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Recommended Citation
A Shah, I. (2013). Indigenously developed close delivery system for oral iodine-131 therapy: nominal cost but phenomenal protection. Indian J Nucl Med., 28(4), 207-209.
Available at: https://ecommons.aku.edu/pakistan_fhs_mc_radiol/92
Indigenously developed close delivery system for oral iodine-131 therapy: Nominal cost but phenomenal protection

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ABSTRACT

Background: Administration of radiopharmaceuticals through intravenous and oral routes is the major source of radiation exposure to nuclear medicine (NM) technologists. Adopting new strategies to minimize radiation exposure is an important step toward safe practice in nuclear pharmacy. Materials and Methods: We have indigenously developed a relatively close delivery system for oral administration of radioiodine-131 ($^{131}$I) to minimize radiation exposure to the technologists. Results: The efficacy of this indigenously developed close system was assessed upon 23 patients who were given $^{131}$I therapies for benign (13 patients) and malignant thyroid disorders (10 patients). There was 64 ± 6% ($P < 0.05$) reduction in exposure rate using indigenously developed delivery system. Conclusion: The cost involved in developing this system was very nominal, but efficacy in terms of radiation safety and confidence of our technologists were phenomenal.

Keywords: Indigenous system, nuclear medicine technologist, radiation exposure, radioiodine-131 therapy

INTRODUCTION

In nuclear medicine (NM) department, technologists are exposed to ionizing radiation in nuclear pharmacy while preparing and administering the radiopharmaceutical, in imaging room and also in handling the patients after the completion of procedures. In a fairly busy NM department, the average radiation dose received by a technologist was below 5 milliSievert (mSv) and about 60% of dose was received during injecting radiopharmaceuticals to the patients.¹ This is well below the annual dose limit of 20 mSv for radiation workers.² In recent days, there has been an increase use of radioiodien-131 ($^{131}$I) for thyroid disorders³ and also $^{131}$I labeled targeted radionuclide therapy for nonthyroidal cancers. For thyroid disorders, $^{131}$I is administered orally and for other target radionuclide therapies, an intravenous infusion is usually used. These procedures carry a potential risk of significant exposure to NM staff and physicians despite of adopting well-known strategies of time, distance, and shielding. In most of NM departments in Pakistan, $^{131}$I is administered orally in a liquid form by the technologists and in our department patients were used to give liquid $^{131}$I in a disposable glass to drink. This indeed was a source of significant but avoidable source of radiation exposure to our technologists. Recently, we have designed an indigenous reasonably close delivery system for oral administration of $^{131}$I to patients with toxic goiters and well-differentiated thyroid cancers.

MATERIALS AND METHODS

We used a thick lead container in which $^{131}$I vial is supplied and transported by the vendor. With the help of our biomedical division, the lumen of the thick lead vial container was broadened to accommodate a disposable plastic glass to be filled with liquid $^{131}$I. A small circular hole was also made in the center of cap (cover) of lead vial container to insert a disposable straw to drink liquid $^{131}$I. To minimize radiation exposure from straw while patient is taking $^{131}$I, we have used a long cylindrical lead covering to house this straw. This lead cylinder to shield a straw was made from 1 mm thick semicircular lead linings around hot column of an expired $^{99}$Molybdenum-$^{99m}$Technetium generator [Figure 1].

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To assess the efficiency of this indigenous, relatively close delivery system, we measured exposure rates at 1 m distance at patient’s torso level using a survey meter (VICTOREEN, Model no: 450, USA) with and without said system for various strength of $^{131}$I. It was tested in first 23 patients who were referred for iodine treatment to our department for benign and malignant thyroid disorders. This was a small prospective study conducted from April 2013 till 15th July 2013 at Nuclear Medicine Department of Dr. Ziauddin Medical University, Karachi, Pakistan.

**Statistical analysis**
Data were analyzed by using commercially available packages the Medcalc® statistical software version 11.3.10 and statistical package for social sciences (SPSS version 17®). A two-tailed student’s t-test was used to compare continuous variables. Bland-Altman’s plot was used to see the difference of exposure rates with and without lead with mean values. $P < 0.05$ was considered significant.

**RESULTS**
We tested this system upon first 23 patients (17 females and 6 males with a mean age of 49 ± 14 years). $^{131}$I therapy was administered for benign thyroid diseases in 13, while 10 patients had well-differentiated thyroid cancers. The average administered dose of $^{131}$I for benign disease was 555 ± 148 MBq (15 ± 4 mCi) and for malignant conditions it was 5032 ± 1443 MBq (136 ± 39 mCi). Average measured exposure in milliRoentgen/hour (mR/h) at 1 m distance without lead vial was 5.416 ± 3.423 and with lead it was 1.903 ± 1.254 [Table 1]. The difference between exposures rates with and without lead was analyzed by Bland-Altman’s curve which revealed all the differences were close to the mean line and no significant outlier was noted [Figure 2]. The percentage reduction in exposure rate by using lead system was 64 ± 6% [t-test: −4.687, $P < 0.05$] [Figure 3].

**DISCUSSION**
In recent years, overwhelming use of radiation-based diagnostic and therapeutic procedures has been noticed. This has indeed been responsible for reported exorbitant radiation exposure to people[9] and also a matter of serious concern for radiation workers. The annual radiation exposure of our technologists has always been well below the statutory limits. But due to significant rise in referral of radioiodine

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**Table 1: Patients’ demographic**

| Variables                               | Total no. of patients (23) |
|-----------------------------------------|-----------------------------|
| Benign: Malignant indications           | 57%:43% (13:10)             |
| Female: Male                            | 74%:26% (17:06)             |
| Average age±SD in years                 | 49±14 years                 |
| Average dose administered in Ca thyroid (mean±SD in MBq) | 5032±1443 MBq               |
| Average dose administered in benign thyroid disease (mean±SD in MBq) | 555±148 MBq                 |
| Average exposure±SD in mR/h without lead container | 5.416±3.423                |
| Average exposure±SD in mR/h with lead container | 1.903±1.254                |

mR/h: MilliRoentgen/hour, SD: Standard deviation, MBq: Mega becquerel

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**Figure 1:** (a) Disposable glass and straw without lead shield for $^{131}$I treatment previously used; (b) Indigenously designed close delivery system with widened cavity of lead vial and an opening in top cover to insert a straw and; (c) Lead shielded straw and heavily shielded vial with liquid $^{131}$I

**Figure 2:** Bland-Altman’s scatter plot of exposure rate difference with and without using lead container for radioactive iodine oral administration

**Figure 3:** Comparative analysis of exposure rate during oral administration of radioactive iodine with and without using lead container
therapies to our center since March 2013, we were skeptical about an increase in radiation exposure to our technologists. Following the As low as reasonable achievable (ALARA) principle, we considered to acquire commercially available close system for $^{131}$I delivery. However, cost of such system was significantly high. This cost limitation had initiated the idea of developing this system indigenously. The measured values of exposure rates have shown efficacy of this close system in minimizing the radiation exposure to our technologists. In Bland-Altman’s curve with fall of measured values close to the mean value also rules out outlier and reproducibility of the measuring methodology. Literature search revealed a close vacuum-assisted system designed for administration of high doses of $^{131}$I by Prabhakar et al., India. No data regarding radiation exposure with and without vacuum-assisted system were presented. In last few years, two important studies have pointed out increased incidence of brain tumor in interventional cardiologists and higher incidence of cancer in offspring of radiation workers. These data are indeed alarming for radiation workers, but adopting every effort to minimize radiation exposures like developing indigenous close delivery system and its validity by on-site measurement improves their confidence. The cost involved in developing this system was very nominal, but efficacy in terms of radiation safety and confidence of our technologists were phenomenal.

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How to cite this article: Fatima N, uz Zaman M, Shah IA, Ul Haq I, Javed A. Indigenously developed close delivery system for oral iodine-131 therapy: Nominal cost but phenomenal protection. Indian J Nucl Med 2013;28:207-9.

Source of Support: Nil. Conflict of Interest: None declared.

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