t-test and reliability difference (calcaneus)

Group	Clinical stage	Amount of patients	Bone mineral density (absolute index), g/cm²	Bone mineral density (M+SD), g/cm²	Groups	Student's t-test	p (reliability)
1	2	3	4	5	6	7	8
1	IIa	1	444,3	453,7±10,24	1:2	7,82113	p<0,001
		2	457,1		1:3	14,77306	p<0,001
		3	419,8		1:4	25,28770	p<0,001
		4	500,8		1:К	10,48946	p<0,001
		5	432,0		2:3	7,245819	p<0,001
		6	412,8		2:4	17,49582	p<0,001
		7	438,8		2:К	17,87662	p<0,001
		8	471,2		3:4	9,38422	p<0,001
		9	436,8		3:К	24,14617	p<0,001
		10	452,4		4:К	34,08086	p<0,001
		11	525,1				
2	IIb	1	364,5	344,9±9,44			
		2	390,8				
		3	326,3				
		4	342,1				
		5	332,7				
		6	330,2				
		7	321,2				
		8	328,0				
		9	314,7				
		10	329,3				
		11	412,8				
3	III	1	205,9	247,9±9,44			
		2	229,6				
		3	229,6				
		4	300,4				
		5	230,2				
		6	310,4				
		7	240,5				
		8	242,0				
		9	260,7				
		10	239,8				
		11	238,5				
4	IV	1	198,8	136,0±7,29			
		2	118,2				
		3	115,5				
		4	144,1				
		5	142,7				
		6	123,6				
		7	121,2				
		8	130,7				
		9	153,9				
		10	120,2				
		11	127,1				
K	-	-	-	620,9±12,22			

The results have shown that the decrease in bone mineral density with chronic limb ischemia caused by atherosclerosis are gradually according to the stages of the circulatory disorders ‘appearance. A decline in BMD is more expressed for bones located more distally, namely the calcaneus compared to the femoral bone that can be explained by aggravation of the CLI in the distal parts of the leg.

This quantitative analysis improves the quality and objectification of diagnostic data of various organs and systems and in this study it fully correlates with the data of dual-energy X-ray densitometry of the medium third of femoral neck with CLI.

4. Conclusions

The proposed technique of quantitative analysis of BMD allows to improve prognosis of the postoperative and rehabilitation period for patients in whom amputation cannot be turned away and, most importantly, it allows to evaluate fully the bone tissue. Respectively it will more accurately determine the current stages of chronic limb ischemia. Prospects for further research of data of bone mineral density, data angiography and ultrasound examination are the ability to establish reverse algorithm between specification of CLI’s degree in accordance with the level of BMD.

5. References

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