

A study of technetium-99m wastage in selected private sector nuclear medicine imaging departments

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Background South African nuclear medicine imaging departments have been fortunate in being able to receive an uninterrupted supply of molybdenum-99 (⁹⁹Mo)/technetium-99m (^{99m}Tc) generators. Nuclear medicine radiographers practising in private sector services in the northern Gauteng region indicated a possible problem with the quantities of wasted and unused ^{99m}Tc radiopharmaceuticals returned to the radiopharmaceutical supply laboratory. Daily radiopharmaceutical deliveries are a combination of ordered packages and standard packages. The purpose of the standard package is to accommodate emergency and after-hours nuclear medicine services. The purpose of the study was to interrogate the unconfirmed reports of ^{99m}Tc radiopharmaceutical wastage.

Methods A descriptive quantitative research design was conducted in six private sector nuclear medicine imaging practices in the northern Gauteng region. Overt observations of the quantities of radiopharmaceutical supply, usage and wastage were conducted over 2 days in each of these practices.

Results Ordered packages comprised 14% of the total ^{99m}Tc radiopharmaceutical deliveries to these six nuclear medicine imaging departments. It was identified that: (1) a total of 83.2% of ordered packages and 35.1% of standard packages of preprepared syringes were

utilized; (2) a total of 36% of ordered packages and 22.6% of standard packages of bulk ^{99m}Tc were utilized; and (3) a total of 70.6% of the total quantity of radiopharmaceuticals was returned to the radiopharmaceutical laboratory. The total wastage represented 45.5% of the ordered packages and 75.8% of the standard packages.

Conclusion Wastage of 74 GBq of ^{99m}Tc from six sites over 12 days should raise concerns for the nuclear medicine industry. A review of the system framework that supports communication between the radiopharmaceutical supplier/s and the nuclear medicine imaging practices is recommended.

Keywords: monitoring ^{99m}Tc clinical wastage, preprepared ^{99m}Tc syringe utilization, ^{99m}Tc after-hours supply, ^{99m}Tc clinical supply chain, ^{99m}Tc ordering

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Introduction

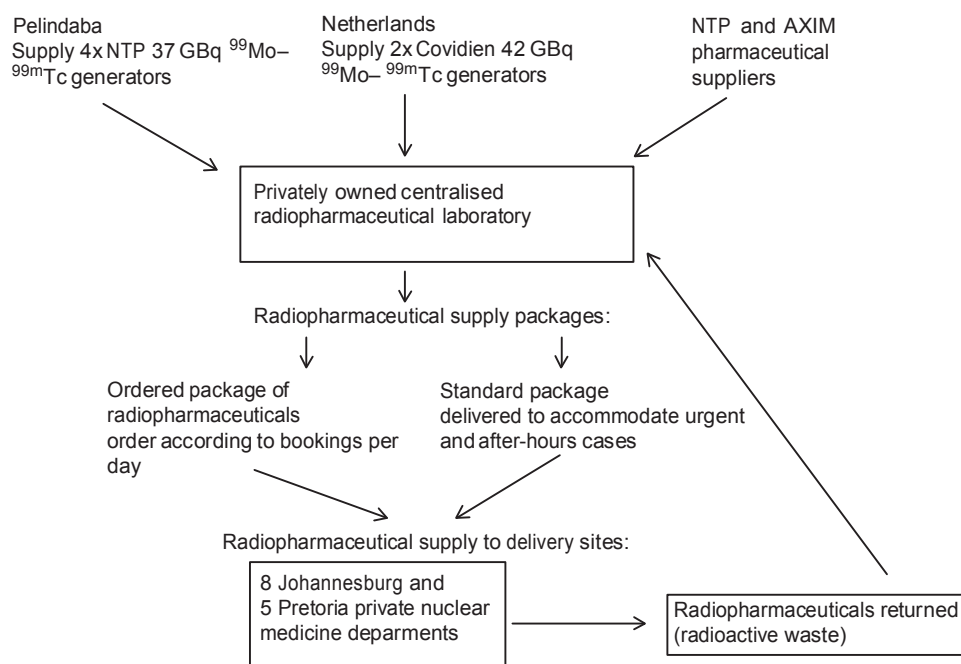
Between 1997 and 2009, numerous international disruptions in nuclear reactor production of molybdenum-99 (⁹⁹Mo) were reported as adversely affecting nuclear medicine patient services in a number of countries [1,2]. In 2009, the Pelindaba nuclear reactor in South Africa was reported as having the highest number of ⁹⁹Mo production days compared with that of other main reactor international sites [1]. Thus, an uninterrupted daily supply of technetium-99m (^{99m}Tc) through ⁹⁹Mo generators and ^{99m}Tc radionuclide preprepared syringes and vials to nuclear medicine imaging departments in public and private sector hospitals in South Africa was sustained [3]. Although the high flux reactor in Petten, the Netherlands, and the National Research Universal reactor in Chalk River, Canada, were restarted in 2010, the Radiological Society of North America expressed concern that 'the world remains vulnerable to a future short-fall of Molybdenum-99' [4]. Figure 1 provides an overview of the ⁹⁹Mo supply to the local radiopharmaceutical laboratory and the subsequent ^{99m}Tc supply to private nuclear

medicine practices in the central and northern Gauteng region. The daily radiopharmaceutical deliveries consist of ordered packages (OPs) and standard packages (SPs).

The quantity and composition of OPs are determined according to the daily number of booked nuclear medicine examinations. The SPs are determined by each nuclear medicine department's management and is based on the weekly nuclear medicine examination profile per department. The purpose of the SP is to accommodate 'walk-in', urgent or after-hours patients. Table 1 provides an overview of the routine ^{99m}Tc ordering and delivery routine to the nuclear medicine departments from the radiopharmaceutical laboratory.

During 2011, anecdotal reports were received from nuclear medicine radiographers (technologists) employed in private sector nuclear medicine imaging departments in Gauteng that significant amounts of ^{99m}Tc were returned unused on a daily basis to the radiopharmaceutical laboratory. Therefore, the aim of this study was to determine the extent of radiopharmaceutical wastage

Fig. 1



Flow diagram of the radiopharmaceutical supply and return system in central and northern Gauteng private sector nuclear medicine imaging departments. ⁹⁹Mo, molybdenum-99; ^{99m}Tc, technetium-99m. NTP, Nuclear Technology Products Radioisotopes (Pty) Ltd; AXIM, Africa X-Ray Industrial Medical.

Table 1 Schedule of radiopharmaceutical laboratory ordered and standard package deliveries

Package	Quantities based on	Daily delivery time	Weekend delivery time
Ordered	Patient appointments	08:00 and 12:00 h	None
First standard package	Profile of examinations performed weekly	08:00 h	08:00 h (for use during the day)
Second standard package		12:00 h	08:00 h for use after 18:00 h
Third standard package		12:00 h (for evening use 18:00 h)	–

from the point of supply to nuclear medicine departments and the return to the radiopharmaceutical laboratory.

Methods

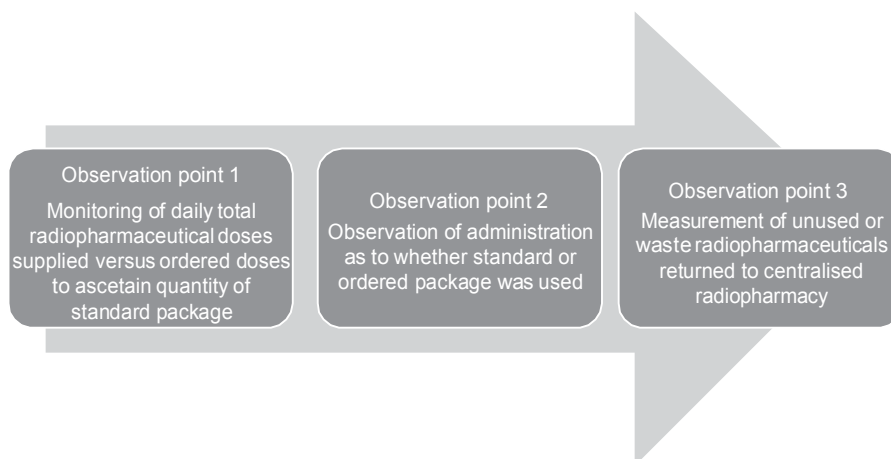
The private radiopharmaceutical laboratory confirmed that it supplies 13 private nuclear medicine practices in Pretoria and Johannesburg. Information on the weekly quantities of radiopharmaceuticals supplied to these nuclear medicine practices was also confirmed. Included in the study were three practices that received more than 7400 MBq of radiopharmaceutical and three that received 5920–7400 MBq per week. Of the remaining seven practices not included in the study, five were reported to receive between 5920 and 4440 MBq; one practice received less than 4440 MBq per week; and one practice received intermittent deliveries as and when ordered. Informed consent to conduct observations in each of the six departments was obtained from the practice owners.

The purpose of the overt observations was to verify the quantities of radiopharmaceuticals ordered and delivered and the quantity of radiopharmaceuticals returned within

nuclear medicine imaging departments. Figure 2 illustrates the points at which the observations were made. Ethics approval to conduct this study was granted by the Ethics Committee of the Faculty of Health Sciences at the University of Pretoria.

Data were collected between 3 April 2012 and 8 May 2012. All observations were made during the week, from 08:00 h until 16:00 h, over 2 consecutive days in each of the six practices. The observations enabled the verification of the OP within the whole package. The SP component of the whole package was identified through a process of exclusion. The radiopharmaceutical packages were cross-checked against the order forms. Checking of packages delivered is in keeping with the guidelines for quality assurance issued by the European Association of Nuclear Medicine Radiopharmacy committee guidelines [5]. According to the radiopharmaceutical laboratory's policy, nuclear medicine practices are billed if the SP is opened, regardless of whether or not the contents are used. Billing for the OP also occurs regardless of whether or not the contents of the OP are used. As a result,

Fig. 2



Data collection points.

the radioactivity of the individual items within each package could not be independently verified in phase 1.

At the point of administration of the dose to the patient, the observer verified as to whether the SP or the OP (preprepared syringes or bulk ^{99m}Tc) was used. The radiopharmaceutical quantities before administration to the patients were also recorded. It was not within the scope of this study to verify the accuracy of injected doses. After administration of radiopharmaceuticals to the patient, the syringes were measured in a dose calibrator to determine the quantity of residue in the syringes. The amount of radiopharmaceuticals that were returned unused was also analysed in terms of their source from the OPs or SPs. No corrections for physical decay were carried out.

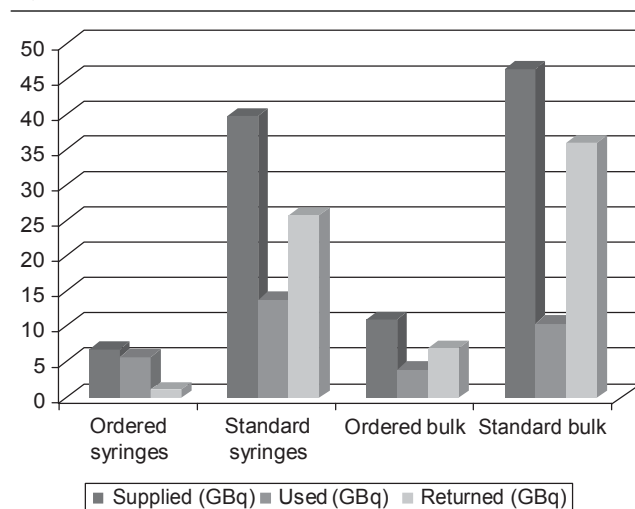
Results

The quantity of radiopharmaceutical in the OPs and SPs was ascertained in order to create a baseline from which the utilization and wastage could be referenced. Figure 3 illustrates the supply, use and return of preprepared syringes and bulk ^{99m}Tc .

It was apparent that the quantities of SP deliveries were consistently higher than those of OPs. It was determined that SPs constituted 86% of the total daily radiopharmaceuticals delivered. An abnormal trend was noted in five (i.e. 41.67%) of the 12 observations, when no radiopharmaceutical orders were placed, despite patient nuclear medicine appointments being made. SPs were used for radiopharmaceutical dose administration on those days.

When radiopharmaceutical doses were administered to the patients, it was observed that: 83% of preprepared syringes in the OPs and 35% in the SPs were utilized. When utilization of bulk ^{99m}Tc from the OPs and SPs was

Fig. 3



Comparison of supply, use and return of preprepared syringes and bulk ^{99m}Tc in ordered versus standard packages. ^{99m}Tc , technetium-99m.

monitored, it was established that the usage was 36 and 22.6%, respectively. It is evident that there is considerable oversupply and wastage of preprepared syringes in SPs. There is yet again a significant oversupply of the SP bulk ^{99m}Tc with a tendency to general underutilization of the OP bulk ^{99m}Tc . The underutilization of the OP bulk ^{99m}Tc and the relatively low return of OP preprepared syringes may imply that there may be a practice of usage of the SP preprepared syringes instead of reconstituting doses from the bulk ^{99m}Tc in the OP. Alternatively, these patterns of utilization may indicate a lack of prioritization with respect to the usage of the contents of these packages by the nuclear medicine radiographers.

The returned radiopharmaceuticals, considered wastage, from the OPs and SPs included unused packages and the residual from opened packages that were not administered to the patient. The SPs are largely returned unused: that is, 75.8% of SPs are returned to the radiopharmaceutical laboratories. The 45.5% of OPs returned may be indicative of failure to adequately monitor patient bookings when orders are placed with the laboratories, or it may be the result of unexpected patient cancellations.

Discussion

Amid the reported international shortage of radiopharmaceutical supplies [1,2], this report presents a rather disconcerting view of radiopharmaceutical wastage occurring within the nuclear medicine imaging departments where this study was conducted. This study did not investigate the quality assurance of the microprocedures within the nuclear medicine process.

The 45.5% return of OPs would seem to indicate a need for greater control in the ordering processes and procedures in the nuclear medicine imaging departments. The relatively high return rate of the SP and OP bulk ^{99m}Tc is an indication that there is a lack of prioritization with respect to the usage of the contents of these packages. Of greatest concern is the apparent excessive quantities and frequencies in the delivery of the SPs. There is clearly a need to re-evaluate the rationale behind the SP supply. A coherent approach to determining the quantities of radiopharmaceuticals for emergency and after-hours usage needs to be developed.

The total returned quantity of ^{99m}Tc amounting to 74.0 GBq, which is 70.6% of the total quantity of doses delivered, represents a sizable financial implication for the industry. This wastage raises concern for the radiation protection issues that are associated with unnecessary handling of excessive radioactive quantities by all parties involved in its production, despatch and usage, as well as in the radioactive disposal chain.

It is recommended that the individual departments conduct their own audits to establish possible reasons within daily practice that might contribute to the wastage of radiopharmaceuticals. Audits are recognized as being an important part of managing and good clinical governance in nuclear medicine [6]. The Japanese study that reported the challenges experienced due to a shortage of ^{99m}Tc -labelled pharmaceuticals highlighted the need for a system framework to improve communication between the suppliers and the nuclear medicine imaging departments [2]. It is advocated that the South African industry review the key communication issues that will promote improvement in the efficiency of the industry. It is advised that systematic records that compare radiopharmaceutical quantities received with the quantities returned be maintained in all nuclear medicine imaging departments. The central capturing of these reports

by the radiopharmaceutical distribution laboratories, and the composite reporting, will create awareness within the industry of both oversupply and undersupply.

Despite the fact that this study was conducted over a very limited period in a very small sample of nuclear medicine imaging departments in South Africa, there is concern that it may be symptomatic of a generalized problem within the industry. It is therefore suggested that a further study be conducted in other public and private sector nuclear medicine practices to identify whether a pervasive problem exists.

Conclusion

In contrast to the international reports, there is no record of South Africa experiencing a shortage of the medical isotope ^{99}Mo , and thus of its daughter product ^{99m}Tc . Nuclear medicine radiographers practising in private sector services in the northern Gauteng region indicated a possible problem with the quantities of wasted and unused ^{99m}Tc radiopharmaceuticals returned to the radiopharmaceutical supply laboratory. The purpose of the study was to interrogate the unconfirmed reports of ^{99m}Tc radiopharmaceutical wastage. Observations of the quantities of radiopharmaceutical supply, usage and wastage were made. The total returned quantity of ^{99m}Tc amounted to 70.6% of the total quantity of doses delivered. This may have sizeable financial and radiation protection implications. It is acknowledged that these results cannot be generalized to all nuclear medicine imaging departments in South Africa. However, in the event of other nuclear medicine imaging departments receiving radiopharmaceuticals in similar quantities and frequencies to the departments in this study, it may be reasonable to predict that a similar pattern of wastage is being experienced. This severe wastage of radiopharmaceuticals cannot be justified and requires further investigation and control.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

References

- 1 Perkins AC, Vivian G. Molybdenum supplies and nuclear medicine services. *Nucl Med Commun* 2009; 30:657–659.
- 2 Kosuda S, Tomita H, Hayashi K, Kita T, Koike K, Arai T. Questionnaire survey of hospitals at Saitama Prefecture regarding the shortage of ^{99m}Tc -labelled radiopharmaceuticals and $^{99}\text{Mo}/^{99m}\text{Tc}$ generators. *Ann Nucl Med* 2010; 24:319–323.
- 3 Du Bruyn C. SA boosts isotope production after Canadian reactor shuts down, 2009; Available at: <http://www.engineeringnews.co.za/article/sa-boosts-medical-isotope-production-after-canadian-reactor-shutdown-2009-07-03> [Accessed 18 March 2013].
- 4 Atchar R, Guerin B. U.S. still vulnerable to isotope shortage, 2011; Available at: <http://www.rsna.org/NewsDetail> [Accessed 21 April 2013].
- 5 European Association of Nuclear Medicine Radiopharmacy Committee. cGRPP-guidelines in the preparation of radiopharmaceuticals. 2nd ed. Vienna, Austria: European Association of Nuclear Medicine; 2007.
- 6 Dennen S, Huggett S. Best practice in nuclear medicine (part 1) – a technologist's guide. Salzburg, Austria: Colordruck Helminger & Co.; 2006.