INTRODUCTION

Differentiated Thyroid Carcinoma (DTC) is the most common endocrine tumor, with an incidence of 1.2 - 2.6/100,000 in males and 2.0 - 3.8/100,000 in females per annum and approximately 1.0% - 1.5% of all new cancers diagnosed each year in the USA with 10 years survival rate of about 90%. Thyroid carcinoma is the 5th most common cancer among females and accounts for 5% of all new cancers diagnosed in 2012. Radioactive Iodine (RAI; I-131) has been used to ablate thyroid cancer postoperatively in patients with DTC with or without evidence of residual disease since 1950s. Patients treated with RAI therapy cause risk of external radiation exposure to the public and family members, thus several criteria and regulations have been established to order hospital discharge of these patients after RAI therapy. Each country has its own rules; Pakistan Nuclear Regulatory Authority (PNRA) adheres to activity limit criteria. If patients receive a dose > 1110 MBq (30 mCi) and the emitting radiation dose rate at one meter is > 20 - 50 µSv/h, they are required to be hospitalized in isolation rooms. The PNRA guidelines state “The patient, to whom more than 1110 MBq of I-131 is administered, should be hospitalized and should not be discharged until the activity is less than 1110 MBq and the measured dose rate at one meter from the patient is less than 20 - 50 µSv/h (as a good practice)”. The aim of the present study was to analyze measurements of emitting radiation dose rate at one meter distance as a function of time to achieve the acceptable radiation dose from the thyroid cancer patients after single and multiple RAI therapies.

METHODOLOGY

This analytical study was performed at Department of Nuclear Medicine and Radiation Physics, Multan Institute of Nuclear Medicine and Radiotherapy (MINAR), Multan, Pakistan, from December 2006 to December 2013. Patients with established Differentiated Thyroid Carcinoma (DTC) of either gender and any age were inducted. Before starting the study the ethical and moral issues were discussed and acceptance from the MINAR Ethical Committee was obtained.
A total of 167 therapies performed in 93 patients with well differentiated thyroid cancer, were treated with different doses of $^{131}$I ranging from 70 mCi (2590 MBq) to 250 mCi (9250 MBq) as an in-patient were included in this study. Fifty four patients were given only single doses of RIT, while 39 patients were given repeated therapies. The patients were admitted in isolation room and were surveyed with calibrated survey meter for dose rate at 1 meter distance daily until dose rate was at or below 25 $\mu$Sv/hr.

All the patients were seen in nuclear medicine outpatient department after having their initial thyroid surgeries or in some cases redo-surgeries, where there was large remnant thyroid tissue on postsurgical thyroid scan. Their baseline thyroglobulin (Tg) and Anti-Thyroglobulin (ATG) antibodies were done. Routine X-ray chest and bone scan in some cases of bone pain were also done.

Patients were treated with RAI as first ablation dose of range from 70 to 150 mCi $^{131}$I depending upon the residual thyroid tissue and involvement of distant metastasis and remained admitted in isolation rooms till the dose rate dropped to below 25 $\mu$Sv/hr. Later patients were discharged and were put on TSH suppression dose of thyroxin. Patients were initially recalled on 10th day of their therapy for post-therapy $^{131}$I whole body scan and later followed up after 05 months of their first RAI therapy, with Tg, ATG and $^{131}$I whole body scan with thyroxin off for 4 weeks.

Two sample t-test was applied on the discrete data, hospital stay time (in hours) for single therapy versus multiple therapy to evaluate statistical significance difference between these two groups by calculating number of observations, mean, standard deviation, t-value and p-value, level of significance 95% by using statistical software Minitab version 15 (Minitab ® Inc. Pennsylvania, USA).

**RESULTS**

The study included 93 patients with well differentiated thyroid cancer of whom 68 (73%) were females with an age range of 15 - 80 years and mean age of 36 ± 14.5 years. All were treated with different doses of $^{131}$I as an in-patient. Seventy percent patients were of papillary carcinoma, 19% had follicular carcinoma and 11% had other types of differentiated thyroid cancer.

Ninety three patients were given first therapy dose with dose range of 70 to 150 mCi $^{131}$I depending upon the residual thyroid tissue and involvement of distant metastasis and remained admitted in isolation rooms till the dose rate dropped to below 25 $\mu$Sv/hr. Later patients were discharged and were put on TSH suppression dose of thyroxin. Patients were initially recalled on 10th day of their therapy for post-therapy $^{131}$I whole body scan and later followed up after 05 months of their first RAI therapy, with Tg, ATG and $^{131}$I whole body scan with thyroxin off for 4 weeks.

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<table>
<thead>
<tr>
<th>Stay in Hospital (in hours)</th>
<th>Number of patients with single therapy with % (n=93)</th>
<th>Number of patients with multiple therapies with % (n=39)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>0 (0%)</td>
<td>9 (23.08%)</td>
</tr>
<tr>
<td>48</td>
<td>34 (36.56%)</td>
<td>28 (71.79%)</td>
</tr>
<tr>
<td>72</td>
<td>26 (27.96%)</td>
<td>2 (5.13%)</td>
</tr>
<tr>
<td>96</td>
<td>25 (26.88%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>120</td>
<td>8 (8.60%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

**DISCUSSION**

Radiation safety hazard is one of the important concerns following RAI treatment of DTC patients and can be measured by exposure rate from these patients.11 The ICRP has not provided recommendations on the criteria to follow regarding the release of patients after...
therapy with unsealed radionuclides. Instead, the recommendations have been directed at dose limits for occupationally exposed workers in hospitals, dose limits for the public, and dose constraints for caregivers. Various release criteria have been used in different countries and regions. Several different approaches have been tried. The most common approaches are release criteria based on activity or dose rate with calculations and estimates of the doses that relatives, caregivers, and the public can expect to receive. Variations in the models and assumptions used have led to widely differing release criteria for patients. According to PNRA guidelines, hospital discharge criteria is the measured dose rate at one meter distance less than 20 - 50 µSv/hr. In this analysis most of the patients who were given RAI therapy for the first time required 48 hours or more to be discharged from the hospital. However, the patients who were given RAI second or more time, majority were discharged in less than 48 hours of RAI administration.

In clinical Nuclear Medicine, treatment of differentiated thyroid cancer is made by the postoperative administration of iodine\textsuperscript{131} doses above 50 mCi to the patients. This regimen has three most important rationales. First is to ablate any residual normal thyroid tissue that is left after surgery, thus helping subsequent detection of residual or recurrent tumor; secondly for detection of any small neoplastic foci within the thyroid remnant or somewhere else in the body, thus improving the long-term outcome; and thirdly this can treat known residual tumor sites.\textsuperscript{12} The administered radioactive iodine is taken up by the functioning thyroid tissue (iodine symporters) and is cleared mainly from the bowel and urinary tract. These patients are kept in isolation room and are monitored daily with calibrated survey meter at one meter distance from the neck area till the activity comes within the acceptable range.

Female to male ratio found in this study was 2.7:1 that corresponds to another study by Zuberi et al. on Pakistani population showing ratio of 2.2:1.\textsuperscript{13} Rahbari reported thyroid cancer 2.9 times more common in females.\textsuperscript{14} In this study, the mean age of the patients with thyroid carcinoma was 36 years. Zuberi et al. reported peak incidence of thyroid cancer was between 30 and 60 years in Pakistani population.\textsuperscript{13}

Papillary carcinoma was the most common type of cancer found in our population, as 70% of the patients were having papillary type on histopathology followed by follicular carcinoma in 19% of our population. Various other reports indicate that papillary thyroid cancer is the most frequent of all thyroid cancer subtypes.\textsuperscript{15,16} Majority of these patients were treated with single therapy dose and were monitored subsequently with serum thyroglobulins, anti-thyroglobulin antibodies and I\textsuperscript{131} whole body scans without any need of further RAI therapy. This data showed that most of the patients who were treated second time or higher, showed rapid clearance of radioactivity as compared to those patients who received RAI therapy for the first time, in spite of the fact that the subsequent therapies always had larger doses as compared to the first time. This could be due to the following facts. First it may be due to the reason that the first dose was mainly accumulated in the residual functioning thyroid or residual neoplastic tissue and was trapped there because of Sodium Iodine Symporters (NIS), resulting into prolonged effective half-life as majority of thyroid cancer (68 - 86%) has functional NIS receptors.\textsuperscript{17,18} Secondly, the chances of radiation induced inflammation are higher in first time RAI therapy, thus resulting into delayed clearance and prolonged biological half-life. Thirdly chances of de-differentiation of residual / metastatic thyroid tissue in subsequent therapies are higher, and failure of radioiodine uptake by these lesions may also result into earlier clearance from the body.

It is concluded that the patients who are treated with I\textsuperscript{131} more than one time, can be discharged earlier as compared to those who are given I\textsuperscript{131} for the first time. With some degree of deflection in cases of thyroid cancer with distant metastases, digestive tract disorder, and impaired renal function.

CONCLUSION

For well differentiated thyroid cancer patients, rapid dose rate reduction is seen in patients receiving second or subsequent radioiodine (RAI) therapy, as compared to first time receiving RAI therapy.

REFERENCES


10. PNRA. Guidance for the users of Iodine-\textsuperscript{131} in nuclear medicine centers. Islamabad: PNRA; 2013.


