

CO₂ Balneotherapy in Japan

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Yoshiaki Komoto, Mitsuhiro Soda, Shunichi Hirai,
Shinhachi Morisue, Ichio Suzuka and Hidenori Yorozu

Institute for Environmental Medicine, Okayama University
Medical School

Abstract: Natural CO₂ springs have been scarcely utilized in Japan, whereas artificial CO₂ bathing has become popular by the introduction of CO₂ tablets and other apparatus for CO₂ water supply. Artificial CO₂ bathing is indicated for degenerative connective tissue disorders such as scleroderma, common stiff and painful shoulders, chronic joint pain, lumbago, and trophic changes due to insufficient peripheral circulation by virtue of the increase of tissue pO₂ and the improvement of tissue perfusion. Artificial CO₂ bathing promotes recovery from fatigue and is beneficial in women whose health has been adversely affected by cold.

Key words: CO₂-balneotherapy, Artificial CO₂-bathing, Tissue pO₂,
Tissue perfusion, Connective tissue disorders.

CO₂ balneotherapy is classified into natural and artificial baths.

1. Natural CO₂ baths.

Natural CO₂ baths are not so well utilized in Japan mainly because, they are located only in the active volcanic zones. Secondly, Japanese people have not familiarized with the beneficial effects of CO₂ baths and parties concerned about spa-resort management have not made serious efforts to popularize CO₂ baths, because of the lack of knowledge. Thirdly, the traditional habit of short time bathing at higher than 40°C constitutes a barrier to bathing in low temperature natural CO₂ baths containing a high

CO₂ concentration. Furthermore, the inadequacy of social health care policies is an obstacle in promoting balneotherapy in the remote places inconveniently situated.

Although there are about 15 medicinal CO₂ springs in Japan, none of them are actively utilized for the treatment (Fig. 1).

2. Artificial CO₂ bathings.

According to the results of the experimental studies on bathing with artificially carbonated water, favorable physiological effects of CO₂ were clarified such as the increase of tissue pO₂ and the improvement of tissue perfusion by means of mass spectrometry prior to other results (Table 1).

These effects ameliorate degenerative tis-

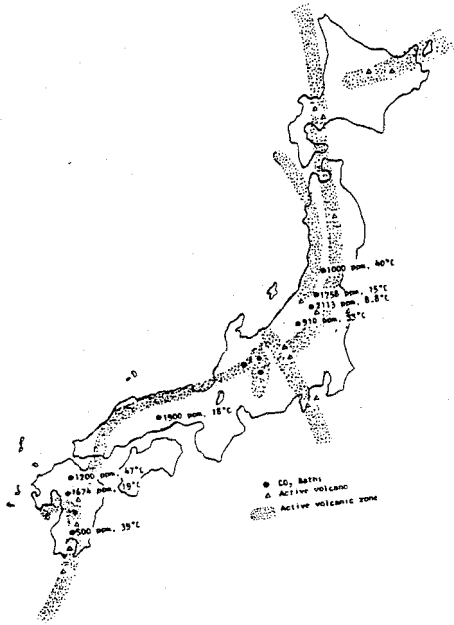


Fig. 1. Location of natural CO₂ springs (●) and active volcanos (△) are shown along the active volcanic zones in Japanese islands.

LEADING WORKS ON THE EFFECT OF CO₂ BATHING
IN THE 1980'S

TITLE	INSTITUTE	YEAR	REF.
TISSUE PO ₂	OKAYAMA	1982	1
TISSUE PERFUSION	OKAYAMA	1984	2
CO ₂ CONCENTRATION	KAO & OKAYAMA	1984	3
DERMAL BLOOD FLOW	KAO & OKAYAMA	1984	4
SERIAL BATHINGS	OKAYAMA & KAO	1986	5
BLOOD LACTIC ACID & MYALGIA	KAO & OKAYAMA	1986	9
INFLAMMATION	KAO & OKAYAMA	1986	10
RED BLOOD CELL VISCOSITY	GUNMA	1986	12
HYPOTENSIVE & CIRCULATORY	KAGOSHIMA	1987	13
OXYGEN-DISSOCIATION CURVE OF HEMOGLOBIN	GUNMA	1988	14

Tabal 1

sue disorders due either to insufficient peripheral circulation or to aging, in which loose connective tissue becomes consolidated leading to retarded tissue perfusion^{1,7,8,11}.

2-1 Effective concentration of CO₂.

The substantial increase in dermal blood

flow has been confirmed by bathing at 38–40 °C in an artificial CO₂ bath containing 59.8ppm or more of CO₂, so that the definition for medicinal CO₂ springs, which has been set at 1000 ppm or more, should be reconsidered^{3,4}.

2-2 A new concept on serial bathing.

The favorable conditions of living body under ameliorated tissue perfusion continue as long as the daily CO₂ bathing is continued. Consequently, artificial CO₂ bathing can be continued as a matter of routine longer than a balneotherapeutic period of 3 weeks⁵.

2-3 The essential factor in CO₂ bathing.

Physiological effects are specifically produced by the chemical substance of CO₂, not by the temperature of bathing water or other factors. Therefore, artificial CO₂ bathing can be used daily apart from the environmental factors of resort area and/or medicinal springs¹¹.

2-4 CO₂ water supply.

For routine CO₂ bathing, we developed 1) a 50 g CO₂ tablet, made from sodium hydrogen carbonate and succinic acid, producing fine bubbles in water; 100ppm in a 150-liter tub at 40°C, (CO₂ tablets for artificial CO₂ bathing are now popularized among the general public, and have a market share of 30% in bath preparations in Japan), 2) an apparatus for mixing CO₂ and water using a dispersion mixer, supplying CO₂ water of 1000ppm in a 280-liter tub at 40°C in 30 minutes⁶(Fig. 2), and 3) an apparatus with a gas condensing heater system, supplying CO₂ water of 100~150ppm at 40°C (Fig. 3).

CO₂ bathing is performed for longer than 10 minutes at a temperature below 40°C.

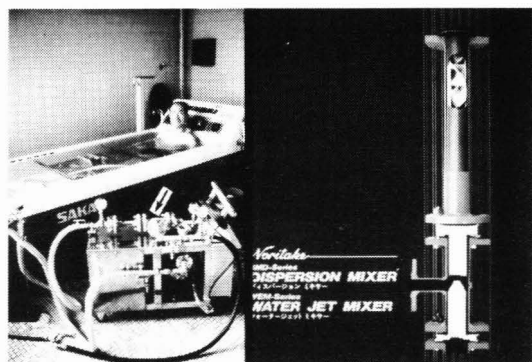


Fig. 2. The principal part of dispersion mixer is shown on the right side ; CO₂ from the side is mixed with a jet stream (water) through the propeller. A dispersion mixer is set on the prototype CO₂ water supply (arrow), shown on the left side (Wakayama Research Laboratories, Kao Co., Ltd., Japan).

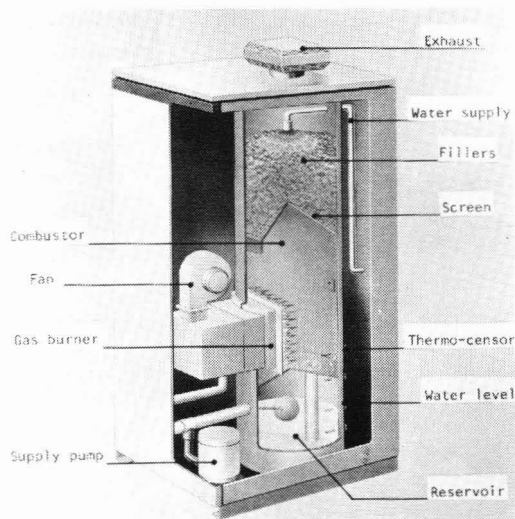


Fig. 3. Illustrates a gas condensing heater system ; 1427 × 355 × 620 (mm), 120kg , (Osaka Gas CO., Ltd., Osaka, Japan).

2 - 5 The indication for CO₂ bathing.

CO₂ bathing is indicated for degenerative

connective tissue disorders such as scleroderma, common stiff and painful shoulders, chronic joint pain and lumbago. Signs of amelioration usually appear in a month or so¹⁵⁾, secondly, for the incurable wounds due to chronic occlusive diseases of the peripheral arteries and pressure sores, in which granulation tissues appear to improve in a couple of months^{8,11,16)}, and thirdly, for essential hypertension, in which a hypotensive effect will be seen in 6 - 12 months¹⁷⁾.

The artificial CO₂ bathing is also useful as a matter of routine for recovery from fatigue and for women whose health has been adversely affected by cold^{10,15)}.

In conclusion, there has been much controversy for many years regarding the relative merits of natural CO₂ springs and artificially prepared carbonated water, but we believe that CO₂ does improve the micro-hemodynamics in tissue apart from other factors in mineral salts without any complications in both experimental and practical bases¹⁸⁾.

References

1. Kohmoto, T., and Komoto, Y.: Changes in tissue partial pressure of oxygen and carbon dioxide in CO₂ vapour bath. *J. J. A. Phys. M. Clim.*, 46 : 76 - 83, 1982 (In Japanese with English summary).
2. Komoto, Y. : On the effects of an artificial CO₂ - bathing and its clinical application. *Fragrance J.*, 69 : 27 - 30, 1984 (In Japanese).
3. Yorozu, H., Kubo, Y., Eguchi, Y., Kohmoto, T., Sunakawa, M., and Komoto, Y. : Research for carbon dioxide bathing, I. On the effective CO₂ concentration for the artificial CO₂ - bathing. *J. J. A. Phys. M. Baln. Clim.*, 47 : 123 - 129, 1984

- (In Japanese with English summary).
4. Yorozu, H., Kubo, Y., Eguchi, Y., Kohmoto, T., Sunakawa, M., and Komoto, Y. : Research for carbon dioxide bathing, II. An increase of dermal blood flow by the CO₂ preparation. *ibidem*, 47 : 130-136, 1984 (In Japanese with English summary).
 5. Sunakawa, M., Kohmoto, T., Komoto, Y., Yorozu, H., and Eguchi, Y. : Experimental Study on the effects of serial CO₂ bathing. *ibidem*, 49 : 83 - 88, 1986 (In Japanese with English summary).
 6. Komoto, Y., Kohmoto, T., Sunakawa, M., Yorozu, H., and Matsumoto, Y. : An aerator made on an experimental basis. *ibidem*, 51 : 37-38, 1987 (In Japanese).
 7. Komoto, Y., Kohmoto, T., Sunakawa, M., Eguchi, Y., Yorozu, H., and Kubo, Y. : Dermal and subcutaneous tissue perfusion with a CO₂ -bathing. *Z. Physiother.*, 38 : 103 -112, 1986.
 8. Komoto, Y., Kohmoto, T., Sunakawa, M., Yorozu, H., and Eguchi, Y. : The effect of artificial CO₂ -bathing on peripheral circulation insufficiency. *Papers of the Institute for Environmental Med., Okayama Univ. Med. School*, 57 : 3 - 8 , 1986 (In Japanese with English summary).
 9. Yorozu, H., Eguchi, Y., Sunakawa, M., Kohmoto, T., and Komoto, Y. : Research for carbon dioxide bathing, V. Effect of the artificial CO₂ -bathing on blood lactic acid and myalgia. *J. J. A.Phys. M. Baln. Clim.*, 49 : 89 - 94, 1986 (In Japanese with English summary).
 10. Yorozu, H., Eguchi, Y., Sunakawa, M., Kohmoto, T., and Komoto, Y. : Research for carbon dioxide bathing, effect of the artificial CO₂ -bathing on the inflammation. *ibidem*, 49 : 113-117, 1986 (In Japanese with English summary).
 11. Komoto, Y., Kohmoto, T., Sunakawa, M., Yagi, N., Yorozu, H., and Matsumoto, Y. : Clinical effects of serial artificial CO₂ baths on degenerative disorders in the improved tissue perfusion. *Papers of the Institute for Environmental Med., Okayama Univ. Med. School*, 58 : 22-30, 1987 (In Japanese with English summary).
 12. Shirakura, T., Kubota, K., Tamura, J. : Effect of artificial carbon dioxide bathing on erythrocyte viscosity. 51st Ann. Meeting for J. A. Phys. M. Baln. Clim., 1986 (In Japanese).
 13. Tanaka, N., Hiyoshi, T., Kawahira, K., and Takesako, K. : Hypotensive and circulatory effects of artificial CO₂ bathing (Bub-KAO Bath) in normal and hypertensive Men. *ibidem*, 50 : 87-93, 1987 (In Japanese with English summary).
 14. Shirakura, T., Tamura, J., Kurabayashi, H., Yanagisawa, T., and Kubota, K. : Effect of artificial carbon dioxide bathing on oxygen-dissociation curve of hemoglobin. *ibidem*, 51 : 83-87, 1988 (In Japanese with English summary).
 15. Yorozu, H., Kubo, Y., Eguchi, Y., Sunakawa, M., Kohmoto, T., and Komoto, Y. : Research for carbon dioxide bathing, IV. Thermal effect of artificial CO₂ bathing. *Papers of the Institute for Thermal Spring Research, Okayama Univ.*, 54 : 1 - 12, 1984 (In Japanese with English summary).
 16. Hiyoshi, T., Tanaka, N., Yaguchi, S., and Tsuchihashi, K. : Effects of artificial CO₂ bathing in pressure sore. *Sogo Rehab.*, 17 : 605 - 609 , 1989 (In Japanese).
 17. Usui, Y., Komoto, J., Sunakawa, M., Kohmoto, T., and Komoto, Y. : Clinical trials with artificial CO₂ bathings.

- Papers of the Institute for Environmental Med., Okayama Univ. Med. School, 57: 12-17, 1986 (In Japanese with English summary).
18. Yorozu, H., Kubo, Y., Eguchi, Y., Kohmoto, T., Sunakawa, M., and Komoto, Y. : Research for carbon dioxide bathing, III. Basic points for the artificial CO₂ bathing and on the effect of CO₂ concentration released in the air. J. J. A. Phys. M. Baln. Clim., 48: 79-85, 1985 (In Japanese with English summary).

日本に於ける二酸化炭素泉療法の現況

古元嘉昭, 曾田益弘, 平井俊一, 森末真八, 鈴鹿伊智雄, 萬 秀憲

岡山大学医学部附属環境病態研究施設

日本では, 天然の二酸化炭素泉は殆ど利用されていない。一方, CO₂ 錠剤, CO₂ 給水装置が

開発されて人工二酸化炭素泉がよく用いられるようになってきた。皮下組織の酸素分圧の上昇と組織循環の改善という好ましい生理作用により, 結合織の退行性変化による慢性障害, すなわち強皮症, 関節症, 慢性関節痛, 腰痛症, および末梢循環障害に伴う組織の栄養障害に適応がある。また, 疲労回復を促進し, いわゆる冷え症に好ましく作用する。