Increased Extremity Uptake on Three-Phase Bone Scans Caused by Peripherally Induced Ischemia Prior to Injection

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During arterial flow scintigraphy, increased tracer uptake in the upper extremity has been noted secondary to induced ischemia distal to blood-pressure cuffs and simple tourniquets, employed prior to the injection. We prospectively studied 68 patients undergoing three-phase bone scintigraphy to evaluate the frequency and magnitude of this artifact. The results showed that when a blood-pressure cuff was applied virtually all patients demonstrated increased activity in the extremity of cuff application. When a simple rubber tourniquet was applied few patients demonstrated the artifact. Only one patient, a case of reflex sympathetic dystrophy syndrome, had increased uptake on blood-pool and skeletal-phase images. We recommend that in flow studies of the hands, wrists, and forearms, blood pressure cuffs not be employed and that at least 3 min should elapse between release of the occlusive device and injection. Asymmetry of flow under these conditions is unlikely to be artifact.

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In triple-phase scintigraphy of the hands, application of either a blood-pressure cuff or a simple tourniquet has been reported to cause an increased ipsilateral activity during the arterial phase on the side to which the cuff or tourniquet was applied (*1–3*). These reports were limited by either a small patient population (*1*) or lack of stipulation as to the duration the blood-pressure cuff or tourniquet was applied prior to release (*2*).

We undertook this investigation to determine the extent to which the type of occlusive device generated the flow artifact, the duration of each device's application necessary to induce the artifact, and whether the increased flow represents artifact or underlying disease.

MATERIALS AND METHODS

Patients were selected from a group of individuals referred for bone scintigraphy for indications not involving the upper extremities, i.e., metastatic surveys or low back pain. Those with clinically obvious hand disease were excluded from the study. Participants were injected by one of four methods.

Group I consisted of 12 patients who were injected in essentially the same fashion as that described by Desai and Intenzo (*2*), i.e., a 19-gauge, 3/4-in butterfly with 12-in of plastic tubing was inserted into an antecubital vein without application of a tourniquet. A blood-pressure cuff was applied to the contralateral arm, inflated to above systolic blood pressure, and immediately lowered to 20 mmHg below systolic pressure. In Group I, however, the cuff remained inflated for 30 sec. Immediately prior to cuff release, 20 mCi of technetium-99m methylene diphosphonate ([^{99m}Tc]MDP) was injected into the antecubital vein. As the cuff was abruptly deflated, the line was flushed with 10 ml of sterile isotonic saline. Serial images of the arterial phase were obtained at 3-sec intervals. Additionally, static images representing the blood-pool phase of both hands were obtained at 1–2 min after injection for 200,000 counts, and skeletal-phase images of both hands were obtained after 3–4 hr for 400,000 counts.

Group II consisted of 12 patients in whom we followed the same protocol as noted above in Group I, except the blood-pressure cuff was inflated for 60 sec.

Group III consisted of 32 patients who were injected according to the method described by Kirsh and Tepperman (*3*). A simple rubber tourniquet was applied for 30 sec or less to the same upper extremity used for injection.

Group IV consisted of 12 patients in whom a simple rubber tourniquet was applied for 120 sec prior to injection, to the upper extremity opposite the upper extremity used for injection.

In Groups III and IV, we reproduced the same degree of tightness of the simple tourniquet as is used routinely in our

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TABLE 1
Patterns of Asymmetry During the Blood-Flow Phase: Application of Blood-Pressure Cuff or Simple Rubber Tourniquet for Various Durations

	Group			
	I	II	III	IV
Asymmetry	Cuff 30 sec	Cuff 60 sec	Tourniquet <30 sec	Tourniquet 120 sec
None	0	1	27	9
Mild	4	4	1	0(2*)
Moderate	4	4	2(2*)	1
Severe	4	3	0	0
Total	12	12	32	12

* Increased activity on side *opposite* application of tourniquet.

clinic. Immediately prior to tourniquet release, the patient's hands were placed palm down on a scintillation camera fitted with a low-energy, all purpose collimator. In Groups III and IV, 20 mCi of [^{99m}Tc]MDP was injected into an antecubital vein, and scintigraphic images were acquired as described for our Group I except that the images during the blood-flow phase were acquired at 5 sec/frame, in order to simulate the technique of Kirsh and Tepperman. In Groups III and IV, blood-pool and skeletal-phase images were obtained as specified in Group I above.

Perfusion images obtained during this study were scored independently by each author and were categorized as follows: none = no discernible asymmetry; mild = slight but definite asymmetry; moderate = definite asymmetry with majority of fingers appearing on one hand before any fingers were visible on opposite hand; severe = marked asymmetry with entirety of one hand visualized before appearance of the opposite hand. In all cases, there was concurrence in the presence or absence of asymmetry. In a few cases, there was slight disagreement in the magnitude of the asymmetry, and in these cases a consensus was reached after discussion. In all cases, the differences were in adjacent categories of asymmetry.

Blood-pool and skeletal-phase images were likewise scored for symmetry versus asymmetry in order to determine whether imaging at these time periods could be used to separate patients with artifactual asymmetric flow studies from patients with pathologic asymmetric flow.

RESULTS

The results of Groups I–IV are shown in Table 1. When a blood-pressure cuff was applied as the occlusive device for 30 sec (Group I), 100% (12 of 12 patients) demonstrated hyperperfusion in the hand of the upper extremity to which the blood pressure cuff had been applied (Fig. 1). As the occlusion was increased to 60 sec (Group II), 92% (11 of 12 patients) also demonstrated the artifact.

Of 32 patients who had a simple rubber tourniquet applied for 30 sec or less (Group III), only 9% (3 of 32 patients) revealed evidence of the artifact. Two other patients (see designated "(2*)" in Group III, Table 1) demonstrated moderately decreased activity on the tourniquet side. In these two patients, one had nontraumatic vascular insufficiency of the upper extremity to which the tourniquet had been applied, as determined by changes in skin temperature and decreased radial pulse. After review of the second patient's study and upon further questioning and physical examination, we concluded that he had reflex sympathetic dystrophy syndrome (RSDS), on the side free of the tourniquet.

In those patients who had a simple tourniquet applied for 120 sec (Group IV), only 8% (1 of 12 patients)

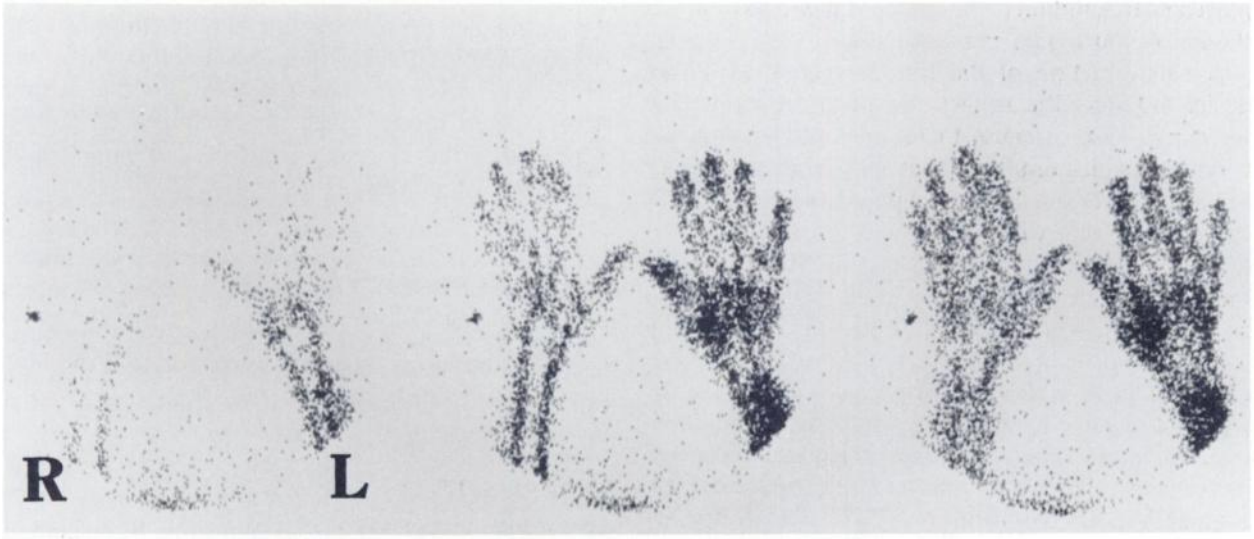

FIGURE 1
Sequential arterial-phase images of the hands (3 sec/frame). Increased activity in left hand (L). Blood-pressure cuff was placed on left arm prior to injection. Injection was made in the right arm.

showed the artifact. Two patients in Group IV showed decreased activity on the side of the tourniquet: one patient had sustained a recent crush injury to the axilla of the upper extremity to which the tourniquet had been applied; the cause of the second patient's mild paradoxical response remains unknown.

With the exception of one patient, all patients in Groups I–IV demonstrated symmetrical activity in the blood-pool and osseous-phase images, discounting minor arthritic changes of the hands and wrists. The patient with RSDS and abnormal arterial asymmetry also demonstrated corresponding abnormalities in the involved hand during subsequent blood-pool and skeletal-phase images.

DISCUSSION

In recent years, there has been an increased use of triple-phase scintigraphy in the diagnosis of musculoskeletal disorders involving the hands and wrists (*4–10*). Recent reports, however, have indicated that use of occlusive devices can cause artifactually increased activity in the upper extremity to which the cuff or tourniquet is applied. Desai and Intenzo reported an increased ipsilateral activity in the hands during the arterial phase in four of four patients who had a blood-pressure cuff applied to an upper extremity, and in one patient who had a simple tourniquet applied (*2*). Kirsh and Tepperman reported increased ipsilateral activity during the flow phase in the hands of 22 of 25 patients who had tourniquets applied (*3*). In the latter report, if the tourniquet was removed for 3 min prior to injection, only four out of 23 patients exhibited asymmetric flow. In both reports, the duration of application of the cuff or simple tourniquet was unspecified, and there appeared no description of the degree of tightness to which the simple tourniquet was applied.

A determination of the time necessary for either device to induce the artifact might provide a guideline for clinical use. Because there are several pathologic conditions which result in unilaterally increased activity in the hands during the arterial phase, the possibility of confusing disease with artifact exists. Of these conditions, the high-flow characteristics of RSDS is the one most likely to be misinterpreted as the artifact described above. Since loss of sympathetic tone and vasodilatation are characteristic of RSDS, the findings of radionuclide angiography in RSDS are indistinguishable from the transient reactive hyperemia caused by induced ischemia. However, blood-pool and skeletal-phase images are virtually always abnormal in RSDS and rarely abnormal in induced ischemia.

The results of our study were in general agreement with those of Desai and Intenzo. Of our 24 patients who had a blood-pressure cuff applied to an upper extremity, 23 patients exhibited increased activity on the side to which the cuff was applied. Whereas their *early* blood-pool images showed the artifact, their second blood-pool images at ~1–2 min were normal, as were our blood-pool images, acquired at 1–2 min.

After obtaining the results of Group III, we increased the duration to 120 sec (Group IV), anticipating a greater frequency and magnitude of artifact. The longer duration of tourniquet application did not result in either a greater frequency or magnitude of asymmetry. Only 9% of Groups III and IV (4 of 44 patients) had an asymmetric pattern involving lateralization to the side of tourniquet application. Thus less than 10% of patients demonstrated asymmetry resulting from the use of a simple rubber tourniquet.

The ischemic artifact appears to be related to the relatively greater arterial resistance, ischemia, and resulting hyperemia, caused by a blood-pressure cuff as compared to a simple rubber tourniquet, the latter impeding only superficial venous flow. The striking difference between our results and those of Kirsh and Tepperman (*3*) might be attributed to differences in the duration of tourniquet application, use of a dissimilar tourniquet, or a difference in the force used to apply the tourniquet.

Our results indicate that use of a blood-pressure cuff prior to arterial injection of a radiopharmaceutical virtually always induces the artifact. Therefore, use of a blood-pressure cuff placed on the arm prior to triple-phase scintigraphy of the hands, wrists, and forearms should be avoided. However, use of a simple rubber tourniquet for short periods of time is unlikely to result in ischemia and subsequent artifact during triple-phase scintigraphy of the same anatomic sites. Because of the possibility of inducing the artifact in any one given patient, we concur with the recommendation of Kirsh and Tepperman (*3*) that waiting 3 min after releasing the tourniquet before injecting should minimize the ischemic artifact. Finally, if diffuse abnormalities of the hands and wrists are noted on the blood-pool and skeletal-phase images, such abnormalities cannot be attributed to the tourniquet artifact, and pathological conditions should be sought.

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