Practical Medical Physics:
Head and Neck Contouring

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Objectives

Review Selection of Normal Organs
  • Brachial Plexus
  • Pharyngeal Constrictors
  • Salivary Glands
    • Parotid
    • Submandibular

Target Audience:
  • Physicists
  • Dosimetrists
  • Radiation Therapists
Outline

Why do we have to Contour?
Which Organs are Important?
How *I* contour?
3 Important Organ Systems
  • Xerostomia: Salivary Glands
    • Parotid
    • Submandibular
  • Dysphagia: Pharyngeal Constrictors
  • Brachial Plexus
Outline (cont)

For Each Organ System
  • Anatomy
  • Literature
  • Examples
Why do we have to contour?

• Target delineation
• Organ avoidance

2D → 3D → IMRT
(your fault)
2D Planning
2D Planning

Gantry 270°
15° Wedge
Weight 100%
6 x 6 cm

Gantry 90°
15° Wedge
Weight 100%
6 x 6 cm

5 MeV

ANT

POST

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2.5D…
3DCRT
IMRT
IMRT & Contours

- Inverse Planning
- Objective Cost Function
- Computers are Binary

There are only 10 types of people in the world: Those who understand binary and those who don’t.
Why take a contouring course?

- IMRT and 3D = standard practice
  - Both techniques require (accurate) contours
  - Clinical trials require dose constraints
- Consistency (precision)
  - Who:
    - Intra- vs inter-contourer
    - Intra- vs inter-institutional
  - Why:
    - Good practice
    - Dose constraints
    - Dosimetric repositories
Why take a contouring course?

• No formal training
• Few reproducible guidelines
• Everyone assumes consistent contouring
  • NCIC HN6, RTOG 0920, 0615, 0225
  • Spinal Cord:
    • Intra-observer: avg 0.1 cm, max 0.7 cm
    • Inter-observer: avg 0.2 cm, max 0.9 cm
Which organs are important

Brain (temporal lobe)
Globe, retina
Lens
Optic nerve, optic chiasm
Pituitary gland
Brainstem, spinal cord
Inner ear
TMJ
Mandible
Larynx
Esophagus
Oral cavity
Thyroid
Vasculature

Xerostomia - Salivary Glands

Dysphagia - Pharyngeal Constrictors

Brachial plexus
For Each Organ System

• Anatomy
• Literature
• Examples

(No Time For)
• Targets (GTV)
• ICRU (xTVs, PRV)
• Contour editing (surface cropping, overlapping)
• Autosegmentation
• Imaging modalities
• Intra-treatment changes
• Dose volume constraints
How *I* Contour

- Standard CT technique
  - 2.5mm slices, 2.5mm spacing
  - Matrix size 512 x 512
  - IV Contrast
- HU Settings
  - Window 400, Level 50
- Maximize visual real estate
- **Scrolling**
- Software tools: above/below
- Tablet/Pen
- Consultation: RO, DI

Holistic Contouring
Digital & Physical Optimization
Xerostomia: Salivary Glands

- Anatomy
- Literature
- Examples
Salivary Glands: Anatomy

- Major Salivary Glands
  1. Parotid
  2. Submandibular
  3. Sublingual

- Secrete saliva
  - Speech, taste, swallowing
  - Digestive enzymes
  - Prevent inflammation and dental caries

- Saliva
  - 0.5 L secreted per day
    - **Resting**: 0.3 mL/min
      - Parotid = 20%
      - **Submandibular = 65%**
      - **Sublingual, Minor = 15%**
    - Stimulated: 1.5–2 mL/min
      - Parotid = 50%
Salivary Glands: Parotid

- paired, 25-30 g, accessory gland: 20%
- borders:
  - superior: zygomatic arch
  - inferior: hyoid bone
  - anterior: anterior ramus mandibular arch
  - posterior: mastoid process
  - medial: carotid sheath or masseter muscle
  - lateral: skin

- Structures within Parotid
  - External carotid artery, Retromandibular vein
  - Facial nerve
- Parotid Duct:
  - 5 cm long, 3 mm wide
  - Crosses masseter, right angle, buccal fat pad/buccinator, runs obliquely forwards, opens @ second upper molar
Salivary Glands: Submandibular

• 10-20 g, size of walnut
• Borders:
  • Superior: medial surface of mandible, lingual N
  • Inferior: soft tissues of neck, hypoglossal N
  • Medial/Anterior: floor of mouth (mylohyoid, hypoglossus mm)
  • Posterior: submandibular LN, carotid sheath
  • Lateral: skin
Salivary Glands: Literature

<table>
<thead>
<tr>
<th>Organ at risk</th>
<th>Anatomic boundaries</th>
<th>Cranial</th>
<th>Caudal</th>
<th>Anterior</th>
<th>Posterior</th>
<th>Lateral</th>
<th>Medial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parotid gland</td>
<td>External auditory canal, mastoid process</td>
<td>Post, part submandibular space</td>
<td>Maseter m., post border mandibular bone, medial and lateral pterygoid m., Lat. surface mylohyoid m., hyoglossus m.</td>
<td>Ant. belly sternoclidomastoid m., lat. side pos. belly of the digastric m. (posterior-medial)</td>
<td>Subcutaneous fat, platysma</td>
<td>Post. belly of the digastric m., styloid process, parapharyngeal space</td>
<td></td>
</tr>
<tr>
<td>Submandibular gland</td>
<td>Medial pterygoid m., mylohyoid m., Fatty tissue</td>
<td></td>
<td></td>
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</tbody>
</table>

Fig. 2. Major salivary glands: the parotid glands are depicted in brown (left) and green (right), the submandibular glands are depicted in blue (the left one is brighter than the right one) and the sublingual glands are coloured dark blue (anterior part oral cavity). (1) Genioglossus m., (2) mylohyoid m., (3) hyoglossus m., (4) posterior belly digastric m., (5) anterior belly digastric m., (6) geniohyoid m., (7) medial pterygoid m., (8) lateral pterygoid m., (9) pharyngeal constrictor m., (10) sternoclidomastoid m., (11) platysma, (12) maseter m., (13) parapharyngeal space, (14) styloid process, (15) mandibular bone.
Parotid Glands: Examples

- superior: zygomatic arch
- inferior: hyoid bone
- anterior: anterior ramus mandibular arch
- posterior: mastoid process
- medial: carotid sheath or masseter muscle
- lateral: skin
Parotid Glands: Examples
Parotid Glands: Use your tools.
Parotid Glands: Examples
Parotid Glands: Examples
Submandibular Glands

- Superior: medial surface of mandible, lingual N
- Inferior: soft tissues of neck, hypoglossal N
- Medial/Anterior: floor of mouth (mylohyoid, hypoglossus mm)
- Posterior: submandibular LN, carotid sheath
- Lateral: skin
Submandibular Glands: Examples
Submandibular Glands: Inferior
Salivary Glands: Summary

- Parotid most variable
- Know potential limits
- Scroll
- Sup/Inf tool
Dysphagia: Pharyngeal constrictors

- Anatomy
- Literature
- Examples
Pharyngeal Constrictors: Anatomy

- Programmed motor behaviour
  - seconds
- Stimulation of sensory nerves in the oropharynx
- 600 and 1000 times in 24 hours
- Eating and drinking are basic human pleasures
  - significant impact upon the quality of life
- Four phases:
  - Oral preparatory
  - Oral transit
  - Pharyngeal
  - Esophageal
Pharyngeal Constrictors: Anatomy

- **longitudinal muscles**: stylopharyngeus, salpingopharyngeus, palatopharyngeus
- **circular constrictors**: superior, middle, and inferior
- **epiglottis, larynx**
- **posterior surface of base of tongue**
- **suprahyoid muscles** (geniohyoid, mylhyoid, digastric)
Pharyngeal Constrictors: Anatomy
Pharyngeal Constrictors: Anatomy, Literature

DARS: dysphagia aspiration related structures

CT:
- Constrictors: median medial thickness – 2.5 mm to 7 mm
- Larynx (supraglottic + glottic): 2 mm to 4 mm

** Primary Structures:
1. Pharyngeal Constrictors
2. Larynx
Pharyngeal Constrictors: Eisbruch

**Pharyngeal constrictors**
- lateral and posterior pharyngeal walls
  - superior: to pterygoid plates
  - middle: to hyoid bone
  - inferior: to thyroid cartilage
  - contoured as single organ

**Supraglottic and glottic larynx**
- contoured as single organ
Pharyngeal Constrictors: Hyoid Bone
Pharyngeal Constrictors: Thyroid Cartilage
Pharyngeal Constrictors

- Larynx
- Oral Cavity
- PTV overlap
Pharyngeal Constrictors: Unilateral PTV
Pharyngeal Constrictors: Bilateral PTV
Pharyngeal Constrictors: Summary

- Clinically important
- Difficult to spare, depending on adjacent targets
  - Ipsilateral vs bilateral RT
- Adjacent structures:
  - Larynx
  - Oral Cavity

- Consider combination:
  - Laryngopharynx
  - Oral Cavity/Pharynx
Brachial Plexus

- Anatomy
- Literature
- Examples
Brachial Plexus: Anatomy

- Cutaneous and muscular innervation “most” of upper limb
  - Two exceptions:
    - trapezius muscle (spinal accessory nerve [CN XI])
    - area of skin near axilla (intercostobrachial nerve)

- The five **roots** merge to form three **trunks**:
  - Super: C5, C6
  - Middle: C7
  - Inferior: C8, T1

**Hard To See!**
Brachial Plexus: 5 Roots → 3 Trunks

** Note **

- Seven cervical vertebrae (C1-C7)
- Eight cervical nerves (C1-C8)
  - C1-C7: emerge *above Cx*
  - C8: emerges *below C7*
  - T1 etc emerge *below T1*
Brachial Plexus: Landmarks

C5, T2
Brachial Plexus: Landmarks

Brachial Plexus travels between:

- **Scalenus Anterior**
- **Scalenus Medius**

Dr. Monty Martin, BCCA (Chief, Neuroradiology)
Brachial Plexus: Ant/Med Scalenus

Anterior Scalenus:
- aka scalenus anterior, scalenus anticus
- transverse processes of C3-C6 to first rib
  - anterior to medial scalenus

Medial Scalenus:
- largest and longest of the three scalene muscles
- posterior tubercles of transverse processes C2-C7 to first rib
Brachial Plexus: Axilla

- Behind **Axillary Artery**
Brachial Plexus: Landmarks

- C5
- T1 or T2
- Anterior scalenus
- Medial scalenus

Axilla:
- Axillary artery
Brachial Plexus: Literature

1. Identify and contour C5, T1, and T2.
2. Identify and contour the subclavian and axillary neurovascular bundle.
3. Identify and contour anterior and middle scalene muscles from C5 to insertion onto the first rib.
4. To contour the brachial plexus OAR use a 5-mm diameter paint tool.
5. Start at the neural foramina from C5 to T1; this should extend from the lateral aspect of the spinal canal to the small space between the anterior and middle scalene muscles.
6. For CT slices, where no neural foramen is present, contour only the space between the anterior and middle scalene muscles.
7. Continue to contour the space between the anterior and middle scalene muscles; eventually the middle scalene will end in the region of the subclavian neurovascular bundle.
8. Contour the brachial plexus as the posterior aspect of the neurovascular bundle inferiorly and laterally to one to two CT slices below the clavicular head.
9. The first and second ribs serve as the medial limit of the OAR contour.

Hall et al, IJROBP, 2008
Brachial Plexus: Examples – C5
Brachial Plexus: Examples – T1
Brachial Plexus: Scalenus mm

- Brachial plexus
- Scalenus Anterior
- Scalenus Medius
Brachial Plexus: Scalenus mm

Brachial plexus

Scalenes Anterior

Scaleneus Medius

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Brachial Plexus: Scalenus mm

- Brachial plexus
- Scalene Anterior
- Scalene Medius
Brachial Plexus: Scalenus mm

Brachial plexus

Scalenus Anterior

Axillary A.
Brachial Plexus: Scaleneus mm

- Brachial plexus
- Axillary V.
- Axillary A.
- B.P.

- Scaleneus Medius
- Brachial plexus
- Axillary artery
- Scaleneus Anterior
- Axillary vein
Brachial Plexus: Scalenus mm

Brachial plexus

Axillary V.

Axillary A.

B.P.
Brachial Plexus: Examples – Foramina
Brachial Plexus: Examples – Non-Foramina
Brachial Plexus: Full Structure
Brachial Plexus: Examples
Brachial Plexus: Axilla
Brachial Plexus: Comments

• Brachial Plexopathy = rare
• Adjacent GTV/LN
• Not contoured off-study @ BCCA
• Reproducible contours possible
• Axilla?
• Further research
  • Dosimetric Repository
H&N Contouring: Summary

- Parotid Gland: variable in shape
- Submandibular Gland: superior end
- Pharyngeal Constrictors: Consider -
  - Laryngopharynx
  - Oral Cavity/pharynx
- Brachial Plexus: requires further study
- General technique:
  - Scroll
  - Superior/Inferior tool
  - Window level, maximize screen real estate
  - Tablet/Pen
  - Consultation: RO, DI
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