BONE CONSOLIDATION - HIGHLIGHTS

A. B. CIUBARĂ [1], O. TIȚA[2]

[1,2]*"Lucian Blaga" University of Sibiu*

Keywords: *bone consolidation, fracture healing, osteogenic proteins*

Abstract: *In this material we have attempted to conduct a review of the current research stages regarding bone consolidation and to determine certain milestones for future research. Fracture healing depends on a cascade of complex events: the induction phase of osteogenic cells, the inflammatory reaction, the formation of the fibrocartillage callus, of bone callus and remodeling, all these stages extending over a period of several months. Physical factors involved in the acceleration of bone consolidation and unanimously accepted in the international medical community are: ultrasonotherapy, electrostimulation and mechanical charge. From a chemical point of view, there are substances that influence the development of the bone callus. In conclusion, the therapies based on the amplification of natural biologic phenomena of healing using electromagnetic media, ultrasounds or osteogenic proteins are the key developments in the research regarding bone consolidation.*

Cuvinte cheie: *consolidarea osoasa, vindecarea fracturilor, proteine osteogenice*

Rezumat: *În materialul prezentat am încercat să facem o trecere în revistă a cercetărilor privitoare la consolidarea osoasă □i să stabilim câteva repere care ar putea fi puncte de plecare pentru viitoarele cercetări. Vindecarea fracturilor depinde de o cascadă de evenimente complexe: faza de inducere a celulelor osteogenice, reacția inflamatorie, formarea calusului fibrocartilaginos, a calusului osos și remodelarea, toate aceste etape succedandu-se pe o perioadă de mai multe luni. Factorii fizici implica□i în accelerarea consolidării osoase □i accepta□i în unanimitate de comunitatea medicală interna□ională sunt ultrasonoterapia, electrostimularea □i încărcarea mecanică. Din punct de vedere chimic, există substan□e care intervin în dezvoltarea calusului osos. În concluzie, terapiile fondate pe amplificarea fenomenelor biologice naturale de vindecare prin medii electromagnetice, ultrasunete sau proteine osteogenice reprezintă principalele repere în cercetarea privind consolidarea osoasă.*

SCIENTIFIC ARTICLE OF BIBLIOGRAPHIC SYNTHESIS

In this material we have attempted to conduct a review of the current research stages regarding bone consolidation and to determine certain milestones for future research. For a long period of time researches in orthopedics – traumatology were centered more on the development of new techniques and implants and less on the intimate mechanisms of bone consolidation. However, the last decade has marked an orientation of research on the possibilities to accelerate bone consolidation, probably due to the fact that the long consolidation period of fractures has a negative social, economic and medico-legal impact.

Fracture healing depends on a cascade of complex events: the induction phase of osteogenic cells, the inflammatory reaction, the formation of the fibrocartillage callus, of bone callus and remodeling, all these stages extending over a period of several months. The existence of certain factors which definitely influence the healing process of the bone tissue leads eventually to the absence of consolidation. These factors act at the level of each stage in the process of bone consolidation. The factors involved are of two types: physical and chemical factors.

Physical factors involved in the acceleration of bone consolidation and unanimously accepted in the international medical community are: ultrasonotherapy, electrostimulation and mechanical charge. With regard to these factors, although the positive consolidation effects have been proven, the intimate mechanism is not yet entirely known and accepted (10). We can certainly assert that these factors act at the level of all consolidation stages, with limitations (3). Thus, it has been demonstrated that any aggression on the fractured ends although it practically destroys the bone capital, has an osteogenic potential. The mechanical charge of the fractured fragments in the direction of the normal force lines also favors bone consolidation. For this reason, an exaggeratedly rigid implant may lead to the creation of pseudarthroses or delays in consolidation. The simple (7,8,9) or pulsating (13,14) ultrasonotherapy proves advantageous at the level of the fracture center, helping in all stages of bone callus formation. However, this method is self-limiting due to the thermal effects which may culminate in periosteal necrosis (6) and also due to the fact that the newly formed bone following stimulation has weaker mechanical properties as compared to the non-stimulated bone. Electrostimulation, although has positive effects, is self-limiting in the presence of metallic implants.

From a chemical point of view, there are substances that influence the development of the bone callus. An important part is played by oxygen. Thus, depending on the presence or absence of oxygen, cellular transformation takes place, resulting in the first instance in the formation of bone tissue and in the second case in the formation of cartilaginous tissue (1). Just like

[1]Corresponding Author: O. Ti□a, Faculty of Agricol Sciences, Alimentar Industry and Environment Protection,7-9, Dr. Ioan Ratiu street, Sibiu, România; e-mail: ovidiutita@yahoo.com; tel +40-0745292031
Article received on 28.05.2011 and accepted for publication on 24.10.2011
ACTA MEDICA TRANSILVANICA December 2011; 2(4)314-315

vitamin D, they have a beneficial influence on the mineralization process of the collagen matrix (2) but, without impacting on the consolidation speed, their effect being more qualitative than quantitative. The first phase of consolidation – namely the inflammatory phase – the formation and organization of fracture related hematoma offers us few possibilities of intervention. Although there are enough factors that act at this moment of consolidation, especially those which influence the coagulation process, the dreadful systemic complications (deep vein thrombosis and pulmonary embolism) prevent us from influencing the process. Furthermore, the medication administered for the prophylaxis of the above mentioned complications is a risk factor for pseudarthroses and delay in consolidation. The first stage that is most accessible in order to accelerate the consolidation of the fracture site is the stage of the fibrous callus. During this stage we may step in with a series of growth factors (12), factors of tumor growth (4,5), osteogenic proteins (15), factors which influence angiogenesis. Thus, the research of the last decade have been centered on the intervention at this level, numerous large scale studies being conducted, with promising results (11).

In conclusion, the therapies based on the amplification of natural biologic phenomena of healing using electromagnetic media, ultrasounds or osteogenic proteins are the key developments in the research regarding bone consolidation.

BIBLIOGRAPHY

1. Abad V., Meyers L.J., Weise M., The Role of the Resting Zone in Growth Plate Chondrogenesis, Endocr. 2002; 143: 1851-1857
2. Bonnucci E, Motta PM, Colagen Mineralization: Aspects of Structural Relationship between Collagen and the Apatic Crystallites, Ultrastructure of Skeletal Tissues, 1990; 3: 41-62
3. Edmund Y.S. Chao, Biophysical Stimulation of Bone Fracture Repair, Regeneration and Remodeling, European Cell and Materials, 2003; 6 :72-85
4. Einhorn T. A. , Lee C. A., Bone Regeneration: New Findings and Potential Clinical Applications, J Am Acad Orthop Surg , 2001; 9(3) 157-165
5. Feng X. Regulatory Roles and Molecular Signaling af TNF Family Members in Osteoclasts Gene. 2005; 350:1-13
6. Frayssinet P, Guichet JM. Aspects cellulaires de la regeneration osseuse: role du perioste et de la moelle osseuse. Rev Chir Orthop Reparatrice Appar Mot 2004 ; 90 :765-70
7. Heybeli N, Yesildag A, Oyar O, Gulsoy UK, Tekinsoy MA, Mumcu EF. Diagnostic Ultrasound Treatment Increases the Bone Fracture-Healing Rate in an Internally Fixed Rat Femoral Osteotomy Model. J Ultrasound Med 2002;21(12):1357-63.
8. Hogan R D, Franklin T D, Fry F J, Avery K A, Burke K M. The Effect of Ultrasound on Microvascular Hemodynamics in Skeletal Muscle: Effect on Arterioles. Ultrasound Med Biol. 1982;8:45–55.
9. Jeune S R, Dyson M. L'effet des ultrasons therapeutiques sur l'angiogenesis. Biol De Med D'Ultrasons. 1989 ;16:261-269.
10. Johns L.D., Nonthermal Effects of Therapeutic Ultrasound: The Frequency Resonance Hypothesis. J. Athl. Train. 2002 ;37(3):293-299.
11. Mandracchia VJ, Nelson SC, Barp EA. Current Concepts of Bone Healing. Clin Podiatr Med Surg 2001;18(1):55-77.
12. Marie JP, Fibroblast Growth Factor Signaling Controlling Osteoblast Differentiation, Gene. 2003; 316:23-32
13. Rodriguez O, Monreal R. Low-Intensity Pulsed Ultrasound Therapy for the Acceleration of Bone Fracture Repair. Anais do Congresso Brasileiro de Engenharia Biomedica 2000;650-655.
14. Tam K.F., Cheung W.H., Osteogenic Effects of Low Intensity Pulsed Ultrasound, Extracorporeal Schockwaves and Their Combination. An in vitro Comparative Study on Human Periosteal Cells, Ultrasound Med. Biol, 2008:2
15. Yamaguchi A, Komori T, Suda T. Regulation of Osteoblast Differentiation Mediated by Bone Morphogenetic Proteins, Hedgehogs, And Cbfa1. Endocrinol Rev 2000; 21:393-411.