MANTLE FIELD
RADIOTherapy PLANNING
INTRODUCTION

- Radiotherapy planning technique for irradiation of contiguous lymph node chains in the supra-diaphragmatic region in treatment of lymphomas.

- It was the single most difficult and complex treatment planning technique with conventional radiotherapy.

- It was recommended that it should not be undertaken by a neophyte.
# STAGING FOR LYMPHOMAS

## Table 1. Cotswolds staging classification

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
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<tbody>
<tr>
<td>Stage I</td>
<td>Involvement of a single lymph-node region or lymphoid structure (e.g., spleen, thymus, Waldeyer’s ring) or involvement of a single extralymphatic site</td>
</tr>
</tbody>
</table>
| Stage II | Involvement of two or more lymph-node regions on the same side of the diaphragm (hilar nodes, when involved on both sides, constitute stage II disease); localised contiguous involvement of only one extranodal organ or site and lymph-node region(s) on the same side of the diaphragm (IIIE). The number of anatomic regions involved should be indicated by a subscript (e.g., II)

| Stage III | Involvement of lymph-node regions on both sides of the diaphragm (III), which may also be accompanied by involvement of the spleen (III) or by localised contiguous involvement of only one extranodal organ site (IIIE) or both (IIIEE) |
| III1 | With or without involvement of splenic, hilar, celiac, or portal nodes |
| III2 | With involvement of para-aortic, iliac, and mesenteric nodes |
| Stage IV | Diffuse or disseminated involvement of one or more extranodal organs or tissues, with or without associated lymph-node involvement |

**Designations applicable to any disease stage**

- **A**: No symptoms
- **B**: Fever (temperature >38°C), drenching night sweats, unexplained loss of more than 10% of body weight within the previous 6 months
- **X**: Bulky disease (a widening of the mediastinum by more than one third of the presence of a nodal mass with a maximal dimension greater than 10 cm)
- **E**: Involvement of a single extranodal site that is contiguous or proximal to the known nodal site


STAGING INVESTIGATIONS

- **History & physical examination**: B symptoms and exam of all LN regions, testes, waldeyer’s ring.
- **Laboratory**: CBC, biochemistry, LDH, ESR, β2 microglobulin.
- **LN biopsy**: adequate for H&E and IHC.
- **BM biopsy**: could be avoided in stage I HD.
- **CSF exam**: testicular/PNS/orbit/epidural/BM involvement and highly aggressive histology in immuno-compromised patients.
- **Cytology**: any effusion.
- **Imaging**: CXR, CT scan of thorax, abdomen and pelvis and PET scan.
Core lymph node regions:
- Right and left cervical (cervical, supraclavicular, occipital, pre-auricular)
- Right and left axillary.
- Right and left infraclavicular.
- Mediastinal.
- Hilar.
- Para-aortic.
- Mesenteric.
- Right and left pelvic.
- Right and left inguino-femoral.

Additional nodal regions or lymphatic organs:
- Epitrochlear.
- Popliteal.
- Internal mammary.
- Occipital.
- Submental.
- Preauricular.
- Spleen.
- Thymus.
- Peyer’s patches.
- Appendix.
- Waldeyer’s ring.
LYMPH NODE REGIONS

Cervical, supraretricular, occipital & pre auricular
Infraretricular
Axillary
Intercostal/brachial
Hiliar
Mesenteric
Inguinal/femoral
Pudendal
Waldenstrom's ring
Mediastinal
Spleen
Paraortic
Ileum
IAEA Pediatric Radiation Oncology
Dr Laskar Version 1 June 2009
HISTORY

- **Rene Gilbert**: HD spreads by contiguity.
- **Vera Peters**: Rationale of prophylactic RT to LN adjacent to those involved → High dose extended field RT.
- **Henry Kaplan**: Successful modern treatment of HD → Low dose reduced field RT with LA.

STAGING LAPROTOMY + TLI/STLI → CMT + IFRT
Fig. 1. Changing standards of care in early stages HD. RT, radiotherapy; HD, Hodgkin’s disease; TNI, total nodal irradiation.
EXAMPLES OF EXTENDED FIELDS

- Standard mantle.
- Minimantle.
- Extended mantle.
- Para-aortic.
- Inverted Y.
- Spade field.
Early Stage favorable
- Stage I, IIA, < 50yr, <3 sites.
- ESR <50 if no B symptoms
  <30 if B symptoms.
- No extranodal involvement

RCT: ABVD x 2 vs ABVD x 4 #
+ Low Dose EFRT (15-30Gy)

CHILDREN
CR - 15 Gy
PR - 25 Gy

ADULT
CR - 20 Gy
PR - 30 Gy
DOSE AND VOLUME-HD

Early Stage favorable non trial
Early stage unfavorable non bulky
(Stage I to IIB)

ABVD x 4 # + IFRT
(15-20Gy)
(Involved field radiation)

CHILDREN
CR - 15 Gy
PR - 25 Gy

ADULT
CR - 20 Gy
PR - 30 Gy
DOSE AND VOLUME-HD

Advanced Stage
Early stage unfavorable bulky
(Stage II B to IV)

ABVD x 6 # + IFRT
(20-35Gy)
(Involved field radiation)

CHILDREN
CR - 20 Gy
PR - 30 Gy

ADULT
CR - 25 Gy
PR - 35 Gy
INDICATIONS OF MANTLE IN PRESENT ERA

- Declining indications.
- Only given if extensive lymph node involvement in the supra-diaphragmatic region i.e. IFRT amounting to mantle irradiation.
- As a part of early stage protocol at TMH.
PLANNING STEPS

- Preplanning
- Positioning
- Immobilization
- Simulation
- Dosimetry
- Verification
PREPLANNING

- **Target volume:** Occipital, submental, sub-mandibular, cervical, SC, infraclavicular, axillary, paratracheal, mediastinal and hilar LNs.

- **Critical structures:**
  - **Anterior and posterior:** Heart, lungs, humeral heads.
  - **Anteriorly only:** Oral cavity, larynx.
  - **Posteriorly only:** posterior cranial fossa, spine.

- **Anatomical landmarks:** Lymph node stations.
SPECIAL POINTS ABOUT DIFFERENT NODAL REGIONS

- Jugular group:
  - Mid-jugular and lower jugular nodes lie anterior to the lateral border of thyroid cartilage and trachea and can get underdosed by incorrect use of laryngeal blocks.
  - Placing the block 1-2 cm below from thyroid notch to lower border of cricoid is safe.

- Infraclavicular group:
Axillary group:

- On AP Chest X-ray, mid axillary nodes are along the lateral edge of rib-cage.
- The apical nodes coincide with the lateral borders of the 1st, 2nd and 3rd rib.
- The lowest level of the nodes are marked by the level of anterior 4th IC space.
- The lateral margin is described on patient by the junction of the lateral margin of pectoralis major muscle with the deltoid.
MEDIASTINAL NODES

- **Superior mediastinal**: High risk nodes lying anterior to the thoracic mid-plane and superior to carina.
- **Inferior mediastinal**: important nodes are
  - Posterior Intercostal (space between head of ribs and lateral border of vertebrae)
  - Juxtavertebral (along the thoracic duct, anterior to vertebral bodies)
  - Para-esophageal nodes.
- **Diaphragmatic nodes** form a circle along the base of heart, resting on the diaphragm.
  - Anterior: behind xiphoid
  - Right pericardial: posterolateral to right heart border in apposition to the right phrenic nerve and IVC.
  - Left pericardial: posterolateral to left heart border along left phrenic nerve.
  - Because of posterolateral position, they have to be quite large to produce changes in cardiac silhouette on XRC.
  - Inclusion of these nodes requires a margin of 1cm to cardiac shadow.
**POSITIONING**

- **Akimbo (A position):**
  - Arms abducted, forearm flexed and resting at the waist.
  - Classical position described by Fletcher.

- **Extended (E position):**
  - Arms abducted, forearms extended.

- **Up overhead (U position):**
  - Overhead arm abduction, forearm flexion.

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*Fig. 1. Three classic positions of the arms utilized in mantle fields. (A) Up over the head, (B) extended, and (C) akimbo.*
CONCERNS

- **Missing target tissue** especially axillary lymph nodes.
  - **Lymphangiographic studies:** detected projection of few axillary nodes on the humeral head. (Weisenburger, Radiology, 1974).
  - **CT based studies:** arm abduction $>55^\circ$ results in blocking of axillary lymph nodes with the use of humeral head block. (Mansur et al, Med Phys 2005).
- **Irradiating normal tissues** especially humeral head and lung.
## Best Position - Individualise

<table>
<thead>
<tr>
<th>Akimbo:</th>
<th>Extended:</th>
<th>Up overhead position:</th>
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<tbody>
<tr>
<td>- Reduces patient rotation.</td>
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<td>- Good if pre-existing lung disease or</td>
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<tr>
<td>- Humeral head blocking possible.</td>
<td>- Safe shielding of both humeral head and lung</td>
<td>bleomycin toxicity.</td>
</tr>
<tr>
<td>- Irradiates more lung parenchyma.</td>
<td>and lung with adequate margins to the axillary</td>
<td>- Impossible to shield humeral head.</td>
</tr>
<tr>
<td></td>
<td>lymph nodes.</td>
<td>- Uncomfortable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Folds in SCF.</td>
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</tbody>
</table>
BEST POSITION INDIVIDUALISE

Pergolizzi IJROBP 2000

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## IMMOBILIZATION

<table>
<thead>
<tr>
<th>PAST:</th>
<th>PRESENT:</th>
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<tbody>
<tr>
<td>Bite block, polyurethane foam</td>
<td>Neck rest, rubber traction, thermoplastic mask</td>
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</table>
- Counseling patient.
- Position supine with laser aligned along midline.
- Arms slightly abducted.
- Demarcation of gross palpable lymph nodes with lead wire.
- Simulation of treatment field:
  - **Superior border:** Neck in slight extension to get chin, mandible, ear lobe and a point 2-3 cm above mastoid tip in same line.
  - **Inferior border:** at the anterior attachment of diaphragm i.e. D10-11 or clinically about 4 cm above xiphoid.
  - **Lateral borders:** generous coverage of axillae, just beyond humeral head.
  - **Mid-point:** usually falls at or slightly below suprasternal notch.
IMAGE GRAB AND QUAD MERGE
FIELD SHAPING - AXILLA

- **Inferior border**: level of 4th costochondral junction.
- **Superior border**: lung block to be drawn 1-2 cm below clavicle for complete coverage of apical axillary node which may lie just below the clavicle.
- **Medial border**: atleast 1 cm of lung in lower axilla and 2-4 cm in upper axilla needs to be incorporated within the portal.
- **Lateral border**: defined clinically by the junction of pectoralis major and the deltoid.
- Shield head of humerus unless axillary LN are involved where humerus shielding might block apical LN too.
Lateral margin:
- **Gross disease**: 1-2 cm margin to enlarged hilar nodes.
- **Microscopic disease in upper mediastinum only**: lateral border to be placed 1.5 cm from vertebral body.

Inferior margin:
- **Gross disease**: apex shielded if possible after 15 Gy.
- **Microscopic disease in upper mediastinum only**: apex shielded since beginning.
MINIMANTLE

- Mantle without irradiation of the mediastinum due to low risk of involvement.
- Inferior mediastinum blocked: Entire heart is shielded from the field & inferior border placed 5 cm below the carina.
- Entire mediastinum blocked: inferior border placed 1 cm below the clavicle.
- **Beam energy:**
  - Can be treated with cobalt 60 or 6 MV photons.

- **Treatment distance:**
  - Most mantle field sizes are 35 x 35 cm at 100 SSD.
  - Some times 40 x 40 cm needed requiring extended SSD and treatment at trolley level.
    - Larger depth, better PDD, better homogeneity.
    - With larger distances any small error in positioning or measure of blocks will cause be magnified.
  - Patient position has to be changed (supine and prone) resulting in set up errors.

- **Depth of prescription:**
  - Midplane distance at SSN.
Basic beam data available for rectangular or square fields only.

Methods described to use these data for irregularly shaped fields like mantle → Large, involve irregular surface contour and use of various blocks.
  - Clarkson’s method.
  - Cunningham method.

Based on the principle of SAR (scatter air ratio) which depends on field size and shape and can be calculated separately from the primary component which is independent of field size and shape.
SAR (Scatter air ratio):
- The ratio of scattered dose at a given point in the phantom to the dose in the free space at the same point.
- Independent of SSD but depends on beam energy, field size and depth.
- SARs have been tabulated as functions of depth and radius of a circular field at that depth.

Correction for SSD variation within the field due to the difference in separation at mediastinum Vs neck → 10-20 % difference in dose delivered.

Correction for tissue heterogeneity along the beam e.g. lung correction factor depending upon the energy.
C L A R K O N’ S  M E T H O D
DOSE POINTS:

- 8 points demarcated for dose calculation.
- The field centre, mid-mediastinum, inferior mediastinum at 3 cm above the lower border, left lower neck, mid neck at the level of thyroid cartilage, upper neck 3 cm within the superior border, a mid-axillary point and a low axillary border 3 cm above the inferior axillary border.

- The neck points are placed on the anterior border of SCM.

- In cases of specific areas of interests points may be added.
- Lead markers are placed at these points so that they are represented on the simulator film for calculation.
- SSD is measured at all the points.
- This is required for depth dose calculation by scatter-air ratio technique.
**BLOCKS**

- **Lung blocks:**
  - For 6 MV photons, with 5 cm lead (4 HVL) lung dose is 10-15% of given dose.
  - Increasing lead thickness reduces lung dose only minimally, but weight of block becomes cumbersome.
  - Partial transmission blocks may be used if pulmonary irradiation is also required.

- **Laryngeal blocks:**
  - Laryngeal shield can be used in the anterior portal extending from the thyroid notch to cricoid about 1-1.5 cm wide.
  - In presence of bulky mid and lower jugular nodes, laryngeal shield may be delayed or omitted till regression occurs.
LUNG CORRECTION

- Lung density much lower than normal tissue density.
- Decrease attenuation → increased transmission to tissues beyond.
- Decreased contribution to scatter → decreased dose delivered to tissues beyond.
- Net effect: increased transmission.
- Depends on energy of beam and field size.

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<thead>
<tr>
<th>Energy</th>
<th>Transmission factor</th>
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<tr>
<td>Co 60</td>
<td>+ 4 % per cm of healthy lung.</td>
</tr>
<tr>
<td>4 MV</td>
<td>+ 3 %...........................................</td>
</tr>
<tr>
<td>20 MV</td>
<td>+ 2 %............................................</td>
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