Arm Vein Uptake of Thallium-201 During Exercise: Incidence and Clinical Significance

Rami Gal and Steven C. Port

Nuclear Cardiology Laboratory, Mount Sinai Medical Center, University of Wisconsin Medical School, Milwaukee Clinical Campus, Milwaukee, Wisconsin

We prospectively analyzed several clinical and technical variables that might be associated with arm vein uptake of ^{201}Tl during stress thallium scintigraphy in 63 patients. The influence of site (medial antecubital vs. other vein) and technique (with or without a 15-cc saline flush) were examined. Arm vein uptake was not seen after medial antecubital injections except in one case injected through a 24-hr-old indwelling catheter. Arm vein uptake was seen in 24/45 (53%) of cases injected into veins other than the medial antecubital. A saline flush did not reduce the incidence of arm uptake. In patients with normal myocardial studies, those with positive arm uptake had 33% lower net myocardial counts on the postexercise images ($p = 0.00008$) and 20% lower net myocardial counts on the delayed images ($p = 0.04$). Myocardial washout of thallium was significantly ($p = 0.009$) slower in those with arm uptake.

J Nucl Med 27:1353–1357, 1986

Thallium-201 (^{201}Tl) myocardial perfusion imaging has achieved widespread application for the diagnosis and management of patients with chest pain or known coronary artery disease. Although considerable attention has been paid to the techniques of data acquisition and data processing, little if any mention has been made of the significance of the site and manner in which the radionuclide is injected during exercise (*1–9*). We have frequently noticed significant activity in the veins of the arm in which the ^{201}Tl was injected during exercise. The arm activity has been present on both the immediate postexercise and delayed images. Consequently, we undertook a prospective study of this phenomenon in an effort to (a) define its frequency, (b) discover any predisposing clinical factors, (c) investigate the roles of the site and manner in which the radionuclide was injected, and (d) determine its significance.

PATIENTS AND METHODS

Study Group

We prospectively studied 63 patients referred for routine exercise thallium myocardial perfusion imaging between January 1, 1985 and April 15, 1985. Patients were selected at random according to the volume of clinical studies on a given day. The 63 patients in the study represent ~¼ of the total number of patients having stress thallium studies during the 10 weeks of recruitment. The group was comprised of 46 males and 17 females age 40 to 75 yr (mean 60 yr). A detailed history was obtained with questions specifically addressed to clinical variables that might affect the peripheral venous system (Table 1).

Thallium Injection Technique

The thallium injection site varied randomly as was typical of our laboratory. An arm vein was used in all cases but the choice of medial antecubital vs. other veins was based on availability and suitability as judged by the technologist. A 20-gauge 1¼-in. cannula was inserted prior to exercise. In seven patients, a cannula that had been in place for at least 24 hr was used. The injection consisted of 2–3 mCi of [^{201}Tl]chloride loaded in a 5-cc syringe. It was injected as a bolus after which blood was withdrawn into the syringe and injected to ensure delivery of all the radionuclide. The latter procedure was performed two to three times for each injection and followed by a saline drip. In 20 patients chosen at random, 15–20 cc of saline were used as a flush after the thallium was injected. The right arm was used in 43 patients and the left arm in 20. The medial antecubital vein was used in 18 patients and other veins in the arm or hand in 45. In no cases was there evidence of extravasation of the radionuclide. The cuff for blood pressure monitoring was always placed on the arm not used for the thallium injection.

Data Acquisition

A large field-of-view single crystal gamma camera was used in all patients. The acquisition matrix was 128 × 128 and 500,000 counts were acquired in each view after exercise. Three views were obtained: an anterior, a 30°–45° left anterior

Received Aug. 5, 1985; revision accepted Jan. 15, 1986.

For reprints contact: Steven C. Port, MD, Mount Sinai Medical Center, P.O. Box 342, Milwaukee, WI 53201.

TABLE 1
Relationship of Clinical Variables to Arm Vein Uptake of Thallium

Historical variables	Arm vein uptake of thallium: Present (n = 25)	Absent (n = 38)
Previous catheterization or cannulation of arm used for injection	8	12
History of arm or shoulder trauma	1	4
History of peripheral venous disease	3	4
History of pulmonary disease	3	3
History of diabetes	1	5
History of congestive heart failure	0	0
History of smoking	9	28*
History of breast surgery (females)	0	0

* $p < 0.01$ Compared with group with arm uptake.

oblique (LAO) (best septal view), and a 60°–75° LAO view. Delayed images were acquired 3 hr later. Each delayed view was acquired for the same amount of time as its corresponding postexercise view. In all patients, images of the arm injected were acquired after the immediate postexercise myocardial images at an average of 20 min after the radionuclide was injected. In seven patients, delayed images of the arm were also acquired.

Data Processing

All images were subjected to a modification of the quantitative circumferential profile analysis described by Maddahi et al. (*5*) and others (*10*). Unprocessed images were displayed and interpreted on the 512 × 512 display monitor of the gamma camera computer. Clinical interpretation was made using both the qualitative and quantitative data. There were 35 patients with abnormal and 28 with normal studies.

In addition, the 28 studies that were free of myocardial perfusion abnormalities were subjected to further processing. A circular region of interest (ROI) was placed around the uncorrected LV image in the shallow LAO view. A 1-pixel-wide circular background ROI was placed around and separated from the LV ROI by 1 pixel. Average cts/pixel in the two ROIs were calculated and the background cts/pixel were subtracted from the LV ROI cts/pixel to give net myocardial cts/pixel. Tracer washout was calculated as (postexercise LV counts)–(delayed LV counts)/(postexercise LV counts).

RESULTS

Of the 63 patients in the study, 25 had unequivocal arm vein uptake of thallium. The intensity and distribution varied considerably (Fig. 1). None of the clinical variables in the history correlated with the presence of arm uptake. Smoking was less common in patients with arm vein uptake than in those without arm uptake ($p < 0.01$, chi-squared).

As seen in Table 2, thallium injection into veins other than the medial antecubital vein resulted in arm vein uptake in 24/45 (53%) cases. In contrast, only 1/18 (5%) of patients

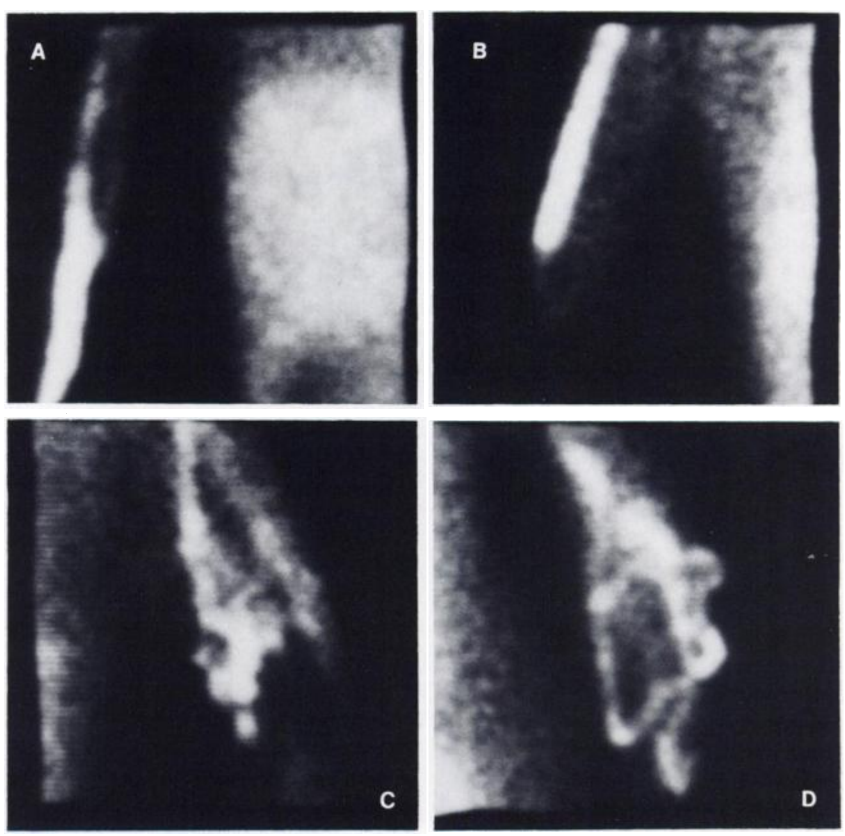

FIGURE 1
Typical examples of arm vein uptake of thallium on immediate postexercise images. A: Wrist injection; B: Lateral cubital vein; C: Small upper arm vein; D: Forearm vein injection

TABLE 2
Technical Variables Associated with Arm Vein Uptake of Thallium

Item	Arm vein uptake of thallium: Present (n = 25)	Absent (n = 38)
Medial antecubital vein	1	17
Other arm vein	24*	21
Saline flush	7	5
No saline flush	17	16
Existing i.v. line 24 hr (one medial, six peripheral)	6†	1
Right arm	14	29
Left arm	11	9

* $p < 0.001$, Chi-squared compared with medial antecubital vein.
† $p < 0.01$, Chi-squared compared with those without an i.v. line 24 hr.

with medial antecubital injections had arm vein uptake ($p < 0.001$, chi-squared). The one patient with arm vein uptake after a medial antecubital injection had the ^{201}Tl injected through a pre-existing indwelling cannula present for 72 hr. In fact, 6/7 (86%) of patients injected through an indwelling cannula that had been in place for 24 hr or more had arm vein uptake compared with 19/56 (34%) in whom the cannula was inserted immediately prior to exercise ($p < 0.01$, chi-squared). Injection of the right or left arm did not make a significant difference, although 55% of the left arm injections showed arm vein uptake compared with 33% of the right arm injections. The use of a 15–20-cc saline flush did not appear to influence the occurrence of arm vein uptake. In 13 of the 25 patients with arm uptake, the site of injection was in the field-of-view and in no case was there evidence of extravasation.

The exercise effort did not appear to influence the occurrence of arm vein uptake. The exercise duration was 435 ± 82 sec in patients without and 423 ± 90 sec in those with arm vein uptake (p = N.S.). Neither the peak heart rate (160 ± 26 vs. 157 ± 22) nor the peak systolic pressure (199 ± 35 vs. 208 ± 39) was significantly different in those without and those with arm vein uptake, respectively.

The cts/pixel in the LV and background ROIs are shown in Table 3 for the 28 patients without myocardial uptake or washout abnormalities. Postexercise, average net myocardial cts/pixel were 33% lower in the patients with arm vein uptake ($p = 0.00008$) compared with those without arm vein uptake. On the delayed images, the average net myocardial cts/pixel were 20% lower in those with arm vein uptake compared with those without arm vein uptake ($p = 0.04$). The washout rate of myocardial thallium was 48.0 ± 9.2% in those without arm vein uptake compared with 36.0 ± 15.3% in those with arm vein uptake ($p = 0.009$).

There were 11 patients without any perfusion abnormalities who had arm vein uptake. Seven of those 11 had both stress and delayed images of the arm with the uptake (Fig. 2). In the 4/7 cases where the arm vein activity was still present on the delayed images, myocardial washout averaged 41%. In the 3/7 cases where the arm vein activity was not seen on the delayed images, myocardial washout averaged 30%.

DISCUSSION

The results of this study show that i.v. injection of [^{201}Tl]chloride into arm veins other than the medial antecubital vein can result in significant residual arm activity on both postexercise and delayed images. The activity is located proximal to the site of injection and appears to be localized to the venous or perivenous tissue. The present study was not designed to determine the exact location of the arm uptake but rather to document its occurrence, possible causes, and significance. In a preliminary report, Silberstein and Robbins previously described localization of thallium in the iliac vein after ipsilateral femoral vein injection in rats (*11*). In that same report, Silberstein and Robbins noted arm uptake in patients during exercise and at rest even after injection into the medial cubital vein. Insufficient information is available from that report to explain the contrary findings.

In addition to the dramatic difference in occurrence of arm vein uptake between medial antecubital and

TABLE 3
Influence of Arm Uptake on Myocardial Uptake and Washout of Thallium

	Stress			Redx			
	LV ROI (cts/pixel)	Bkd ROI (cts/pixel)	Net LV (cts)	LV ROI (cts/pixel)	Bkd ROI (cts/pixel)	Net LV (cts)	LV (%) washout
No arm uptake (n = 17)	79.0 ±8.2	51.4 ±5.2	27.5 ±5.2	48.6 ±9.5	34.2 ±6.8	14.4 ±4.0	48 ±9.2
Arm uptake (n = 11)	65.6 ±7.9	47.1 ±5.0	18.5* ±5.3	45.0 ±5.8	33.5 ±2.9	11.5† ±3.9	36‡ ±15.3

* $p = 0.00008$ Compared with no arm uptake group.
† $p = 0.04$ Compared with no arm uptake group.
‡ $p = 0.009$ Compared with no arm uptake group.

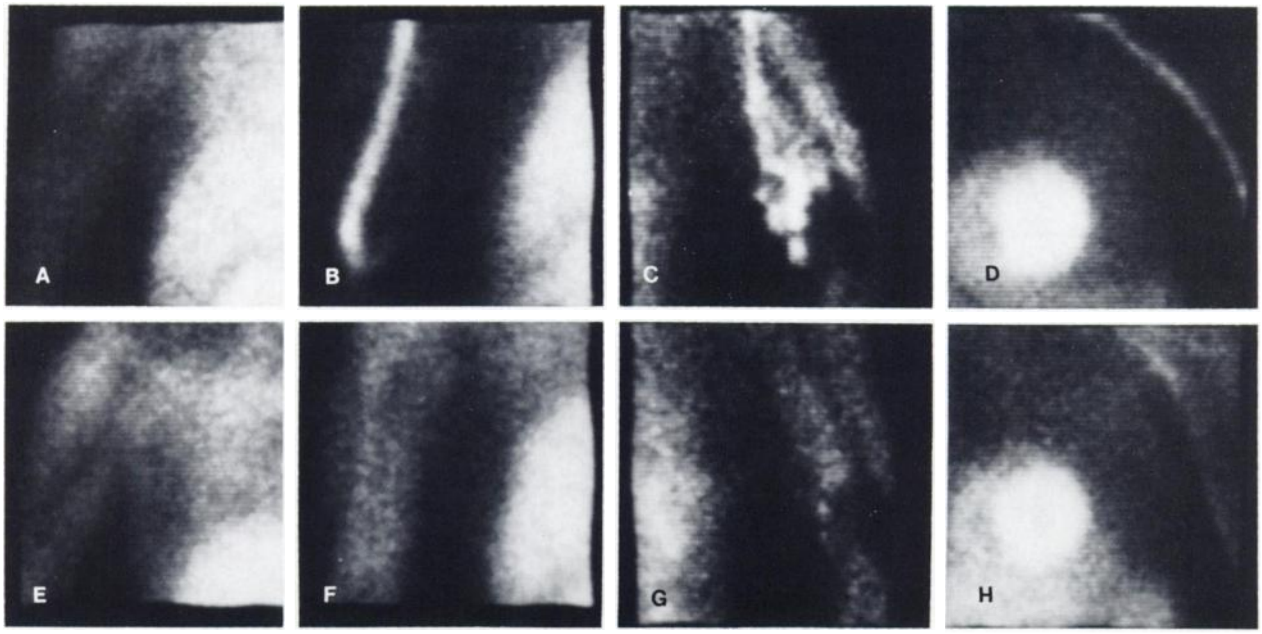

FIGURE 2
Postexercise (A–D) and delayed (E–H) images in cases with (from left to right) no arm vein uptake, arm vein uptake with complete clearance at 3 hr and two cases with arm vein uptake and partial clearance at 3 hr

other arm vein injections, there was an 86% incidence of arm uptake when the radionuclide was injected into an i.v. cannula that had been in place for at least 24 hr. In fact, the only medial antecubital vein injection that resulted in arm vein uptake was one made into a cannula placed 72 hr prior to the exercise test. The use of a 15–20-cc saline flush did not appear to influence the occurrence of arm vein uptake after peripheral injections.

No clinical variables were associated with arm vein uptake of thallium. In our limited study, there were fewer smokers in those with arm vein uptake than in those patients without arm vein uptake. The significance of the latter is unclear.

The uptake of thallium in the arm is not a trivial finding. In this study, arm vein uptake was associated with 33% lower average myocardial cts/pixel after background correction compared with those found in patients without arm uptake. Similarly, there were 20% fewer net myocardial cts/pixel in the delayed images in those patients with arm vein uptake.

In addition, and perhaps most importantly, myocardial washout rates were slower in patients with arm vein uptake. The latter could result in erroneous clinical interpretation of the data. It is interesting to note that the myocardial washout appeared slowest (30%) when the arm vein uptake completely cleared by the time of the delayed images in contrast to the 41% myocardial washout when the arm vein activity was still present on the delayed images. The group without any arm vein uptake showed 48% washout. Those data suggest that the slower myocardial washout in patients with arm vein uptake may be due to a slow, constant infusion of thallium into the blood stream from the arm during the redistribution period. The more rapid that infusion, the slower the myocardial washout since myocardial activity tends to equilibrate with blood-pool activity over time.

In summary, our results show that the injection of ^{201}Tl into upper extremity veins other than the medial antecubital vein frequently results in the retention of a significant amount of the radionuclide within the veins or lymphatics of the arm injected. The latter can produce a significant compromise of myocardial statistics and appears to be associated with a slower myocardial washout of thallium.

REFERENCES

1. Massie BM, Botvinick EH, Brundage BH: Correlation of thallium-201 scintigrams with coronary anatomy: Factors affecting region by region sensitivity. *Am J Cardiol* 44:616, 1979
2. Kirshenbaum HD, Okada RD, Boucher CA, et al: Relationship of thallium-201 myocardial perfusion pattern to regional and global left ventricular function with exercise. *Am Heart J* 101:734, 1981
3. Wackers FT, Sokole EB, Samson G, et al: Value and limitations of thallium-201 scintigraphy in the acute phase of myocardial infarction. *N Engl J Med* 295:1, 1976
4. Iskandrian AS, Hakki AH: Thallium-201 myocardial scintigraphy. *Am Heart J* 109:113, 1985
5. Maddahi J, Garcia EV, Berman DS, et al: Improved non-invasive assessment of coronary artery disease by quantitative analysis of regional stress myocardial distributions and washout of thallium-201. *Circulation*

64:924, 1981
6. Wainwright RJ, Maisey MN, Sowton E: Segmental quantitative analysis of digital thallium-201 myocardial scintigrams in diagnosis of coronary artery disease. *Br Heart J* 46:478, 1981
7. Gibson RS, Watson DD, Craddock GB, et al: Prediction of cardiac events after uncomplicated myocardial infarction: A prospective study comparing predischarge exercise thallium-201 scintigraphy and coronary angiography. *Circulation* 68:321, 1983
8. McCarthy DM, Blood DK, Sciacca RR, et al: Single dose myocardial perfusion imaging with thallium-201: Application in patients with nondiagnostic electrocardiographic stress tests. *Am J Cardiol* 43:899, 1979
9. Hammond HK, Kelly TL, Froelicher VF: Non-invasive testing in the evaluation of myocardial ischemia: Agreement among tests. *J Am Coll Cardiol* 5:59, 1985
10. Wackers FT, Fetterman RC, Mattera JA, et al: Quantitative planar thallium-201 stress scintigraphy: A critical evaluation of the method. *Semin Nucl Med* 15:46, 1985
11. Silberstein EB, Robbins PJ: Thallium-201 venography. *J Nucl Med* 21:P34, 1980 (abstr)