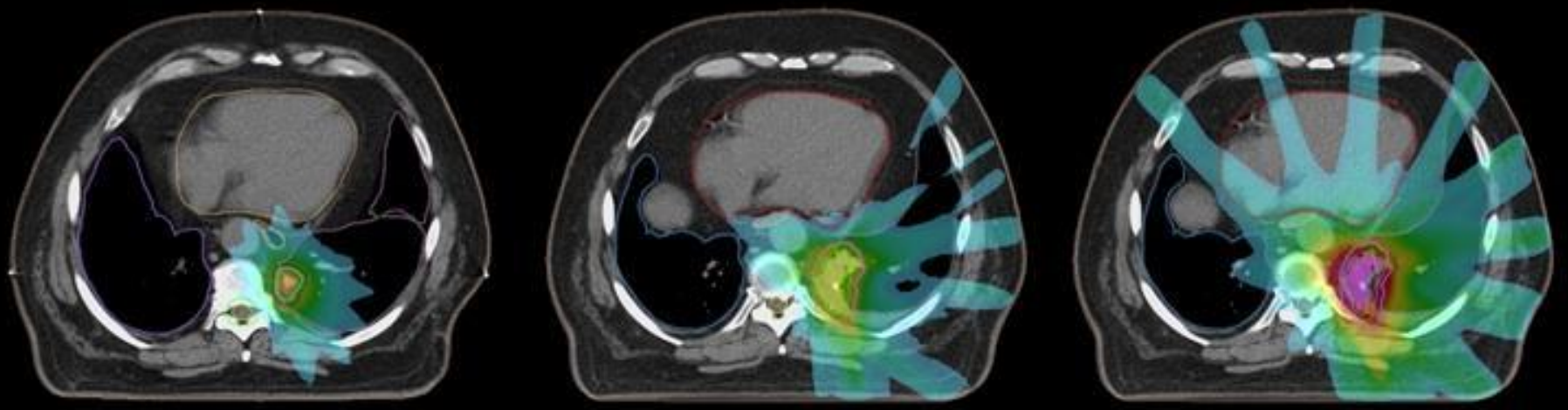


Imaging in radiotherapy

R3: Yang-Hong Dai

Department of Radiation Oncology

學習目標

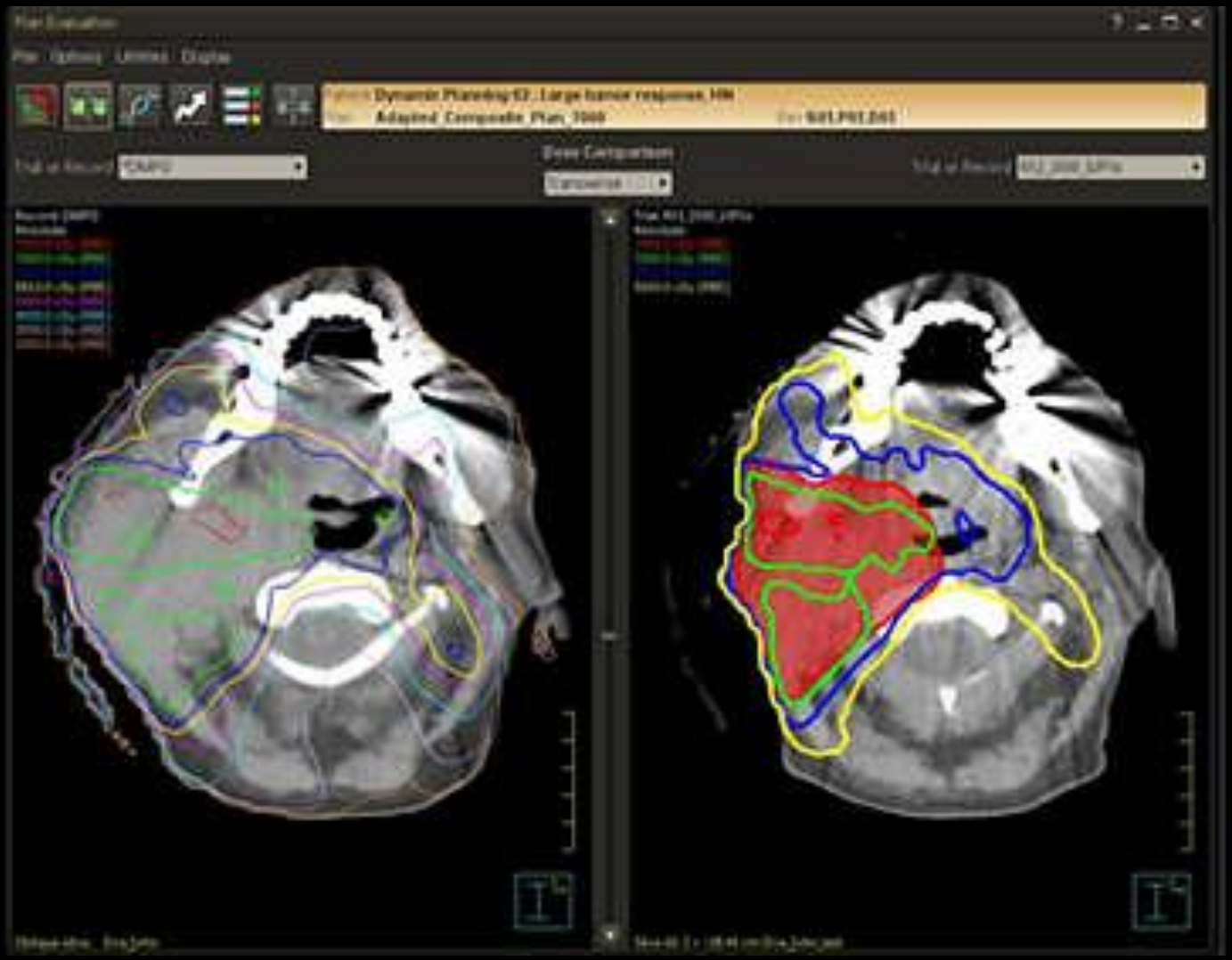
放射治療標靶的圈劃原擇(GTV,CTV,PTV)

製作人　　戴揚紘醫師

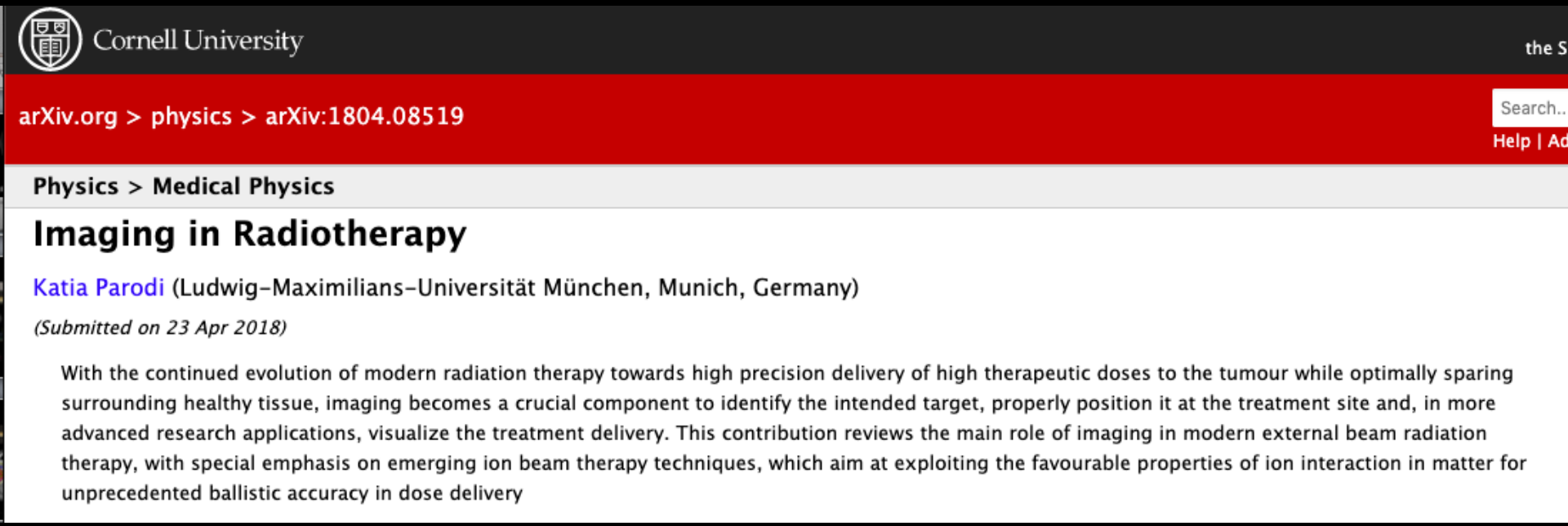
製作日期　2019年 9月 最後更新

???

Current planning system: Pinnacle[3]



Imaging in radiotherapy



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Imaging in Radiotherapy

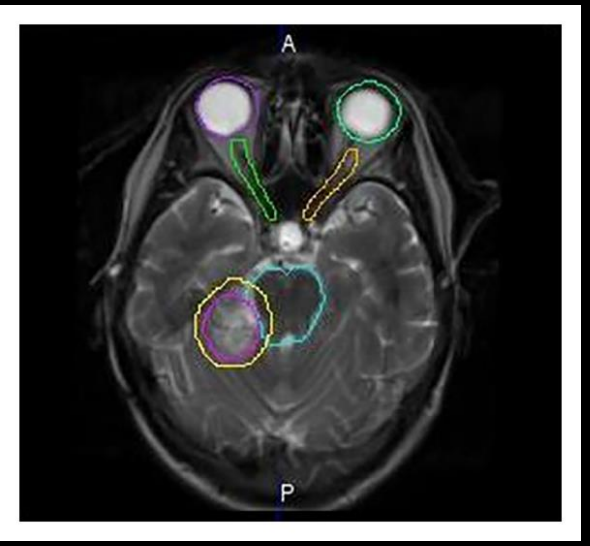
Katia Parodi (Ludwig-Maximilians-Universität München, Munich, Germany)

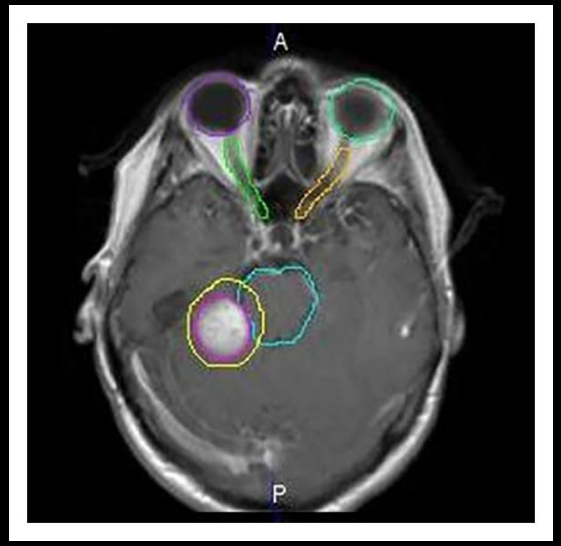
(Submitted on 23 Apr 2018)

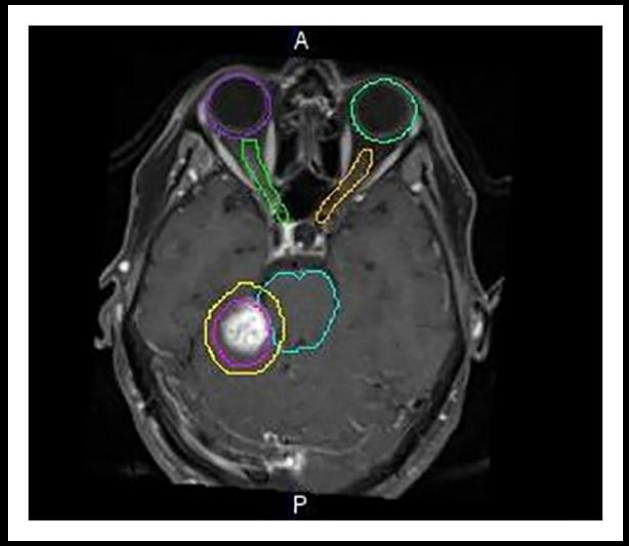
With the continued evolution of modern radiation therapy towards high precision delivery of high therapeutic doses to the tumour while optimally sparing surrounding healthy tissue, imaging becomes a crucial component to identify the intended target, properly position it at the treatment site and, in more advanced research applications, visualize the treatment delivery. This contribution reviews the main role of imaging in modern external beam radiation therapy, with special emphasis on emerging ion beam therapy techniques, which aim at exploiting the favourable properties of ion interaction in matter for unprecedented ballistic accuracy in dose delivery

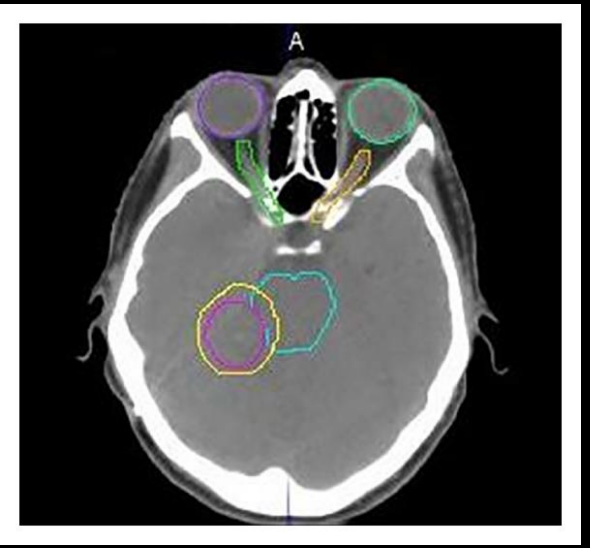
Roles of imaging in RT

- CT: Despite some disadvantages, CT remains the only three-dimensional imaging modality used for dose calculation.
- MRI: Better tissue contrast and resolution than those of CT, improves tumor definition compared with CT planning alone.
- PET: PET also provides metabolic information to supplement the CT and MR anatomical information.

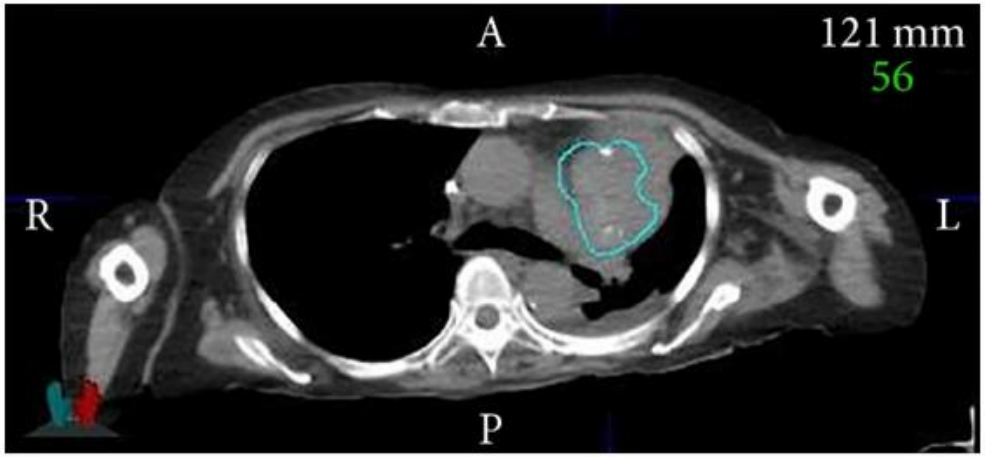








The Role of Imaging in Radiation Therapy Planning: Past, Present, and Future. 2014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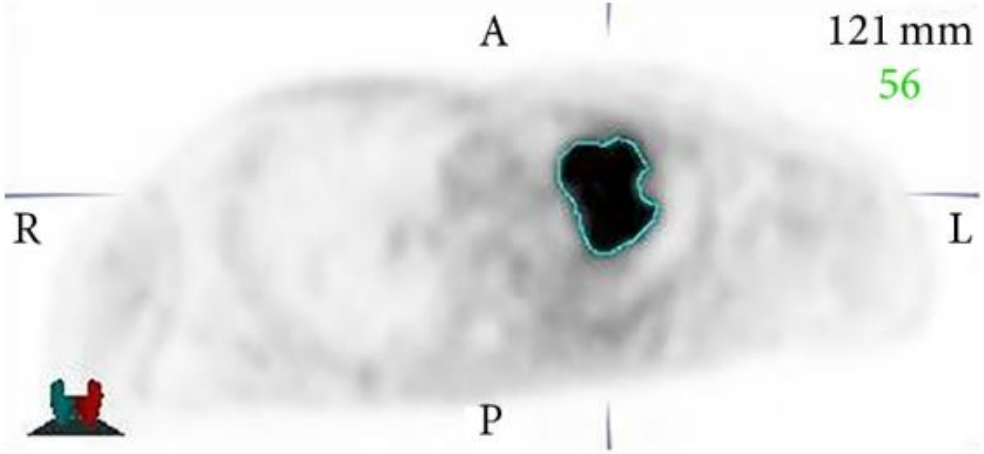
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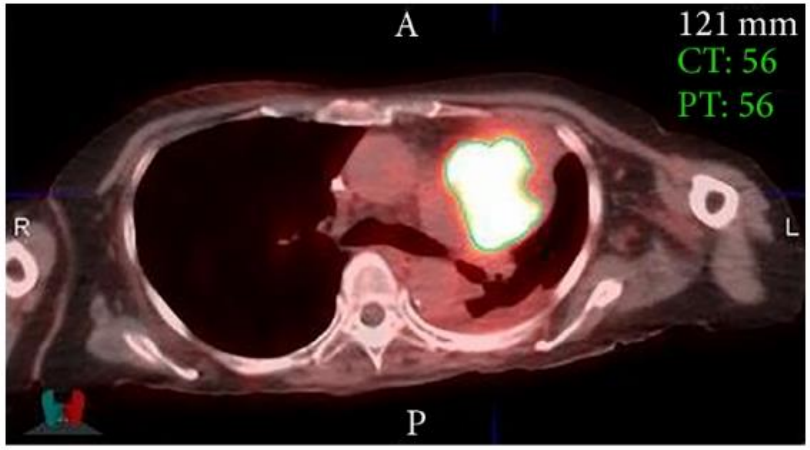
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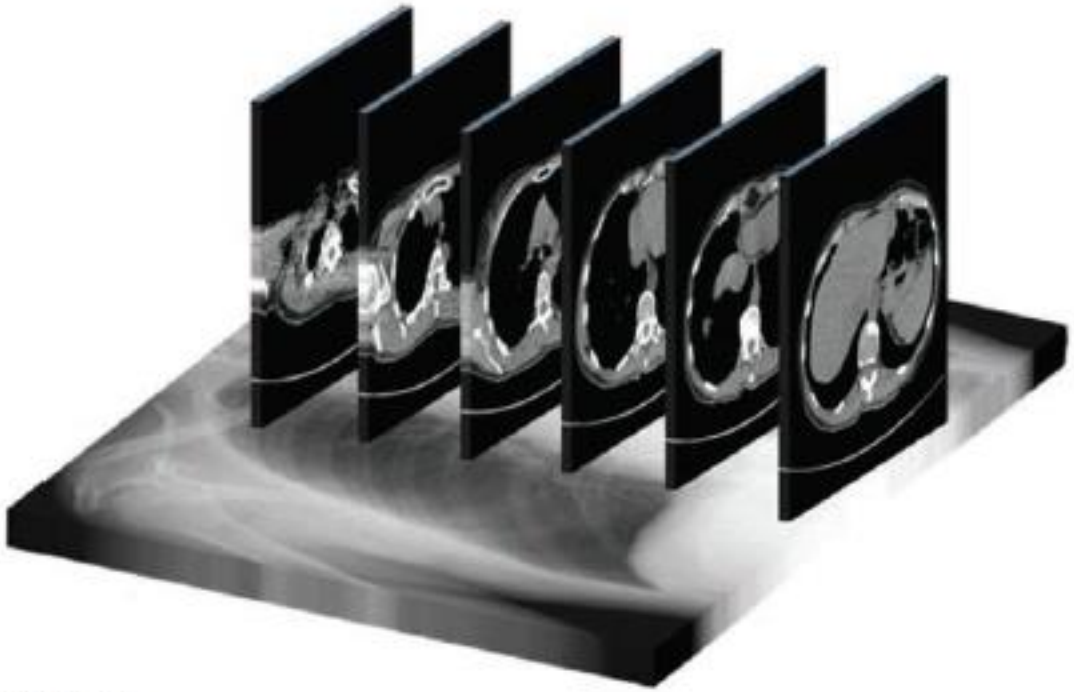
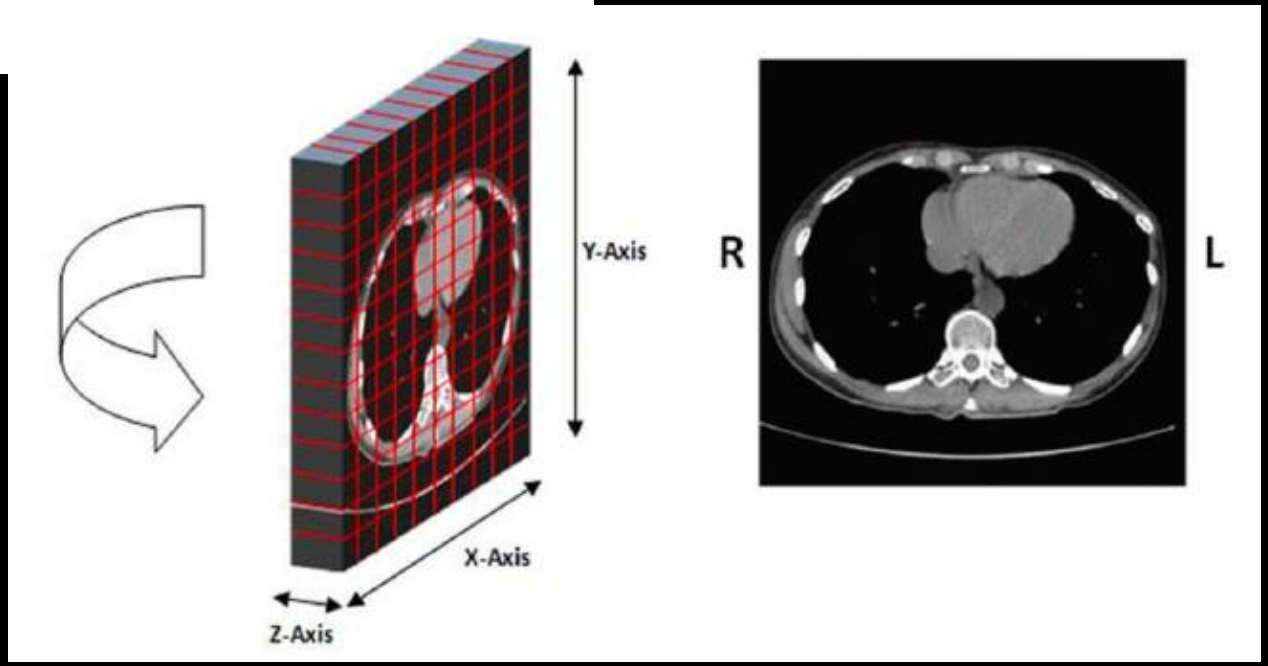
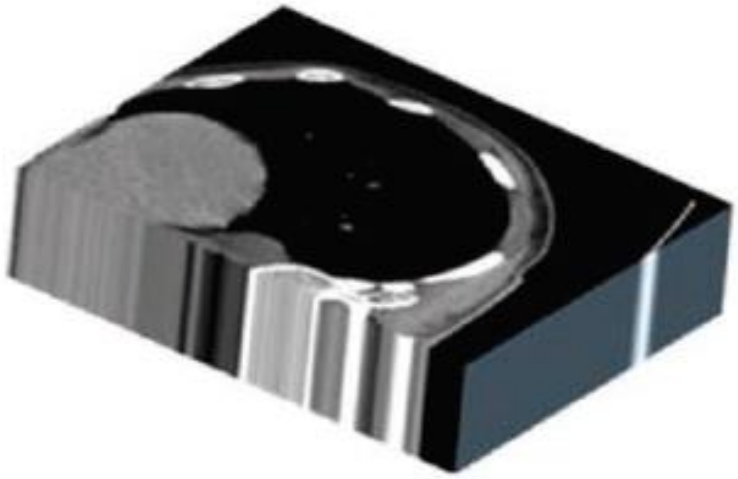


Figure 1.3.1



Example



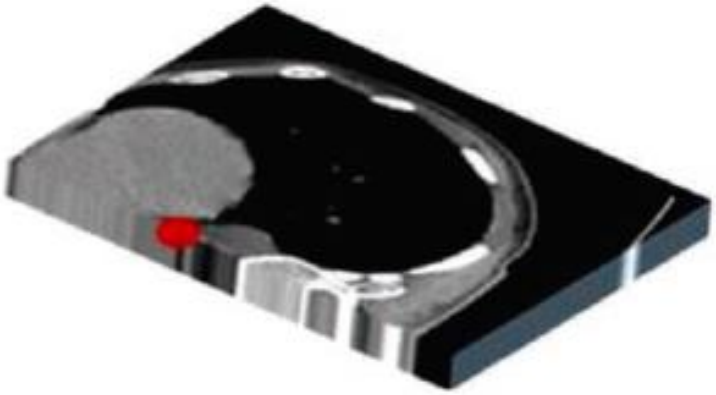
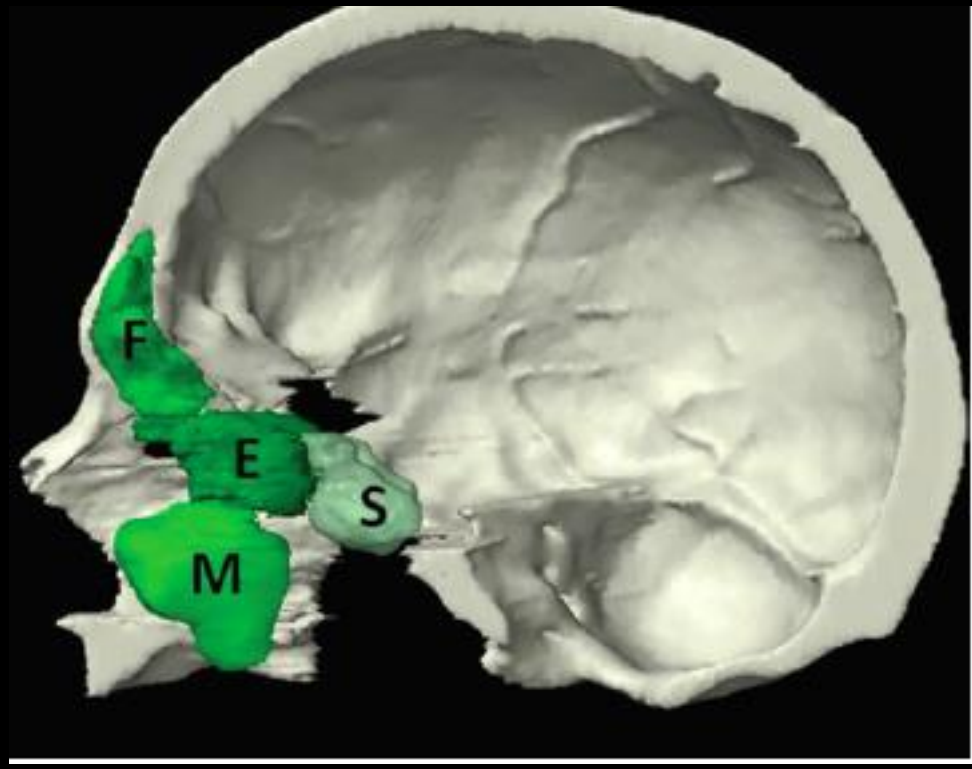
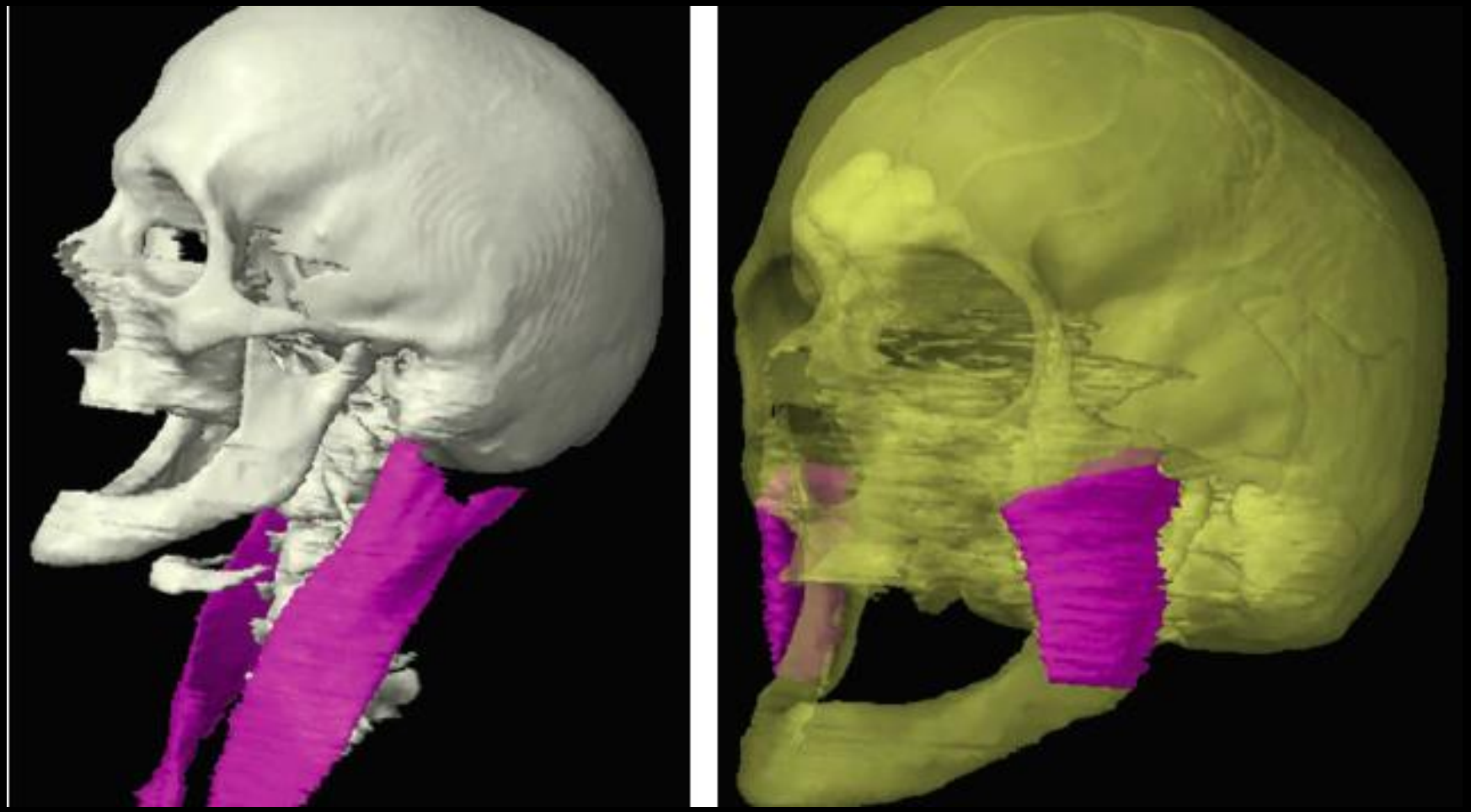


Figure 1.3.3

Bony structure and sinuses



Muscle



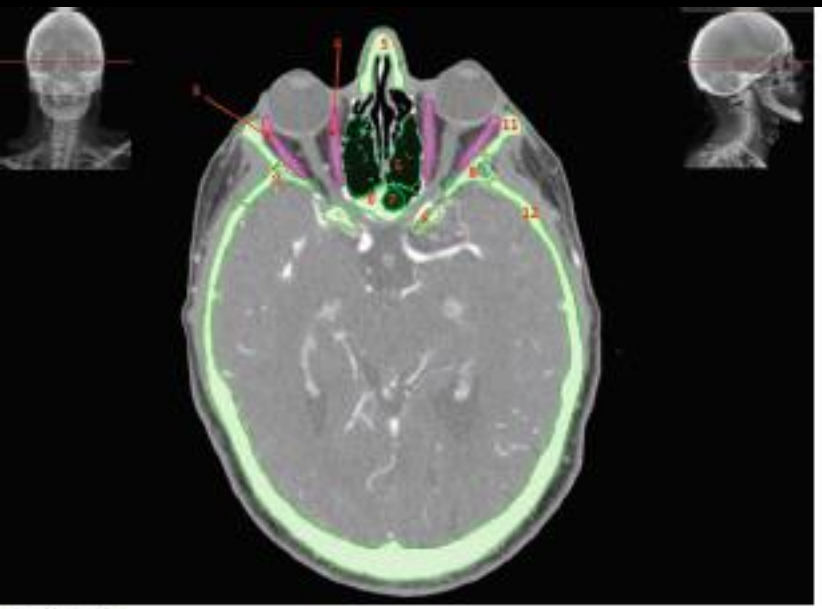
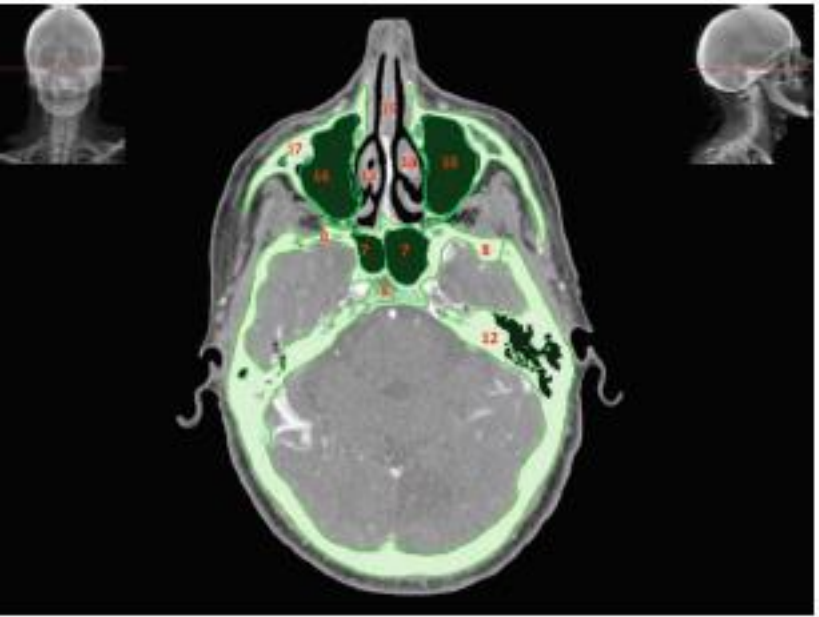


Figure 4.1.8



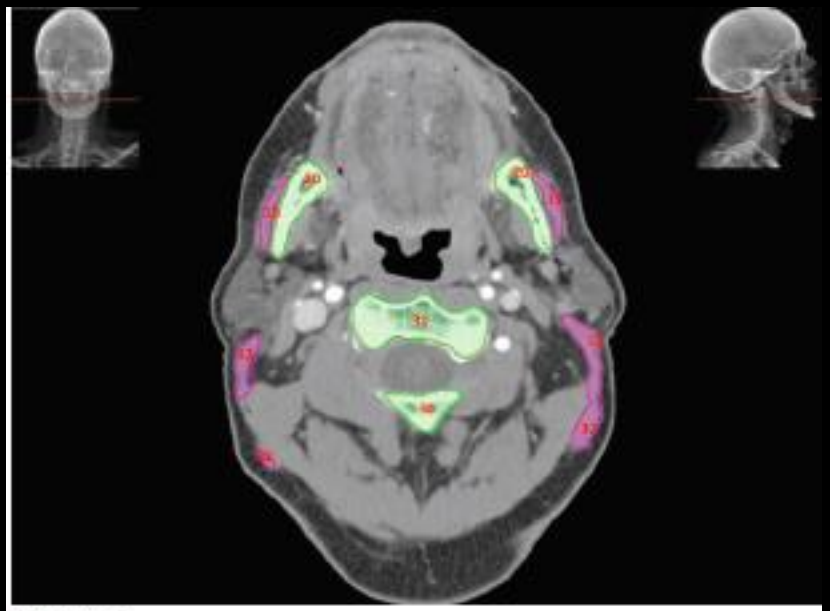
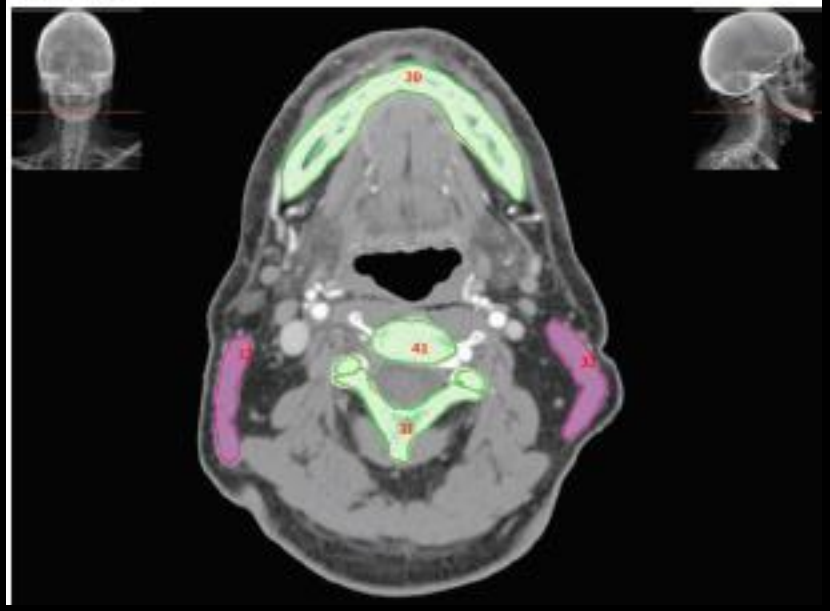
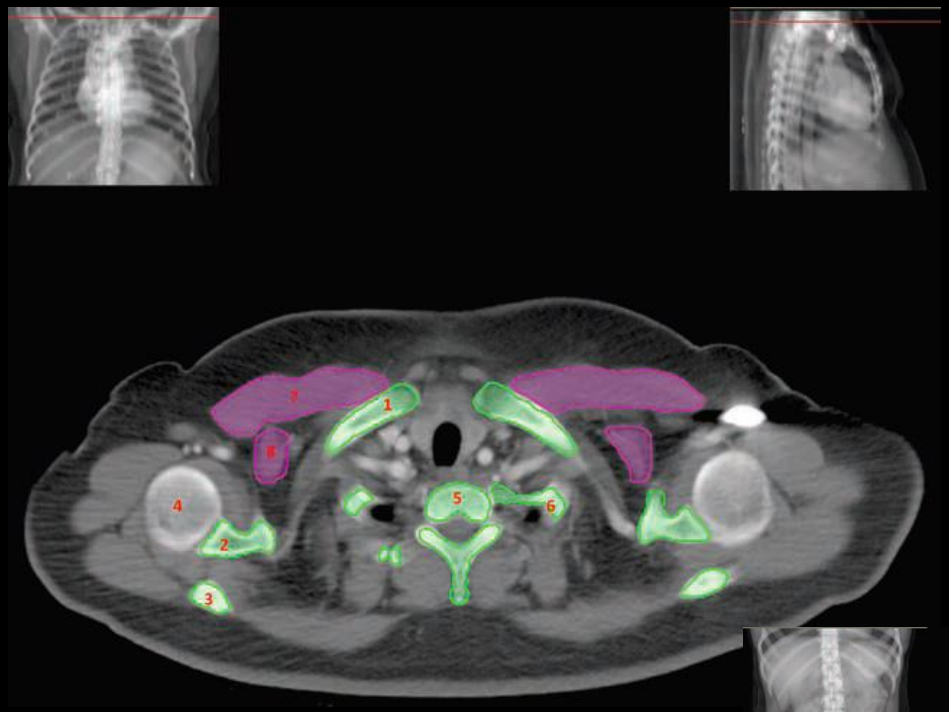


Figure 4.1.17

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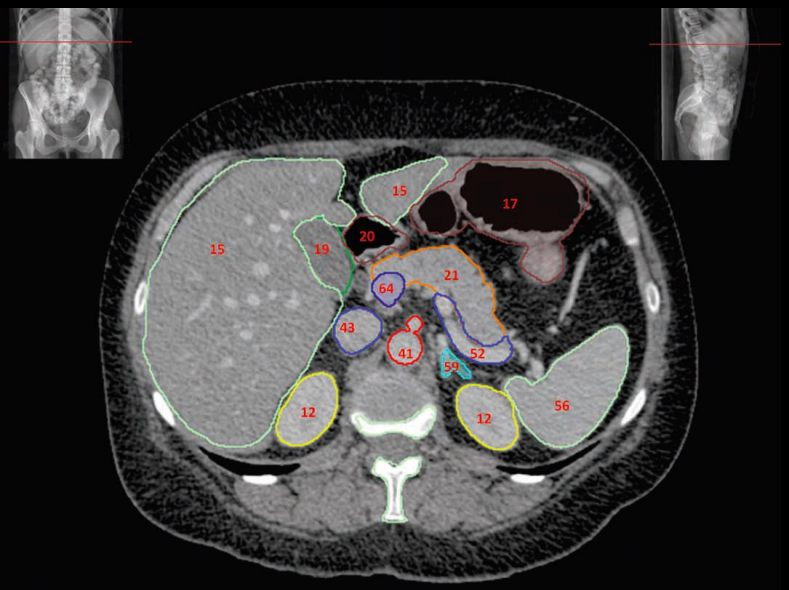
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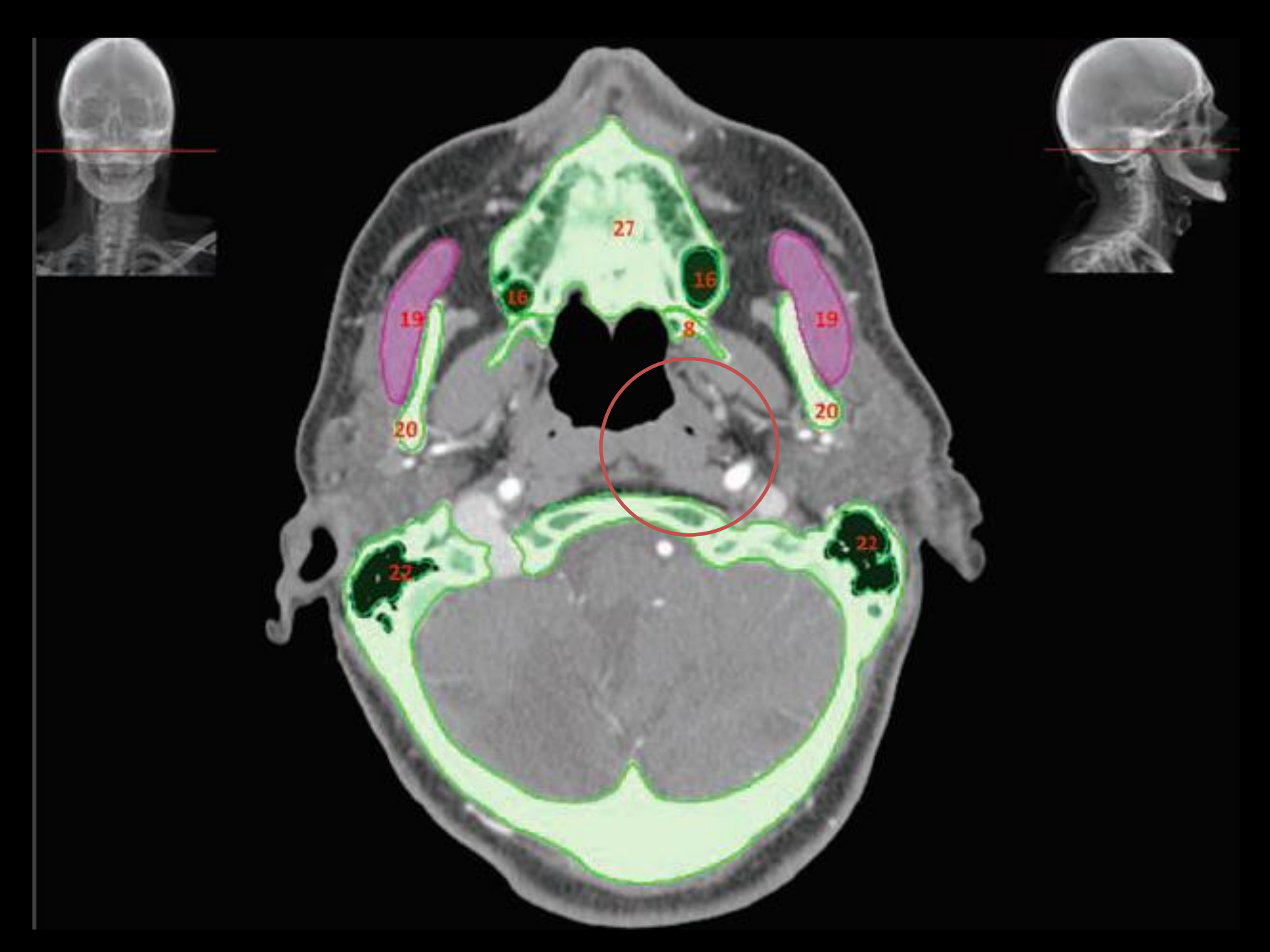
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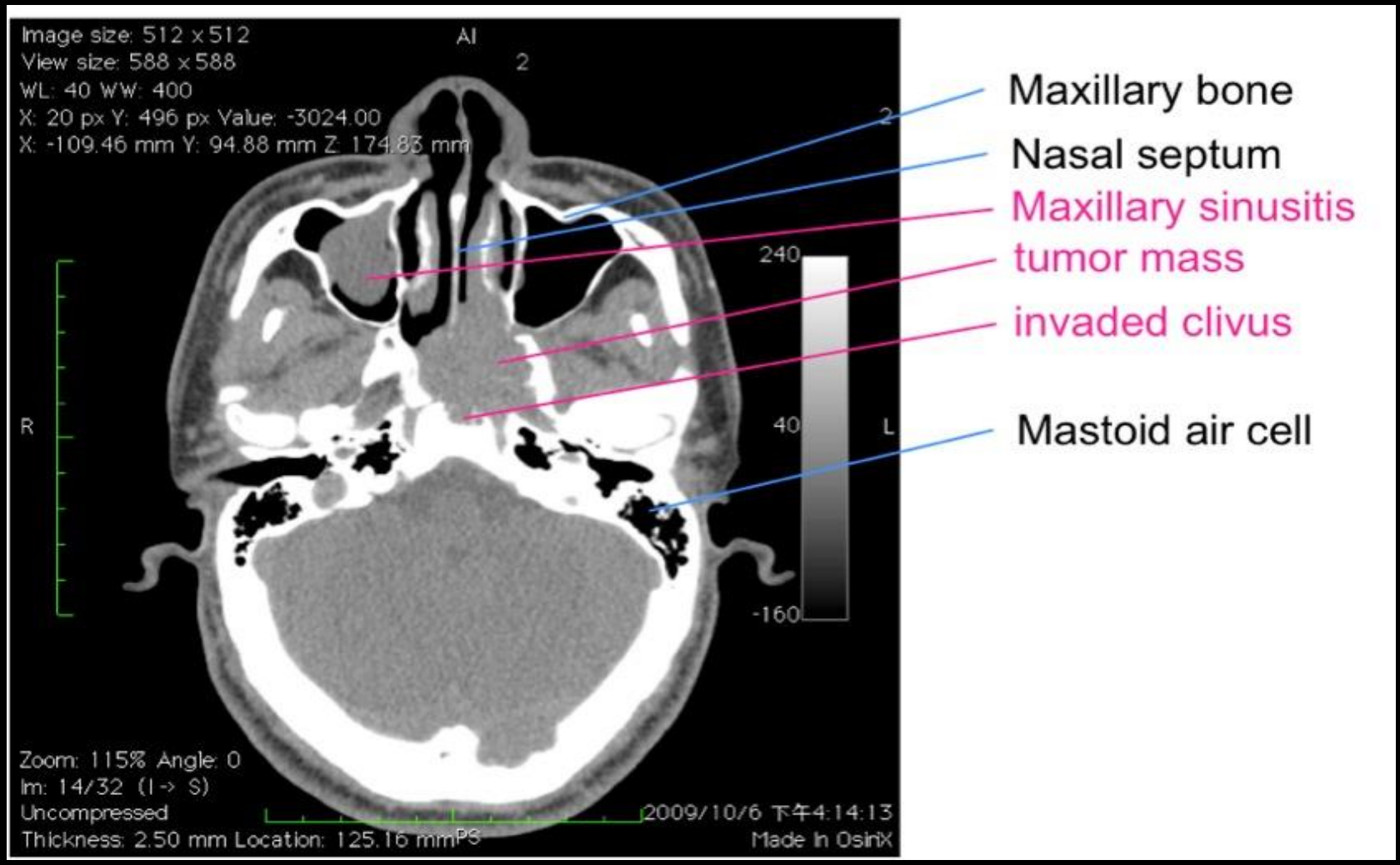
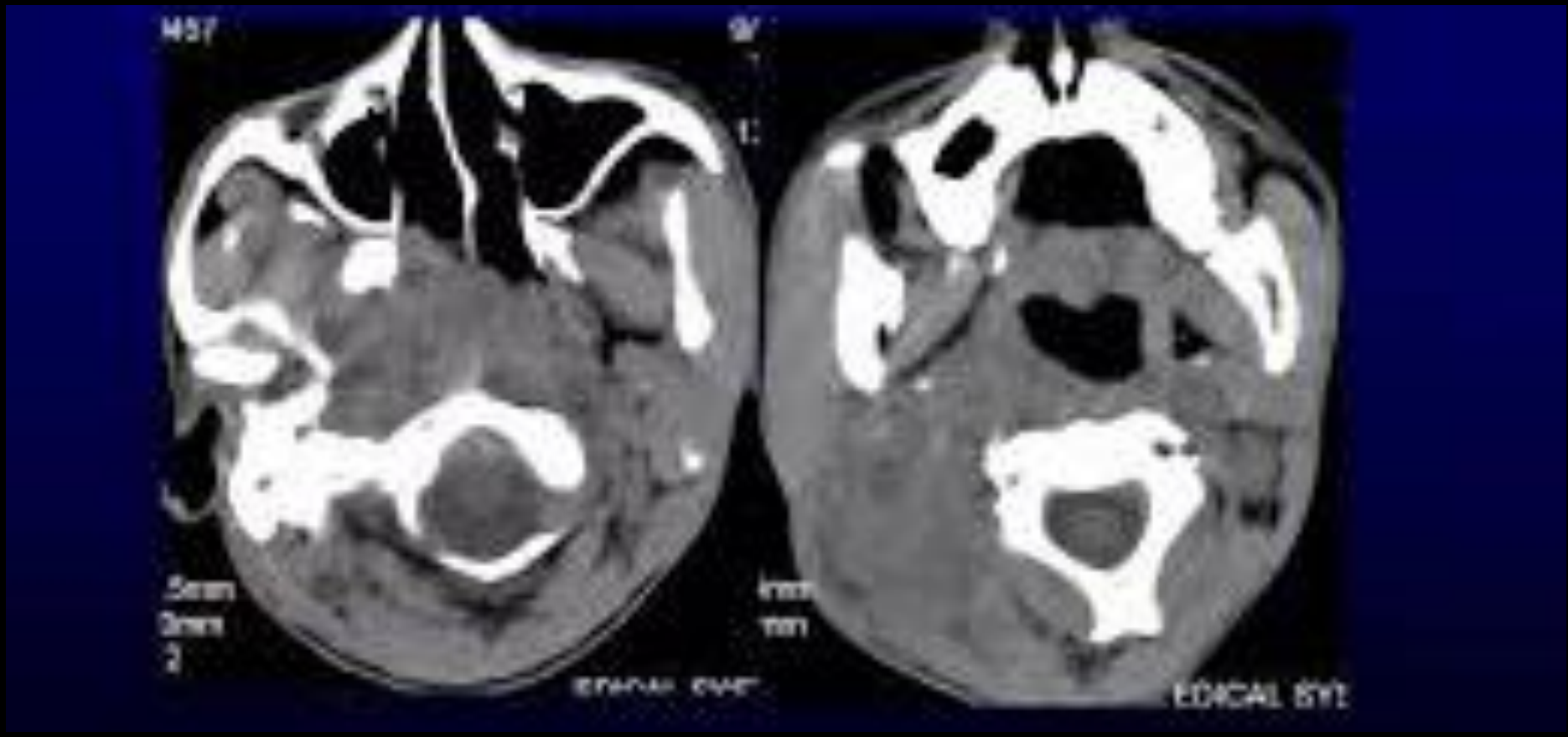
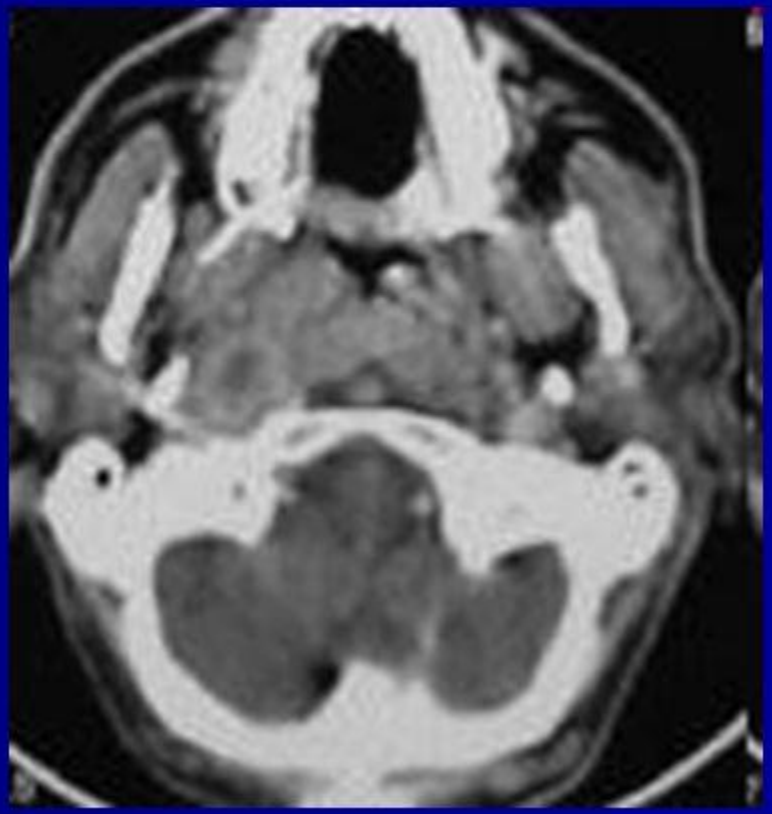
Nasopharyngeal carcinoma

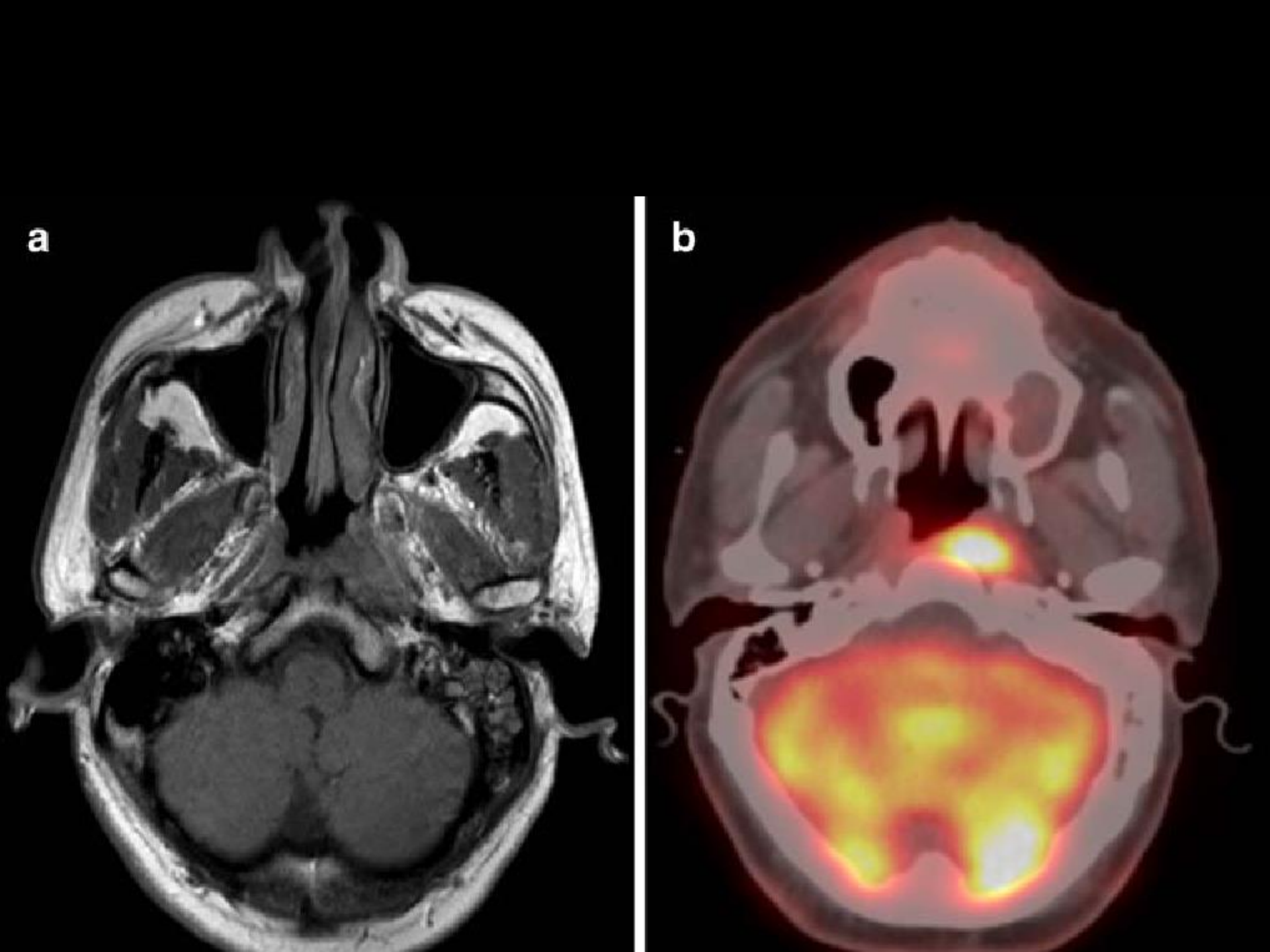




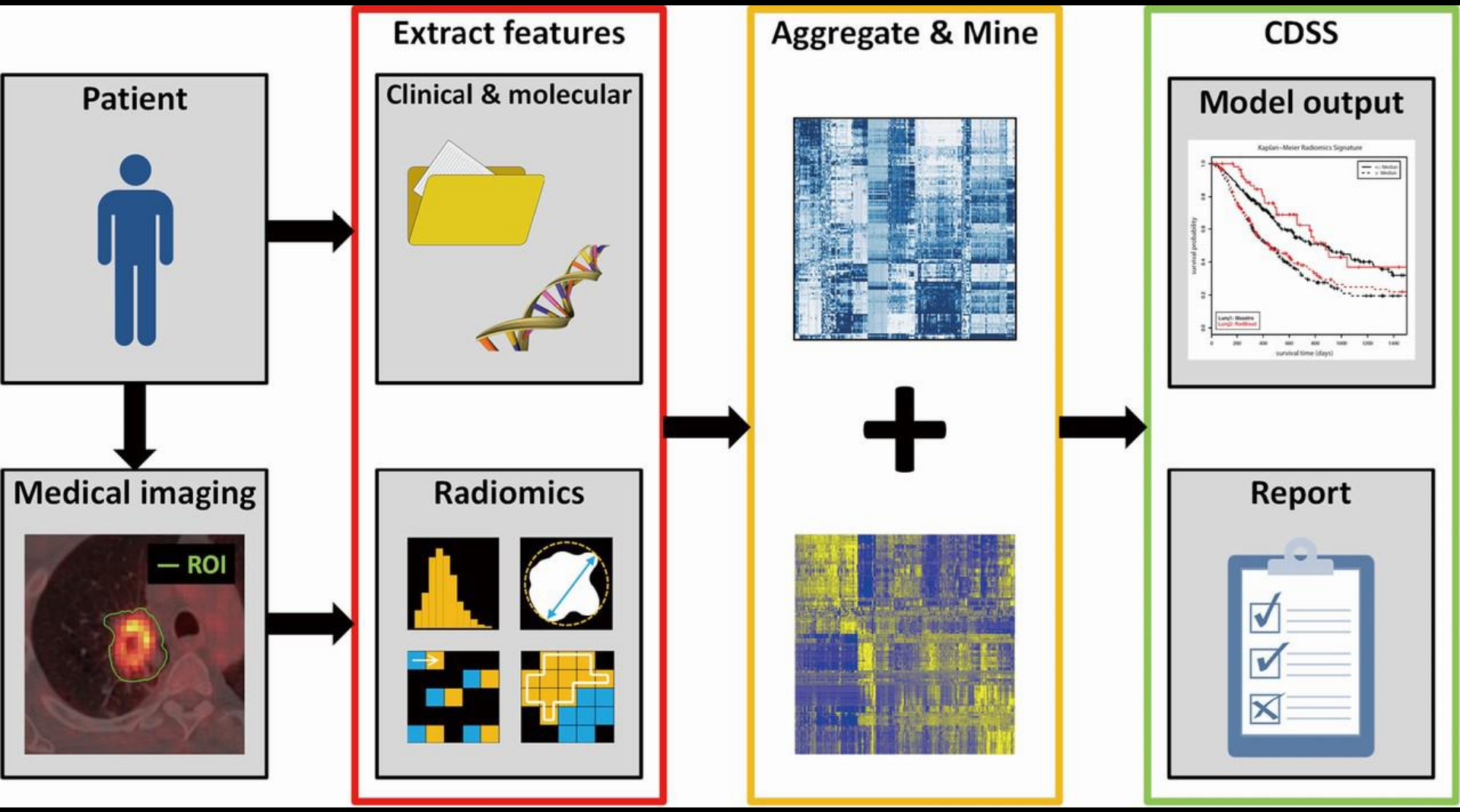
Imaging studies

- Cross sectional CT:
  - Paranasopharyngeal spread: one of the most common modes of NPC extension[28]
  - Perineural spread (through the foramen ovale)
    - Important route of intracranial extension[28]
    - Cavernous sinus involvement without skull-base erosion[29]




a
b

Radiomics and radiogenomics



jupyter Pancancer_RSI_analysis Last Checkpoint: 上星期五15:46 (autosaved)

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Trusted Python 3

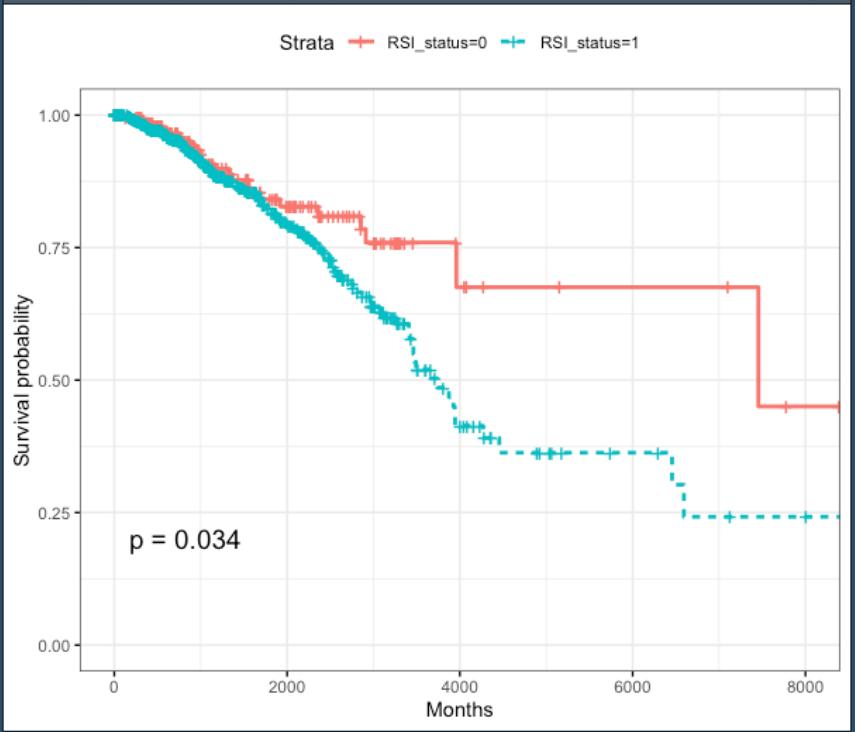
Run Code

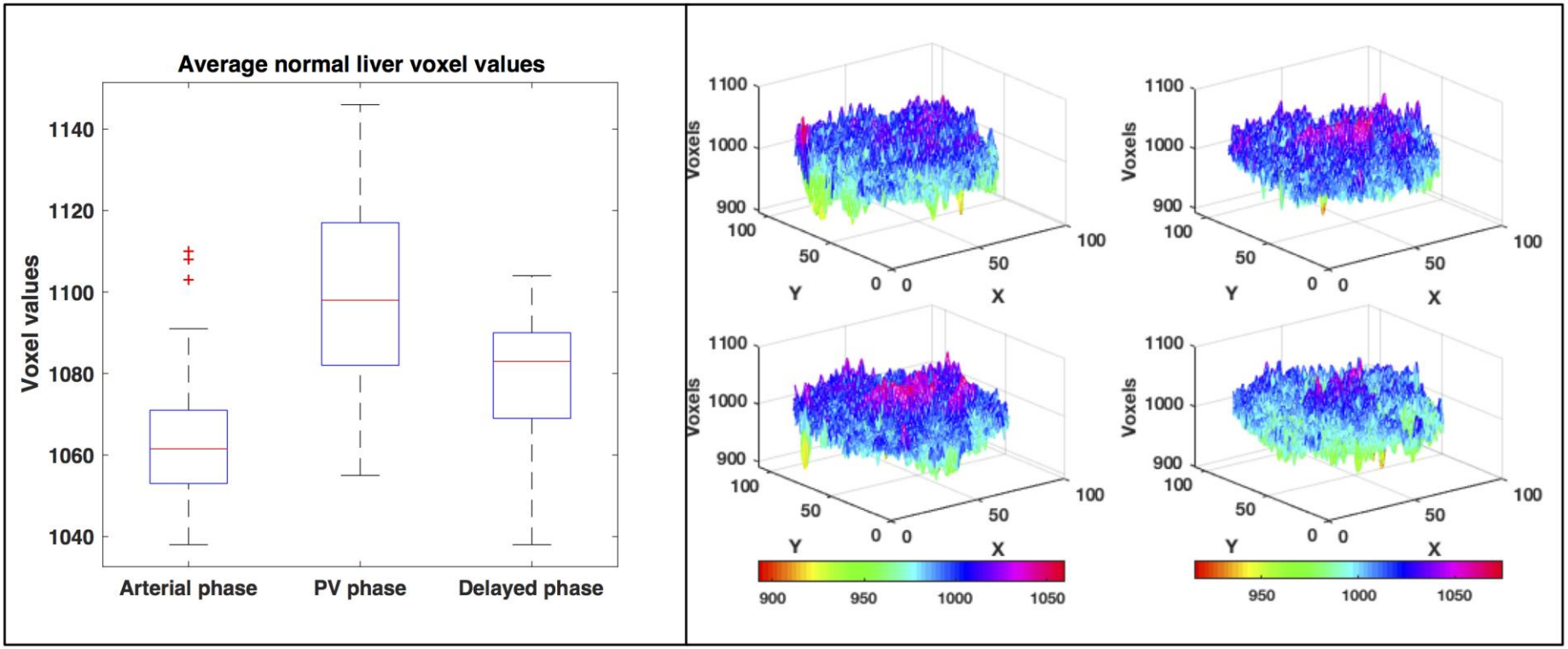
In [1]:
```
import pandas as pd
import os
os.chdir('/Users/apple/Desktop/Precision_oncology/GSE')
```

In [2]:
```
def get_rank_based_table(df):
    #df_temp = df.sort_values(axis=1, by = 1, ascending = True, inplace = False)
    gene_order = []
    for i in list(df.index):
        c = df
        b = df.sort_values(axis=1, by = i, ascending = True)
        gene_order.append(list(b.columns))
    gene_order
    index_map = list(df.columns)
    new_order = pd.DataFrame(gene_order, columns = index_map)
    for i in range(len(df.index)):
        for j in range(len(df.columns)):
            lst = gene_order[i].index(index_map[j])
            new_order.iloc[i,j]=lst+1
    new_order.index = df.index
    return new_order
```

```
#violin$gender
#violin$ajcc_pathologic_tumor_stage
summary(res.cut)

gse_survival <- coxph(Surv(RFS.time, RFS)~RSI_rfs

gse_survival <- coxph(Surv(OS.time, CSS)~RSI_stat

summary(gse_survival)
```

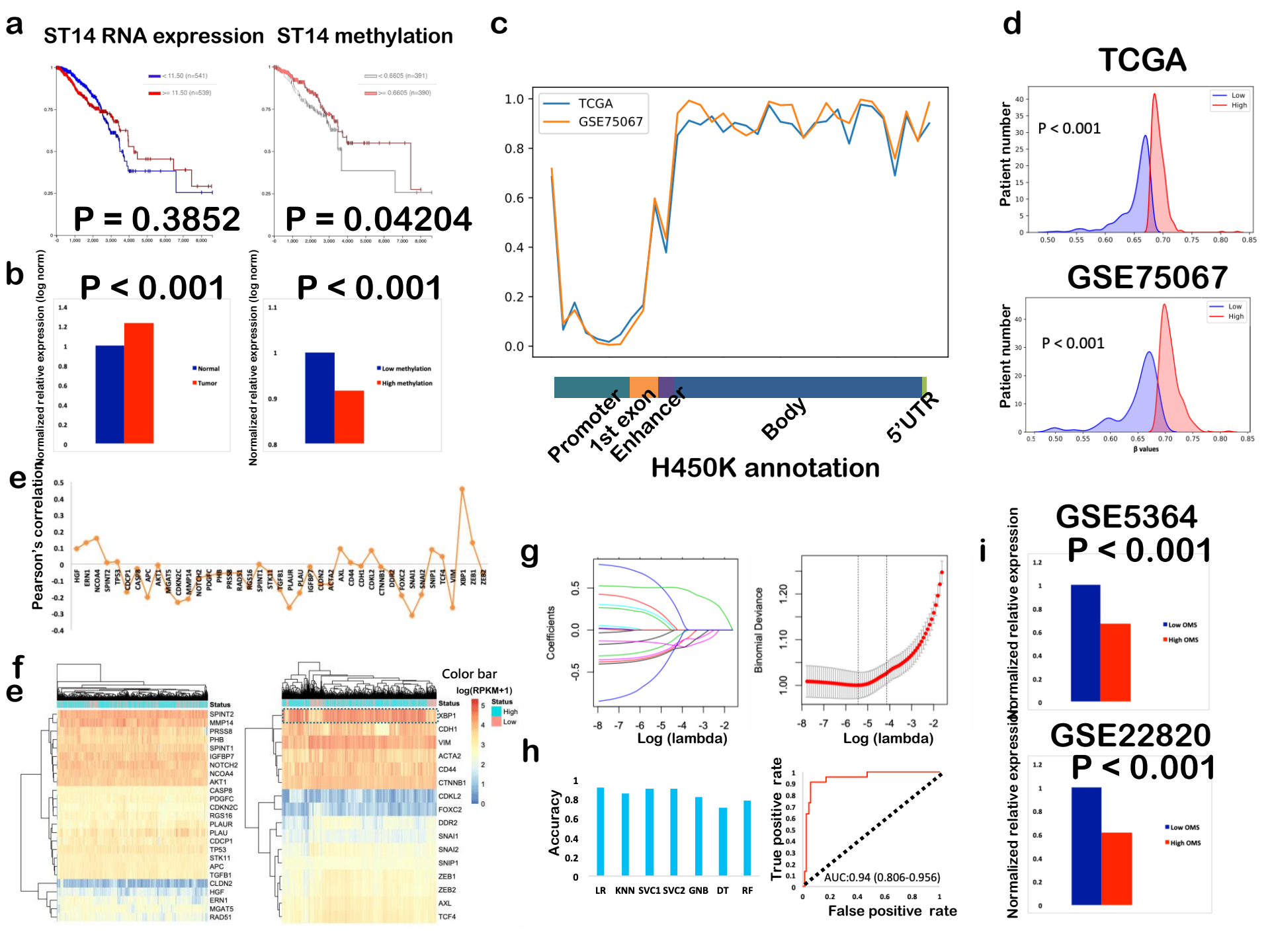
```
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
 0.1 ' ' 1

            exp(coef) exp(-coef) lower .95 upper .95
RSI_status      4.473     0.2236     1.055     18.96

Concordance= 0.606  (se = 0.034 )
```




Average normal liver voxel values
Voxel values
1140
1120
1100
1080
1060
1040
Arterial phase
PV phase
Delayed phase
Voxels
1100
1000
900
100
50
0
Y
X
900
950
1000
1050

a.

b.


a
ST14 RNA expression
ST14 methylation
< 11.50 (n=541)
>= 11.50 (n=539)
P = 0.3852
< 0.6605 (n=391)
>= 0.6605 (n=390)
P = 0.04204
b
P < 0.001
Normalized relative expression (log norm)
Normal
Tumor
P < 0.001
Low methylation
High methylation
c
TCGA
GSE75067
Promoter
1st exon
Enhancer
Body
5'UTR
H450K annotation
d
TCGA
Patient number
P < 0.001
Low
High
GSE75067
β values
e
Pearson's correlation
HGF
ERN1
NCOA4
SPINT2
TP53
CDCP1
CASP8
APC
AKT1
MGAT5
CDKN2C
MMP14
NOTCH2
PDGFC
PHB
PRSS8
RAD51
RGS16
SPINT1
STK11
TGFB1
PLAUR
PLAU
IGFBP7
CLDN2
ACTA2
AXL
CD44
CDH1
CDKL2
CTNNB1
DDR2
FOXC2
SNAI1
SNAI2
SNIP1
TCF4
VIM
XBP1
ZEB1
ZEB2
f
e
Color bar
log(RPKM+1)
Status
High
Low
SPINT2
MMP14
PRSS8
PHB
SPINT1
IGFBP7
NOTCH2
NCOA4
AKT1
CASP8
PDGFC
CDKN2C
RGS16
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ERN1
MGAT5
RAD51
XBP1
CDH1
VIM
ACTA2
CD44
CTNNB1
CDKL2
FOXC2
DDR2
SNAI1
SNAI2
SNIP1
ZEB1
ZEB2
AXL
TCF4
g
Coefficients
Log (lambda)
Binomial Deviance
Log (lambda)
h
Accuracy
LR
KNN
SVC1
SVC2
GNB
DT
RF
True positive rate
False positive rate
AUC:0.94 (0.806-0.956)
i
GSE5364
P < 0.001
Normalized relative expression
Low OMS
High OMS
GSE22820
P < 0.001
Low OMS
High OMS

GTV

- The GTV is the gross palpable, visible, or clinically demonstrable location and extent of the malignant growth.
- It can consist of primary tumor and metastatic lymphadenopathy, or other metastases.
- The methods used to determine the GTV should meet the requirements for staging the tumor according to the AJCC systems.

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GTV

- There is a value in indicating whether a given GTV or CTV represents the primary tumor, or grossly involved nodes, or grossly visible metastases.
- GTV-T, GTV-N, GTV-M

CTV

- The CTV is a tissue volume that contains the GTV(s) and/or sub-clinical malignant.
- Delineation of the CTV is based on:

  1. The probability of microscopic extension at different distances around the GTV, and the probability of sub-clinical invasion of regional lymph nodes or other tissues.

  2. The judgement of the radiation oncologist.
- The CTV delineation should be based on knowledge of pathways of tumor infiltration in three dimensions.

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CTV

- There might be no macroscopic disease, and hence no GTV, after gross resection or, occasionally, after chemotherapy as the gross tumor might then no longer be evident or even present.
- In such a case, only a CTV, and not a GTV, would be defined.
- CTV could be identical to GTV.

ITV: Internal Target Volume

- Allowance for the internal component of uncertainty (organ motion, variation in size and shape) is termed the internal target volume (ITV).
- The margin between the ITV and the CTV is termed the internal margin.

PTV: Planning Target Volume

- The PTV allows for two components of uncertainty:
  - internal uncertainties (e.g., physiologic movements and variations in size, shape, and position of the CTV within the patient)
  - uncertainties in factors external to the patient (e.g., set-up uncertainties).
- To ensure that the prescribed dose is actually delivered to all parts of the CTV.

PTV: Planning Target Volume

- A generally satisfactory approach is to assess them explicitly in the six cardinal directions: AP, PA, left, right, cephalad, and caudad.
- To ensure that the prescribed dose is actually delivered to all parts of the CTV.

PTV: Planning Target Volume

- It should be noted that the estimated distribution of dose within the PTV is an underestimate of the dose distribution in the CTV.
- This results because the CTV can remain well within the PTV and hence not experience the reduced dose often delivered at the PTV boundary.

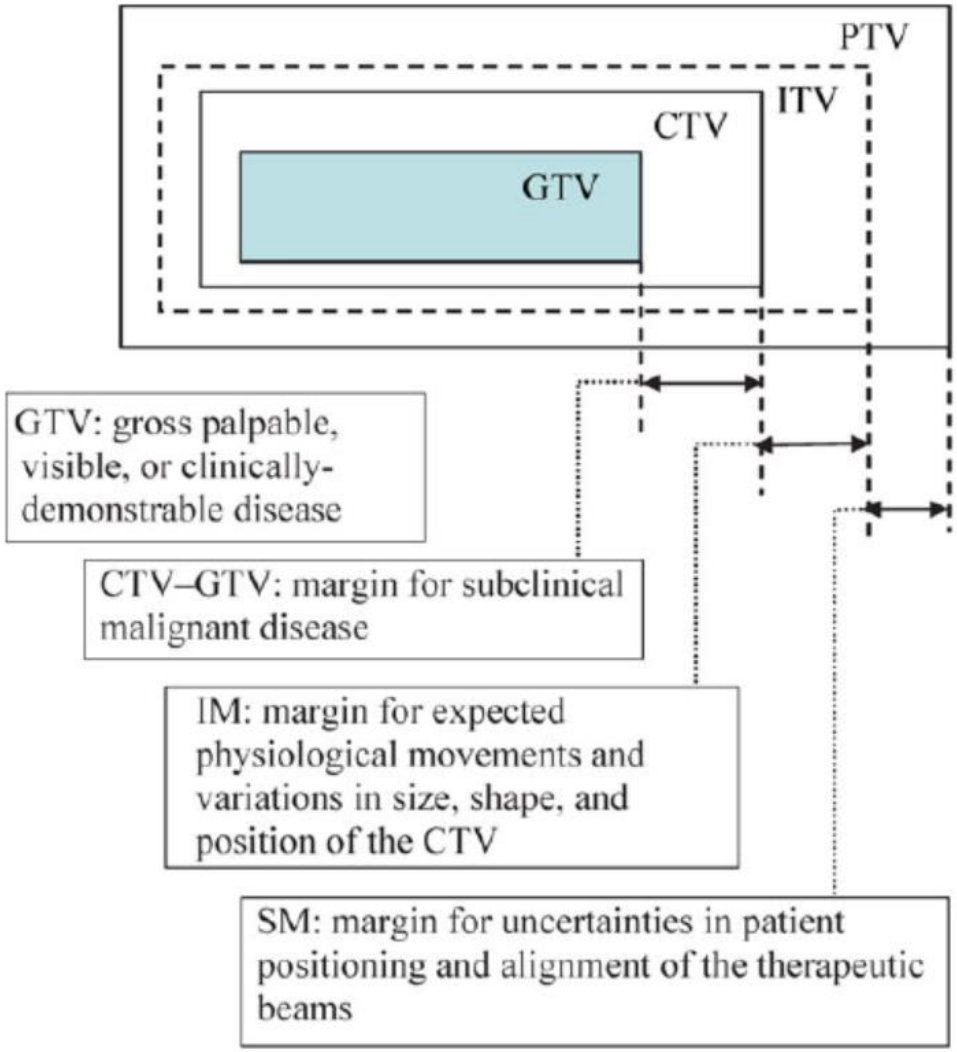

Figure 5.1. Illustration of the volumes and margins relating to the definition of the target volume.

ICRU Report 83. Prescribing, Recording, and Reporting Photon-Beam Intensity-Modulated Radiation Therapy (IMRT)

Reference

- DeVita VT, Lawerence TS, et al: Cancer: Principles and practice of Oncology. 10th ed. Lippincott Williams & Wilkins, 2015.
- Washington CM and Leaver DT: Principles and Practice of Radiation Therapy, 3rd ed. Mosby Elsevier, 2010.