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MENINGIOMA OVERSIGHT

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Meningioma, the most common benign intracranial neoplasm
Accounts for 30% of primary CNS neoplasm

Has an old age predilection
That occurs in female more often

NF2, prior radiation and atom bomb exposure
All these are major risk factors to consider

Mostly occurs intracranial
Can also be found in spinal

MRI is the imaging modality of choice as it defines the tumour extent
68Galium DOTATATE PET helps in uncertain or equivocal tumour extent

Tumours that are asymptomatic and diagnosed incidentally
Are observed initially up by Magnetic Resonance Imaging (MRI) annually

In symptomatic or growing tumours, surgery is the primary treatment
Either Gross Total Resection (GTR) or Sub-Total Resection (STR) in curative intent

Surgically grading is done as per Simpson
That is based on the extent of resection

Grade 1-3 is categorised as GTR
While 4-5 is considered as STR

2016 WHO classification is based on histopathology
Graded as 1, 2 and 3 as per tumour morphology

Recent 2021 WHO CNS5 integrates molecular biology[1]
This is in addition to the 2016 WHO morphology

Presence of CDKN2A/B deletion and pTERT mutation
Classifies it as high risk irrespective of any risk stratification[1]

Low risk is newly diagnosed grade 1 with GTR
Close observation is required with serial imaging MR[2]

Intermediate risk is new GTR grade 2 or recurrent GTR grade one
Adjuvant radiation up to 54Gy is its treatment plan[3]

All grade 3 or recurrent grade 2 is considered as high risk
Must receive adjuvant radiation with 60Gy as its only fix[4]

Postop tumour bed, nodular enhancement and hyperostotic bone constitute GTV
Don’t contour peritumoral edema and dural tail as part of GTV or CTV

RTOG 0539[3-4] and EORTC 22042-26042[5] deals with post radiation
Follow these guidelines for contouring and dose specification

For intermediate grade meningioma, early post op RT vs Observation
ROAM/EORTC 1308 trial[6] will give answer for this situation

In case any contraindication to surgery
Small tumours can be treated with stereotactic radiosurgery

Follow-up done up to 10 years by MR imaging
Using the RANO criteria[7] for response assessing

There is no high level evidence on use of systemic therapy
Novel treatment options include anti VEGF, targeted and immunotherapy

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Original Reports | Head and Neck Cancer

Multicentric Cross-Sectional Survey to Assess the Variation of Fractionation Strategies Used in the Management of Head and Neck Cancers in the Asian Region (INNOCENCE-ASIA)

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ABSTRACT

PURPOSE Head and neck cancers (HNCs) are in general treated with conventional fractionation regimen of 1.8-2 Gy per fraction. Altered fractionation (ALFT) strategies such as hypofractionation radiotherapy (HYPO-RT), accelerated fractionation radiotherapy (AFRT), and hyperfractionation radiotherapy (HFRT) have not been practiced uniformly across centers in different parts of the world. Countries in Asia share common cancer demographics, and we designed this survey for Federation of Asian Radiation Oncology (FARO) member countries to understand the usage and challenges in the delivery of ALFT in HNCs.

MATERIALS AND METHODS A 21-point electronic survey (Federation of Asian Radiation Oncology Research Network [FERN]-S-005) was designed by the FERN and was circulated through the FARO research secretariat to the FARO council member countries and the responses were collected between August and November 2023.

RESULTS Twelve of 14 member countries (85.7%) responded to the survey. Twenty-seven responses were received and 78% of the respondents belonged to government/teaching academic institute. 4/27 (14.8%) reported never using HYPO-RT for any of the clinical subsite of HNCs, while the majority (85.2%) used it for glottic cancers and 22% also used it for postoperative setting. Majority (77.7%) used a fractionation schedule with dose per fraction ranging between 2.2 and 2.5 Gy. 6/27 (22.2%) used AFRT for definitive setting and five of these also used concurrent chemoradiotherapy. 4/27 (14.8%) centers reported using HFRT. The most common reason (62.9%) for the limited usage of AFRT/HFRT was reported to be logistical, such as unavailability of machine slots, patient load, and so on.

CONCLUSION The result of the survey suggests that among the ALFT strategies for HNCs, HYPO-RT schedules have common interest and feasibility among the FARO member countries and also highlights the challenges in the delivery of AFRT/HFRT in the Asian region.

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INTRODUCTION

With about 9.3 million incident cases and 5.15 million deaths annually, cancer is a major health burden in the Asian region.[1] In India, head and neck cancers (HNCs) are the most common cancers among males and fifth most common cancer among females. In Pakistan, it accounts for 21% of cases in males and 11% in females.[2] HNCs are among one of the top five most common cancers in Thailand.[3] According to GLOBOCAN 2022, HNCs account for 0.6 million incident cases in Asia.[1]

Definitive concurrent chemoradiotherapy (CCRT) is the current standard of care for locally advanced HNCs, and postoperative radiotherapy (RT) with or without chemotherapy is recommended for those undergoing curative-intent surgeries on the basis of postoperative high-risk factors such as T3/T4 disease, node positive, lymphovascular invasion or peri-neural invasion positivity, close margin (≤5 mm), depth of invasion, and so on. Adjuvant CCRT is indicated for involved node with extranodal extension or positive margins, and is often also considered for presence of multiple high-risk features.[4-6] Recommended

CONTEXT

Key Objective
Understand the variations in the fractionation practices of head and neck cancers (HNCs) among different countries in Asia.

Knowledge Generated
Among the altered fractionation strategies in HNCs, hypofractionated radiotherapy (RT) appears to have common interest and feasibility. Accelerated and hyperfractionated RT practices have some common and others unique challenges specific to different countries.

Relevance
The results of this survey may help identify common strategies, which could be valuable for multicentric collaborative work for HNCs in the Asian region.

RT dose in the definitive and adjuvant settings usually is in the range of 66-70 Gy and 60-66 Gy, respectively, at a conventional fractionation schedule of 1.8-2 Gy per fraction delivered as five fractions per week. The concurrent chemotherapy delivered is usually intravenous cisplatin either once every week 40 mg/m^2 or once every three weeks 100 mg/m^2.

In patients unsuitable for cisplatin-based CCRT in both definitive and postoperative setting, treatment options are limited and often they are either treated with other concurrent regimens such as cetuximab, carboplatin, docetaxel, and so on. Many a times, owing to either comorbidities or other factors, these patients are not suitable for even these concurrent regimens and have inferior outcomes if treated with RT alone at conventional fractionation.[7-11] The goal of treatment for HNCs is to complete the entire treatment within a stipulated time. Prolongation of the overall treatment time (OTT) may lead to a loss of locoregional control (approximately 10%-14% per week) necessitating a daily dose increase of 0.6-0.9 Gy to compensate for the increase in OTT. Use of CCRT does not appear to overcome this loss in studies reported till date.[12,13] Patients in several Asian regions report delay in initiation of RT because of late referral and long waiting times leading to prolongation of OTT affecting their clinical outcome.[14]

Altered fractionation (ALFT) strategies have been evaluated in the management of HNCs. Studies including meta-analysis have shown hyperfractionation radiotherapy (HFRT) and accelerated fractionation radiotherapy (AFRT) to have survival advantage compared with RT alone.[15-18] AFRT can also be used as an intuitive method to mitigate the effect of prolonged OTT. However, increased acute toxicities with these regimens, logistical issues involved in the delivery of these radiation therapy schedules, and personal preferences of the clinicians have led to variations in the practice of these ALFT approaches.

Hypofractionation radiotherapy (HYPO-RT) offers a promising alternative, wherein the number of fractions is reduced while maintaining dose efficacy. Although HYPO-RT schedules have been established in the management of certain cancers such as prostate and breast cancers, the use of this approach for HNCs have been varied.[19,20] In HNCs, HYPO-RT has been used predominantly for early glottic cancers, for palliative schedules, for localized melanoma after nodal dissection, and for other malignancies of head and neck, majority with skin and salivary gland carcinoma.[21-24]

HYPO-RT has been practiced for quite long time, although not used popularly as the standard of care or one of the treatment options at majority of the centers. However, during the COVID-19 pandemic, HYPO-RT made a comeback and was practiced at several centers across the globe. HYPO-RT additionally is very valuable for centers across Asian regions where RT waiting times are long with constrained RT resources.[25-27] There has also been renewed interest in the evaluation of HYPO-RT protocols for HNCs.[28-30]

The implementation of ALFT strategies may have unique as well as common challenges in the Asian region and it was realized that a survey would help us understand the patterns of practices and variations in its use. The hypothesis of this survey study was that there exists variation in the patterns of practices with respect to fractionation in the management of HNCs. The aim of this study was to understand the common fractionation schemes used in HNCs across various centers in the Asian region, understand the use of AFRT/HFRT in the management of HNCs in the Asian region, assess the variation in the use/practices of HYPO-RT in HNCs, and highlight the challenges/concerns faced in the implementation of ALFT RT in HNCs.

MATERIALS AND METHODS

The questionnaire was constructed on Google Survey form encompassing various domains of ALFT strategies in HNCs. A 16-point questionnaire was designed with survey

questions. The designed survey was circulated among the head and neck working group (HNWG) members for opinion and was modified accordingly to arrive at the final survey questionnaire with 21-point. The HNWG members of the Federation of Asian Radiation Oncology (FARO) research committee are two to six members designated by the respective national organizations who primarily practice HNCs and are also aware of the state of research and common treatment policies in their respective nations and organizations regarding HNCs. The questionnaire was designed to capture information on demographics of the practicing center, volume of cases seen, prevalent practices, trends in the usage over time, and challenges in the usages of ALFT in HNCs. A copy of the survey can be accessed at Forms.[31]

Definition of ALFT was also provided as an introductory note along with survey to the respondents as follows: HYPO-RT was defined as a dose per fraction 2.2 Gy per fraction or higher; AFRT as six or more fractions per week; and HFRT as two or more fractions daily with a dose per fraction of ≤1.5 Gy.

After finalization of the survey, it was circulated through the FARO Research Secretariat to the FARO council members and the HNWG members. Responses from centers (preferably from a unit practicing HNC) from various countries in the Asian region were collected. The survey responses from each country were capped to a maximum of four to six to maintain uniformity and representation of responses from countries across Asia. The survey was rolled out on August 7, 2023, and the results were collected from August 2023 to November 2023. Two rounds of survey reminders were given each 1 month apart. The survey results were analyzed using simple descriptive analysis and the results have been summarized for depiction.

RESULTS

Demographics of Respondents

Twenty-seven responses were received from 12 participating countries and the geographical distribution of responses has been summarized in Figure 1. Seventy-eight percent of the respondents belonged to government/academic teaching institutes. The percentage of centers with volume of HNCs treated per year were 18.5%, 14.8%, 25.9%, and 40.7% for <50, 50-100, 100-200, and >200 cases, respectively. Similarly, the percentage of centers treating HNCs with intensity-modulated radiotherapy (IMRT) for <10%, 10%-30%, 30%-70%, 70%-90%, and 100% of all HNCs treated at their center were, respectively, 18.5%, 11.1%, 22.2%, 14.8%, and 33.3%. The number of institutions reporting oral cavity, larynx, and oropharynx as the most common HNCs being seen at their respective institutions were, respectively, 12/27 (44.4%), 5/27 (18.5%), and 10/27 (37%) centers.

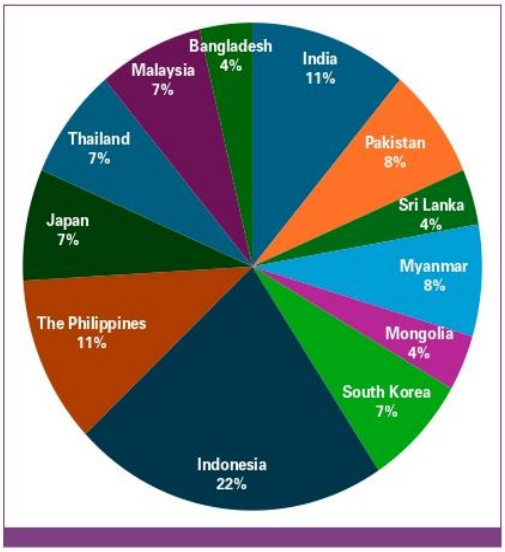

FIG 1. Geographical distribution of the survey responses.

Use of Hypofractionation

4/27 centers (14.8%) reported to have never used HYPO-RT for any of the clinical subsites of HNCs. Number of institutions using HYPO-RT for definitive treatment of glottic larynx, supraglottic larynx, oropharynx, hypopharynx, and oral cavity were 23/27 (85.2%), 7/27 (25.9%), 6/27 (22.2%), 5/27 (18.5%), and 5/27 (18.5%), respectively. Twenty-two percent centers used HYPO-RT for postoperative scenarios and 74% reported using this for palliative treatment of locally advanced HNCs. Although 18.5% reported using CCRT with HYPO-RT in definitive setting, only one center used CCRT in the adjuvant setting. The dose per fraction for HYPO-RT schedules was as follows: 2.2-2.5, 2.5-2.75, 2.75-3.0, and >3 Gy for 21 (77.7%), five (18.5%), two (7.4%), and one (3.7%) center, respectively. Table 1 summarizes the various clinical scenarios for the use of HYPO-RT and Table 2

TABLE 1. Indications for the Use of HYPO-RT Schedules

Indications for the Use of HYPO-RT	No. of Centers (%)
For selected clinical sites such as glottic cancers, definitive treatment	23 (85.2)
For palliative treatment for advanced head and neck cancers	20 (74)
For patients not suitable for concurrent chemotherapy in definitive cases	5 (18.5)
As boost after initial conventional fractionation in definitive cases	3 (11.1)
For postoperative cases with treatment delays between surgery and initiation of RT	2 (7.4)
For elderly and frail patients in definitive cases	2 (7.4)

Abbreviations: HYPO-RT, hypofractionation radiotherapy; RT, radiotherapy.

TABLE 2. Dose Fractionation Schedules for HYPO-RT

Dose Fractionation Schedules Followed for HYPO-RT	No. of Centers (%)
55 Gy in 20 fractions for definitive cases	12 (44.4)
63 Gy in 28 fractions for stage I glottic cancer	8 (29.6)
65.25 Gy in 29 fractions for stage II glottic cancer	8 (29.6)
66 Gy in 30 fractions for definitive cases	8 (29.6)
67.5 Gy in 30 fractions for definitive cases	2 (7.4)
59.5 Gy in 17 fractions for glottic cancers	2 (7.4)
60-64.8 Gy in 25-27 fractions for glottic cancers	1 (3.7)
63 Gy in 28 fractions for postoperative cases	2 (7.4)
50 Gy/20 fractions for postoperative cases	1 (3.7)
56 Gy in 22 fractions for postoperative cases	1 (3.7)

Abbreviation: HYPO-RT, hypofractionation radiotherapy.

summarizes the various dose fractionation schedules used for HYPO-RT.

Except five centers, all other centers (81.5%) reported using moderate HYPO-RT schedules as component of simultaneous integrated boost (SIB) IMRT. In the schedule of SIB-IMRT, the dose per fraction of 2.15-2.5 per fraction was used by 16 (59.2%) centers for definitive setting (13/16 centers also used it with CCRT) and four centers (14.8%) for adjuvant setting (all four used it with CCRT). Only four centers (14.8%) used a dose per fraction of >2.5 Gy with SIB-IMRT protocols.

6/27 centers reported use of stereotactic body radiotherapy (SBRT) for recurrent HNCs. Of these six, two also used SBRT in the management of glottic cancers in the definitive setting. Over the period, 12 (44.4%) reported increase in the use of HYPO-RT mainly in the setting of SIB-IMRT, five (18.5%) increased its usage for glottic cancers, and one center each had increased use of HYPO-RT protocols for postoperative oral cavity cancers and for all HNCs after the COVID-19 pandemic as part of the change in institutional policy.

Use of AFRT/HFRT

6/27 centers (22.2%) reported using AFRT for definitive management of HNCs and three of these six centers used AFRT for postoperative HNCs. Only one center reported use of CCRT with AFRT. Five centers used it for patients not suitable for concurrent chemotherapy in definitive cases and three used it for postoperative cases with treatment delays between surgery and initiation of RT. One center used AFRT for patients to compensate for the treatment interruptions. AFRT was prescribed as six fractions per week treatment at three centers and as concomitant boost in three centers. Over the period, four centers reported an increase in the usage of AFRT, while one reported decline.

4/27 centers reported using HFRT: three for reirradiation and one for definitive HNC case not suitable for CCRT. None of the centers reported using HFRT for postoperative cases. The HFRT schedule used was 1.1-1.2 Gy, two fractions per day to 74-82 Gy. One center reported increase in the use of HFRT over time.

DISCUSSION

HNCs in the Asian region are different compared with the Western countries in terms of sites (higher prevalence of oral cavity, and nasopharynx subsites) and stage at presentation (often presenting at higher stages), and poses unique challenges (such as resource constraints, radiation waiting time, etc) in terms of management.[1-3]

In patients ineligible for standard cisplatin-based CCRT, the treatment options both in the definitive and adjuvant settings are often limited. ALFT strategies such as AFRT/HFRT could be a valuable tool in these subset of patients as well as in special scenarios such as HFRT for reirradiation, and AFRT for compensating treatment delays and in patients to compensate for treatment interruptions. Use of AFRT and HFRT has been shown to improve locoregional control without an increase in the late morbidities,[32] and HFRT has been shown to be particularly valuable in patients unsuitable for CCRT.[33] However, the use of AFRT and HFRT has been varied across centers in the world, and the patterns of practices in the Asian region are not understood properly.

The use of HYPO-RT for HNCs has been predominantly for palliative treatment of locally advanced cases.[24] Use of HYPO-RT for definitive and adjuvant management of HNCs has been traditionally limited to centers in the United Kingdom and few European countries except in certain HNC subsites such as melanomas or salivary gland carcinoma.[21,23] The billing practices of insurance companies that have financial implications also hinder the use of HYPO-RT schedules in the United States and other Western nations. The use of HYPO-RT for HNCs has been fraught with increased toxicities (predominantly late) owing to exposure of large mucosal surface to a higher dose fraction of radiation dose. However, the use of HYPO-RT schedule has been increasing in clinical sites with evidence of benefit and small volume of irradiation such as glottic cancers, and there has been a renewed interest in the evaluation of these schedules after the COVID-19 pandemic.[23,25-27] Large multicentric trials (HYPNO) and prospective clinical trials are defining the resurgence of HYPO-RT schedules.[28-30,34,35] Additionally, HYPO-RT schedules could lead to sparing of the resources with reduction in OTT beneficial for both patients as well as communities.[36]

Recently, with the efforts of FARO, there has been a thrust to understand the patterns of practices pertaining to the fractionation strategies prevalent in the Asian region. ALFT strategies adapted to the needs of Asian region need to be developed and this survey may form the foundation for future study designs to evaluate various fractionation strategy in HNCs. The HNWG members, in concert with the central research wing of FARO, designed a 21-point questionnaire to understand the patterns, practices, trends, and challenges in the use of ALFT strategy in the Asian region. Instead of rolling out the survey

openly to various centers in different countries through an open social platform, a defined strategy of sending the questionnaire through the FARO secretariat was followed to optimize representation of response from maximum Asian countries.

FARO constitutes amalgamation of 14 radiation oncology societies in the Asian region, and the present survey results represent the response from 14 participating countries. Majority of the centers in our survey belonged to government or academic teaching institutes with approximately two third of centers registering high case load of HNCs (>100 per year). The use of advanced treatment modalities such as IMRT/image guided radiotherapy was varied, with one third of centers using it for all their patients with HNCs.

Among ALFT strategies, the most frequently used was the HYPO-RT schedule. Commonly, it was used in the definitive management of glottic carcinoma and sparingly for other clinical sites such as supraglottic larynx, oropharynx, hypopharynx, and oral cavity. None of the centers reported using it for nasopharynx, paranasal sinuses, or for other subsites of HNCs. Definitive CCRT with HYPO-RT schedule was practiced in 18.5% centers and only few practiced CCRT in the adjuvant setting. Majority of the centers using HYPO-RT schedules restricted to the use of dose per fraction between 2.25 and 2.5 Gy, with <10%-20% using a fractionation schedule of 2.75-3.0 or 2.5-2.75 Gy per fraction. Recently, Meade et al reported on the feasibility of using a HYPO-RT schedule of 64 Gy in 25 fractions with concurrent cisplatin in human papilloma virus–negative oropharyngeal squamous cell carcinoma and found it to be tolerable and effective.[37]

Moderate hypofractionation (2.15-2.5 Gy per fraction) has been practiced as part of the SIB-IMRT protocols at more than three fourth of the centers for definitive and adjuvant settings. CCRT was also used by 13/16 centers practicing SIB-IMRT for definitive cases as opposed to 4/4 centers using CCRT for adjuvant SIB-IMRT protocols. Fewer centers used a dose fractionation schedule of >2.5 Gy under the purview of SIB-IMRT.

The fractionation schedules varied widely across centers as summarized in Table 2 with 55 Gy in 20 fractions being the most used schedule in the definitive setting. Use of SBRT for HNCs were limited to recurrent cases and for glottic cancers. There had been a trend toward increase in the use of HYPO-RT protocols predominantly as part of SIB-IMRT protocols and for glottic cancers. There has been an upsurge in the usage of SBRT for recurrent HNCs. Diao et al[38] recently reported median overall survival of 44.3 months in their cohort of recurrent HNCs treated with SBRT. A multicentric phase II study evaluating the role of SBRT for early postoperative oropharyngeal and oral cavity cancers is also currently recruiting patients.[39]

The use of AFRT was very limited and less than one fourth of centers accepted using it, mainly for patients not suitable for CCRT in the definitive setting or for those with treatment delays in the adjuvant setting. AFRT with six fractions of RT delivered per week was the most used strategy and few centers reported a trend in the increased usage compared with the past decade at their institution. A randomized controlled trial recently reported increase in both disease-free survival and overall survival with AFRT for postoperative patients with multiple high-risk factors (T3/4 with N2/N3 diseases and extracapsular extension) compared with adjuvant RT alone.[40] The use of HFRT was even more limited than AFRT with only few centers reporting to have used it for niche indications such as reirradiation. Most common reason for nonuse of AFRT/HFRT was the logistics issues with delivery of these treatment schedules such as patient load, scheduling issues, and unavailability of radiation slots on machine (Table 3). Although logistical limitations may hamper wider application of AFRT regimens, the use may be adapted to certain limited indications such as adjuvant RT in patients with multiple high-risk features as has been emphasized in the OCAT study.[34] Approximately, one third of centers were also worried with the increased acute and late toxicities with AFRT/HFRT schedules. Some of these toxicity concerns may be not supported by the scientific evidence and these misconceptions can be dispelled with society-endorsed guidelines. Among other reasons for the nonuse of AFRT/HFRT was noncompliance with the Medicare/health insurance and reimbursement issues, and national society or FARO endorsement of ALFT strategy guideline for HNCs may help tide over these regulatory issues.

There is lack of similar survey in the literature to understand the variation in practices in the usage of ALFT in HNCs. A multicentric survey on variations from the standard-of-care practices in HNCs during the COVID-19 pandemic revealed a change to HYPO-RT schedules from a conventional fractionation schedule in 65% (radical RT) and 43.5% (post-operative RT) patients.[34] The result of our survey supports the acceptance and feasibility of HYPO-RT schedules across the centers in the Asian region and this would lend support for the design and formulation of HYPO-RT clinical trials. Asian countries share unique challenges and opportunities in the HNC domain, and recommendations and guidelines suited to the resources and needs of the patients and centers have been recently

TABLE 3. Reasons for Nonuse of AFRT/HFRT Schedules

Reasons for Nonuse of AFRT or HFRT	No. of Centers (%)
Logistical issues with the use of these regimens such as unavailability of machine slots, scheduling issues, patient load, and so on	17 (62.9)
Increased acute toxicities with accelerated RT	8 (29.6)
Increased acute toxicities with HFRT	4 (14.8)
No clear advantage in terms of clinical outcome for accelerated RT	3 (11.1)
No clear advantage in terms of clinical outcome for HFRT	4 (14.8)
Increased late toxicities with HFRT	3 (11.1)
Increased late toxicities with accelerated RT	3 (11.1)
Reimbursement/noncompliance with health insurance	3 (11.1)

Abbreviations: AFRT, accelerated fractionation radiotherapy; HFRT, hyperfractionation radiotherapy; RT, radiotherapy.

published,[14,35] and similar consensus recommendations may be done in the future on the fractionation strategies in HNCs.

The strength of the present survey lies in the representation of responses from 12 of 14 participating countries of the FARO. It captures the commonality and diversity of the patterns and practices of various ALFT strategies prevalent in the Asian region.

The present survey may have certain limitations such as small sample size (N = 27) mainly from government and academic centers, and may not truly represent the clinical practice at all the practicing centers such as private and community centers. The participants in the survey were properly designated by their respective national organizations with experience in the management of HNCs and by using this balanced representation, we tried to ensure that the viewpoint is fairly neutral and not biased toward large organizations with a large membership. Nevertheless, we agree that a small size of the present survey may limit its generalizability, considering the vast population and geographical diversity of the Asian region. The use of IMRT for HNCs (which is considered as the current standard of care) was also not fully utilized at all the reporting centers, which may have limited the use of certain fractionation strategies such as HYPO-RT schedules.

The landscape of management of HNCs has been rapidly changing and with the growing burden of HNCs in the Asian region, timely delivery of the effective radiation treatment is equally important, and multicentric collaborative work to establish resource sparing RT schedules is earnestly needed. It may also be necessary to critically examine certain difficulties, such as the financial ramifications of the multicentric trials and logistical problems specific to each institution. With the current survey results, it is imperative that the HYPO-RT schedules are practically feasible, are being practiced at majority of the Asian centers, and have the potential to refine the practices. Future studies on the HYPO-RT schedules in the FARO region would further unfold the true potential of the ALFT strategy in the horizon of HNCs.

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Principles Of Imaging In Clinical Practice In Radiation in oncology

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Imaging equipment used in the pretreatment clinical setting are useful for diagnostic as well as treatment planning purposes, and help in getting a precise idea of all anatomical structures that potentially harbor tumor cells and therefore merit receiving tumoricidal doses of radiation. Similarly, on-treatment imaging is a cornerstone of modern radiotherapy, playing a critical role in ensuring precise delivery of radiation to the intended tumor target while sparing adjacent healthy tissues.

The clinical aspects and applications of these imaging equipment in relation to their technological aspects, as well as factors impacting choices with respect to different treatment techniques & anatomical sites will herein be elucidated and discussed.
Pretreatment Imaging:
Different anatomical areas and diagnoses require different imaging techniques to optimize decision making by the team of treating oncologists.

a) Radioisotope imaging-

Compared to conventional radiographic imaging, radioisotope imaging has the additional advantage of giving a functional insight of the disease on the basis of accumulation & uptake of radionuclides in different tissues. Examples include bone scan and thyroid scan for visualization of disease; MUGA scan for cardiac function assessment; and V/Q scan, which is helpful in contouring the functional segments of lungs as an avoidance structure (OAR).

b) PET imaging & PET/CT-

Similar to radioisotope imaging, PET images provide functional information. However, in order to provide sufficient anatomical information to guide radiotherapy planning, these images need to be fused with other imaging modalities due to poor spatial information of PET images alone. This fusion allows the radiation oncologist to be more precise and conformal in terms of primary and nodal target volumes.

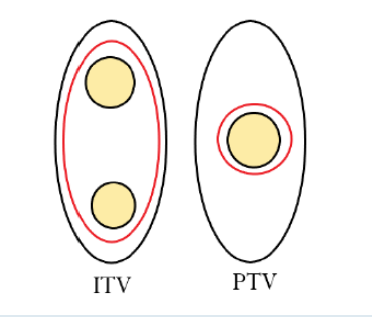
c) 3D-CT-

It is the most common form of pretreatment RTP imaging used by majority of RT departments. These images have relatively high spatial resolution, good contrast resolution and higher signal to noise ratio; and are required for dosimetric purposes.

d) 4D-CT-

A patient's normal breathing motion can produce artefacts, which can hamper the visualization of a target volume that is potentially affected by respiratory motion. This can be encountered in patients with mediastinal and upper gastrointestinal tumors.
In case of a fast CT, there is a probability of the tumor being imaged in a variety of positions, thus leading to uncertainty, distortion and impaired estimation of volumes, which is suboptimal for RT planning.

A 4DCT scan reduces these issues, wherein different different breathing phases of the patient, ranging from maximum inspiration to maximum expiration, are identified during image acquisition. This helps in creating an extended volume encompassing the tumor in all phases of respiration; which is known as Internal Target Volume or ITV (CTV with margins accounting for organ motion), and is larger than a standard PTV.

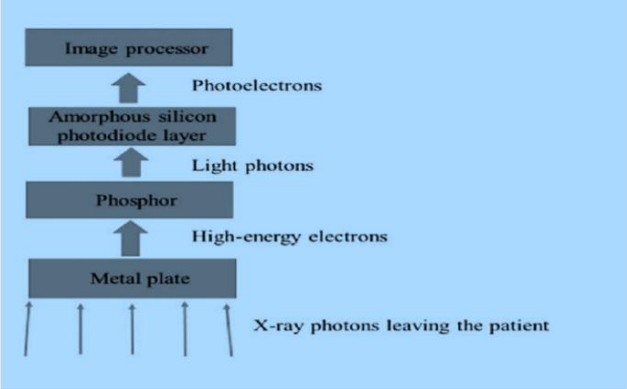


e) MR imaging-

The principle of MRI is production of images depending on response to a magnetic field by individual types of tissues, thus leading to better differentiation of anatomical boundaries and finer details of structures, and subsequent precise delineation of volumes.
It is of special significance in pelvic tumors like anorectum, prostate and cervix, intracranial SOLs, soft tissue sarcoma, and head & neck structures in certain cases.

On-treatment imaging:

The origins of on-treatment imaging has evolved into Image-Guided Radiotherapy, an approach which uses real-time images to help precisely guide and deliver radiotherapy treatments. It started with the Active Matrix Flat-Panel Imager (AMFPI), which now forms the basis of current x-ray based imaging methods on C-arm linacs.



A schematic representation of the fundamental layers within an AMFPI and the typical interaction processes, wherein incident x-ray photons are converted into high-energy electrons, then to optical photons, and then into photoelectrons that affect the charge stored in each of the pixels, thus forming an image
The currently used methods of on-board imaging are discussed as follows:

a) 2D-MV imaging-

It allows visualisation of the exact treatment field. Lower subject contrast is experienced using MV energies, thus creating clear images of bony structures. It is suitable for use when bony anatomy is a reliable surrogate for the target volumes.

b) 2D-kV imaging-

This involves better spatial resolution and subject contrast, resulting in clear images. Additionally, it involves lower dose delivered to the patient during image acquisition. It is also possible to take a combination of MV and kV images, since the kV image equipment is mounted to the Linac gantry separately from the treatment head.
However both MV and KV energies produce flat images of 3D structures.

c) Cone beam CT (CBCT)-

A cone-shaped radiation beam is employed to acquire images, and the patient does not move through the RT field, i.e., the patient is static and the RT source with its corresponding detector rotate around the patient, producing a 3D image.
Advantages- Better soft tissue visualisation can be achieved than 2D imaging, which results in reduced CTV to PTV margins. Rotational corrections are also possible with this modality.
Limitation- The static position of the patient limits the scan length. For larger volume visualization, the FOV needs to be expanded. This can create an issue with larger treatment volumes, where the treatment centre is off-set from treatment isocenter.
If we take an example of a case of prostate EBRT, there are two possible scenarios:

A) CBCT verification: Complete volumetric estimation

Possible to verify if target volume is being encompassed by delineated PTV margin
OARs in proximity, i.e., bladder and rectum also visualized.

B) 2D planar imaging with fiducial marker match: Quicker and simpler modality with similar results in terms of precision.

d) CT on rails-

The image quality of CBCT is superior to planar imaging, but inferior to diagnostic imaging, along with limitations of restricted scan length. To overcome these limitations, a full working diagnostic quality CT machine can be used within the RT treatment room. The CT equipment is placed at 180 degrees to the Linac head gantry. The diagnostic CT scanner moves around the immobilized patient in treatment position, followed by treatment on the same couch after image verification.

e) Stereoscopic in room imaging-

Here, kV tubes are not attached to the gantry, but rather present in the floor, with corresponding kV detectors mounted on the ceiling opposite the tubes, along with separate image equipped treatment gantry as well; thus allowing oblique-angled images through the treatment isocenter.

=> Non ionizing techniques for on treatment imaging: These techniques have a distinct advantage in not contributing to the concomitant dose burden to the patients. They are particularly useful for those clinical sites where intrafractional motion (target movement and deformation) is more likely to occur during delivery of RT.

a) Ultrasonography-

USG is of special significance in prostate EBRT, wherein boundaries of the prostate with urinary bladder and rectum are easily identifiable. Moreover, it obviates the requirement of invasive fiducial implantation. It monitors and tracks the internal changes in the position of the prostate. The USG system can work together with the treatment delivery system to enable auto shut-off of the beam if the prostate moves out of a predefined tolerance position.
It has utility in breast EBRT as well, where it can localize and verify the position of cavities or seroma in breast tissue, which forms the target volume for RT in cases of partial breast irradiation (PBI) or tumor bed boost. Limitation- Inter and intra observer variability can introduce uncertainties.
Pressure exerted by the probe can alter image quality and cause displacement of underlying anatomy. Perineal USG can be used instead of abdominal USG to overcome this issue of anatomical displacement.

b) Surface Guided Radiotherapy (SGRT)

SGRT involves the use of camera systems to monitor external
movements of the patient's surface. This can be achieved either by imaging the patient's actual skin surface, or with the use of externally placed markers that can be monitored for movement. It is a non invasive modality with no patient contact, resulting in no anatomical displacement.
In order to monitor patient movement during treatment, these systems employ 2 to 3 ceiling or wall-mounted projectors and cameras. They capture light reflected off the patient's surface, creating a real-time reference surface image of the patient. Daily surface images are then continuously compared to the pre-treatment reference image. The software continuously tracks this reflected light, immediately halting treatment if any detected motion exceeds predefined tolerance limits.

This technique is suitable for breast RT in cases of deep inspiration breath holding (DIBH), or partial breast radiation; as well as during SRS. Accuracy levels of 1 to 2 mm or lesser have been reported in terms of patient movement.
Limitation- SGRT cannot replace standard radiation imaging, since the position of patients still requires verification using 2D or volumetric on treatment imaging, because internal organs move independently of skin surface. It is useful when used as an adjunct to on-treatment radiography.

c) Implanted Transponders

In cases of mobile target volumes like prostate, simple on treatment imaging is not suitable for continuous organ tracking. SGRT also cannot identify the exact position of the prostate itself. To overcome these challenges, electromagnetic transponders can be implanted in the prostate for real-time tracking of its position during RT without utilizing any ionizing radiation. The Calypso system uses 3 electromagnetic transponders to provide sub-millimetric information on the prostate's intrafractional positioning. It helps in reducing CTV to PTV margins by greatly reducing uncertainties during treatment delivery.
Limitation- The procedure of implantation is relatively invasive.

d) MRI guided RT

The main potential designs for MR-guided radiotherapy integrate a small, compact linac into the mid-transverse plane of the
MR imaging coils. Cobalt sources mounted on a slip-ring gantry can also be utilized for the radiation delivery system. An MR on-rails system is also feasible, which can be moved into the vicinity of the Linac in the treatment room, similar to diagnostic CT on-rails. The latest version now incorporates a compact, 6 MV in-line FFF Linac in place of the three Cobalt sources. In terms of on-treatment imaging, the integrated MR system enables real-time, volumetric imaging during treatment, including static and dynamic (cine) modes. This enables precise intrafractional tracking of the target volumes and OARs, as well as facilitates daily adaptive treatment adjustments, by comparing the real-time MR images with the pretreatment planning CT.

Clinically, enhanced soft-tissue imaging is expected to be significantly beneficial in improving treatment for tumors in areas like the brain, spine, head & neck, abdomen (such as hepatopancreaticobiliary tumors) and pelvis, leading to better identification of critical organs.

On Treatment Imaging Techniques In Radiation Oncology

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On-treatment verification imaging refers to the process of capturing images during radiation therapy to ensure that the treatment is being delivered accurately to the targeted area. Traditionally, this imaging was closely associated with the linear accelerator (linac), however, with advancements in medical technology, several other treatment delivery systems and imaging methods have emerged over the years which utilize different forms of imaging for verification, helping to improve precision in targeting the tumor and avoiding healthy tissues, which is crucial in minimizing side effects. How treatment is verified and adjusted largely depends on the type of therapy and the available imaging technology integrated with the treatment system. This article will explore various on-treatment imaging equipment and strategies on other types of advanced technology alternatively based on non-C-arm platforms.

The helical tomotherapy system (TomoTherapy)

It is a single–unit machine based upon a CT gantry and technology. It was purposely built for image guided RT and IMRT, with its own binary MLC, dedicated inverse planned TPS, a CT (MV) detector subsystem, together with an in-line 6 MV linear accelerator. Because it uses slip-ring CT technology, the couch can move continuously allowing for helical MVCT imaging (like a standard CT scanner) and helical treatment delivery, avoiding the slice-to-slice dosimetric junction errors associated with axial delivery. In terms of on-treatment verification imaging, the technology is very similar to that of conventional helical CT scanners. The ring gantry contains the 6 MV linac x-ray source which is collimated to produce a fan beam of 0.5 cm (in the longitudinal y-direction) by 40 cm (in the lateral x-direction). This type of arrangement is therefore called “fan-beam MV CT.” Opposite to the linac, tomotherapy has an arc-shaped array of 768 conventional xenon ion chamber CT detectors at a source-to-detector distance of 142 cm with each detector projecting to a transverse width of 0.73 mm at the isocenter This arrangement has the advantage of acquiring volumetric on-treatment images postpatient set-up and prior to treatment delivery with a standard image matrix. There is a secondary benefit that lends itself well to adaptive radiation therapy—the detectors can collect data and back-project it through the acquired CT dataset to assess the actual dose distribution delivered to a patient during the fraction. The image quality (at a peak of 3.5 MV) is visibly poorer in contrast and spatial resolution with greater noise compared to that of conventional CT or CBCT scans taken at kV x-ray energies due to subject contrast differences between x-rays at kV and MV energies; but the overall quality is acceptable for the purpose of on-treatment verification with reasonable image doses of approximately 0.4 to 3 cGy per volumetric scan

This is highly comparable with MV EPID 2-D portal imaging (1 to 3 cGy per 2-D image) and kV CBCT 3-D volumetric imaging (3 to 5 cGy), making daily imaging feasible. The system is set-up to acquire a set of image slices for on-treatment verification imaging. By changing the pitch (the longitudinal distance that the couch moves during a single gantry rotation), these can have nominal slice thicknesses of 2, 4, or 6 mm, which are termed “fine,” “normal,” or “coarse” settings, respectively.

The image-matching process is a two-stage one; first using a rapid automated match (utilising bone and soft-tissue protocols assessing six degrees of freedom), which establishes any gross error detection with action levels of between 2 and 15 mm for translations and 2 to 5 degrees for rotations. A gross error detection would trigger a reset-up of the patient and a rescan – but this is a rare occurrence of only in approximately 0.3% of patient scans. After the initial match, the process is repeated automatically (assessing four degrees of freedom) and with final manual refinement, with action levels of 0 to 1 mm for translations and 0 to 1 degree for roll (Bates et al. 2013; Burnet et al. 2010). Initial results can identify substantial random displacements compared with the CT planning scan for most patients, including those within thermoplastic immobilisation; these are corrected on-line before treatment delivery

The Cyberknife System

The Accuray Cyberknife system is a treatment technology based upon a robotic delivery system which consists of distinct subsystems, based around a lightweight compact X-band 6 MV linac, a linac robotic manipulator, a similar robotic couch and a crossfire (orthogonal) 2-D kV ontreatment imaging system. The combination of in-room kV imaging and the highly versatile and precise robotic manipulator (which has full six degrees of freedom and a 0.12 mm precision for the present system) means that it is primarily designed for frame-less stereotactic radiosurgery—both intracranial and extracranial. It allows for a very high degree of accuracy and precision for the treatment geometry, but requires sophisticated on-treatment imaging techniques using both ionising and non-ionising radiation to ensure accuracy of clinical delivery, even though the mechanical movements of the robotic manipulators are reproducible to within about 0.12 mm. As the Cyberknife system is non-isocentric with a large degree of flexibility in terms of position and direction of treatment beams, on-treatment imaging is vital to ensure the highly precise positioning capability of the system is then delivered geometrically accurately to the patient. The primary imaging technology used for this is in-room 2-D kV energy x-ray systems. Two diagnostic quality x-ray tubes are mounted in the ceiling of the room, whose beam directions are orthogonal to one another and at 45 to the floor. Mounted on the floor are two corresponding amorphous silicon flat panel imagers set-up either at 90 degrees to each imaging beam or set within the floor, flush to the surface (so at 45 degrees to the imaging beam directions). Typically, the x-ray source to detector distance is about 3.5 m. The beams form a crossfire arrangement, so that the Cyberknife targeting, and the imaging alignment centre is defined by the isopost – the centre of the coordinate system reference for the Cyberknife system, the geometric isocenter.

The patient is ideally placed with their clinical target volume at or close (within about 10 cm) to the intersection of the imaging beams and hence the geometric isocenter; but the treatment isocenter does not need to be at this point – the treatment plan and associated reference images (DRRs) relate the treatment isocenter to the geometric centre and the image alignment centre (allowing for posi-tional tolerances). It relies heavily on secure, rigid geometry between the geometric centre and the image alignment centre for treatments to be delivered accurately and precisely as planned. The flat panel imagers are approximately 41 × 41 cm square, and mounted flush in the floor. Because of this, software corrections are required (in real-time) to remove the distortion from the images, since they are not perpendicular to the beam direction. In addition to x-ray imaging, non-ionising radiation methods are used, often in con-sort with xray imaging, especially to exploit more fully the tracking capabilities of the Cyberknife system where there is likely to be significant intrafractional motion – i.e. in clinical sites involving the lungs and respiration. An optical tracking system is also avail-able, which uses a stereo camera system which can track optical markers placed on the patient's skin or surface during treatment. These are often used in conjunction with the x-ray on-treatment imaging system in, e.g., their Synchrony Respiratory Tracking System explained further in the article.

The main reference images used for initial and beam alignment are a pair of 2-D DRRs; reconstructed for the directions of the crossfire kV imaging beams in the room. These are obtained from the CT planning scans during pretreatment planning; so like most C-arm gantry based 2-D imaging procedures, the reference views are orthogonal to each other, but unlike the C-arm systems, they are non-orthogonal to the patient. Beam alignment at the start of treatment is based on automatic registration of the DRRs with live images acquired in the treatment room. From these 2-D imaging pairs, 3-D transformations are computed so that the patient can be translated into a correct set-up – since the geometric relationship between the in-room x-ray imaging system and the geometric isocenter is known, and so too (from the treatment plan) the expected relationship between the anatomy around the target volume and the intended treatment delivery plan (the treatment isocenter). These initial adjustments are made using the robotic couch at the start of treatment. Further 6D corrections are possible throughout the delivery of treatment intrafraction-ally. The ideal tolerances and limitations to the extent of geometric correction in real-time, in order to maintain positional accuracy for the Cyberknife system these are up to about +/− 2.5 cm for translations and about +/− 5 degrees for rotations – so initial set-up is used to ensure that any likely intrafractional corrections needed will be within these tolerances. During treatment, further additional translations and rotational corrections are achieved by feedback to the robotic manipulator of the linac to compensate for small target movement or, in the case of target volumes which move due to respiration and other internal organ motion, to track and follow the position during treatment. Typically, 2-D kV image pairs can be acquired, the target localised, and alignment corrections made every 30–60 secs; but clearly with a close monitoring of the overall concomitant dose burden involved for the patient.
In terms of on-treatment image guidance, several methods and algorithms are employed to register and track anatomy for initial set-up and during treatment which currently include:

Bony anatomy registration and tracking: For example skull tracking (for intracranial SRS with full 6D movement and head and neck targets which may be considered rigidly related to the skull) where the high radiographic contrast of bony features with kV energy x-rays is utilized.

Spine Tracking Used for targets within or near the spine, this method relies on the high radiographic contrast of bony detail. The spine can be analyzed and tracked either as a rigid body or as a non-rigid one, since vertebrae can naturally move independently of one another.

Fiducial Markers For example, using implanted fiducials—usually 1 to 5 cylindrical gold seed markers (approximately 0.8 to 1.2 mm in diameter and 3 to 6 mm in length)—inserted into soft tissue for initial set-up and real-time tracking of soft tissue targets such as the lung, liver, prostate, and pancreas. The positions of the fiducials are identified within the digitally reconstructed radiographs (DRRs) from planning CT scans, and automatically registered with the markers' locations detected in the in-room stereoscopic on-treatment images.

Lung Tracking This method can utilize implanted fiducials (as mentioned above) or track the lung tumour directly, depending on its size, location, and density relative to surrounding lung tissue. Localisation is a two-stage process involving a global search for the target volume during initial set-up, followed by loco-regional tracking around the lung tumour during treatment delivery.

Synchrony Respiratory Tracking This approach combines and correlates the positions of external light-emitting markers placed on the patient’s chest—captured by a stereoscopic optical tracking system—with dynamic stereoscopic 2-D x-ray images acquired during treatment. Using linear or non-linear motion modeling, this combination allows a motion model to be developed and fed back to the CyberKnife system. The linac and treatment beams are then dynamically adjusted to match the patient’s breathing motion. The correlation model is continually updated throughout the treatment fraction based on the motion detected in both optical and x-ray on-treatment images.

In Tempo Adaptive Imaging : It is used for clinical sites where the imaging frequency needs to be adapted because of potential unexpected movements during the fraction, e.g. the prostate. The concept is to change the frequency of x-ray images dependent upon the anticipated and/or detected motion within the live images; the frequency of imaging and re-alignment is therefore changes in response to the rapidity of target motion. During shallow or slow drift, the imaging frequency can be slow. Once rapid (amplitude) movement is detected, the imaging frequency is increased to monitor and correct for the displacemen.
Once stable positioning is regained, the imaging frequency is then automatically reduced accordingly. In this way, on-treatment concomitant imaging dose is reduced. With this array of target and motion tracking methods, the overall accuracy of localisation and correction of set-up error is achieved

The Gamma Knife System

The most traditional dedicated equipment for delivering stereotactic radiosurgery, particularly for intracranial lesions, has come over many years in the form of the Leksell Gamma Knife (LGK). A key development was the use of an automatic positioning system (APS) in 1999, which allowed the patient's head to be moved with high-precision motors and encoded verification of the movement. This enabled multiple shots without user intervention and user verification, sped up treatment planning and delivery, and allowed more conformal treatments (which could be delivered in a sensible timescale). The Gamma Knife Perfexion(GKP) was first introduced, with many describing it as a paradigm shift from the original version. For this version, 192 Co-60 sources were used, which were able to move on the outside of a single stationary collimating structure that still provided collimated beams of 4, 8, and 16 mm diameters. No collimator helmet changeover was required, and the sources were mounted on eight sector plates, which could be moved independently of one another automatically; each sector could produce 24 cobalt beams of different diameters (instead of all the sources being restricted to the same collimation diameter at any one time). Since each sector can move, positioning the sources in-between collimation holes effectively turns the beams "off," thus dramatically reducing the radiation protection issues for patients and operators. The commercial Icon system, an add-on for the GKP incorporates acquiring CBCT by mounting a kV x-ray tube and flat-panel imager onto the front face of the system and also employs a stereoscopic, optical on-treatment imaging technology termed the high-definition motion management system, or HDMM, particularly for improving the assured accuracy of frameless treatments. This is a stereoscopic infrared camera system used to continuously monitor the patient during irradiation by means of reflective markers on the patient's nose relative to four fixed markers on the GKP head-support system. Any movement (beyond a user defined threshold) detected by the HDMM automatically interrupts irradiation.
With the improved on-treatment verification imaging capability and the treatment delivery innovations of the GKP system, there are continuing indications with maintained or improved QOL and emerging indications for fractionated GK procedures that extends the clinical compass to treating, for example, large meningiomas, perioptic tumours, and vestibular schwannomas

The Halcyon System

The new Halcyon system combines a 6 MV FFF standing-wave compact linac mounted in-line on an O-ring gantry with a maximum dose rate of 800 MU per minute and a gantry rotation speed of about 4 rpm; four times faster than that permitted on C-arm linacs. A jawless MLC is utilised with a unique stacked and staggered leaf arrangement. The field shaping was achieved mainly by using the lower bank of MLC leaves (those closest to the patient) with the upper leaf banks tracking the leaf ends of the lower leaf bank and ensuring minimal interleaf leakage.
Halcyon features MV-only-based on-treatment imaging; using the main treatment beam and a flat panel imager-style EPID and uses the treatment isocenter. Imaging (and dose reconstruction from the treatment beam) both match the treatment geometry. All the facilities of 2-D MV on-treatment imaging together with 3-D MV CBCT are available

Two principle imaging modes are permitted in the first version; 2-D static and 3-D volumetric imaging. MV-MV 2-D mode uses orthogonal imaging pairs (at fixed gantry angles of 0 and 90 degrees with 2 MU per image for a low-dose mode and 4 MU per image for a high-quality mode. The MLC collimator angle is fixed at 0 degrees for on-treatment imaging and the maximum field size permitted is the maxi-mum treatment field of 28 × 28 cm. Volumetric imaging is achieved using MV CBCT through continuous gantry rotation from 260 degrees to 100 degrees; both full-fan and half-fan imaging modes are possible. Here, 5 MU are used for a low-dose mode and 10 MU for a high-quality mode with collimators again fixed at an angle of 0 degrees. For general set-up, the patient is aligned first with a virtual indicated by the internal lasers within the system and then the couch moved into the centre of the wide bore (as in a CT simulator), MV image guidance is then used for set-up correction prior to treatment delivery. Aligning with continuing development, the second version of Halcyon now features kV ontreatment imaging with all the associated benefits of imaging using kV energy x-rays (for both 2-D and 3-D imaging) in terms of subject contrast and contrast-to-noise ratio that one obtains with current kV systems on conventional C-arm platforms. kV imaging brings likely image quality and concomitant dose benefits, with the improved efficiency and speed of imaging that Halcyon's technology and design affords.

The Vero 4DRT System

The Vero 4DRT is a highly innovative new hybrid radiotherapy platform that brings together a variety of treatment delivery and on-treatment imaging options into an O-ring technology format. Built on an O-ring gantry, unique features included a rotating floor for the O-ring gantry (so that the gantry face need not be orthogonal to the couch for non-coplanar treatments), 2-D and 3-D kV and MV imaging facilities mounted on the gantry, an IR-marker detection system, and a gimbal-mounted C-band linac capable of a pan and tilt movements of the MV treatment beam. The innovative Vero system has a range of image-guidance options using both ionising and non-ionising radiation. The main x-ray options are mounted on the O-ring gantry and rotate with the treatment beam; the non-ionising radiation system uses an IR camera mounted in the ceiling of the room, similar to that used on ExacTrac, enabling position monitoring in real time at no concomitant dose cost, and is independent of gantry position. Opposite the MV treatment beam is a traditional active-matrix flat-panel imager (AMFPI), and EPID for 2-D MV ontreatment imaging. Mounted either side of the linac-MV AMFPI axis are two kV x-ray tubes (orthogonal to one another) with associated AMFPIs in a crossfire geometry through the patient with their imaging isocenter adjusted and calibrated to coincide with that of the treatment isocenter. Both MV and kV imaging options can be used in both static and real time (dynamic) modes, dependent upon concomitant dose burden. Initial set-up is achieved using a pair of 2-D kV on-treatment images, a kV CBCT scan, an initial patient localization using the IR camera system, or a combination of these. One of the key design objectives was intra-fractional imaging and, in particular, dynamic tracking of moving targets using the gimballed MV linac mounting with or without combined dynamic couch movements. This is achieved using the pair of 2-D kV AMFPIs and the MV EPID panel, in consort with the IR imaging system. The reference images for 2-D imaging (kV and MV) are DRRs computed for the appropriate treatment beam and/or the imaging gantry angles for the kV x-ray tubes. KV CBCT volumetric images are compared with the pretreatment CT planning scans.

For IR tracking, the position of the target is first identified through implanted fiducial markers and a 4-D predictive model is developed mapping the position of IR external markers with the internal fiducials in real time. During beam delivery, the future 3-D target position is calculated from the displacements of the IR markers using the 4-D model; the corresponding data is sent to the gimballed head for continuous tracking. The internal markers are also monitored and were found to deviate outside predefined tolerances (e.g. 3 mm or more on three consecutive kV imaging frames), treatment can be interrupted, and remodelling performed during the treatment session. Experience with this 4-D technique has shown an excellent and stable tracking system, with some studies showing a predictive and tracking accuracy of less than 0.5 mm and average intrafractional errors less than 2 mm when using systematic prediction correction

Studies have demonstrated comparable performance of the 4-D dynamic tumor tracking (DTT) function with other clinical systems, using both phantom and patient studies; gimbal tracking for moving targets is very close to matching intended static dose distributions. Motion and tracking can be combined effectively for noncoplanar treatments under dynamic control, termed Dynamic Wave Arc. Whilst more research is always needed (especially into imaging frequency, concomitant dose, tracking accuracy, and clinical outcomes), the initial accuracy and clinical results for DTTs using Vero seem very promising.

Proton-beam therapy

One of the biggest clinical challenges to accurate and appropriate treatment delivery, so that the high-dose volume is delivered as planned within the patient, comes from the nature of proton-beam dose deposition (i.e. the Bragg peak) and internal anatomy changes either between planning and first fraction, or during the treatment course itself which, if unnoticed and unaccounted for, could lead to significant adverse effects (i.e. under-dose of the target volume and over-dose of the OARs and nearby normal tissues). The purpose of on-treatment imaging for PBT is primarily three-fold. First, for geometric patient set-up, secondly, in helping to verify accurately the range of the proton beam because of the changes in vivo that can affect it, as well as the uncertainties in beam characterisation and treatment planning that affect our knowledge of it (such as dose algorithms, accurate stopping power determination, RBE and LET etc.) and thirdly, in terms of plan adaptation during treatment because of the potential consequences to the dose distribution and therefore the efficacy of the treatment, if internal anatomical changes occur and go unnoticed. Accurate and reproducible set-up has mainly relied upon excellent immobilisation and external set-up markers (skin tattoos, laser alignment, markers on immobilisation equipment etc.) with the use of 2-D radiographs and bony landmarks. These 2-D radiographs, as we have for photons, are compared against DRRs from the planning CT scans for correcting set-up errors at the beginning of treatment fractions. This type of imaging has been central to PBT throughout its development for each delivered field and fraction.

Most newer PBT systems now come with a variety of on-treatment imaging options for geometric verification—a range of 2-D, 3-D and 4-D imaging techniques. Two-dimensional kV planar imaging is still available, either gantry-mounted and using flat-panel AMFPI technology either as a single x-ray tube and panel (which can take an orthogonal image pair, as on standard C-arm linacs, with a rotation of the gantry) or twin-mounted tubes and AMFPIs in a crossfire technique through the isocenter, providing orthogonal imaging simultaneously. Twin kV tubes and AMFPIs also may be mounted in the room (in a similar fashion to ExacTrac) at floor and ceiling levels at approximately 60 degrees to each other and 45 degrees relative to the floor again in a crossfire technique through the isocenter. Reference images for set-up correction are 2-D DRRs from the planning CT scans reconstructed for the appropriate geometric view through the patient. Both bony landmarks and implanted fiducial markers can be used with planar images and/or fluoroscopic modes for real-time movement monitoring and tracking during treatment, again in a similar way to Exactrac.

Volumetric imaging is also now developing for PBT treatment rooms. For the gantry mounted kV imaging systems, this is through CBCT by gantry rotation and acquiring CBCT scans from one or both of the gantry mounted panels. This brings considerably better anatomical imaging to bear on-treatment, enabling anatomical changes to be spotted volumetrically on-treatment and plans adapted accordingly

Volumetric imaging can also be achieved through in-room CT systems (CT-on-rails) with the added benefit of identical 3-D/4-D high image quality to that of the planning CT scan set. Nonionising radiation technologies can also be used for on-treatment imaging, monitoring the external surface of the patient (with or without x-ray localisation) either directly or through surrogate surface markers. A number of approaches are being examined including MR and PET for on-treatment verification imaging compatible with PBT.

MR on-treatment imaging

On-treatment imaging technologies which use non ionising radiation techniques have a distinct advantage in not contributing to the concomitant dose burden - and therefore can be used much more frequently (daily) for set-up correction and monitoring throughout the delivery of each treatment fraction. With its enhanced soft-tissue visualisation capability and full volumetric imaging capacity, MR systems would seem ideal for this purpose, with faster, cine sequences already showing acceptability for clinical studies of internal organ motion and deformation. The potential gains are numerous, but it is an on-treatment technology and technique which is not without its challenges; for example, with regard to health economics, adaptive strategies and algorithms, practical bore size, geometric distortion and linac calibration, workflow development, patient selection and staffing/training; to name but a few. The key designs integrate a small, compact linac into the mid transverse plane of the MR imaging coils or through/between the planes of open MR systems. In terms of on-treatment imaging, the integrated MR system provides full volumetric images in real time, in both static and dynamic (real-time cine) modes for comparison with pretreatment planning CT slices, and for target volume/OAR tracking intrafractionally and daily online adaptive treatments. Such precise image-matching enables greater margin reduction for the PTV and therefore potential dose escalation/hypofractionation

Emission-Guided/Biology-Guided Radiotherapy (EGRT/BGRT)

To be able to refine the target volume to concentrate high therapeutic dose in areas likely to contain concentrations of actual tumour cells, rather than through purely a visualisation of gross anatomy, is a powerful tool. Its use for pretreatment imaging, usually in process or technological combination with CT and MR, has been highlighted in aiding diagnosis, staging, and treatment planning. A natural extension of this is to introduce its use into the on-treatment scenario for either biological geometric verification of the target volume, an aid to plan adaptation during treatment or for helping to guide and pinpoint, biologically, the treatment beams themselves directly to concentrations of tumour cells. Using PET as the imaging modality for on-treatment guidance requires understanding of all the difficulties, opportunities and challenges associated with PET imaging, but provides a unique potential for treatment delivery technology. It is a technique now being termed emission-guided radiotherapy (EGRT) or biologically guided radiotherapy (BGRT). Traditional x-ray-based on-treatment imaging is used for obtaining good anatomical set-up geometrically, but then the radiolabelled tracer, once injected and accumulated into the target (tumour) cells, makes these cells a type of biological fiducial markers for inherently tracking motion and correcting set-up uncertainties. PET gamma ray emissions is used in real time for direct tumour-cell tracking during treatment delivery. Treatment beams or beamlets are then directed to the target volume along the lines of response (LOR) determined from the gamma ray emissions and coincidence counting for PET. A fast-rotating ring gantry is used for the in-line linac and imaging, alongside a ring structure of PET detectors. The preproduction system consisted of a compact 6 MV in-line linac with a binary MLC (similar to that on tomotherapy), ring mounted PET detectors, kV CT imaging and MV imaging flat panels. All are combined onto a slip-ring gantry structure that can rotate around the patient at approximately 60 rotations per minute as the patients is translated through the bore of the system (again, like tomotherapy). Dose delivery and modulation is achieved through the 64-leaf binary MLC.

An axial delivery mode is used, so the couch is translated in small steps and intensity modulated beams fired back along the PET lines of response over many gantry rotations while the couch is stationary; treatment delivery is axial rather than helical. Initial clinical set-up, on-treatment imaging verification, and delivery is envisaged along the following pathway:

• Patient is administered PET tracer and waits for a time to allow optimum uptake, as per a standard PET protocol

• Patient is positioned on the couch and set-up corrections made using an on-treatment localisation kV CT scan and/or MV CBCT imaging protocol; reference is a planning CT scan set.

• A short duration PET/MVCT (if used for alignment) scan is acquired for alignment and calibration, and additionally to update the planning map.

• Treatment is delivered following LOR detection (and qualification) and beamlet delivery back along the valid LORs. The intensity modulation is achieved following a planning map, updated and modified by LOR detection.

Recently (October 2018), the system was launched commercially at the American Society for Radiation Oncology (ASTRO) annual meeting through RefleXion Medical as a fully integrated biology-guided radiotherapy system (ARO 2018; RefleXion 2018).

All the above-mentioned systems and techniques focus on the common goal of enhanced treatment accuracy and precision, motion management, and adaptability which translates into improved tumor control probabilities (TCP) and reduced normal tissue complication probabilities (NTCP). On-treatment imaging facilitates safe dose escalation in certain cases, potentially leading to better therapeutic ratios and improved long-term outcomes for patients.

World Cancer Day celebration at JNMC, AMU, Aligarh

- On the occasion of World Cancer Day, the Department of Radiation Oncology, JNMC, AMU, Aligarh, conducted a 2-day event from 27th to 28th January 2025, with the theme “United By Unique”. We are happy to inform that this program has been conducted under the Aegis of AROI-UP Chapter.
- During this event, Doctors, Scholars, and students from diverse backgrounds participated enthusiastically in various competitions (including quiz competition, slogan writing, poster making, image reimagination, story-telling, reel making, and cancer ribbon reimagined.)
- Moreover, we had Two Faculties from outside AMU, Prof Kailash Mittal from UPUMS, Saifai and Prof Surabhi Gupta from SN Medical College, Agra, who not only participated in some of the events to encourage the students, but also Judged few events. We thank them for sparing their precious time.
- On 4th February (World Cancer Day), the Department organized a programme to facilitate the winners of the competitions. The programme also included interaction with few of the cancer survivors and their attendants, who shared their story of fight against cancer.
- We hope to continue the conduction of such events in future also.

Glimpses of World Cancer Day Celebration
JNMC, AMU, Aligarh

Winter Donation Drive Programme under UPAROI Society

In a compassionate initiative aimed at supporting underprivileged cancer patients, the Department of Radiation Oncology, JNMC, AMU, under the aegis of UPAROI Society, organized a Winter Donation Programme in December 2024. The programme focused on providing warmth and comfort during the harsh winter season to those bravely undergoing cancer treatment.

As part of this outreach, winter jackets were distributed to over 50 poor cancer patients currently receiving care at the department. The event reflected the department's ongoing commitment not only to medical treatment but also to the overall well-being of its patients.

The programme was graced by the presence of Prof. Mohd Akram, Chairman of the Department of Radiation Oncology, JNMC, AMU, and Dr. Md Shadab Alam, General Secretary of UPAROI Society. Faculty members, resident doctors, and departmental staff also participated actively in the event, demonstrating a strong spirit of community and service.

This initiative stands as a testament to the compassionate care philosophy embraced by the department and UPAROI Society, making a meaningful difference in the lives of patients beyond the clinical setting.

Winter Donation Drive Programme under UPAROI Society

The 11th Young Radiation Oncologists Conference (YROC 2025)
A Grand Success!

The 11th edition of the Young Radiation Oncologists Conference (YROC 2025), held on January 25th and 26th in Madurai, concluded on a high note, marking a significant milestone in advancing radiation oncology.

With an impressive 270 registrations, the conference featured 126 scientific presentations, including 32 oral sessions, showcasing cutting-edge research and innovative clinical practices.

Centered around the theme "Challenges & Controversies in Clinical Oncology," the event fostered insightful discussions on critical topics such as Stereotactic Radiosurgery, Brachytherapy, and Re-irradiation.

A blend of expert-led debates, panel discussions, and practical "How I Do It" sessions provided participants with valuable knowledge and emerging perspectives in the evolving field of oncology.

The conference commenced with a grand inaugural ceremony, setting an enthusiastic tone for the two-day event. The inauguration highlighted the importance of addressing challenges in clinical oncology while encouraging collaborative learning and innovation. The Welcome Address was delivered by Dr. K.S. Kirushna Kumar, Organising President – YROC, followed by the lighting of the Kuthuvilakku by all dignitaries, Dr. Ramesh Ardhanari, Medical Director, MMHRC, Madurai, Dr. V. Srinivasan, Secretary General, AROI, Dr. Vikas Jagtap, Jr. Vice President, AROI & YROC Convener, Dr. B. Kannan, Medical Administrator, MMHRC, Madurai, Dr. P. Ananda Selvakumar, Organising Secretary – YROC and Dr. Manirathinam -Organising Treasurer -YROC.

The overwhelming participation and engaging scientific discourse reaffirmed YROC 2025 as a premier platform for knowledge exchange, collaboration, and shaping the future of radiation oncology.

Glimpses of YROC 2025

AROI West Bengal Chapter Annual State Conference 2025

The Annual State Conference of the AROI West Bengal Chapter for the year 2025 was held on the 15th and 16th of February 2025 at the Dhono Dhanyo Auditorium in Kolkata.

The conference was attended by over 250 delegates, including more than 100 faculty from across West Bengal, various parts of India, and international institutions. The scientific program comprised six broad academic sessions, including a Target Volume Delineation (TVD) workshop, a debate, and a resident quiz competition.

Inauguration

The conference was inaugurated in the esteemed presence of the Honorable AROI President, Prof. Dr. Surendra Nath Senapati,Honorable AROI Secretary General, Dr. V. Srinivasan, along with Padma Shri Pandit Tejendra Narayan Majumdar, a world-renowned Sarod maestro who graced the event as the Chief Guest. Following the ceremonial lamp-lighting by the dignitaries, President of AROI WB Chapter, Dr. Litan Naha Biswas, and Secretary of AROI WB Chapter, Dr. Abhishek Basu, felicitated the Chief Guest and the AROI President and Secretary General.

The President and Secretary General of AROI, applauded the AROI WB Chapter and its office bearers for their continued efforts towards academic excellence as well as organizing a wonderful Conference, commending them for the remarkable achievement of organizing a state conference in the same year as the immense responsibility of hosting AROICON 2025, the national conference, in Kolkata under the AROI WB Chapter.Theyformally launched the new logo of the AROI West Bengal Chapter which was designed by Dr. Jibak Bhattacharya.

Senior Member, Dr. Debabrata Mitra was conferred the AROI WB Lifetime Achievement Award.

Highlights of Day 1

The conference commenced with sessions on Thoracic Malignancies and Gynaecological Malignancies, featuring engaging talks and expert panel discussions. One of the highlights of the first day was the Dr. Abhijit Basu Memorial Oration (which was started from this year), delivered by senior member Dr. Anup Majumdar on the topic 'Oncology: Looking Back at the Last Four Decades.'

Other key sessions of the first day included discussions on Sarcoma &Haematolymphoid Malignancies, a virtual keynote lecture by Dr. Matthias Guckenberger (President of ESTRO) on 'Redefining Cure in Oligoprogressive Cancers,' and an engaging debate on the topic, 'Subsidized Healthcare in Oncology is a Damocles' Sword.'

The Annual General Body Meeting 2025 took place in the evening, with participation from over 80 members. Key discussions centered around the upcoming AROICON 2025, which will be hosted by Narayana Superspeciality Hospital, Howrah, under the aegis of AROI West Bengal Chapter.

AROI West Bengal Chapter Annual State Conference 2025

Highlights of Day 2

The second day began with a Target Volume Delineation Workshop on Oral Cavity Cancers, followed by academic sessions focused on Gastrointestinal Malignancies. A special panel discussion on Hepatocellular Cancer Management was also conducted.

A significant highlight of the day was the Dr. Chandan Dasgupta Memorial Young Oncologists' Session: 'Think Out of the Box!' This session, featuring an open forum titled 'Research in Oncology is an Obligatory Evil!' included insights from eminent oncologists and young researchers.

The final segment of the conference featured two highly anticipated events:

1. The Quiz for Residents, moderated by Dr. Anupam Datta.
2. The Best Paper Presentation Session, where the top 10 selected e-posters were presented.

Fellowships and Awards

The AROI WB Fight Cancer Fellowship 2025 was awarded toDr. Indranil Hait, 2nd year Resident of Medical College Hospital, Kolkata and Dr. Sattwik Basu & Dr. Sattama Samanta, 3rd Year Resident of Medical College, Kolkata.

The AROI WB Young Oncologist Fellowship 2025 was awarded to r. Shinjini Chakraborty, Senior Resident, Medical College & Hospital, Kolkata.

The Best Paper Oral Presentation Award was conferred uponDr. Sattama Samanta from Medical College, Kolkata; Dr. Aryan Malhotra of Burdwan Medical College, Burdwan being First runner - up and Dr. Arshmeen Kaur of Tata Medical Centre, Kolkata being Second runner-up. It was decided that the First position holder of Best Paper Award for Residents would also receive a Dr. Abhijit Basu Memorial Gold Medal from this year, which shall be conferred later.

Conclusion

The AROI WB Annual Conference 2025 was a grand success, fostering academic discussions, clinical knowledge-sharing, and networking opportunities for oncology professionals. The Organizing Committee extends heartfelt gratitude to all faculties, delegates, sponsors, and attendees for their participation and contributions.

The Conference ended with a warm welcome to all Delegates for the upcoming 45th Annual National Conference of AROI – AROICON 2025 which shall be held from the 27th to the 30th of November, 2025 at Biswa Bangla Convention Center, Kolkata.

Glimpses AROI West Bengal Chapter Annual State Conference 2025

9th Annual Meeting of AROI Odisha Chapter

The 9th annual conference of the Association of Radiation Oncologists of India- Odisha State Chapter was held at Puri on 22nd & 23rd of february,2025. The theme for this meet was "Precision Paving to Cure". Organised under the able guidance of Professor Sanjukta Padhi, Secretary, AROI Odisha State Chapter, this academic fiesta was attended by delegates from various parts of Odisha as well as from various parts of India. The scientific session saw various deliberations and debates with 2 keynote address by Dr. Kaushik Bhattacharya, Director, Dept of Radiation Oncology, AIG hospitals, Hyderabad and Prof. S.K Das Mazumdar, Dept of Radiation Oncology, AIIMS Bhubaneswar.

As a novel endeavour the Prof. K.C. Sahoo Memorial Oration was instituted in the honour of late Prof K.C. Sahoo, former Professor and Head of The Dept, Dept of Radiotherapy, AHPGIC, Cuttack. Professor Surendra Nath Senapati, President, AROI, was awarded the first Professor K.C Sahoo Memorial Oration.

Honourable Vice Chancellor, Odisha University of Health Sciences Professor Manas Ranjan Sahoo graced the inauguration ceremony as the Chief Guest. The national executive committee members of the Association of Radiation Oncologists of India viz. President Professor Surendra Nath Senapati, President Elect Dr. C.S Madhu and Secretary General Dr. V. Srinivasan, graced the occasion as the guest of honour. The souvenir was unveiled by the esteemed guests.

Various issues were discussed in the general body meeting with the decision to launch a website and to have a permanent office for the AROI, Odisha State Chapter.

New office bearers of AROI Odisha State Chapter took charge of the various offices as follows:

President: Professor Sanjukta Padhi
Vice President: Dr. Durga Prasad Sahoo
Secretary: Dr. Sailendra Narayan Parida.
Joint Secretary: Dr. Saumya Ranjan Mishra
Treasurer: Dr. Deepak Kumar Das

Executive Committee Members:

Dr. Tapan Kumar Sahoo
Dr Tanushree Mishra
Dr Sulagna Mohanty

Advisors:

Professor K.B Das
Professor B.K Mohanty
Professor Niharika Panda.

The winners of paper presentation Dr Aamir Soel, Dr Nirlipta Mohanty, Dr Sasmita Priyadarshinee and Dr Shankar R- were awarded in the valedictory function.

Glimpses 9th Annual Meeting of AROI Odisha Chapter

5th Annual Meeting of AROI Gujarat Chapter

Pooja Nandwani Patel conducted “Gujarat Radiating’s Mahakumbh 2025” (5th Annual Meeting of AROI Gujarat Chapter) as Organizing Secretary at Diu on 8th and 9th March 2025 with total 86 attendees from all over the state. On day 1 there were E poster presentations by postgraduate students followed by sessions on lung, head and neck, CNS, Breast and upper GI cancers. This was followed by the General Body meeting of the state AROI chapter. Dr Samir Batham started the GBM, with declaration of increase in AROI Gujarat Chapter membership number increasing from 155 to 186.

Dr Samir congratulated Dr Pooja Nandwani Patel for the successful meeting attended by over 80 delegates and faculties from Gujarat. Dr. Samir gave a brief about the inception of AROI Gujarat chapter and the past 4 meetings organised so far, he also informed about the bank accounts, ITR filing and income and expenses of the AROI Gujarat chapter. Suggestions were taken from the house and seniors for raising funds in the state chapter account and also regarding utilising the funds. Dr. Kinjal Jani suggested investing 50% of the savings money into fixed deposits which was seconded by Dr. Nilesh Mahale and Dr. Surendrasingh Solanki. Dr. Samir also informed that the chapter is trying to register itself which currently is an AOP(Association of persons), which will be followed by switching the bank account from the Central Bank of India to a private bank for ease of transactions. Next point was raised by Dr Rahul Misra about the winners of abstract papers from this conference. He suggested that the winners should be offered discounted/complimentary registration for national AROICON. Dr Pooja Nandwani Patel took the suggestion and reassured the house to implement it from the next organizing committee of the conference.

Dr.Samir recommended the formation of the executive committee of chapter, to which Dr. Hemendra Mod proposed keeping one representative each from four major cities of Gujarat - Ahmedabad, Vadodara, Rajkot and Surat. This was seconded by Dr. Kinjal Jani and Dr. Pramod Patil. Dr Samir invited suggesting names for the same and the names of Dr Hemendra Mod from Rajkot, Dr Nilesh Mahale from Surat, Dr Rushi Panchal from Vadodara and Dr Malhar Patel from Ahmedabad were proposed by Dr Kinjal Jani and Dr Rahul Misra and were seconded by Dr Sonal Patel Shah and Dr. Surendrasingh Solanki.

It was also proposed to allocate the responsibility of AROI Gujarat chapter’s social media handling to Dr Malhar Patel, newsletter to Dr Nilesh Mahale and PG teaching and academics to Dr Hemendra Mod and Dr Rahul Misra. Dr Rahul Misra was also appreciated and acknowledged for his online webinars for PG students.

Dr Samir declared the tenure of the office bearers(President and Secretary) to be complete and requested the house to decide or suggest names for the next office bearers. Dr. Kinjal Jani proposed that Dr. Pooja Nandwani Patel and Dr. Samir Batham should continue for one more term of two years as President and Secretary of AROI Gujarat chapter respectively This proposal was seconded by Dr Maitrik Mehta, Dr Malhar Patel, Dr Sonal Patel Shah and Dr. Hemendra Mod. Dr. Samir invited volunteers for the vacant position of treasurer of state chapter, Dr Pooja proposed the name of Dr. Maitrik Mehta, which was seconded by Dr. Sonal Shah and Dr. Rahul Misra.

Dr. Samir invited bids for the next state chapter annual conference and Dr Prashant Patel and Dr Rushi Panchal volunteered for the same as organising secretary and organising chairman for the conference respectively , since there was no other bidder they were given the responsibility to host the next annual meeting during December 2025- January 2026. It was seconded by Dr Ankit Thakkar, Dr Chandni Shah and Dr Pramod Patil.

The GBM ended with inauguration of the conference with lamp lighting by all the office bearers and executive committee members.

Day 2 started with Oral presentations from the shortlisted papers from day 1 followed by sessions on rectal, Genitourinary and gynecological sessions. The event concluded with a valedictory function and vote of thanks by the Organising committee.

Glimpses 5th Annual Meeting of AROI Gujarat Chapter

Obituary

Dr Pincy Deka
3rd Year Resident
MD Radiation Oncology
Dr B Borooah Cancer Institute.

With deep sorrow, we inform the passing of Dr Princy Deka, who was under treatment for Viral Meningitis. She initially received care at Guwahati Medical College, Guwahati, followed by treatment at Fortis Hospital, Gurgaon, and was later shifted to VMMC & Safdarjung Hospital, New Delhi.

She breathed her last at around 6 PM on 20 January 2025 at VMMC & Safdarjung Hospital, New Delhi.

We extend our heartfelt condolences to the bereaved family and pray for peace to the departed soul.

ESTRO

3rd AROI- ESTRO
HEAD AND NECK ONCOLOGY TEACHING COURSE

Theme – Carcinoma Larynx & Hypopharynx

5th-7th, June 2025

Venue : Regional Cancer Centre, Trivandrum, Kerala, India

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- Evidence based management and recent advances
- Case based discussions
- Contouring sessions
- Interactive panel discussions

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Dr. Rejnish Ravi Kumar
Course coordinator

Organized by the Department of Radiation Oncology, Regional Cancer Centre, Trivandrum
WhatsApp: **+91 - 9446 800 850**

3rd AROI ESTRO HEAD & NECK ONCOLOGY COURSE

June 5-7, Trivandrum, Kerala

Theme: Management of Carcinoma Larynx & Hypopharynx

1st Day

Time	Topic
0845 - 0900	Introduction
0900 - 0920	Landscape of Ca Larynx and hypopharynx - India/ Europe
0920 - 0950	Ca Larynx & Hypopharynx -work up
0950 - 1035	Imaging and staging in Ca Larynx and hypopharynx
1035 - 1105	Inauguration
1105 - 1125	Tea /Coffee break
1125 - 1155	Role of Surgery in the Management of Ca Larynx (Both early & late: role of surgery)
1155 - 1225	Management of early laryngeal cancer (RO perspective)
1225 - 1255	Management of Advanced laryngeal cancer (RO perspective)
1255 - 1400	Lunch
1400 - 1430	Role of chemotherapy in the curative treatment of Laryngeal & Hypopharyngeal Cancers
1430 - 1530	Target volume delineation in Ca Larynx and Case demonstration
1530-1550	Tea /Coffee break
1550 - 1650	Homework-1: Ca Larynx
1650 - 1720	Research without borders – ca larynx as an example
1720 - 1750	Concluding remarks

2nd Day

Time	Topic
0830 - 0845	Introductory remarks
0845 - 0915	Role of speech pathologist in the management of Laryngopharyngeal Cancers
0915 - 1015	Radiotherapy planning – Physics lecture (combined)
1015 - 1045	Tea/ coffee break
1045 - 1115	Plan evaluation in Ca Larynx – Demonstration
1115 - 1215	Outline in the management of recurrent Ca Larynx
1215 - 1315	Lunch
1315 - 1415	Panel discussion -Ca Larynx
1415 - 1500	Management of Carcinoma Larynx: Contentious Issues
1500-1520	Tea/ coffee break
1520 - 1600	Management of Ca Hypopharynx (RO)
1600 - 1640	Management of Ca Hypopharynx (SO)
1640 - 1650	Day Summary

3rd Day

Time	Topic
0830 - 0845	Introductory remarks
0845 - 0945	Target volume delineation in Ca Hypopharynx and case demonstration (Early & Late)
0945 - 1045	Homework -2 Ca hypopharynx
1045 - 1115	Tea/ coffee break
1115 - 1145	Role of chemotherapy in advanced and metastatic Laryngeal & Hypopharyngeal Cancers
1145 - 1230	Role of Immunotherapy in Hypopharyngeal and Laryngeal Cancers
1230 - 1330	Lunch
1330 - 1430	Case demonstration and plan evaluation – Ca hypopharynx
1430 - 1530	Multi-modality palliative care in Ca larynx and hypopharynx
1530 - 1600	Tea/ coffee break
1600 - 1700	Panel discussion –Ca Hypopharynx
1700 - 1730	Follow-up evaluation after Organ Preservation in Ca Lx/ Hpx
1730 - 1745	Valedictory, Feedback

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Academic Wing of

Association of Radiation Oncologists of India (AROI)

49TH ICRO PG Teaching Program

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Teaching Schedule Medical Physics & Radiobiology

DAY 1 - 21st June 2025		
9.30 AM – 11:30 AM	Basics of Radiation Physics	Mr Mahendran. C
11.30 AM -1:00 PM	Beam Modifying Devices	Dr Virendra Bhandari
1:00 PM – 1:45 PM Lunch		
1:45 PM - 4:00 PM	Radiobiology-I	Dr Virendra Bhandari
4:00 PM - 5:00 PM	Electron Therapy	Dr OP Gurjar
5:00 PM - 6:00 PM	Physics in Brachytherapy	Dr Ashar Iqbal Lodi

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Teaching Schedule Medical Physics & Radiobiology

DAY 2- 22nd June 2025		
9:00 AM - 11:00 AM	Radiobiology-II	Dr Virendra Bhandari
11.00AM – 11.40 AM	Particle Therapy	Ms Gomathi. R
11:40 AM – 11:50 AM Tea Break		
11:50 AM - 1:00 PM	Radiation Safety & Protection-I	Dr Priyusha Bagdare
1:00 PM – 2:00 PM Lunch		
2:00 PM - 3:00 PM	Radiation Safety & Protection-II	Dr Priyusha Bagdare
3:00 PM – 4:00 PM	Advance Radiotherapy Techniques	Dr Deepika Malik
4:00 PM- 4:30 PM	Radiotherapy Shielding Calculation	Mr Mahendran. C
4.30 PM – 5.00PM	Concluding Remarks & Questionnaire	Dr Virendra Bhandari

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Teaching Schedule Medical Physics & Radiobiology

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4:00 PM- 4:30 PM	Radiotherapy Shielding Calculation	Mr Mahendran. C
4.30 PM – 5.00PM	Concluding Remarks & Questionnaire	Dr Virendra Bhandari

Course Co-ordinator : ***Dr. Virendra Bhandari,***
Professor and HOD,
Department of Radiation Oncology
Sri Aurobindo Institute of Medical Sciences, Indore

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For Contact: 0731 423 1498/1807, 9893115337, 9452363314 |
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3. For accommodation please contact: Dr Amresh Kumar: 9990882719

Dr Mohini Gurjar: 9926909093

For Contact: 0731 423 1807/1498, 9893115337, 9452363314

MCQs On
BASICS OF RADIATION ONCOLOGY PHYSICS

Prof. Abhijit Mandal, Dr Ganesh Kumar Patel
Department Of Radiotherapy And Radiation Medicine, IMS,BHU,

1. Atom is specified by the formula
A $_{Z}^{M}X$
B $_{Z}^{A}X$
C $_{A}^{Z}X$
D $_{M}^{Z}X$

2. Nucleus consists of
A Neutron , electron and proton
B Proton and electron
C Neutron and proton
D Neutron and electron

3. Isotopes Atoms having nuclei with
A Same atomic number but different mass number
B Same mass number but different atomic number
C Same neutron number but different atomic number
D Same electron number but different atomic number

4. 1amu =
A 9.31 MeV
B 931 eV
C 931 KeV
D 931 MeV

5. Half Value Thickness (HVT) of lead for Co-60 beam is
A 12 cm
B 21 cm
C 1.2 cm
D 0.12 cm

6. Tenth Value Thickness (TVT) =
A 2.3 HVT
B 3.3 HVT
C 4.3 HVT
D 1.3 HVT

7. For diagnostic range x ray beam most predominant interaction with matter is
A Coherent Scattering
B Photo-Electric Absorption
C Compton Scattering
D Pair Production
8. For therapeutic range x ray beam most predominant interaction with matter is
A Coherent Scattering
B Photo-Electric Absorption
C Compton Scattering
D Pair Production

9. Bragg`s peak is the property of
A Electron beam
B Heavy charged particle
C Neutron beam
D Photon beam

10. SI Unit of Radioactivity is
A Gray
B Sievert
C Coulomb
D Becquerel

Units and measurement of radiological quantities

1. SI unit of exposure is
A Roentgen (R)
B Gray (Gy)
C Coulomb / kg
D Joule / kg

2. Gray (Gy) is equal to
A Coulomb / kg
B Joule / kg
C Curie / kg
D Calorie / kg

3. SI unit of effective dose is
A Roentgen (R)
B Curie
C Gray (Gy)
D Sievert (Sv)

4. One Gray (Gy) of alpha dose is
A More effective than one Gray (Gy) of gamma dose
B Less effective than one Gray (Gy) of gamma dose
C Equally effective than one Gray (Gy) of gamma dose
D Beyond comparison with one Gray (Gy) of gamma dose

5. Units of KERMA are same
A As radiation exposure
B As equivalent dose
C As radiation absorbed dose
D As radioactivity

6. 1 eV =
A 1.602×10^{-19} C
B 1.602×10^{-19} J
C 1.602×10^{-11} J
D 1.602×10^{-19} Cal

7. Thermoluminescent dosimeter is
A one type of ion chamber
B one type of chemical dosimeter
C one type of solid state device
D one type of calorimeter

8. Radiation units are defined and re defined by
A AERB
B IAEA
C ICRP
D ICRU

9. Free Air Ionization Chamber is a
A Primary standard dosimeter
B Secondary standard dosimeter
C Tertiary standard dosimeter
D Nonstandard dosimeter

10. The quantity exposure is
A Total absorbed energy per unit mass
B Total produced charge of one sign per unit mass
C Total produced charge per unit mass
D Total energy imparted per unit mass

Medical radiation generators

1. PET is one kind of equipment based on
A Compton effect
B Photoelectric effect
C Annihilation phenomenon
D Pair production

2. Diagnostic radiology based on
A Compton effect
B Photoelectric effect
C Annihilation phenomenon
D Pair production

3. Radiation therapy based on
A Compton effect
B Photoelectric effect
C Annihilation phenomenon
D Pair production

4. Radiotherapy simulator used for
A Staging of the disease.
B Diagnosis of the disease.
C Radiation treatment
D Duplicating the therapeutic situation.

5. Bremsstrahlung radiation is
A Continuous spectrum
B Discrete spectrum
C No spectrum
D Continuous- discrete spectrum

6. Average energy of Co-60 radiation beam is
A 1.25 KeV
B 1.25 eV
C 1.25 MeV
D 1.50 MeV

7. Half life of Co-60 radioisotope is
A 52.6 years
B 52.6 months
C 5.26 months
D 5.26 years

8. Klystron is a
A Microwave power amplifier
B Microwave power divider
C Microwave power modulator
D Microwave power generator

9. LINAC has only
A Photon mode
B Electron mode
C Both electron and photon mode
D Proton

10. Flattening filter is used for
A Photon mode
B Electron mode
C Both electron and photon mode
D Proton

Classical Radiation Therapy

1. Water is a suitable phantom material because
A Water closely approximates the muscles and other soft tissues
B Water is universally available
C Water have reproducible radiation properties.
D All the above

2. Percentage Depth Dose (PDD) =
A f (Beam energy, field size , source to diaphragm distance, depth)
B f (Beam energy, field size , depth)
C f (Beam energy, field size , source to surface distance, depth)
D f (Beam energy, field size , source to surface distance)

3. Tissue Air Ratio (TAR) =
A f (Beam energy, field size , source to diaphragm distance, depth)
B f (Beam energy, field size , depth)
C f (Beam energy, field size , source to surface distance, depth)
D f (Beam energy, field size , source to surface distance)

4. To calculate the dose rate at any point in patient, we need not to know
A Source to diaphragm distance
B Source to surface distance
C Field size
D Beam energy

5. It is not a beam modifying device
A Wedge
B Compensator
C Collimator
D Flattening filter

6. Tissue compensator is a
A Beam directional device
B Beam modifying device
C Beam shaping device
D Beam converging device

7. For effective shielding of normal tissues, how many HVL is required
A 5 HVL
B 10 HVL
C 3 HVL
D 2 HVL

8. HVL is dependent of
A Beam energy
B Beam geometry
C Material types
D All the above

9. Bolus materials are
A Tissue equivalent material
B High Z material
C Low Z material
D Any material

10. Increase the number of fields will
A Increase the dose homogeneity of target volume
B Increase the dose conformity of target volume
C Decrease the dose homogeneity of target volume
D Decrease the dose conformity of target volume

Brachytherapy

1. Brachytherapy is
A Medium distance therapy
B Long distance therapy
C Short distance therapy
D Not related to therapeutic distance

2. High Dose Rate brachytherapy defined by dose rate
A 0.2 – 2 Gy / hr
B > 12 Gy / hr
C < 12 Gy / hr
D 2 – 12 Gy / hr

3. Current standard of source strength specification is
A Apparent activity
B Activity
C Air Kerma Strength
D Exposure rate at a specified distance

4. Which is not a dosimetry system used for interstitial brachytherapy
A New York system
B Quimby system
C Paterson –Parker system
D Paris system

5. Quimby system defined as
A Non uniform source distribution leads non uniform dose distribution
B Uniform source distribution leads uniform dose distribution
C Non uniform source distribution leads uniform dose distribution
D Uniform source distribution leads non uniform dose distribution

6. Paterson –Parker system defined as
A Non uniform source distribution leads non uniform dose distribution
B Uniform source distribution leads uniform dose distribution
C Non uniform source distribution leads uniform dose distribution
D Uniform source distribution leads non uniform dose distribution

7. Which statement is not true for Point A
A 2cm superior to the cervical OS.
B 2 cm lateral to the cervical canal.
C 3 cm superior to the cervical OS.
D In the plane of uterine cavity

8. Which statement is not true for LDR brachytherapy
A It's a fractionated irradiation
B Very localized irradiation around the radiation sources.
C Sharp dose fall off beyond the target volume.
D Very high dose to the target volume.

9. To define ICRU -38 System Bladder reference points, we use
A 10cc balloon
B 7 cc balloon
C 5cc balloon
D 15 cc balloon

10. Which statement is not true for HDR brachytherapy
A It's a fractionated treatment
B It's a continuous treatment
C Very localized irradiation around the radiation sources.
D Sharp dose fall off beyond the target volume.

Modern Day Radiation Therapy

1. Multileaf collimator (MLC) made of
A Molybdenum
B Lead
C Depleted uranium
D Tungsten Alloy

2. Which of the following statement is incorrect about IMRT technique?
A There is non-uniform dose distribution
B Intensity modulation achieved by MLC motion
C Better OAR sparing than 3D CRT technique
D Beam energy changes due to modulation

3. Which of the following statement is correct about 3D CRT technique?
A Planning CT is not required
B MLC is not required
C Intensity Modulation is not possible
D Wedge cannot be used in this technique

4. The tongue and groove effect in MLC:
A Decreases the intra-leaf transmission
B Increases the inter-leaf transmission
C Decreases the inter-leaf transmission
D Decreases inter- and intra-leaf transmission

5. Hexapod couch has how many degrees of freedom?
A Six
B Four
C Five
D Three

6. About VMAT which following statement is false?
A Gantry continually rotates around patient.
B Dose rate changes with gantry rotation
C Radiation delivered during rotations
D MLC shape remains constant

7. Which of the following is a calculation algorithm?
A Monte Carlo
B Collapsed Cone Convolution
C Anisotropic Analytical Algorithm
D All of the Above

8. DVH stands for?
A Dose voxel Histogram
B Dose variable Histogram
C Dose volume Histogram
D Dose verification History

9. Which of the following statement is incorrect about KVCBCT?
A It is a volumetric imaging
B It is ionizing radiation based imaging
C It provides better soft tissue visualization
D It uses MV source for imaging

10. What is the full abbreviation of DRR?
A Digitally Reformed Radiograph
B Dynamic Reconstructed Radiograph
C Digitally Reconstructed Radiograph
D None of the above

Radiation Protection and Regulatory Aspects

1. Ideal Detector for Radiation Survey is
A Proportional Counter
B GM detector
C Ionization Chamber
D None of the above

2. As per RPR 2004 act of AERB, the minimum age limit of Radiation worker and trainee are ___ and ____respectively.
A 16 & 18
B 18 & 16
C 18 & 21
D 18 & 15

3. Radiation level at the entrance door of Linear accelerator is contribution of
A Proton and Neutron
B Photon and Neutron
C Photon and Electron
D All of the above

4. Equivalent dose limit for the eye lens of Radiation worker is?
A 15 mSv/year
B 150 mSv/year
C 50 mSv/year
D 500 mSv/year

5. Which of the following is not the Radiation safety Interlock?
A LMOS
B Door Interlock
C Radiation Warning Lamps
D Emergency switch

6. Which of the following is not an ionizing Radiation?
A Protons
B Photons
C Gamma rays
D Infrared

7. Equivalent dose limit for the skin of trainee Radiation worker is?
A 15 mSv/year
B 150 mSv/year
C 50 mSv/year
D 500 mSv/year

8. What is dose limit for Trainee as per AERB?
A 5 mSv/year
B 6 mSv/year
C 7 mSv/year
D 8 mSv/year

9. What is a Gamma zone monitor?
A Radiation survey instrument
B Monitoring instrument
C Protection instrument
D none of the above

10. What is transportation index (TI)?
A Reading in mR/h at surface of package
B Reading in mR/min. at surface of package
C Reading in mR/h at 1m from the surface of package
D Reading in mR/min. at 1m from the surface of package

Quality Assurance of Radiation Therapy Equipment

1. Spoke test at different gantry angles performed to check:
A Central axis x-ray beam variation due to collimator rotation
B Central axis x-ray beam variation due to gantry rotation
C Central axis x-ray beam variation due to couch rotation
D Central axis x-ray beam variation due to gantry, couch and collimator rotation

2. The correct formula of Hounsfield number is:
A $H= (\mu_{tissue}-\mu_{water})/\mu_{tissue} \times 1000$
B $H= (\mu_{tissue}-\mu_{water})/ \mu_{water} \times 1000$
C $H= 1000-(\mu_{water}/\mu_{tissue}) \times 1000$
D $H= 1000-(\mu_{water}/\mu_{tissue})$

3. LINAC machines output (1cGy per MU) are defined :
A At 100cm SSD, the reference depth and for maximum open field size 40 x 40cm^2
B At 100cm SAD, the reference depth and for reference field size 10 x 10cm^2.
C At 100cm SSD, maximum dose depth and for reference field size 10 x 10cm^2.
D At 100cm SAD, the maximum dose depth and for maximum open field size 40 x 40cm^2

4. The function of the maze is to :
A Prevent excess exposure to therapists working on the console
B Prevent direct incidence of radiation at the treatment door
C Minimize radiation to the control area
D Prevent radiation to affect workers and equipment in the console area

5. Threshold energy for neutron emission in a linear accelerator is

A > 6 MeV
B > 10 MeV
C > 15 MeV
D > 20 MeV

6. What is a purpose of T-rod in Cobolt machine

A To set the patient
B To push the couch when it stuck
C To fix shielding blocks
D To push the source back when it stuck during treatment

7. Tolerance limit for isocenter verification of SRS and SRT technique is

A ±2 mm
B ±1 mm
C ±3 mm
D +1 mm

8. Which of the following is not a characteristics of beam profile

A Flatness
B Symmetry
C Sharpness
D Penumbra

9. For absolute dose measurement which chamber is used?

A Semiflex ion chamber
B Farmer type chamber
C Diode chamber
D Pin point chamber

10. What is beam quality index for 10 MV approximately?

A 0.72
B 0.73
C 0.76
D 0.67

Answer key

Basics of radiation Physics

Question Number	Answer
1	B
2	C
3	A
4	D
5	C
6	B
7	B
8	C
9	B
10	D

Classical radiation therapy

Question Number	Answer
1	D
2	C
3	B
4	A
5	C
6	B
7	A
8	D
9	A
10	B

Units and measurement of radiological quantities

Question Number	Answer
1	C
2	B
3	D
4	A
5	C
6	B
7	C
8	D
9	A
10	B

Classical radiation therapy

Question Number	Answer
1	C
2	B
3	C
4	A
5	D
6	C
7	C
8	A
9	B
10	B

Medical radiation generators

Question Number	Answer
1	C
2	B
3	A
4	D
5	A
6	C
7	D
8	A
9	C
10	A

Modern day radiation therapy

Question Number	Answer
1	D
2	D
3	C
4	D
5	A
6	D
7	D
8	C
9	D
10	C