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Pain Relief by Bone Drilling and Osseous Pain Sensitization: A Hypothesis

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Abstract

Bone drilling (BD) is reconsidered to be a novel treatment for pain including vertebral compression fracture (VCF), vertebral spondylosis, osteoarthritis (OA) and osteonecrosis of the knee and hip, and neuropathic pain. BD is simple and harmless. The technique of BD is the similar to that of bone marrow puncture. BD is conducted under X-ray fluoroscopy and regional anesthesia. Exact penetration of bone cortex is required for intramedullary decompression, and sufficient aspiration of medullary blood is important to eliminate intramedullary inflammatory cells (ICs) and inflammatory chemical mediators (ICMs). Onset of the effect is immediate, and the effect lasts several months or a few years. However, precise of the underlying mechanisms of BD is remained unclear. On the other hand, effectiveness of BD was also shown in neuropathic pain, a representative of complex regional pain syndrome (CRPS.) Neuropathic pain was induced after the nerve root injury, and the bone is generally intact. However, BD alleviates a foot ache that is produced thereafter. This fact may indicate that subsequent medullary inflammation occurs and bone tissue is involved in CRPS. Therefore, a certain change within the bone is induced by CRPS. The fact suggests a hypothesis that a self-facilitating mechanism of pain is provided independently within bone marrow. We term this mechanism 'osseous pain sensitization'. Also medullary ICs cause bone resorption, and the ultimate bone dystrophy due to CRPS may be 'Sudeck dystrophe'.

Keywords: Bone drilling; Pain relief; Intramedullary decompression; Neurogenic inflammation; Dorsal root reflex; Osseous sensitization

Introduction

Bone drilling (BD) had been undergone for treatment of pain in knee and hip osteoarthritis (OA) by Makenzie in 1936 [1]. Thereafter BD has been kept barely for treatment of pain in osteonecrosis of the femur head [2]. Kohashi et al. [3] found in 2004 that the backache due to vertebral compression fracture (VCF) is alleviated by BD alone: bone cement injection was failed in percutaneous vertebroplasty (PVP). They focused on this phenomenon. They performed BD of the vertebra for the treatment of backache in vertebral compression fracture (VCF). On the other hand, Shinjo [4] have shown effectiveness of treatment on arthralgia of knee OA in 2005. They did give the BD an important post for pain relief. Recently, the pain relief effect of BD in VCF is ensured to be nearly equivalent between BD and PVP [5].

Thereafter, BD has been considered to be one of the important treatments for pain, and the indication of BD has been extended to various pains including neuropathic pain in Japan [6]. The simple method, immediate onset, long-lasting effect, and harmlessness are the appreciable characteristics [1-7]. The effect becomes evident immediately after BD, and develops further for a few days. Thereafter steady pain relief is obtained [7]. The effect lasts for several months [6] or a few years [7].

Effectiveness of BD is shown in backache due to VCF [3,5,7,8] and vertebral spondylosis [7,8], arthralgia due to OA of the knee, hip and shoulder [1,4,8] as well as osteonecrosis of the hip [2,8], and neuropathic pain [6]. In acute pain due to VCF, BD is more effective [7]. Usually, an effect of BD on most pain due to malignant tumors may be insufficient, and BD has been scarcely attempted in pain due to trauma (a bruise, a sprain or fracture) except for VCF (mentioned above). As a matter of course, the underlying disorder should be treated first.

Bone drilling is possible repeatedly, when the effect become faint.

Methods and Complication of BD

The technique of BD has been published elsewhere [8], Briefly, BD is performed under X-ray fluoroscopy and regional anesthesia at a puncture point. Procedure is similar to bone marrow puncture. Bone marrow puncture needle (11-14 G, with a notched tip) are usually used for BD, while for small bones a more slender needle (a conventional or nerve block needle, 18-22 G) is also used. For BD of vertebral body, the same route as PVP, transpedicular approach is adequate [9]. For arthralgia, one side or both sides of juxta-bones is drilled [4]. In complex regional pain syndrome (CRPS), multiple tender points are selected for the targets of BD [6].

To verify the location of a needle tip, radio-opaque contrast medium, 1-10 ml, is injected into bone marrow for osteophlebography. Two important actions, penetration of bone cortex and aspiration of medullary blood, should be important. The penetration may lower intramedullary pressure (IP), while the aspiration may remove inflammatory cells (ICs) and inflammatory chemical mediators (ICMs), as mentioned below. Medullary blood, occasionally tens ml or more, is aspirated into an attached syringe.

Complications (infection, hematoma, and ectopic puncture) associating with BD are also similar to those with bone marrow puncture. In rare cases, bone fracture and breaking a needle may be

probable. Antibiotic medication to prevent infection, especially osteomyelitis, is required in some case. BD to patients undergoing anti-coagulant therapy should be conducted with caution. To avoid an incorrect or accidental tap, practice under X-ray fluoroscopy should be inevitable.

Discussion

Intramedullary Pressure (IP)

Most authors have ever considered that arthralgia and backache are caused by intramedullary hypertension, and pain relief after BD is brought about by intramedullary decompression [1-7]. IP was measured by some investigators. According their studies, IP fluctuates easily receiving various inputs from circumstances. Vertebral IP fluctuated parallel with cerebrospinal fluid (CSF) pressure [10]. Femoral IP varies among animals [11]. An obstacle of venous return elevated IP in the tibia medulla [12], while IP and systemic pressure were linearly related [13]. Intramedullary hypertension followed after intra-articular hypertension of juxta-joint of the metacarpal bone [14].

Thus bone marrow receives incessantly various inputs from circumstances. When these inputs are accumulated all together, the fluctuations may become a potent stress to the bone marrow. Therefore, in the pathological conditions with hyperalgesia, pain sensitization, and complex regional pain syndrome (CRPS) [15], the bone marrow may sensitively react to the stress, and may transmit nociceptive impulses to the central nervous system (CNS). Probably, the bone hole opened by BD may release from intramedullary hypertension. Considering these, therefore, the reason of immediate alleviation of pain is explainable by intramedullary decompression.

Medullary edema and inflammation

Medullary edema of the vertebra with compression fracture [16], and of the tibia with OA [17,18] is shown. The edema is a potent risk factor for bone destruction and arthritis [19,20]. After aspiration of medullary blood, however, the edema does not consider to vanish immediately. Therefore, the immediate pain relief effect may not relate to intramedullary decompression, but the later (a few days after) effect may be brought about by disappearance of the edema following elimination of ICs and ICMs. Thus, to eliminate ICs and ICMs may also be very important for the pain relief.

Remote induction of medullary inflammation

Effectiveness of BD was also shown in neuropathic pain that is a representative of CRPS [6]. Neuropathic pain occurred initially at the nerve root after back bone surgery (failed back surgery syndrome). Thereafter, a severe foot ache occurred in spite of absence of any history of trauma or injury. BD of the foot bones was undergone, and BD alleviated the foot ache. This fact shows that the foot ache is induced remotely by nerve root CRPS. Consequently, the foot bones are involved in CRPS associating with severe pain and inflammation.

First, one of the factors causing the phenomenon may be neurogenic inflammation [21], which is brought about by antidromic nerve impulses (ANIs) to sensory nerve endings via dorsal root reflex (DRR) [22,23]. By receiving ANIs, neurogenic inflammation (NI) occurs in the bone innervated segmentally by the spinal cord. Next, inflammation (edema and dystrophy) of the bone is also induced by stimulation via autonomic (including sympathetic) reflex (sympathogenic inflammation; SI) [14]. Thus the foot bones are involved in the CRPS. Furthermore, the initial and subsequent injuries and inflammations may be linked to each other through intermediation of the same spinal segment (Figure 1).

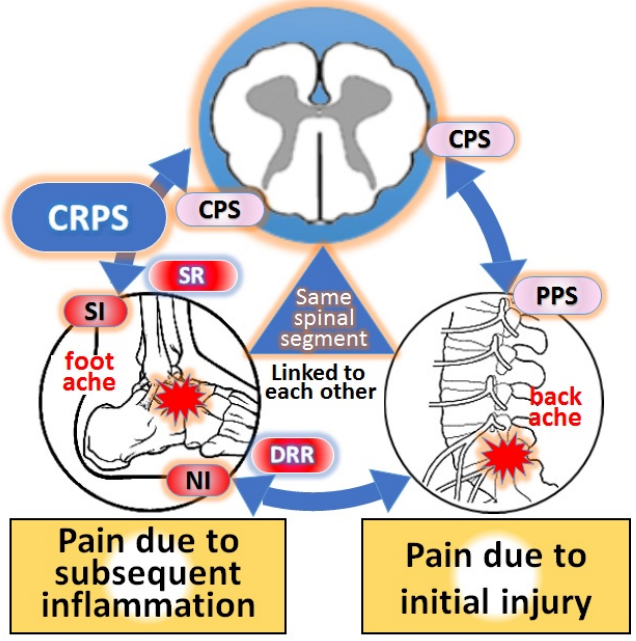

Figure 1: Osseous pain sensitization in the remote bone. Nociception originated in an injured site induces primary and secondary hyperalgesia, and establishes peripheral pain sensitization (PPS). Nociceptive impulses stimulate the central nervous system (CNS) and establish central pain sensitization (CPS), which induces central hyperalgesia. Both PPS and CPS build up complex regional pain syndrome (CRPS). With severe pain in CRPS, aitidromic nerve impulses (ANIs) are delivered to the nerve endings via dorsal root reflex (DRR), and induce neurogenic inflammation (NI) in the local bone. Thus neuropathic pain induces medullary inflammation in a remote bone. In addition, inputs via sympathetic reflex (SR) induce medullary inflammation (edema and dystrophy) in CRPS. Thus sympatogenic inflammation (SI) is also important. The initial injury site and the subsequent inflammation site are linked to each other through intermediation of the same spinal segment. The NI and SI may occur in remote and/or adjacent tissues, including bone, which are innervated segmentally by the spinal cord.

Osseous Pain Sensitization: A Hypothesis

Thus bone inflammation is induced by ANIs via DRR as well as stimulation via autonomic reflex. The edema is a potent risk factor for bone destruction. In the bone marrow with edema, infiltration of ICs and release of ICMs is observed [18,19]. Released ICMs such as TNFα and IL-6 are induce further edema and inflammation [24,25], which exacerbate again the IP and inflammation to the higher level. Therefore, the pain becomes still more intensive. These sequential phenomena form a vicious circle, which rolls independently within the bone marrow. On the other hand, ICs such as macrophages or

osteoclasts work for bone resorption causing bone destruction (if absorbed violently) or dystrophy (if absorbed diffusely).

Thus, the self-facilitating mechanism is provided naturally in the bone marrow. We term this mechanism 'osseous pain sensitization'. The ultimate result of CRPS in the bone tissue may be the 'Sudeck dystrophy' (Figure 2).

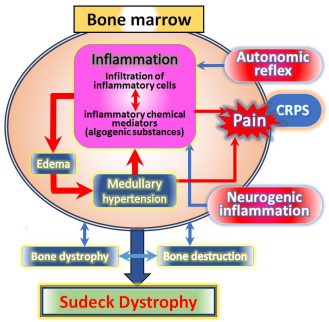

Figure 2: Hypothesis of osseous pain sensitization. See the text "Osseous pain sensitization, a hypothesis"

Conclusion

We should reconsider the BD for a novel treatment of pain. In spite of the evident effect, the clinical findings concerning BD are inadequately documented. Furthermore, histopathological and cytopathological knowledge concerning pain relief by BD is nonexistent. Therefore, studies on the underlying mechanisms of the pain relieving effect of BD are necessary. Then BD should be given an important post as a novel treatment for pain, and will be used even more widely.

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