Outline of Content

- Atlas for lung, esophagus, and spinal cord
- Atlas for brachial plexus
- Atlas for proximal bronchial tree
- Atlas for chest wall
- Atlas for pericardium, heart and great vessels (including normal pericardial recesses)
<table>
<thead>
<tr>
<th>Structure</th>
<th>Description</th>
<th>Structure definition and contouring instructions</th>
</tr>
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<tbody>
<tr>
<td>Lungs</td>
<td>Lungs – PreGTV (composite of CT1GTV and PETMTV)</td>
<td>Both lungs should be contoured using pulmonary windows. The right and left lungs can be contoured separately, but they should be considered as one structure for lung dosimetry. All inflated and collapsed, fibrotic and emphysematic lungs should be contoured, small vessels extending beyond the hilar regions should be included; however, pre GTV, hilars and trachea/main bronchus should not be included in this structure.</td>
</tr>
<tr>
<td>Heart</td>
<td>Heart</td>
<td>The heart will be contoured along with the pericardial sac. The superior aspect (or base) will begin at the level of the inferior aspect of the pulmonary artery passing the midline and extend inferiorly to the apex of the heart.</td>
</tr>
<tr>
<td>Esophagus</td>
<td>Esophagus</td>
<td>The esophagus should be contoured from the beginning at the level just below the cricoid to its entrance to the stomach at GE junction. The esophagus will be contoured using mediastinal window/level on CT to correspond to the mucosal, submucosa, and all muscular layers out to the fatty adventitia.</td>
</tr>
<tr>
<td>SpinalCord</td>
<td>Spinal Canal</td>
<td>The spinal cord will be contoured based on the bony limits of the spinal canal. The spinal cord should be contoured starting at the level just below cricoid (base of skull for apex tumors) and continuing on every CT slice to the bottom of L2. Neuroforamanines should not be included.</td>
</tr>
<tr>
<td>BrachialPlexus</td>
<td>Brachial Plexus</td>
<td>This is only required for patients with tumors of upper lobes. Only the ipsilateral brachialplexus is required. This will include the spinal nerves exiting the neuroforamnine from top of C5 to top of T2. In contrast to prior RTOG lung studies of contouring the major trunks of the brachial plexus with inclusion of subclavian and axillary vessels, this trial requests contouring the nerves according to the CT anatomy on every other CT slice. The structure should extend at least 3 cm above the PTV.</td>
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<tr>
<td>Pericard</td>
<td>Pericardium</td>
<td>The structure of pericardium includes pericardial fatty tissue, part of great vessels, normal recesses, pericardial effusion (if applicable) and heart chambers. Pericardium starts at one slice above the top of aortic arch, ends at the last slice of heart apex at diaphragm. Pericardium includes the heart.</td>
</tr>
<tr>
<td>Greatves Aorta SVC</td>
<td>Great vessels Aorta Superior vena cava Inferior vena cava pulmonary vein pulmonary artery</td>
<td>The great vessels should be contoured separately from the heart, using mediastinal windowing to correspond to the vascular wall and all muscular layers out to the fatty adventitia (5 mm from the contrast enhanced vascular wall). The great vessel should be contoured starting at least 3 cm above the superior extent of the PTV and continuing on every CT slice to at least 3 cm below the inferior extent of the PTV. For right sided tumors, SVC will be contoured, and for left sided tumors, the aorta will be contoured. The ipsilateral PA will be delineated for tumor of either side.</td>
</tr>
<tr>
<td>Pbtree</td>
<td>Proximal Bronchial Tree</td>
<td>This structure includes the distal 2 cm of the trachea, the carina, the right and left mainstem bronchi, the right and left upper lobe bronchi, the intermedius bronchus, the right middle lobe bronchus, the lingular bronchus, and the right and left lower lobe bronchi.</td>
</tr>
<tr>
<td>CW2cm</td>
<td>Chest wall 2 cm outside of lung</td>
<td>Chest wall can be autosegmented from the ipsilateral lung with a 2-cm expansion in the lateral, anterior, and posterior directions. Anteriorly and medially, it ends at the edge of the sternum. Posteriorly and medially, it stops at the edge of the vertebral body with inclusion of the spinal nerve root exit site. CW2cm which include intercostal muscles, nerves exclude vertebrate bodies, sternum and skin. This can be accomplished through auto-expansion of the ipsilateral lung (within 3 cm range of PTV).</td>
</tr>
</tbody>
</table>
Atlas of lung, esophagus, and spinal cord

Esophagus starts at the level of cricoid
Lung is visible now of the left apex

Spinal cord should also start at this level just below the cricoid or from the base of skull C1 if scan is available, particularly when the tumors involve neck or apex.
The structure of spinal cord should include the entire spinal canal to decrease contouring variations.
Esophagus, lung and cord continue…

Great vessels delineation is recommended, but not mandated.

SVC = superior vena cava

Proximal bronchial tree delineation is recommended, but not mandated.
Esophagus, lung and cord continue…

great vessels start from the level of aortic arch

Proximal bronchial tree starts at 2 cm above carina
Esophagus, lung and cord continue…

and great vessels, proximal bronchial tree

AA=ascending aorta, PA=pulmonary artery, DA=descending aorta, SVC=superior vena cava
Esophagus, lung, cord, great vessels and proximal bronchial tree

AA=ascending aorta, PA=pulmonary artery, DA=descending aorta, SVC=superior vena cava
Esophagus, lung, cord, great vessels and proximal bronchial tree

AA=ascending aorta, PA=pulmonary artery, DA=descending aorta, SVC=superior vena cava
Esophagus, lung, cord, great vessels and proximal bronchial tree continue…

AA=ascending aorta, PA=pulmonary artery, DA=descending aorta, SVC=superior vena cava
Esophagus, lung, cord, great vessels and proximal bronchial tree

AA=ascending aorta, PA=pulmonary artery, DA=descending aorta, SVC=superior vena cava
Esophagus, lung, cord continue…

DA=descending aorta
Esophagus ends at gastric-esophageal junction, Lung and cord continue...

IVC=inferior vena cava, DA=descending aorta
Lung ends, cord continues until the bottom of L2 Vertebral body

IVC=inferior vena cava, DA=descending aorta
Atlas for Brachial Plexus

- Jugular vein
- Middle scalene muscle
- Brachial plexus
- Subclavian vein

Note: Usual composition shown. Posterior plexus has large C4 contribution but lacks T1. Posterior plexus lacks C5 but has T2 contribution.

Locating the Brachial Plexus

Timmerman’s Trick-1

- Vein, artery, and nerve (VAN, anterior to posterior) will go over the 1\textsuperscript{st} rib and under the clavicle
- Using coronal images, find the plane where vascular/nerve structures (tubes and wires) pass between the 1\textsuperscript{st} rib and clavicle
- Roughly contour these neurovascular tissues in this coronal plane (as shown in yellow)
- You will use these rough contours in the next step
Locating the Brachial Plexus

Timmerman’s Trick-1

- Project coronal contours onto axial images (yellow points shown on axial image)
- In the region between the projected points, identify the VAN on either side. Contour the “N” as the root(s) of the brachial plexus
- Note: Finding the brachial plexus on the uninvolved side will help in finding it on the involved side
- Note: IV contrast greatly facilitates this task (see contrast in artery)
Brachial plexus starts between C4 C5
Superior (C5,C6) trunk, C6 root, C5 /C6 disk

Superior (C5,C6) trunk, C6 VB
C5, C6, C7, C8 trunks, T1 root, T1VB

C5, C6, C7, C8 trunks, T1 root, T1/T2 disk
Superior (C5, C6), middle (C7), and inferior (C8 & T1) trunks, T2VB
Vein

Artery

Nerve

Superior (C5, C6), middle (C7), and inferior (C8 & T1) trunks, T2VB

The most inferior right trunk and vessels, T2/T3 disk
Brachial plexus not visible any more
Proximal Bronchial Tree (PBT)

PBT should include the distal 2 cm of the trachea, the carina, the right and left mainstem bronchi, the right and left upper lobe bronchi, the intermedius bronchus, the right middle lobe bronchus, the lingular bronchus, and the right and left lower lobe bronchi (a, b, c, d, e, f, g in the figure)

PBT can be contoured by autosegmenting the airspace of the central airway with 3 mm expansion (2 mm for lobar bronchus, 3 mm for main bronchus, 4 mm for trachea)
Proximal Bronchial Tree

• The proximal bronchial tree can be contoured using mediastinal windows on the CT scan to correspond to the mucosal, submucosa, and cartilage rings and airway channels associated with these structures. It can be contoured as one structure, including the most inferior 2 cm of distal trachea and the proximal airways of both sides. Contouring the lobar bronchi should end immediately at the level of a segmental bifurcation.

Recommendation based on Timmerman et al for RTOG 0236 and RTOG 0618, Bezjak et al for RTOG 0813
PBT starts at 2 cm above carina
Proximal Bronchus Tree continues...
Proximal Bronchus Tree continues...
Proximal Bronchus Tree Continues...
Proximal Bronchus Tree continues...
Proximal Bronchus Tree Ends
at the level of lobar bronchus bifurcating into segmental bronchus
Chest Wall Contours

• Chest wall can be autosegmented from the ipsilateral lung with a 2-cm expansion in the lateral, anterior, and posterior directions. Anteriorly and medially, it ends at the edge of the sternum. Posteriorly and medially, it stops at the edge of the vertebral body with inclusion of the spinal nerve root exit site.

• This recommendation was:
  – Supported by “CW2cm consistently enabled better prediction of CW toxicity than CW3cm” in Mutter et al, Int J Radiat Oncol Biol Phys. 2011 Aug 23. [Epub ahead of print]
Chest Wall (CW)

CW refers to CW2cm which include intercostal muscles, nerves exclude vertebral bodies, sternum and skin. This can be accomplished through auto-expansion of the ipsilateral lung (within 3 cm range of PTV).

CW contouring starts at 3 cm above the PTV
Chest Wall

CW refers to CW2cm which include intercostal muscles, nerves exclude vertebral bodies, sternum and skin.

The superior end of PTV
Chest Wall

CW refers to CW2cm which include intercostal muscles, nerves exclude vertebral bodies, sternum and skin.

The superior end of GTV
Chest Wall

CW refers to CW2cm which include intercostal muscles, nerves exclude vertebral bodies, sternum and skin.

Chest wall contours around GTV.
Chest Wall

CW refers to CW2cm which include intercostal muscles, nerves exclude vertebral bodies, sternum and skin. CW ends at 3cm from the inferior edge of PTV.

The inferior end of PTV

3 cm below PTV

CW ends at 3cm from the inferior edge of PTV.
Pericardium, Heart, Great Vessels, Heart Chambers, and Normal Pericardial Recesses

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Pericardium, normal recesses and heart chambers

The structure of pericardium includes pericardial fatty tissue, part of great vessels, normal recesses, pericardial effusion (if applicable) and heart chambers.
Anatomy of Pericardium

Pericardial sac and normal recesses

Fig. 1.—Drawing of interior of serosal pericardial sac seen from front after section of large vessels at their cardiac origin and removal of heart. Aorta (A) and pulmonary trunk (P) are enclosed in one tube. Superior vena cava (SVC), inferior vena cava (IVC), and pulmonary veins (asterisks) are enclosed in other tube forming inverted J. Cul-de-sac within curve of J is oblique sinus located behind left atrium. Transverse sinus is complex interconnecting passage between these two tubes. Double layer of serous pericardium (arrow) separates transverse sinus and oblique sinus. 1 = superior aortic recess of transverse sinus, 2 = right pulmonic recess of transverse sinus, 3 = left pulmonic recess of transverse sinus, 4 = postcaval recess, 5 = right pulmonary venous recess, 6 = left pulmonary venous recess, 7 = oblique sinus.

(Drawing by Lang N; printed with permission from Department of Visual Arts, M. D. Anderson Cancer Center)
Pericardial Normal Recesses

Vesely et al, 1986
Groell et al, Radiology, 1999
AA=ascending aorta, SVC=superior vena cava
AA=ascending aorta, V(superior vena cava

Posterior superior anterior recesses (pSAR)
AA=ascending aorta, DA=descending aorta, SVC=superior vena cava
AA=ascending aorta, DA=descending aorta, SVC=superior vena cava
AA=ascending aorta, DA=descending aorta, SVC=superior vena cava, PA=pulmonary artery
AA=ascending aorta, DA=descending aorta, MPA=main pulmonary artery
Right superior aortic recess (rSAR)

Left pulmonic recess (LPR)

Pericardium

AA=ascending aorta, DA=descending aorta, V=superior vena cava, PA=main pulmonary artery, PA=right pulmonary artery, LA=left atrium
RA=right atrium, AA=aortic arch, LV=left ventricle, LA=Left atrium, MPA=main pulmonary artery, DA=descending aorta, E=esophagus
RA=right atrium, RV=right ventricle, LV=left ventricle, LA=Left atrium, AA=aortic arch, DA=descending aorta, E=esophagus
RA=right atrium, RV=right ventricle, LV=left ventricle, LA=Left atrium, AA=Ascending Aorta
RA=right atrium, RV=right ventricle, LV=left ventricle, LA=Left atrium, AA=aortic arch
Pericardial effusion (PEFF)

RA=right atrium, RV=right ventricle, LV=left ventricle, LA=Left atrium
Pericardial effusion (PEFF)
Atlas for Heart and Pericardium

Pericardium: based on anatomy

Heart: based on consensus contours of most RTOG centers/previous trials, actually including part of pericardium
Pericardium starts at 1-2 slices (5-6 mm) above the superior end of the aortic arch.
Pericardium continues...

SVC = superior vena cava
Pericardium continues...

SVC = superior vena cava
Pericardium continues...

SVC = superior vena cava
Pericardium continues...

SVC=superior vena cava
AA=Ascending aorta
DA=Descending aorta
Pericardium continues...

SVC=superior vena cava
PA=Pulmonary artery
AA=Ascending aorta
DA=Descending aorta
SVC=Superior vena cava  
PA=Pulmonary artery  
AA=Ascending aorta  
DA=Descending aorta
Pericardium Continues...

SVC=Superior vena cava
PA=Pulmonary artery
AA=Ascending aorta
DA=Descending aorta
Pericardium Continues...

SVC = superior vena cava
PA = Pulmonary artery
AA = Ascending aorta
DA = Descending aorta
Pericardium Continues...

SVC = Superior vena cava
PA = Pulmonary artery
AA = Ascending aorta
DA = Descending aorta
Pericardium Continues...

SVC = Superior vena cava
PA = Pulmonary artery
AA = Ascending aorta
DA = Descending aorta
Pericardium continues...
Heart contour starts at this level, 1 slice below pulmonary artery trunk passing the midline

Heart and pericardium are to be overlapped.
Heart and pericardium continue...

AA=Ascending Aorta, PA=pulmonary artery, RA=right atrium, RV=right ventricle, LV=left ventricle, LA=Left atrium, PV=pulmonary vein, DA=descending aorta, SVC=superior vena cava
Pericardium and Heart continue...

Heart
Pericardium

RA=right atrium, RV=right ventricle
LV=left ventricle, LA=Left atrium
DA=descending aorta
Pericardium and Heart continue...

AA=Ascending Aorta, PA=pulmonary artery, RA=right atrium, RV=right ventricle
LV=left ventricle, LA=Left atrium, PV=pulmonary vein, DA=descending aorta
Heart and pericardium continue...

RA=right atrium, RV=right ventricle
LV=left ventricle, LA=Left atrium
DA=descending aorta
Heart and pericardium continue...

RA=right atrium, RV=right ventricle
LV=left ventricle, LA=Left atrium
DA=descending aorta
Heart and pericardium continue...

RA=right atrium, RV=right ventricle
LV=left ventricle, LA=Left atrium
DA=descending aorta
Heart and pericardium continue...

RA=right atrium, RV=right ventricle
LV=left ventricle, LA=left atrium
DA=descending aorta
Heart and pericardium continue...

IVC=inferior vena cava
RA=right atrium, RV=right ventricle
LV=left ventricle
DA=descending aorta
Heart and pericardium continue...

IVC = inferior vena cava
RA = right atrium, RV = right ventricle
LV = left ventricle
DA = descending aorta

RA = right atrium, RV = right ventricle
LV = left ventricle
DA = descending aorta
Heart and pericardium continue...

IVC=inferior vena cava
RA=right atrium, RV=right ventricle
LV=left ventricle
DA=descending aorta

RA=right atrium, RV=right ventricle
DA=descending aorta

IVC=inferior vena cava
LV=left ventricle
DA=descending aorta
Heart and pericardium continue...

IVC = inferior vena cava
RA = right ventricle
LV = left ventricle
DA = descending aorta
Heart and pericardium continue...

IVC = inferior vena cava
LV = left ventricle
DA = descending aorta
Heart and pericardium end at diaphragm

IVC = inferior vena cava
LV = left ventricle
DA = descending aorta
Chest Wall Contours

• Chest wall can be autosegmented from the ipsilateral lung with a 2-cm expansion in the lateral, anterior, and posterior directions. Anteriorly and medially, it ends at the edge of the sternum. Posteriorly and medially, it stops at the edge of the vertebral body with inclusion of the spinal nerve root exit site.

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Chest Wall

CW refers to CW2cm which include intercostal muscles, nerves exclude vertebral bodies, sternum and skin.

The superior end of PTV
Chest Wall

CW refers to CW2cm which include intercostal muscles, nerves exclude vertebral bodies, sternum and skin.

The superior end of GTV
CW refers to CW2cm which include intercostal muscles, nerves exclude vertebral bodies, sternum and skin.

Chest wall contours around GTV.
Chest Wall

CW refers to CW2cm which include intercostal muscles, nerves exclude vertebral bodies, sternum and skin.

The inferior end of PTV

3 cm below PTV

CW ends at 3cm from the inferior edge of PTV.
Acknowledgement

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