

Adsorption of Some Technetium-99m Radiopharmaceuticals onto Disposable Plastic Syringes

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Objective: The purpose of this study was to determine the adsorption behavior of some widely used, commercially available ^{99m}Tc radiopharmaceuticals onto different types of plastic syringes.

Methods: Kits were reconstituted with ^{99m}Tc -pertechnetate diluted with 0.9% saline to produce maximum radioactive concentrations, as stated by the manufacturers. Aliquots of the solutions were transferred to four different brands of 2-ml syringes. The activity in the syringes was measured before and after injections or simulated injections. The amount adsorbed to the plastic syringe barrel and plunger before and after washout also was measured at different time intervals. Comparisons between products from different manufacturers were made for ^{99m}Tc succimer (DMSA) and ^{99m}Tc macroaggregated albumin (MAA).

Results: Some ^{99m}Tc preparations undergo significant adsorption to plastic syringes. Adsorption differs considerably between products from different manufacturers. There was significantly higher residual activity in some types of syringes. In some cases the residual was as high as 40%–50% of the initial activity, and most of the adsorption occurred within 15 min of filling the syringe.

Conclusion: The data suggest that the extent of adsorption depends on pharmaceutical excipients in the kits and/or the type of syringe used. When inappropriate syringes are used, the reduction in the administered activity may result in poor-quality images. Therefore, the compatibility between radiopharmaceutical and syringe should be investigated under normal conditions of preparation and use every time a new brand of syringe or a new radiopharmaceutical comes into use in diagnostic nuclear medicine.

Key Words: adsorption; adsorption; plastic syringes; technetium-99m radiopharmaceuticals

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A good-quality nuclear medicine examination is the result of optimizing each step from the hardware, such as the gamma camera, to the software, including information. One compo-

nent is the quality of the image which, in part, is dependent on the registered counts in the areas of interest compared with the background counts. The registered counts depend partly on the injected activity.

The radiation burden to the patient should be minimized. However, a certain minimum activity is necessary for each examination. In our institution we have protocols stating the activity in MBq which is to be administered for each examination.

When examining children we follow the EANM Pediatric Task Group recommendations. Since the child has to lie still we must minimize the examination time by using as high activity as acceptable without exceeding the limit for radiation exposure.

The radiation exposure to adults also should be as low as possible. When minimizing the dose to be administered it is of paramount importance that the entire quantity is used for the examination.

We assumed that the patient received all of the activity drawn up into the syringe, but after getting some poor-quality images with a new myocardial agent intended for use in diagnostic nuclear medicine, we found out that this was not true.

TABLE 1
Syringes Included in This Study

Name	Material		
	Barrel	Plunger	Lubricant
Becton Dickinson*			
Plastipak (BD-3)	Polypropylene	Latex	Silicone oil
Discardit (BD-2)	Polypropylene	Polyethylene	TiO ₂
Codan Once (CO)**	Polypropylene	Silicone ring	Silicone oil
Braun Injekt (BI)†		Polyethylene	
	Polypropylene	(HDPE)	—

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TABLE 2
Radiopharmaceuticals Included in This Study

Generic name	Abbreviation
^{99m}Tc -succimer	DMSA (A) DMSA (B)
^{99m}Tc -furifosmin	Furifosmin
^{99m}Tc -oxidronate	HDP
^{99m}Tc human serum albumin	HSA
^{99m}Tc macroaggregated albumin	MAA (A), MAA (B), MAA (C), MAA (D)
^{99m}Tc -tiatide	MAG3
^{99m}Tc -albumin colloid	MIC
^{99m}Tc -sestamibi	Sestamibi
^{99m}Tc -tetrofosmin	Tetrofosmin

MATERIALS AND METHODS

This study included 2-ml disposable plastic syringes of four different types, one of which was lubricant-free (Table 1). The adsorption behavior of nine different types of ^{99m}Tc preparations was studied under varying experimental conditions. Technetium-99m-pertechnetate was used as a control. Three different myocardial agents were studied: DMSA from two manufacturers and MAA products from four manufacturers

were compared. The radiopharmaceuticals included in the study are listed in Table 2.

The kits were prepared according to the respective manufacturer's instructions, by the addition of sodium pertechnetate from a $^{99}\text{Mo}/^{99m}\text{Tc}$ generator (UltraTehneKow FM, Mallinckrodt, Inc. B.V., Petten, The Netherlands) and diluted with 0.9% saline for injection when necessary.

After preparation 2-ml aliquots were transferred to 2-ml syringes, which were emptied within 15 min or at different time intervals (up to 6 hr) after dispensing. Total activity of the subdispensed aliquots was measured immediately after dispensing and after emptying the syringe. The activity retained was expressed as a percentage of the total activity in the syringe and statistical analysis of the experimental data was performed by Student's t-test using a significance level of 0.05. The measurements were made in connection with examinations when the dose was administered to the patient or after simulated injections in which the dose was allowed to be drawn into an empty elution vial under negative pressure.

RESULTS AND DISCUSSION

Many studies have been performed to investigate the properties of pharmaceuticals stored under various conditions.

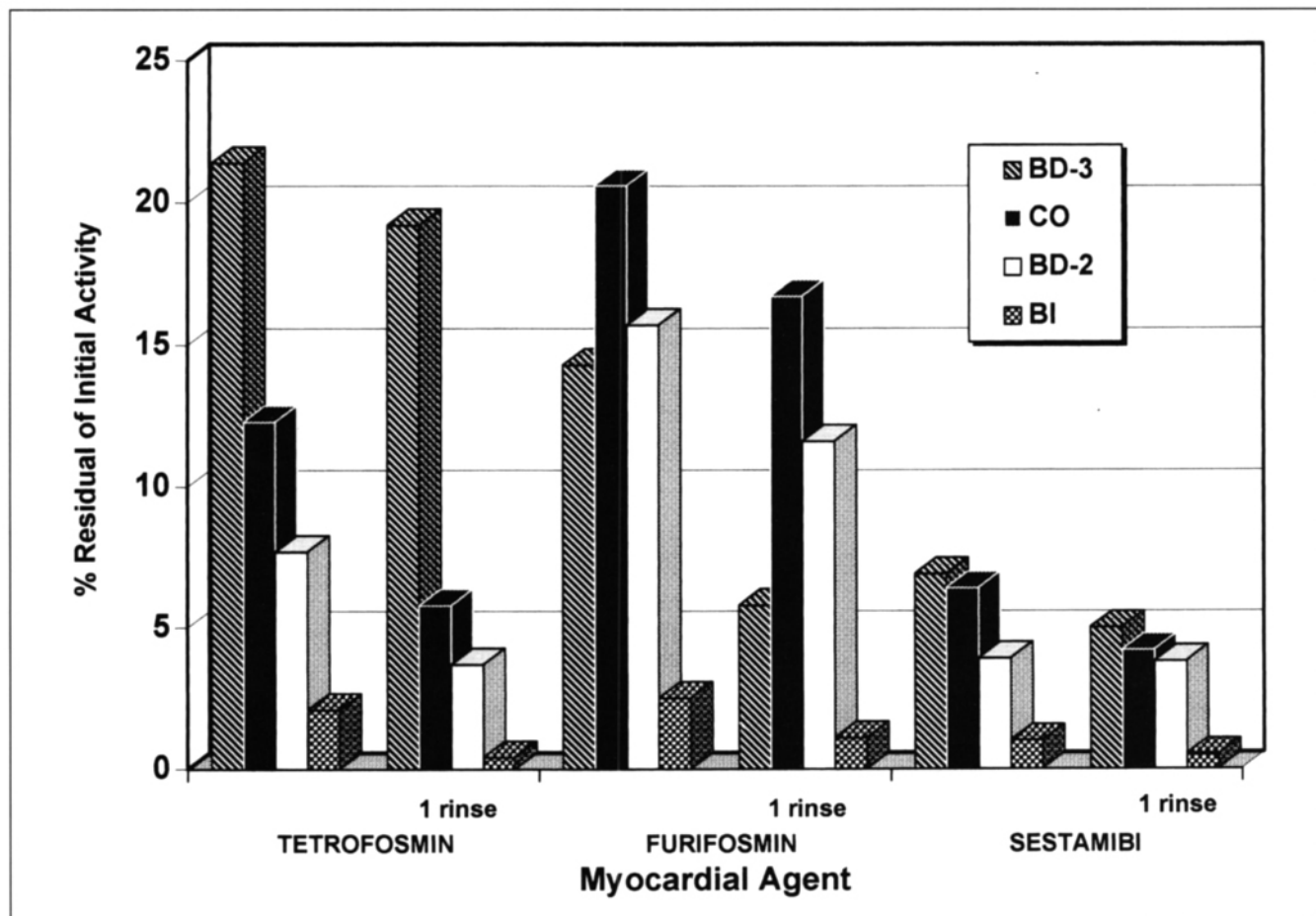


FIGURE 1. Adsorption of three technetium-99m myocardial agents onto disposable plastic syringes.

However, the effect of material in syringes mainly has focused on differences between glass and plastic syringes.

In measuring blood gases Muller-Plathe and Heyduck (1) observed that pO_2 generally is unstable in plastic syringes and, therefore, must be analyzed within 15 min after sampling. Pecosky et al. (2) showed that calcitriol has a greater affinity for polyvinyl chloride than for polypropylene.

Bis(2,2,6,6-tetramethyl-4-piperidiny)sebacate (BTMPS) is a light and radiation stabilizer used as an additive to medical plastics. Neuronal nicotinic receptor subunits are inhibited for 1–4 hr by BTMPS. Papke et al. (3) warned that erroneous interpretation regarding nicotinic receptors may result from BTMPS released from certain plastic syringes.

It is well known that some products, such as proteins, present stability problems if kept for a long period of time in plastic syringes. Particle suspensions, such as microspheres and micro- and macroaggregated serum albumin, should not be kept in syringes for long periods of time as the particles may be taken up by lubricants in the syringes (4).

In 1984 Millar (5) reported on the adsorption of ^{99m}Tc DMSA onto injection vials and later Miller and Stewart (6) investigated the adsorption of several commercially available radiopharmaceuticals onto injection vials. Their results were disputed by Palmer (7) who found lower adsorption in similar experiments, particularly for the CIS brand of MAA.

A group at Östra sjukhuset in Gothenburg, Sweden (8,9) investigated the adsorption pattern of ^{99m}Tc DMSA from

TABLE 3
Adsorption of Three Myocardial Agents onto Four Types of Syringes*

Syringe	% Residual of the initial activity		
	Tetrofosmin	Furifosmin	Sestamibi
BD-3			
15 min	21.4 ± 5.1 (22)	14.3 ± 5.6 (31)	6.9 ± 2.0 (8)
6 hr	24.2 ± 6.5 (6)	25.6 ± 6.2 (7)	6.7 ± 1.6 (7)
CO			
15 min	12.3 ± 4.4 (16)	20.6 ± 4.5 (10)	6.4 ± 1.1 (11)
6 hr	16.7 ± 6.0 (6)	28.3 ± 4.5 (7)	6.0 ± 1.8 (6)
BD-2			
15-min	7.7 ± 3.2 (12)	15.7 ± 2.9 (8)	3.9 ± 0.8 (5)
6 hr	8.2 ± 2.3 (6)	15.9 ± 1.4 (7)	3.5 ± 0.7 (5)
BI			
15 min	2.1 ± 1.0 (29)	2.5 ± 0.8 (16)	1.0 ± 0.1 (5)
6 hr	2.8 ± 1.0 (8)	3.2 ± 0.8 (6)	1.5 ± 0.5 (5)

*All values are expressed as mean ± s.d.
(n) = Number of measurements.

two manufacturers onto the Codan Once syringe. They concluded that DMSA adsorbs onto plastic syringes, an effect that increases with time. This must be corrected for when the amount of radioactivity to be dispensed is calculated, and the correction must be reevaluated if the type of syringe is changed. Gunasekera et al. (10) found significantly higher

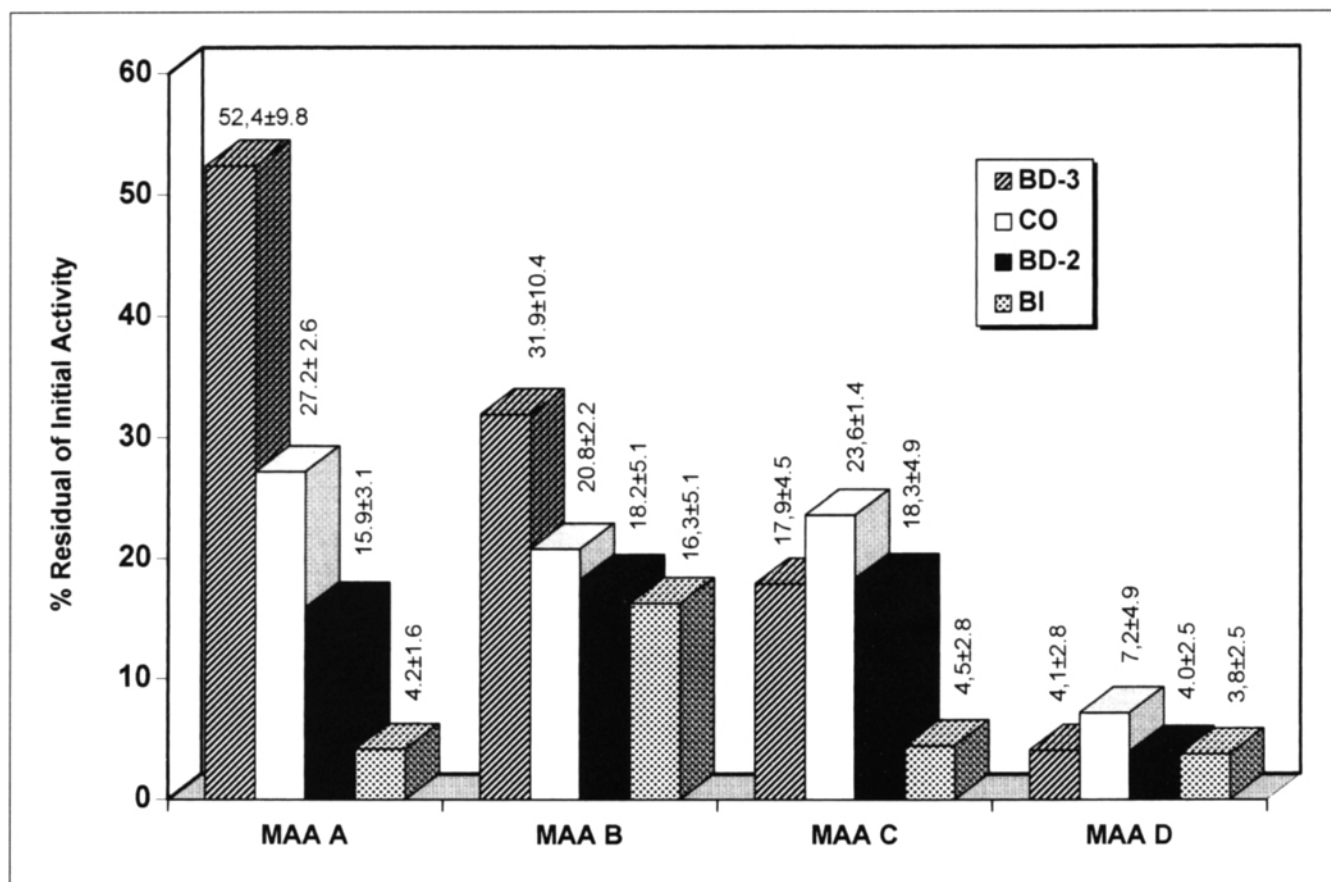


FIGURE 2. Adsorption of four MAA kits onto disposable plastic syringes.

TABLE 4
Adsorption of Six Commercially Available Radiopharmaceuticals onto Plastic Syringes

Radio-pharmaceutical	Syringe:	% Residual of initial activity								
		3	BD-		Once		BD-2		BI	
			Time kept in syringe:	15 min	6 hr	15 min	6 hr	15 min	6 hr	15 min
DMSA(A)		1.9	3.5	3.0	4.2	2.2	4.8	2.2	3.5	
DMSA(B)		5.5	12.5	6.0	11.0	5.9	9.6	4.6	9.8	
HDP		2.0	2.8	1.9	2.0	2.2	2.4	2.0	1.8	
HSA		2.8	3.1	2.5	2.3	2.7	2.2	2.6	4.1	
MAG3		2.5	2.5	3.2	5.3	3.1	3.5	2.4	3.1	
MIC		1.8	7.5	2.5	7.6	2.0	5.0	2.6	6.5	

residual activity after tetrofosmin injections in two out of three brands of syringes.

We compared three commonly used myocardial agents. As can be calculated from Table 3, there is significantly ($p < 0.05$) less sestamibi residual activity compared to tetrofosmin and furifosmin in all types of syringes tested. However, retention of activity was generally very low in the BI syringe with a worst case (furifosmin stored in the syringe for 6 hr) of $3.2 \pm 0.8\%$ of the initial activity. Adsorption of furifosmin onto BD-3 and CO syringes increases significantly with time. With tetrofosmin the increase over time is nonsignificant. With sestamibi the adsorption to all types of syringes is low and occurs within 15 min of preparing the injection. Rinsing the syringes once with 2 ml of saline after injection resulted in release of some activity from all types of syringes (Fig. 1).

Most of the activity (80%–85%) was absorbed onto the plungers with the myocardial agents. But with particle suspensions, such as MAA, the barrels absorb more than the plungers.

The results of the tests with four commercially available MAA kits are given in Figure 2. The significantly highest residual activity of all (52%) was found in the BD-3 syringe with MAA from Manufacturer A. The CO syringe absorbs significantly more of MAA (A) than the BD-2 syringe, which in turn absorbs more than the BI syringe.

The manufacturer of MAA (D) solved the problem of adsorption by adding an effective surfactant to the product. Therefore the adsorption of MAA (D) onto all types of syringes is low. Adsorption to the BD-3, CO and BD-2 syringes is significantly lower than with the other macroaggregates. Dilution of MAA particles did not alter the extent of absorption observed. For example, dispensing 300,000 particles of MAA (C) in a BD-3 syringe resulted in an adsorption of $46.9 \pm 7.2\%$. With 150,000 particles the adsorption was $52.4 \pm 9.8\%$ and with 75,000 particles adsorption was $48.0 \pm 10.1\%$.

When studying the adsorption behavior of DMSA from two manufacturers, we found a twofold increase in activity in all syringes when using DMSA (B) compared to DMSA (A). The

results are tabulated in Table 4 together with the results from the HSA, HDP, MAG3 and MIC studies. All of these kits are retained in the syringes only to a minor extent when measured after emptying the syringes 15 min after dispensing. DMSA (A), HDP, HSA and MAG3 did not show any increase of adsorption after 6 hr storage in the syringes, while DMSA (B) and MIC showed significantly higher adsorption to all types of syringes.

CONCLUSION

Plastic materials are not inert substances under all conditions of use. One must be aware of the risk of adsorption of product constituents among other unacceptable characteristics of certain plastic formulations. Therefore, the need to determine the compatibility of a plastic syringe with the kit formulation cannot be overstated.

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