ORIGINAL ARTICLE

Is intermittent pneumatic compression (IPC) an appropriate method for increasing 99m Tc-MDP uptake in bone scan?

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ABSTRACT

Background: Currently, intermittent pneumatic compression (IPC) is a standard method of lymphedema treatment. Recently, the effect of this modality in patients with limb arterial insufficiency has been researched. It has been suggested that the arterial inflow to the long bones is also increased by IPC. The purpose of this paper is to assess the effect of lower limb IPC on the blood flow as well as delayed bone uptake.

Methods: In this prospective study, we evaluated 30 patients who were referred for whole body bone scan to our Nuclear Medicine Department. All the patients had been examined by a vascular surgeon for ruling out any peripheral neuropathy, vasculopathy or ulcer in the lower limbs. Also, all the patients were questioned about hypertension, diabetes mellitus, and other chronic diseases with peripheral complications. Following 925MBq of 99mTc-methylenediphosphonate (MDP) injection, perfusion and blood pool images of both legs as well as static delayed images were done after the completion of IPC.

Results: Thirty patients (10 male) with the age range of 30–84 years (mean = 53.4) were included. Radiotracer uptake in flow and blood pool images in the compressed limb was significantly more than the contralateral limb, however, on delayed images, no significant difference was noted between two limbs.

Conclusion: Although IPC can significantly increase blood flow of the compressed limb, MDP uptake on the delayed images was not increased. According to this study, IPC may not be useful as a technique to increase releasing chemotherapy drugs or other substances to the bone and promoting bone growth.

Keywords: Intermittent pneumatic compression, IPC, bone scan, MDP uptake, vascular flow.

INTRODUCTION

Nowadays, intermittent pneumatic compression (IPC) is approved as a standard method of therapy in lymphedema [1]. This method can also be used for prevention of deep vein thrombosis as well [2]. Recently, the effect of this method in patients with lower limb arterial insufficiency has been assessed as a therapeutic modality [3–5].

In patients with venous leg ulcer (VLU), especially at erect position, valvular incompetence can result in high venous pressure and affect the local blood flow of the lower limb. These process may damage macro and microcirculation, which in turn lead to failure of muscular pomp of the calf [6].

Several studies have shown that the microcirculation of the skin around VLUs is increased and is associated with venous hypertension. Venous hypertension can disturb regulatory function of capillaries [6]. Various modalities are proposed to decrease this peripheral resistance to the vascular bed (surgical sympathectomy and oral vasodilators). However, these methods are associated with some adverse effects and have not been recommended. In this way, IPC is a non-invasive method with reducing venous pressure below the normal level and increasing tissue perfusion [7].

On the other hand, it is well known that the primary cause of venous ulceration is primary venous reflux. IPC can reserve valvular function and decrease or stop venous reflux [6].

IPC of the thigh alone or in combination with calf compression can decrease peripheral vessels resistance due to increase end diastolic velocity and decreased pulsatility Index [4].

In this method, muscle blood vessels are compressed at compression phase which can result in venous blood or lymphatic drainage to the proximal parts and also, stimulate muscle pumps. At release phase, the veins refill and can transfer hyperemia to the arteries. This arterial hyperemia can be used as a method of treatment in the arterial diseases [3].

It has been proposed that the arterial inflow to the long bones of lower limb is also increased by IPC. But, it has not been established yet. If this effect of IPC has been proved, it can be used in other situations, such as increasing in releasing chemotherapeutic drugs or other substances to the bone and promoting bone growth [3].

Venous limb ulcer is an unfavorable complication of diabetes mellitus and leads to atrocious morbidities and even mortality, as well as high cost. Foot Limb ulcer is seen in 2% of diabetic patients. Ulcer treatment and healing in these patients is problematic [8].

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Recent studies showed that the IPC on foot could improve wound-healing after debridement in diabetic patients [8].

Several techniques have been proposed for evaluating the effect of IPC on the lower limb blood flow, such as Doppler plethysmography ultrasonography, venography, laser Doppler flowmetry, capillary microscopy, radioisotope clearance methods, and magnetic resonance flowmetry [6]. However, variable results are reported due to methodological problems and acute changes in blood flow of the lower limb, especially within bone, cannot currently be measured non-invasively [6].

Evaluating radioisotope clearance is one of these methods and 99mTC-methylenediphosphonate (MDP) is a good tracer in this regard [3,9].

Accordingly, in this study, we assessed the effect of lower limb IPC on the calf and foot blood flow as well as delayed bone uptake, using 99mTc-MDP.

MATERIALS AND METHODS

In this prospective study, we evaluated 30 patients who were referred to Nuclear Medicine Department of Ghaem hospital for whole body bone scan, without any focus of evaluation on the lower limbs. All the patients had been examined by a vascular surgeon for ruling out any peripheral neuropathy, vasculopathy, or ulcer in the lower limbs. Additionally, all the patients were questioned about hypertension, diabetes mellitus, and other chronic diseases with peripheral complications. If they had any positive history, they were excluded from the study.

The study was approved by the local ethical committee of our institute and all the patients gave an informed consent before recruitment into the study.

Preventing any bias due to select right or left limb for compression, random number generation was used.

IPC has been done by starting compression (of 60 mmHg for all patients, as was ordered by instrument producer for biginers) on the foot extending to the calf and thigh. Every IPC phase contained about 50-second compression and 15-second release while the patient was supine.

Injected radiotracer was 925MBq of 99mTc-MDP in all the patients and imaging included perfusion and blood pool images of both legs immediately after tracer injection, blood pool images of both feet in two lateral and plantar views, and static delayed images with same protocol 2.5 hours after completion of IPC.

All the static images were performed with dual head gamma camera in two anterior and posterior views and time of every image was 3 minutes and the matrix was 128 * 128.

Before starting the study, patients were blindly divided to three groups, considering time of compression and the time interval between compression and tracer injection.

In group 1, following tracer injection and perfusion and blood pool images, IPC was done for 1 hour followed by delayed imaging 2.5 hours of IPC completion. In the second group, 1 hour IPC was done before tracer injection and three phase bone scan was performed with the same protocol. For the third group, IPC for 30 minutes performed continued by tracer injection and perfusion and blood pool imaging, followed by another 30 minutes IPC. Delayed imaging 2.5 hours after IPC completion was done.

Region of interest was drown on lower limbs (foot and calf) on all the images. Total count and average count were recorded in both anterior and posterior views and geometric mean was compared with contralateral side (Figure 1).

SPSS software (version 16.0; SPSS Inc.) was used for data analysis. Quantitative variables were expressed as mean ± SD.

RESULTS

Thirty patients (10 male) with the age range of 30–84 years (mean age = 53.4) were included. One case was excluded due to inappropriate position of the lower limbs during imaging. Consequently, nine patients in the first group and 10 cases in the other two groups remained. Compression has been done on the right limb in 11 cases and in other patients; the left lower limb was compressed. The age range did not show any difference between three groups.

Data analysis showed that radiotracer accumulation in blood pool images was significantly higher in the compressed limb comparing to the contralateral side (p value < 0.05). On delayed images, no significant difference was noted between two limbs. These results were similar in all the three groups. The only difference between three groups was related to radiotracer uptake ratio in blood pool images. This ratio was a little higher in the feet blood pool images comparing with the other parts; however, the difference was not statistically significant. Comparison between radiotracer uptake on blood pool and delayed images of the compressed and uncompressed limbs are illustrated in the Figure 2.

DISCUSSION

IPC can increase the blood flow of the skin and soft tissue in the compressed limb. However, it is not clearly confirmed whether this method is useful to increase blood flow of the bone or not. If vascular flow of the skeletal system increase, radiotracer uptake is expected to be higher in that region. Additionally, compression may have an effect on the radiotracer extraction with increase osteoblastic activity [3].

To the extent of our knowledge, only one study has been done in this regard. The study proposed that intermittent compression with 60 mm Hg pressure could be efficient for emptying veins of the limb without any obstructive effect on the arteries. However, they did not determine the lower limit of compressing pressure. Although three-phase scanning with perfusion and blood pool images was not performed in the mentioned study, the researcher suggested that IPC may increase radiotracer uptake on delayed images [3]. In the current study, all the phases of bone scan including perfusion and blood pool imaging were performed as well as delayed imaging and showed that blood pool of the lower limb can be increased following IPC, especially in the feet which are compressed in longer phases as the compression began at foot area and ended in the same region. Therefore, the foot was compressed more than other parts.

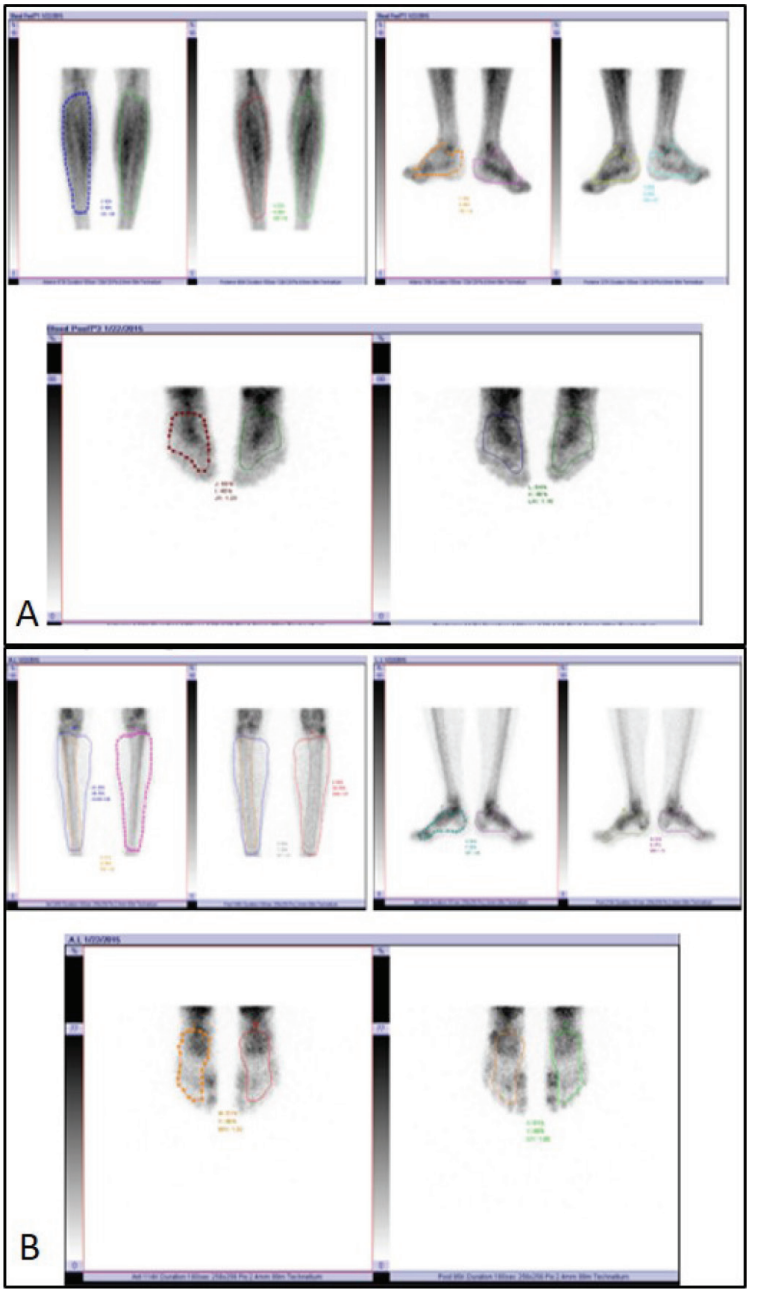

Figure 1. Comparison of tracer activity in the compressed and contralateral legs in a patient in blood pool (A) and delayed (B) images.

In this study, difference of tracer accumulation between compressed and contralateral limbs was only seen in the blood pool images, with no significant difference in MDP uptake in delayed phase. The used IPC device was arranged with consecutive periods of compression and relaxation. Each of these phases was less than 60 seconds. We suggest that apart from the degree of pressure on each compression interval, the length of compression period may have an effect on tracer uptake.

By our used protocol, compression began from foot extending to the calf and thigh. It means that the skin and soft tissue of the foot region were compressed longer than other parts of the limb. This finding again supports this hypothesis that length of compression is an important factor in vascular flow change.

No difference was noted between three groups of patients. It can be concluded that time of compression in relation to radiotracer injection is not an important factor in flow change. Consequently, the only significant usage of compression can be increasing blood flow of compressed limb, before or immediately after chemotherapy with the same results. According to this study, IPC may not be a good method for releasing more chemotherapic drugs, osteoblastic activity rising, or developing bone remodeling. Conduction of another study with larger sample size and longer compression phase may help in achieving more consistent results.

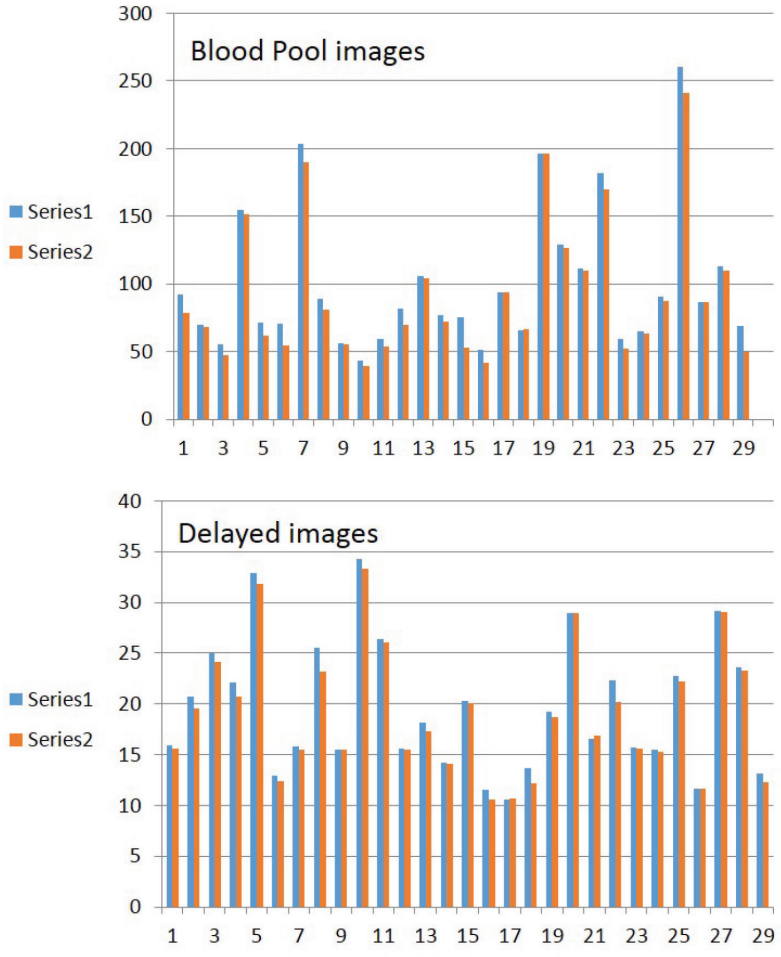

Figure 2. Comparison of blood pool (top) and delayed (bottom) tracer uptake between compressed and uncompressed lower limbs in all 29 patients.

CONCLUSION

Although IPC can significantly increase blood flow of the compressed limb in the first two phases of bone scan, MDP uptake on delayed images was not increased. According to this study, IPC (with compression phase less than 60 seconds) may not be useful as a technique to increase releasing chemotherapy drugs or other substances to the bone and promoting bone growth.

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List of Abbreviations

IPC	Intermittent Pneumatic Compression
VLU	Venous leg ulcer

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Conflict of interests

The authors declare that there is no conflict of interest regarding the publication of this article.

Consent for publication

Written informed consent was obtained from all the participants.

Ethical approval

This study was approved by Ethics Committee, Mashhad University of Medical Sciences, dated: 2013-Apr-08, approval code: 911321.

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