



Integration of Temporal Subtraction and Nodule Detection System for Digital Chest Radiographs into PACS



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Computer Aided Diagnoses (CADs) for Chest Radiography

- Temporal subtraction
- Nodule detection
- Massive training artificial neural network (MTANN)
- Differential diagnosis of pulmonary nodule
- Measurement of cardiac-thoracic ratio
- Categorization of interstitial lung disease
- Patient recognition using an image-matching technique
- Etc.

Temporal Subtraction



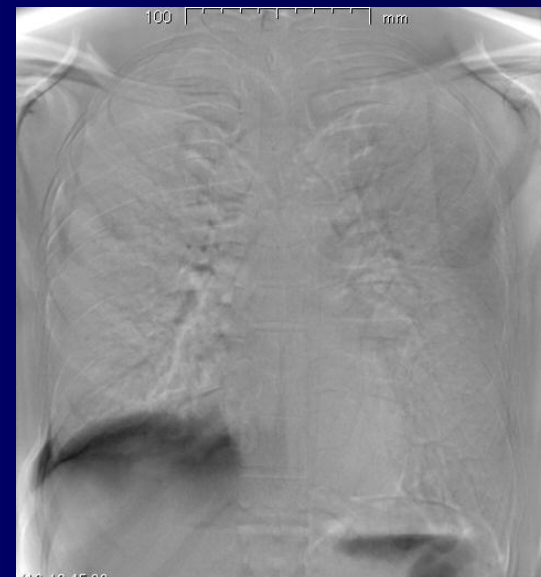
Current

—



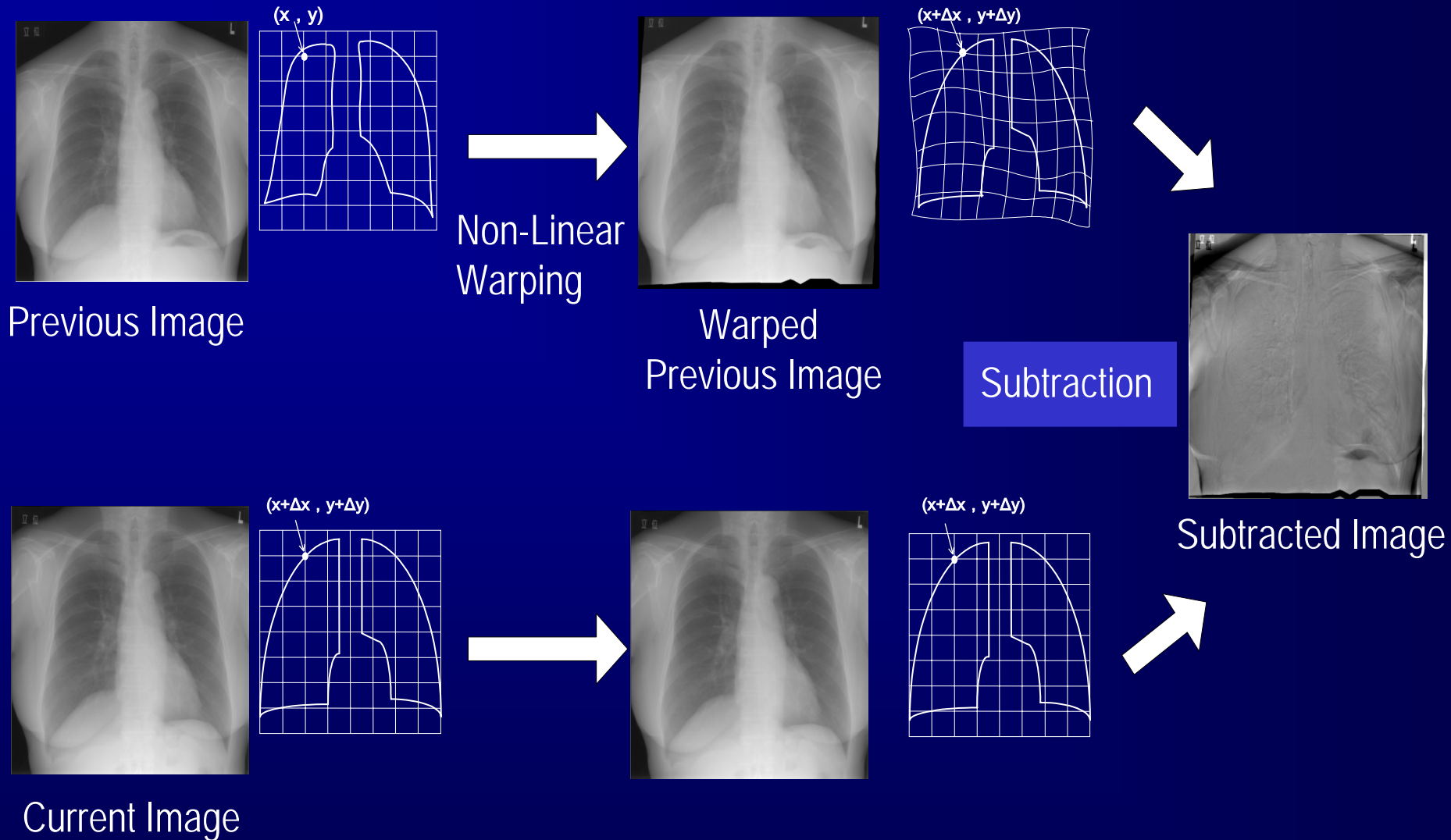
Previous

=



Pleural Effusion

Temporal subtraction is a technique in which a previous chest radiograph is automatically registered with and subtracted from a current radiograph in order to enhance interval changes.

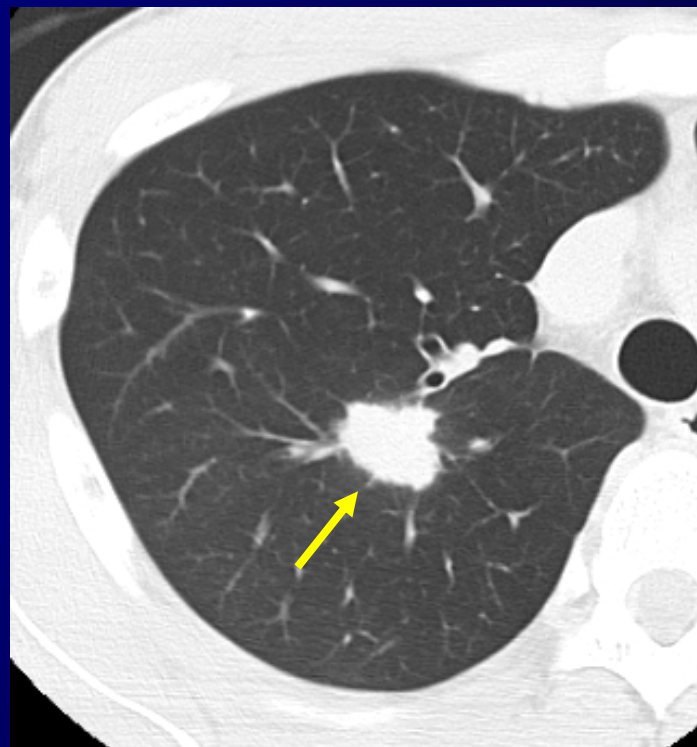


This technique is based on non-linear warping registration.

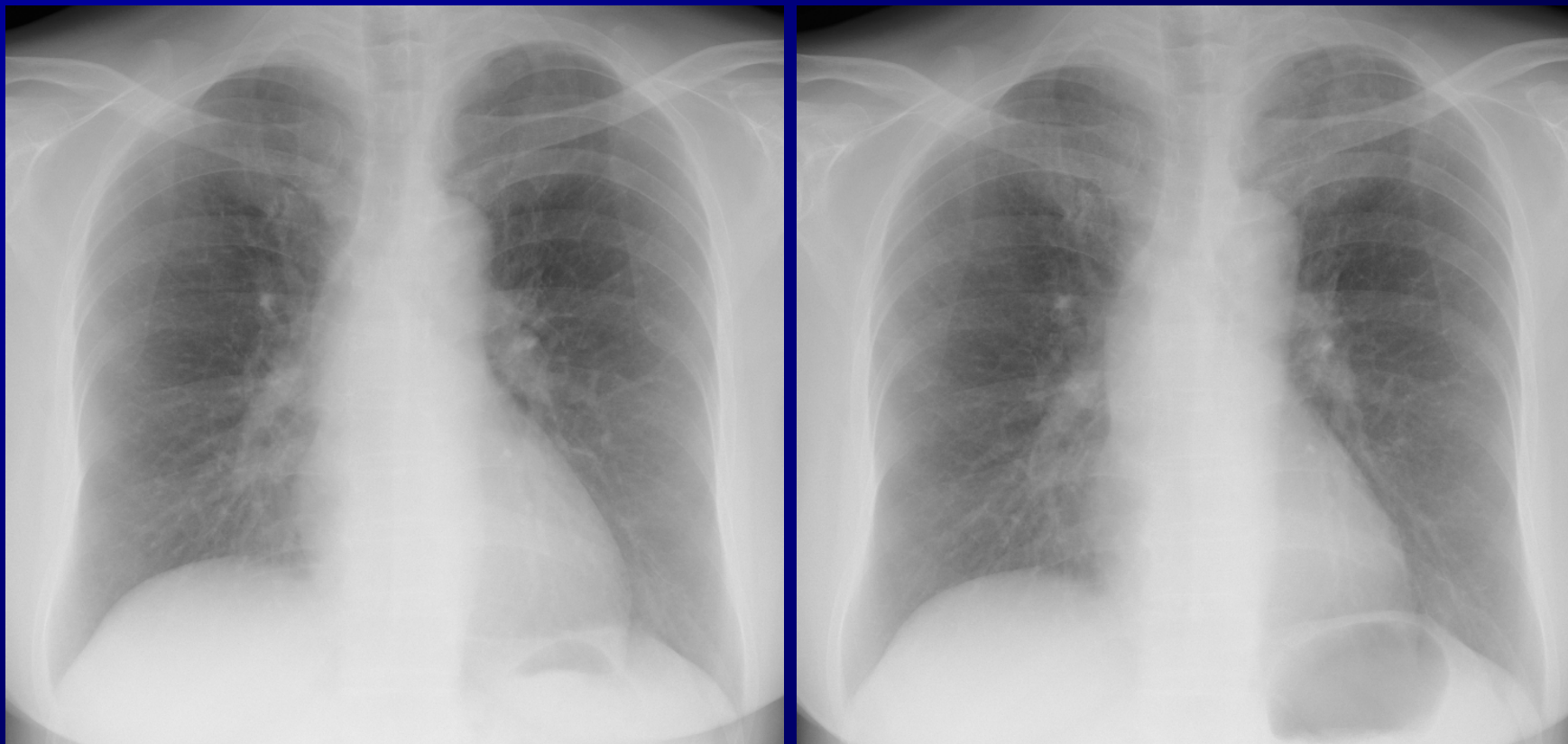


Three months later

24-year-old male was followed-up for osteosarcoma.

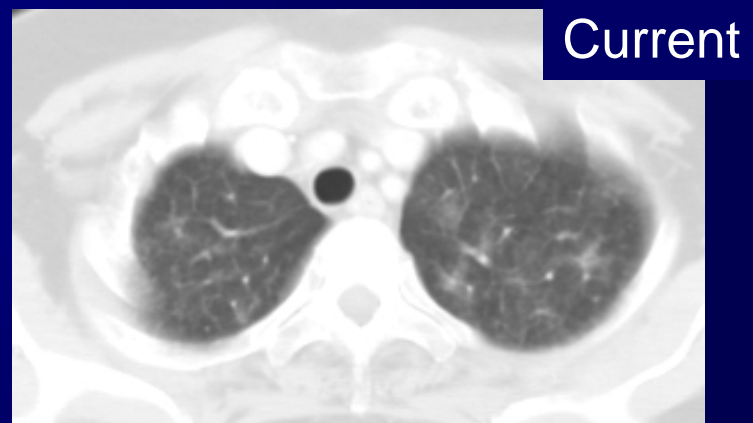
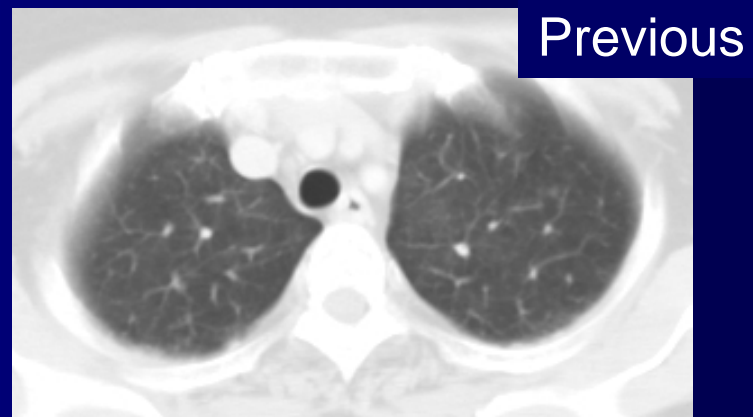
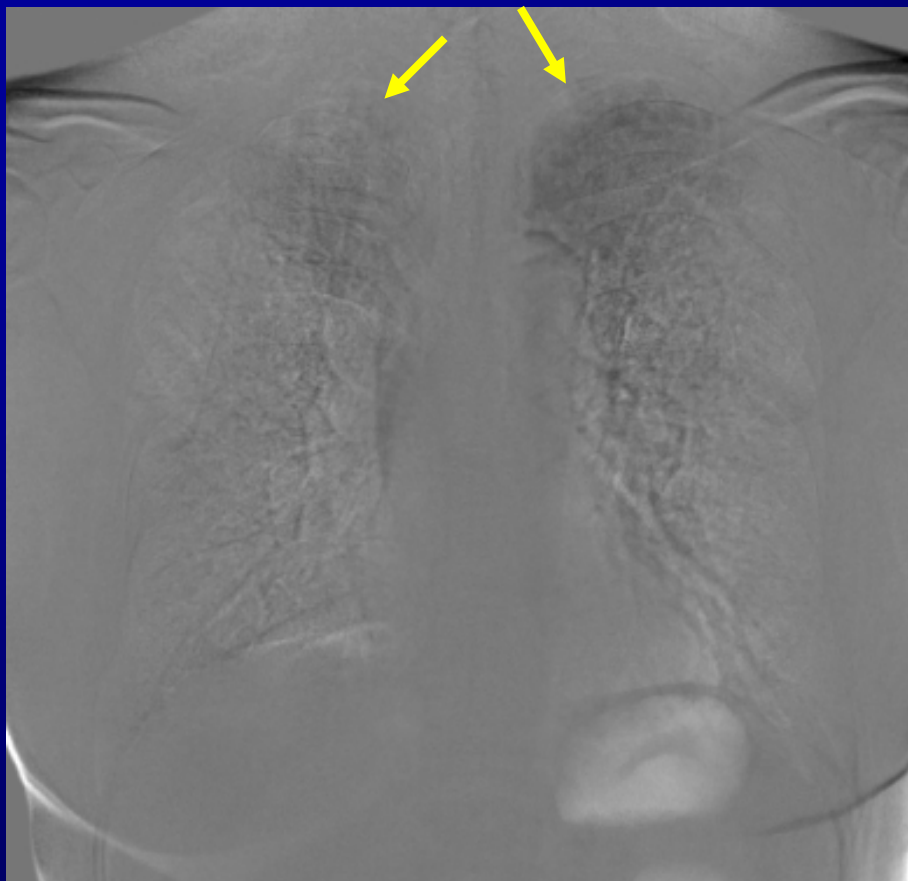


Diagnosis: Lung Metastasis



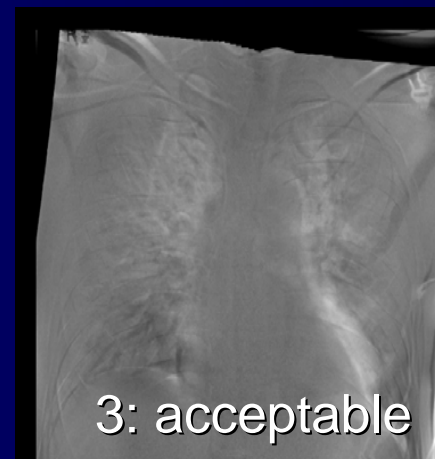
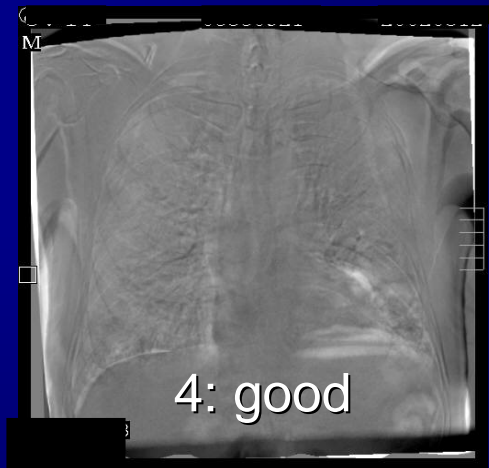
Six weeks later

58-year-old female underwent radiotherapy for malignant lymphoma.



Diagnosis: Radiation Pneumonitis

Evaluation of the Image Quality of Temporal Subtraction in PACS environment



Tab.1 Ratio of Warping Mode to Non-Warping Mode and Subjective Image Quality in Two Positions

Position	Mode	Number	Subjective Image Quality
Upright			4.2
	Warping	55 (100%)	4.2
	Non-warping	0 (0%)	
Supine			2.9
	Warping	46 (74%)	3.1
	Non-warping	16 (26%)	2.7

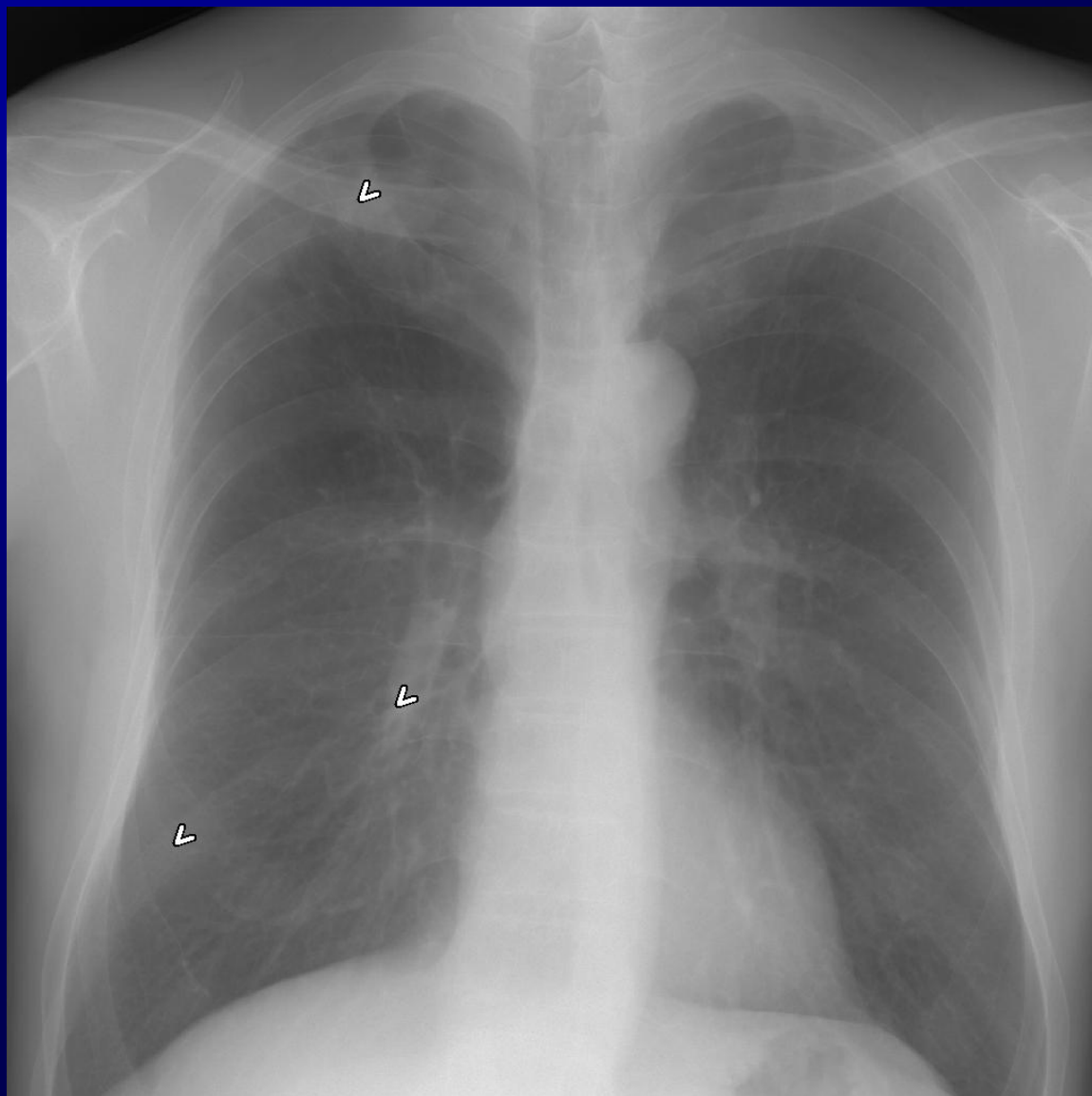
]
] p<.01

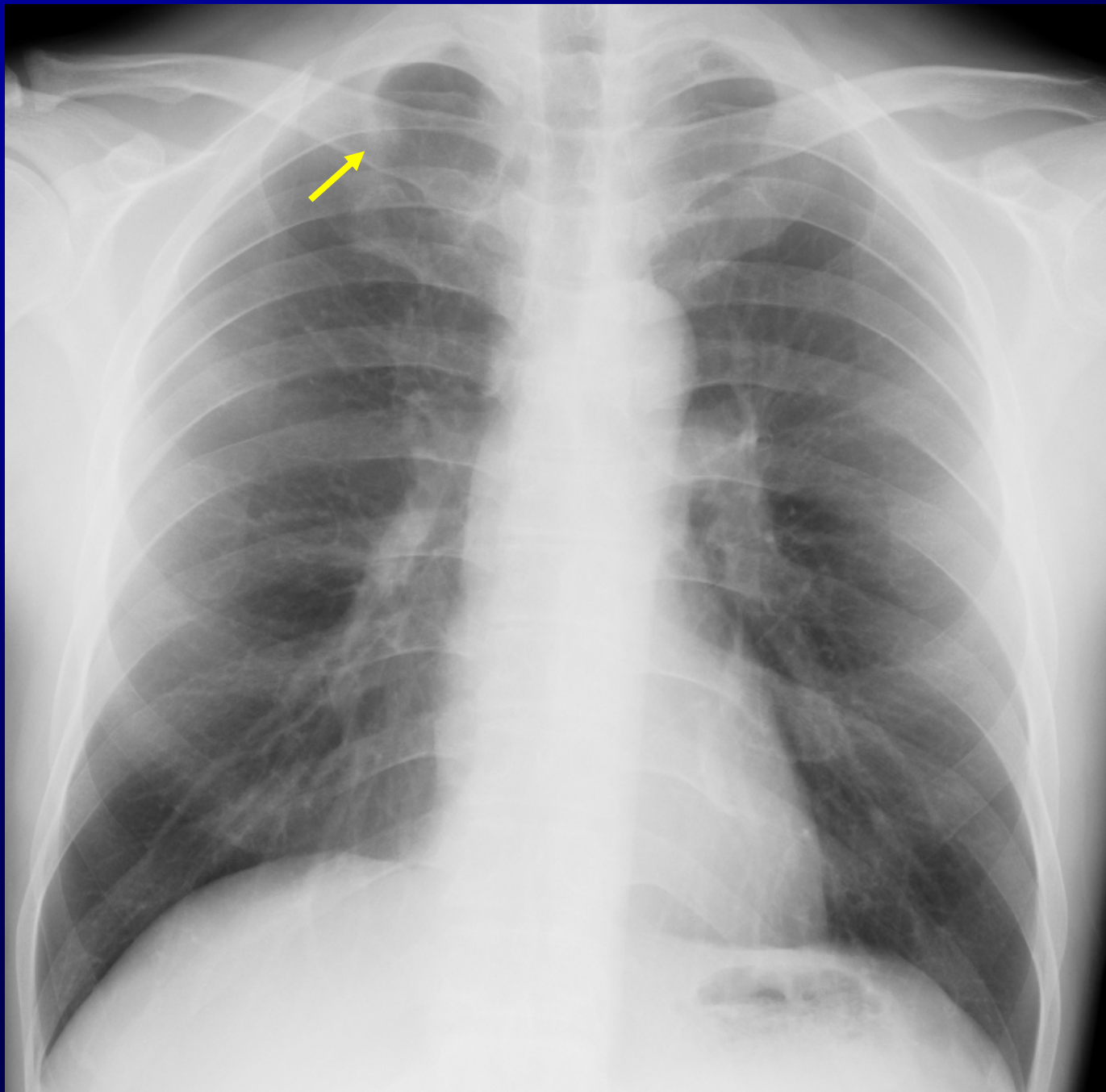
Mann-Whitney test

Conclusion of this Study

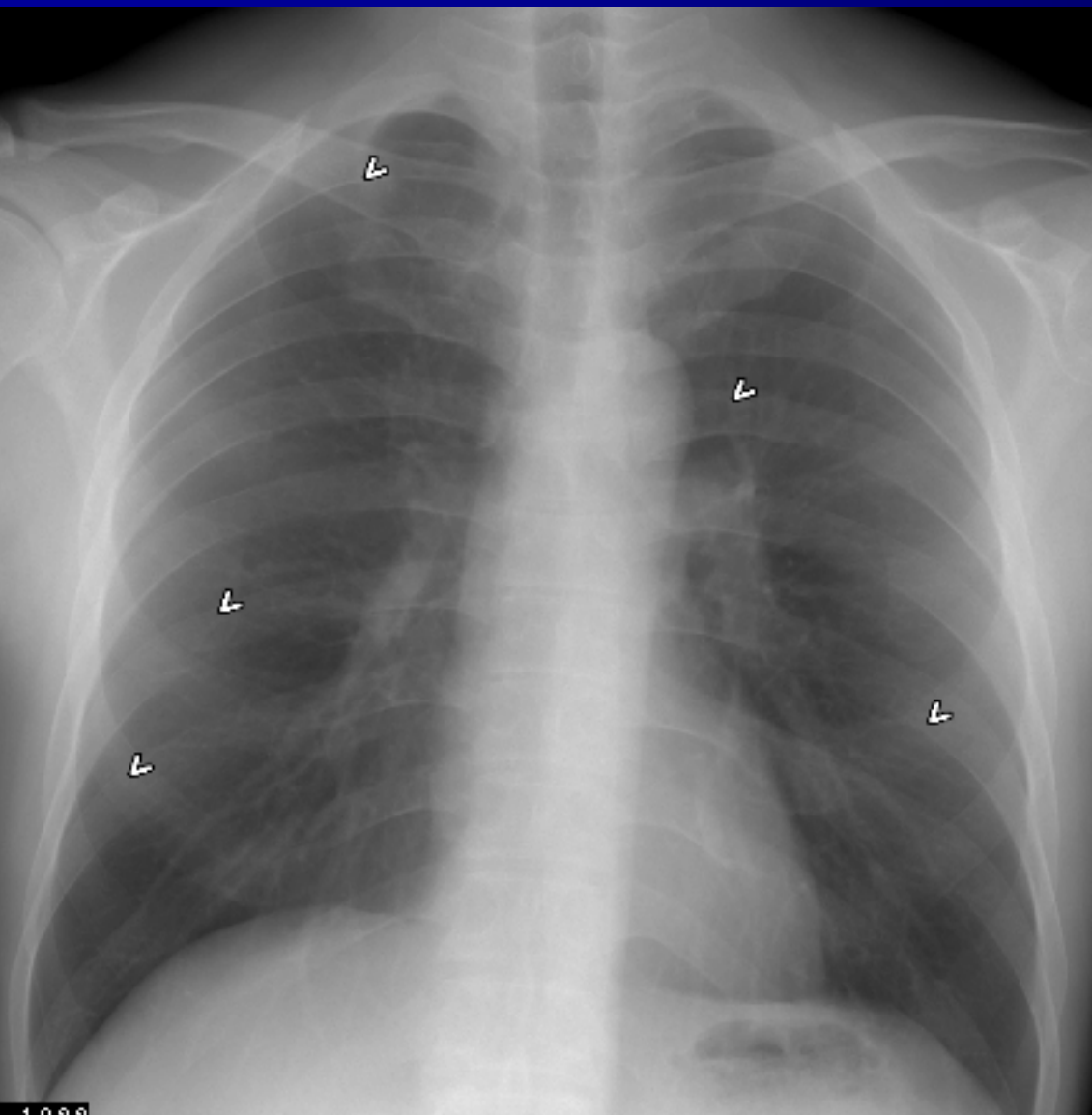
- The percentages of acceptable temporal subtraction images were 100% in the upright position and 66% in the supine positions.
- In the upright position, temporal subtraction images were acceptable quality for clinical use.

Nodule Detection





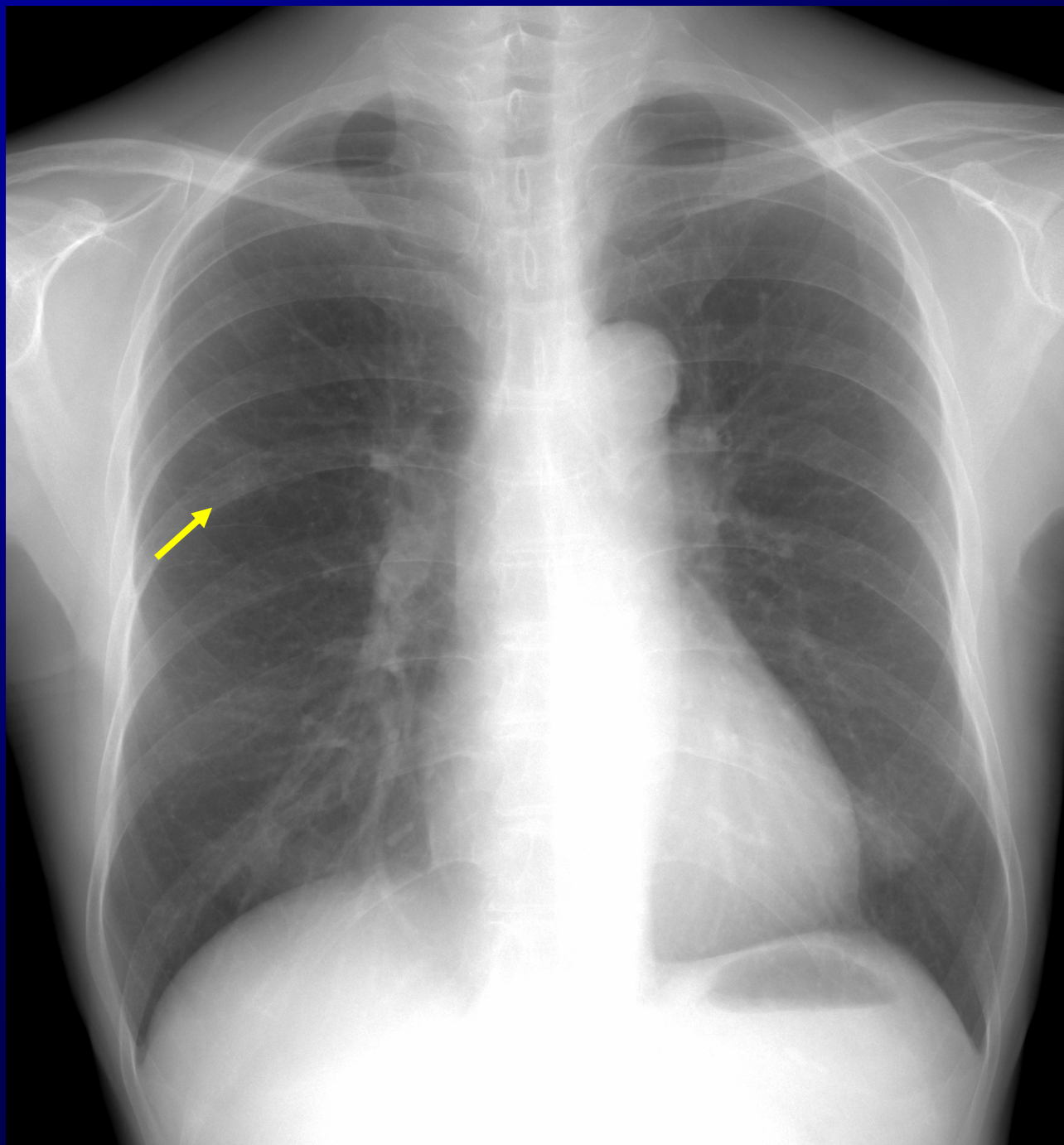
43 y/o M



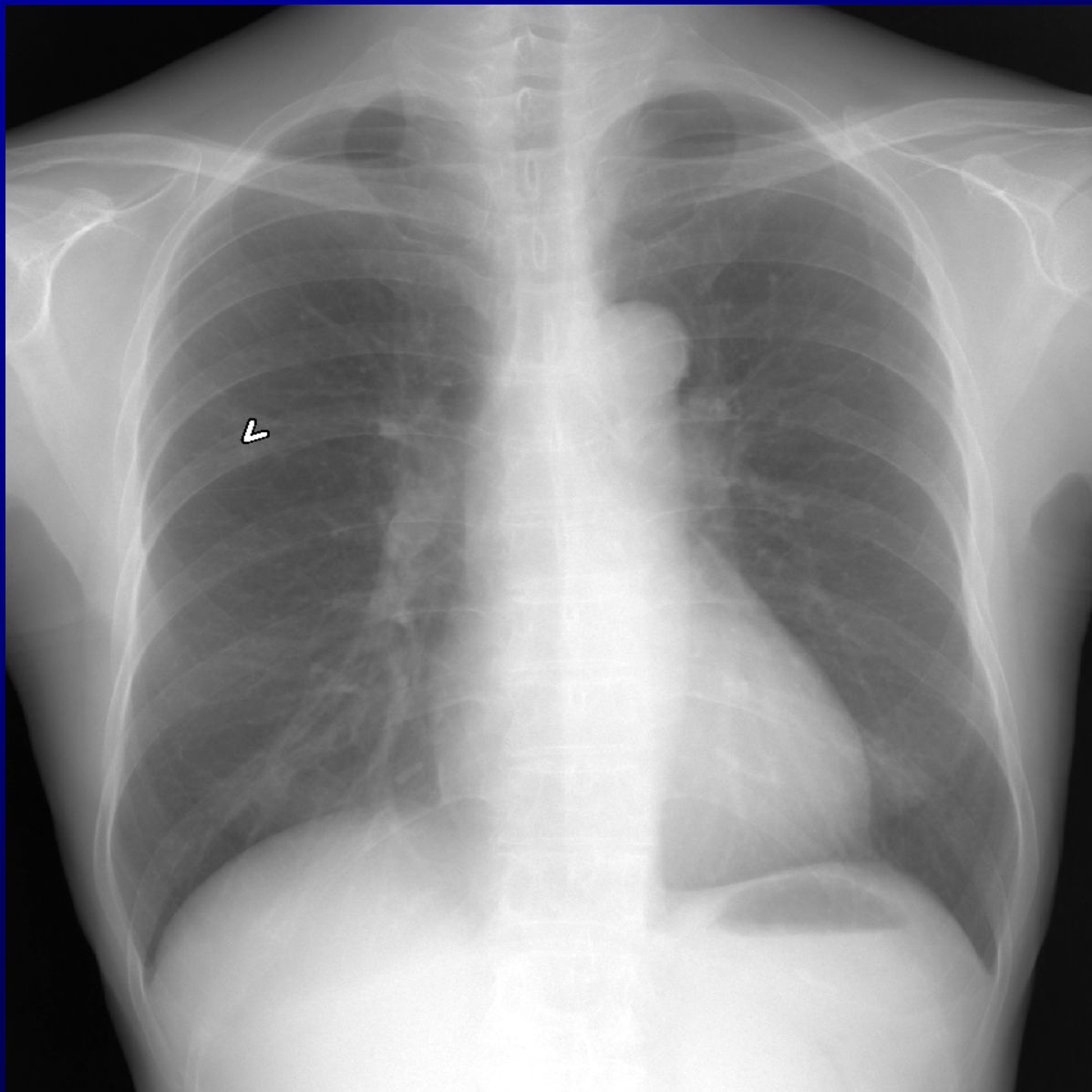
Nodule detection image



HRCT



64 y/o F



Nodule detection image

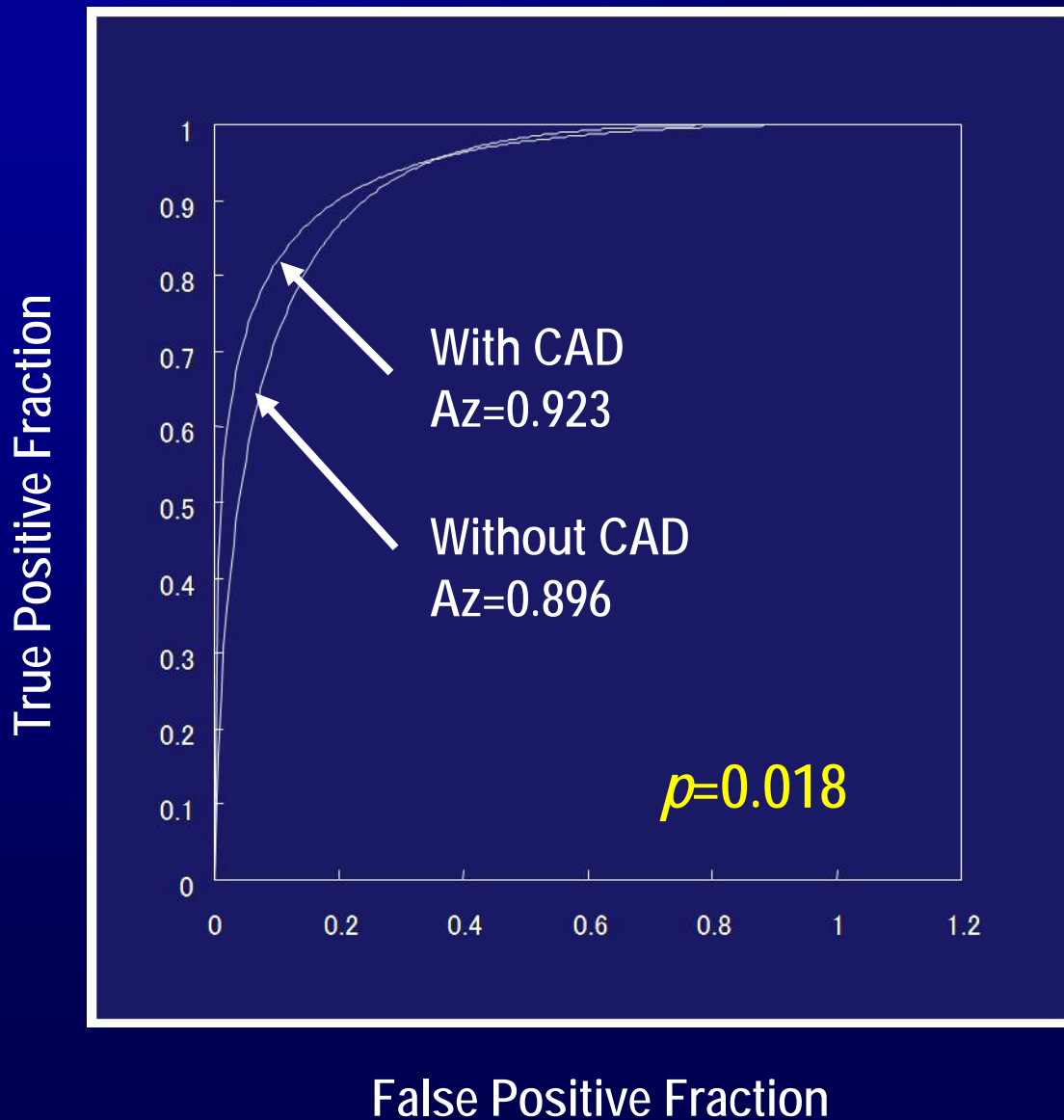


HRCT

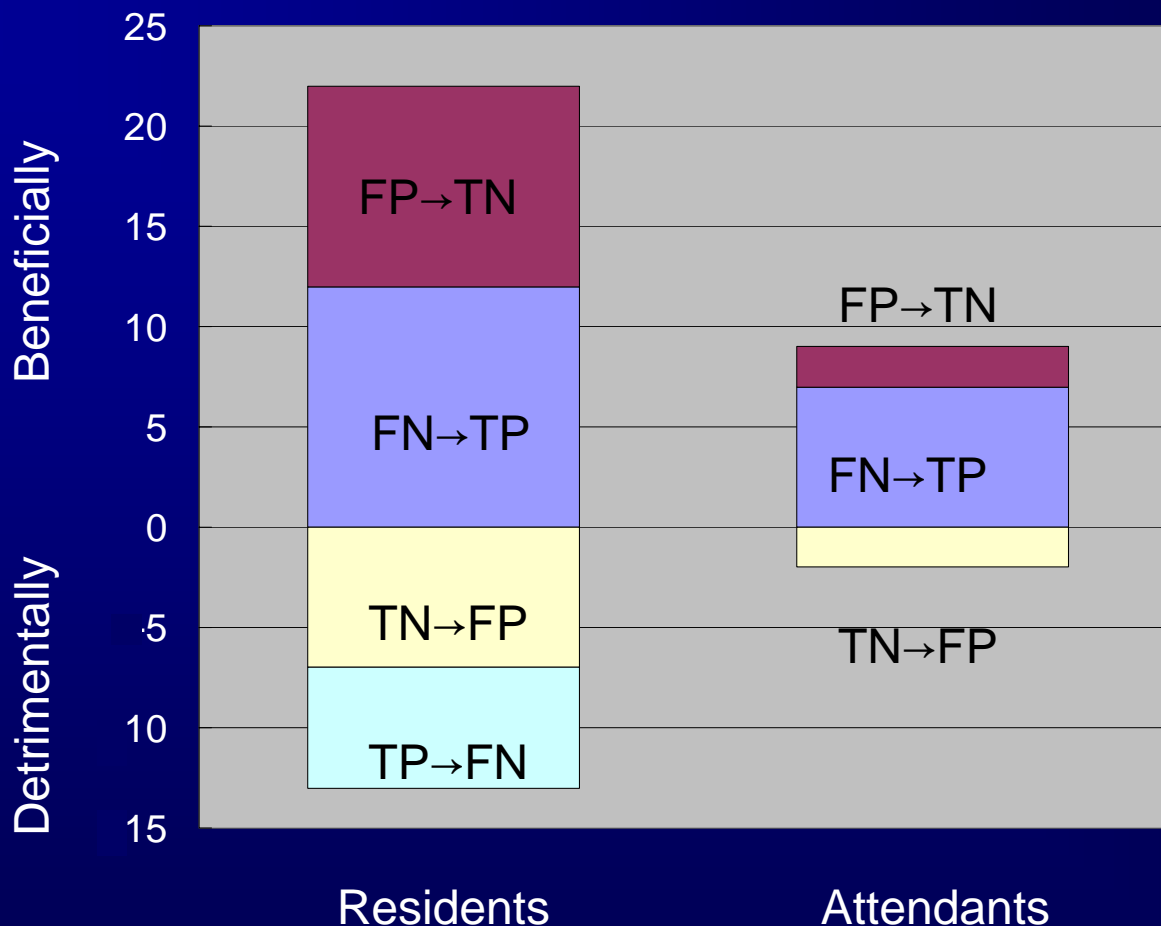
Performance in Kyushu University Hospital

- The overall detectability of the computer aided nodule detection system was 37/50 (74%) for consecutive T1 cases with resectable lung cancer.
- The false-positive rate for lung cancer and normal cases was 2.04 and 2.28 false positives per case, respectively.

The mean Az value of all observer



The relevant change in confidence levels

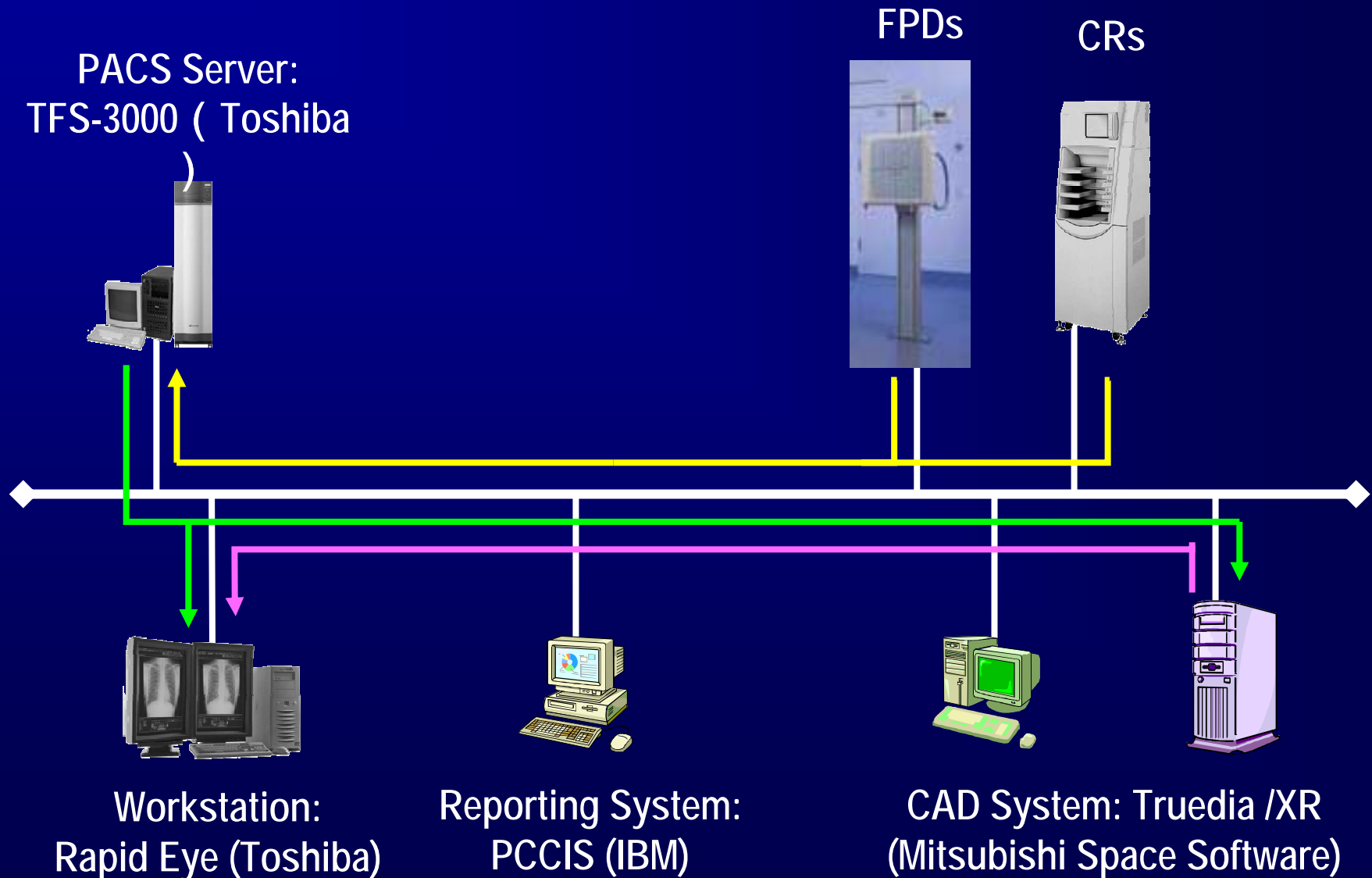


TP: True Positive TN: True Negative FP: False Positive FN: False Negative

Clinical Practice in Kyushu University Hospital

- For routine interpretation, we began to use temporal subtraction images since January 2001 and nodule detection images since May 2002.
- The CAD system was integrated into PACS.
- Loading style of CAD Images has been changed conventional DICOM protocol into Web browser type in 2007.

Previous method of Integration into PACS





Reporting System:
PC-CIS (IBM)

Workstation
: DICOM Viewer
TWS-2500 (Toshiba)

Work Flow of Interpretation

ファイル(F) 読影(R) 検査(E) シリーズ(S) 表示(V) 階調変更(W) 画像処理(P) マウスドラッグ機能(D) 3D(K) ツール(T) ヘルプ(H) 終了(X)

CR - 2002/08/05 - 09:25 - CHEST - [デフォルト並び]

054Y
F
092544.000000

WW = 2727
WL = 1527
REX318E:*. *D*****04988. X 11

CR - 2002/08/05 - 09:25 - CHEST - [デフォルト並び]

F
092544.000000

WW = 2921
WL = 1769
REX169E:*. *D*****GCS. 10. 5

04988779 - CR - 2002/08/05

04988779

読影グループ名 CR
表示条件 すべて

読影者ID	受診者名	検査日付時刻	読影日付	検査	1次
20020805	093013000	CR	CHEST		
20020805	092927000	CR	ABD.		
20020805	092846000	CR	CHEST		
20020805	092808000	CR	CHEST		
20020805	092644000	CR	CHEST		
20020805	092308000	CR	CHEST		
20020805	092202000	CR	CHEST		
20020805	092019000	CR	CHEST		
20020805	091617000	CR	CHEST		
20020805	091454000	CR	ABD.		

読影者コメント
モダリティ CR
検査部位 CHEST
装置型名 CXD1
シリーズ番号 2
絞像番号

読影期間: 指定なし!

読影者ID	検査日付時刻	検査部位
OT	2002/08/05 09:25	CHEST
CR	2002/08/05 09:25	UNKNOWN
CT	2002/07/24 09:52	UNKNOWN
MR	2002/07/23 10:34	UNKNOWN
CT	2002/07/22 09:43	UNKNOWN
CT	2002/05/21 09:51	UNKNOWN
CT	2002/05/14 13:02	UNKNOWN
OT	2002/04/04 11:49	CHEST
CR	2002/04/04 11:49	CHEST
CR	2002/04/04 11:49	UNKNOWN
CR	2002/03/01 15:59	UNKNOWN

Enlarged previous examination list

検索期間: 指定なし

	検査種別	検査日付	検査時刻	検査部位
☐	OT	04/11/15	午前 09:13:08	CHEST
☐	CR	04/11/15	午前 09:13:08	UNKNOWN
☐	CR	04/11/15	午前 09:13:08	UNKNOWN
☐	CR	04/11/09	午後 02:46:58	UNKNOWN
☐	CR	04/11/09	午後 02:35:21	UNKNOWN
☐	CR	04/11/09	午後 02:35:21	UNKNOWN
☐	OT	04/10/18	午前 11:33:31	CHEST
☐	CR	04/10/18	午前 11:33:31	UNKNOWN
☐	CT	04/10/14	午前 08:31:48	UNKNOWN
☐	CR	04/10/12	午前 10:26:07	UNKNOWN
☐	CR	04/10/04	午前 10:05:14	UNKNOWN
☐	CR	04/09/28	午前 09:34:34	UNKNOWN
☐	CR	04/09/28	午前 09:07:53	UNKNOWN
☐	CR	04/09/17	午前 11:44:29	UNKNOWN
☐	MR	04/09/09	午後 05:18:3...	UNKNOWN

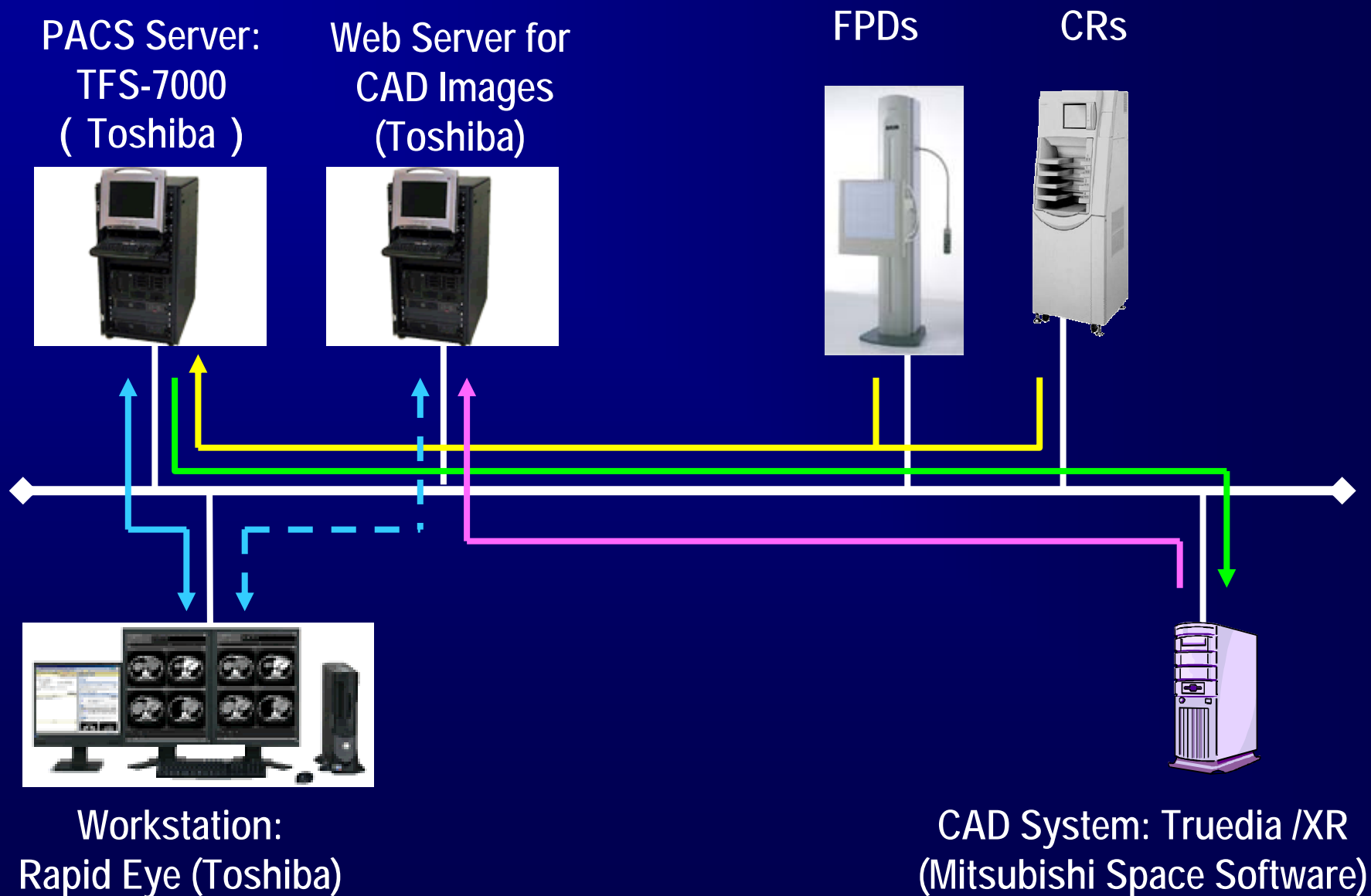
Comparative Interpretation referring to CAD images

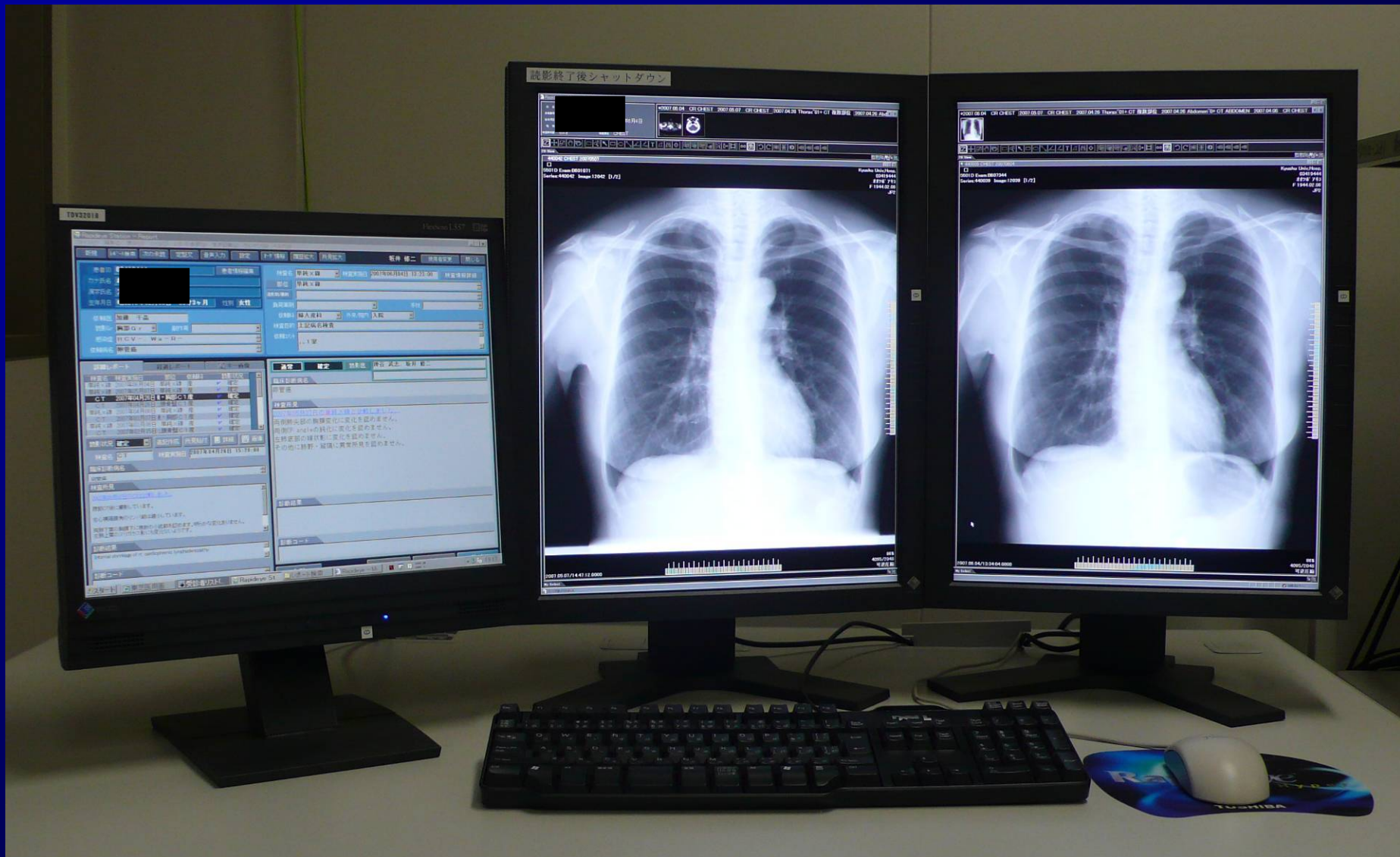
File (F) View (V) Window (W) Help (H) [Icons]

受診者ID	内容	読影グループ名	CR	検査期間	指定なし
0041115	093856000	CR	BREAST	04/11/15	午前 09:13:08
0041115	093126000	CR	BREAST	04/11/15	午前 09:13:08
0041115	092305000	CR	CHEST	04/11/09	午後 02:46:58
0041115	092110000	CR	BREAST	04/11/09	午後 02:35:21
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0041115	091714000	CR	CHEST	04/10/18	午前 11:33:31
0041115	091609000	CR	CHEST	04/10/14	午前 08:31:48
0041115	090995000	CR	CHEST	04/10/12	午前 10:26:07
0041115	090529000	CR	CHEST	04/10/04	午前 10:05:14
0041115	085928000	CR	CHEST	04/09/28	午前 09:34:34
0041115	085819000	CR	CHEST	04/09/28	午前 09:07:53
0041115	085204000	CR	ABC...	04/09/17	午前 11:44:29
0041114	164217000	CR	ABC...	04/09/09	午後 05:18:33

附属項目 撮影条件 読影リスト 検査星取表 コマンドリスト

Present method of Integration into PACS





Workstation with Reporting System
Rapid Eye (Toshiba)

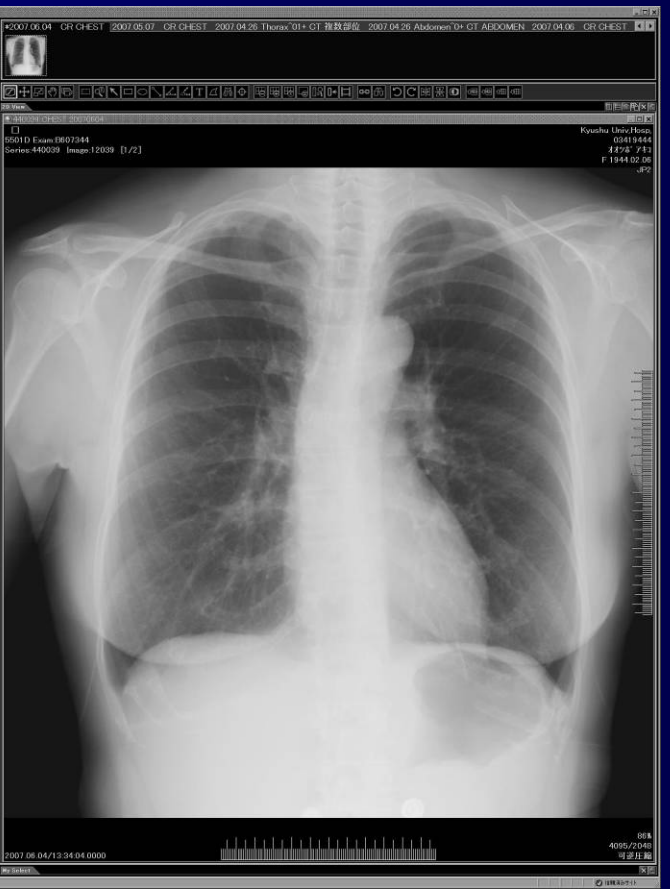
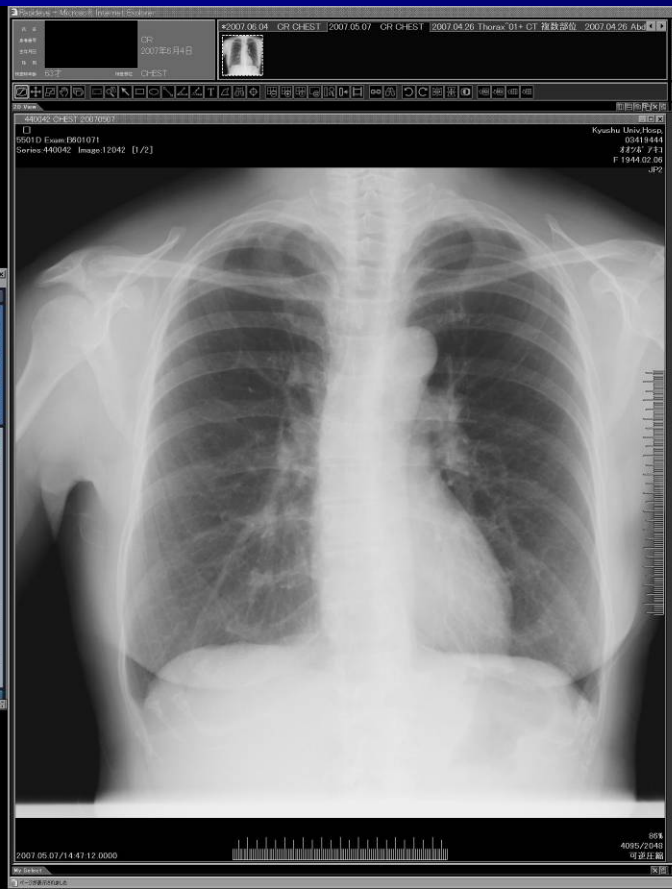
Mediaca - Medical Information System

患者情報
 氏名: 伊藤 文雄
 生年月日: 2007年06月04日
 性別: 男
 病歴: 肺がん
 検査種別: 胸部X線

検査情報
 検査日時: 2007年06月04日 13:23:00
 検査部位: 胸部X線
 検査機: 伊藤 文雄
 読影医: 伊藤 文雄

検査結果
 2007年06月04日 胸部X線 健常
 2007年06月04日 胸部X線 健常
 2007年06月04日 胸部X線 健常
 2007年06月04日 胸部X線 健常
 2007年06月04日 胸部X線 健常

検査結果
 2007年06月04日 胸部X線 健常
 2007年06月04日 胸部X線 健常
 2007年06月04日 胸部X線 健常
 2007年06月04日 胸部X線 健常



Radview - Microsoft Internet Explorer

007 06 04 07 05 07 CR CHEST 2007 04 26 Thorax 01 = CT 画像読影 2007 04 26 Abdomen 01 = CT 画像読影

患者氏名: [Redacted] 性別: 女性 生年月日: 2007年6月4日

検査種別: 呼吸器科 検査部位: 胸部

検査日時: 2007年06月04日 13:23:00

検査結果: 肺野明瞭、心臓大動脈正常、肋骨骨折なし。

Radview - Microsoft Internet Explorer

007 06 04 07 05 07 CR CHEST 2007 04 26 Thorax 01 = CT 画像読影 2007 04 26 Abdomen 01 = CT 画像読影

患者氏名: [Redacted] 性別: 女性 生年月日: 2007年6月4日

検査種別: 呼吸器科 検査部位: 胸部

検査日時: 2007年06月04日 13:23:00

検査結果: 肺野明瞭、心臓大動脈正常、肋骨骨折なし。

Radview - Microsoft Internet Explorer

007 06 04 07 05 07 CR CHEST 2007 04 26 Thorax 01 = CT 画像読影 2007 04 26 Abdomen 01 = CT 画像読影

患者氏名: [Redacted] 性別: 女性 生年月日: 2007年6月4日

検査種別: 呼吸器科 検査部位: 胸部

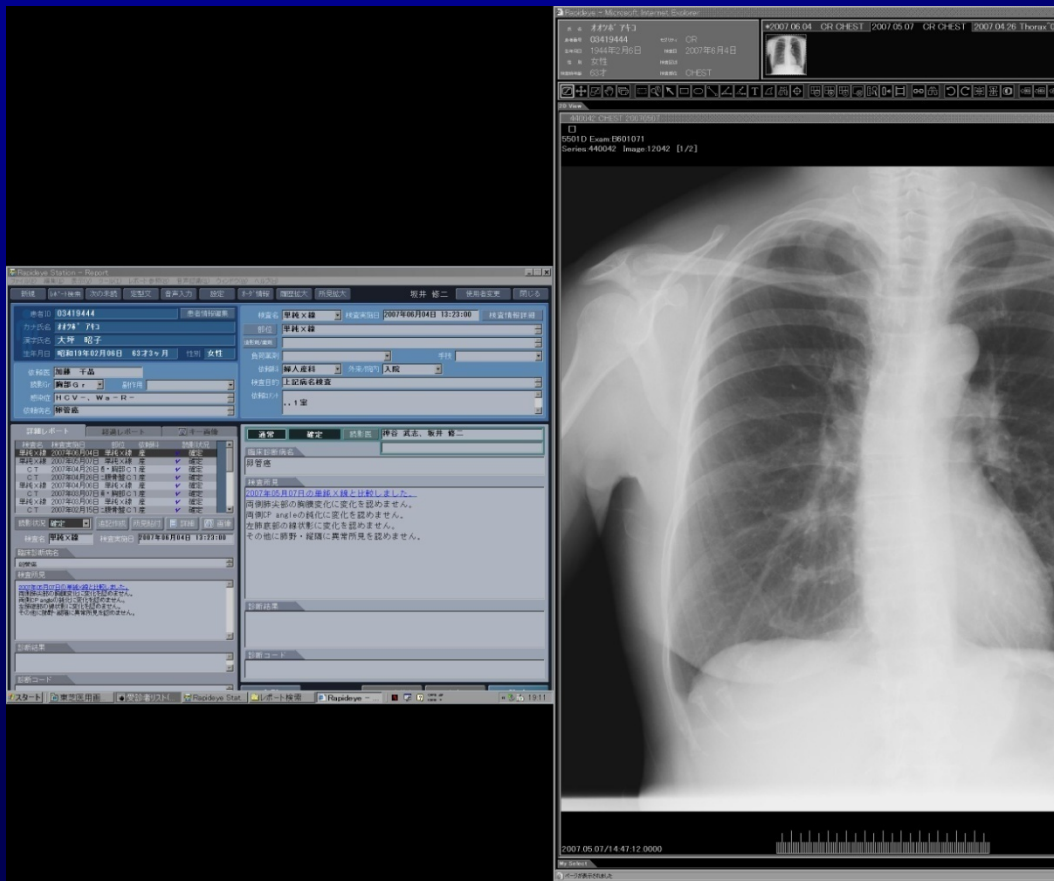
検査日時: 2007年06月04日 13:23:00

検査結果: 肺野明瞭、心臓大動脈正常、肋骨骨折なし。

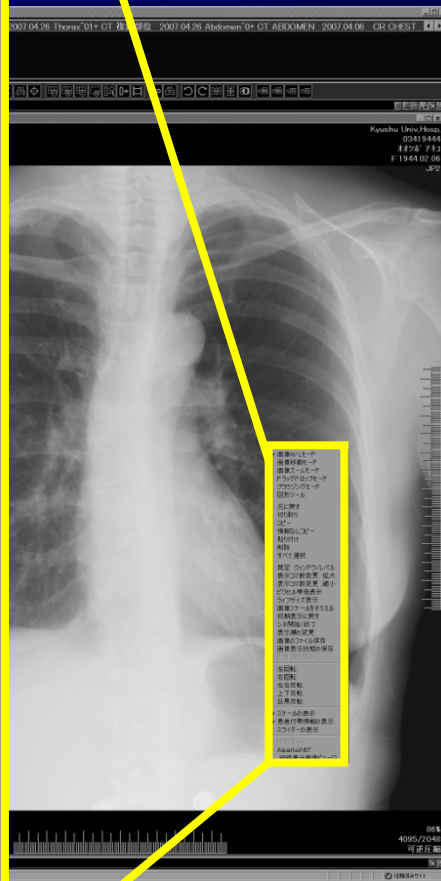
2007年05月07日の画像と比較しました。
両肺野の陰影に変化を認めません。
肋骨骨折の陰影に変化を認めません。
その他に肺野・縦隔に異常所見を認めません。

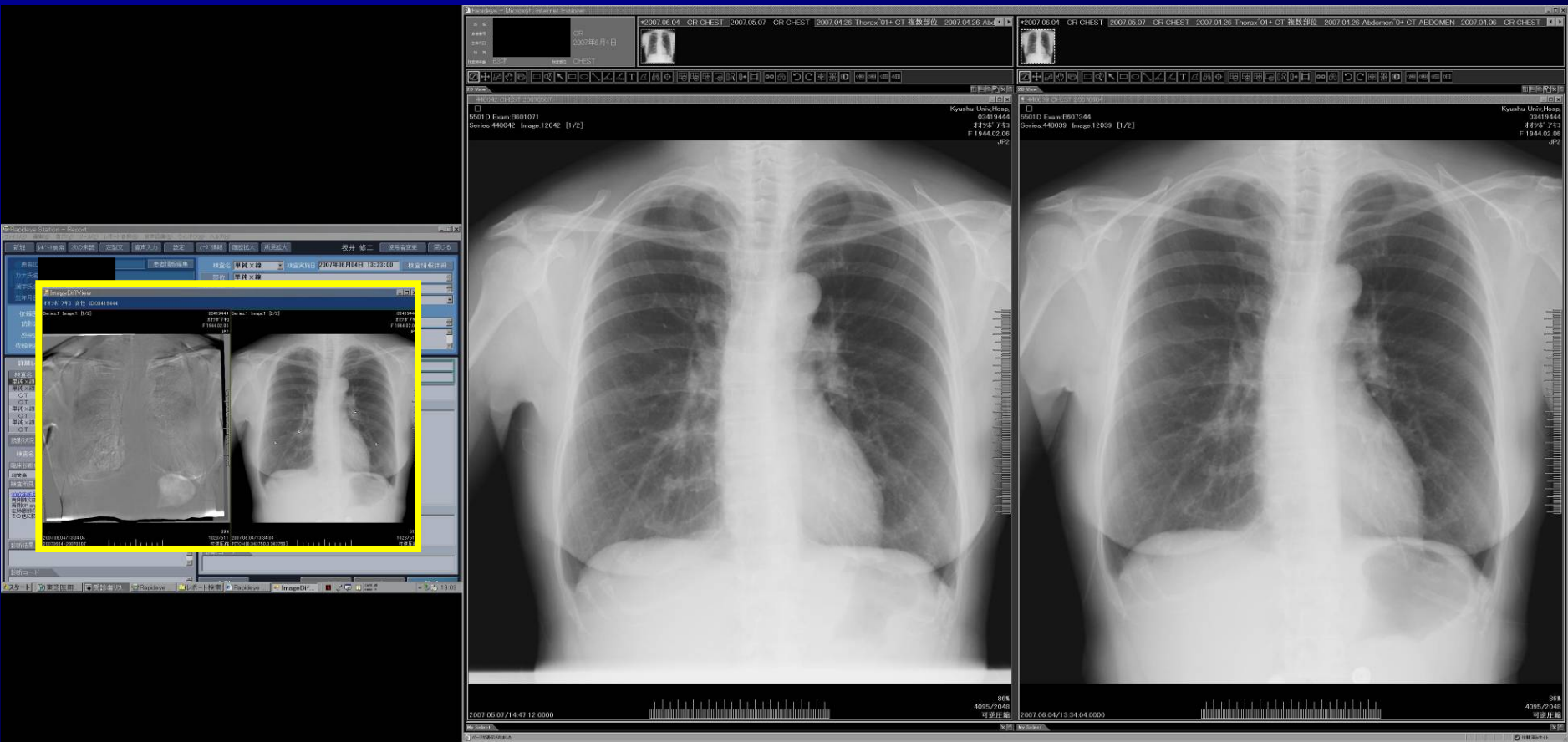
2007 05 07 14:47:12 0000 4095/2048 呼吸器科

2007 06 04 13:24:04 0000 4095/2048 呼吸器科



- ✓ 画像W/Lモード
- 画像移動モード
- 画像ズームモード
- ドラッグドロップモード
- ブラウジングモード
- 図形ツール ▶
- 元に戻す
- 切り取り
- コピー
- 情報なしコピー
- 貼り付け
- 削除
- すべて選択
- 既定 ウィンドウ/レベル ▶
- 表示コマ数変更 拡大
- 表示コマ数変更 縮小
- ピクセル等倍表示
- ライフサイズ表示
- 画像スケールをそろえる
- 初期表示に戻す
- シネ開始/終了
- 表示順の変更 ▶
- 画像のファイル保存
- 画像表示状態の保存
- 計測値の保存
- 左回転
- 右回転
- 左右反転
- 上下反転
- 白黒反転
- ✓ スケールの表示
- ✓ 患者付帯情報の表示
- スライダーの表示
- MPR View
- AquariusNET
- 経時差分画像ビューワ





Medical software interface showing a chest X-ray and a CT scan. The interface includes a top navigation bar with patient information, a central image area, and a bottom status bar with technical details.

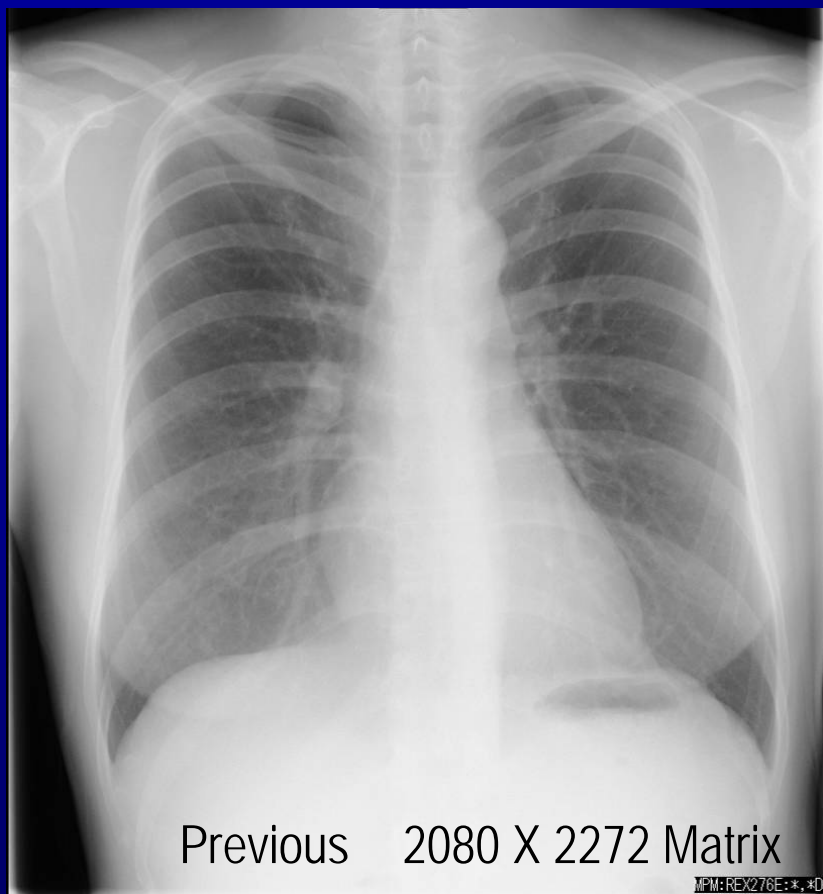
Top Navigation Bar:
*2007.06.05 CR CHEST 2007.05.25 真高透視撮影) RF 2007.05.24 CT 2007.05.23 LS 2007.05.22

Left Panel (Anatomical Model):
Anatomical model of the thorax with a control panel. The control panel includes a grid of icons for different anatomical views and a list of labels: 肺 (Lung), 心 (Heart), 大動脈 (Aorta), 大静脈 (Vena Cava), 肋骨 (Ribs), 胸骨 (Sternum), 膈 (Diaphragm), 胃 (Stomach), 肝 (Liver), 脾 (Spleen), 腎 (Kidney), 膀胱 (Bladder), 腸 (Intestine).

Central Image Area:
A large chest X-ray image showing the lungs, heart, and ribcage. The image is labeled "CR CHEST" and "2007.05.25 真高透視撮影".

Right Panel (CT Scan):
A cross-sectional CT scan of the chest. The image is labeled "2007.06.05 CR CHEST 2007.05.25 真高透視撮影) RF 2007.05.24 CT 2007.05.23 LS 2007.05.22 真高透視撮影) RF 2007.05.22 CR ABDOMEN".

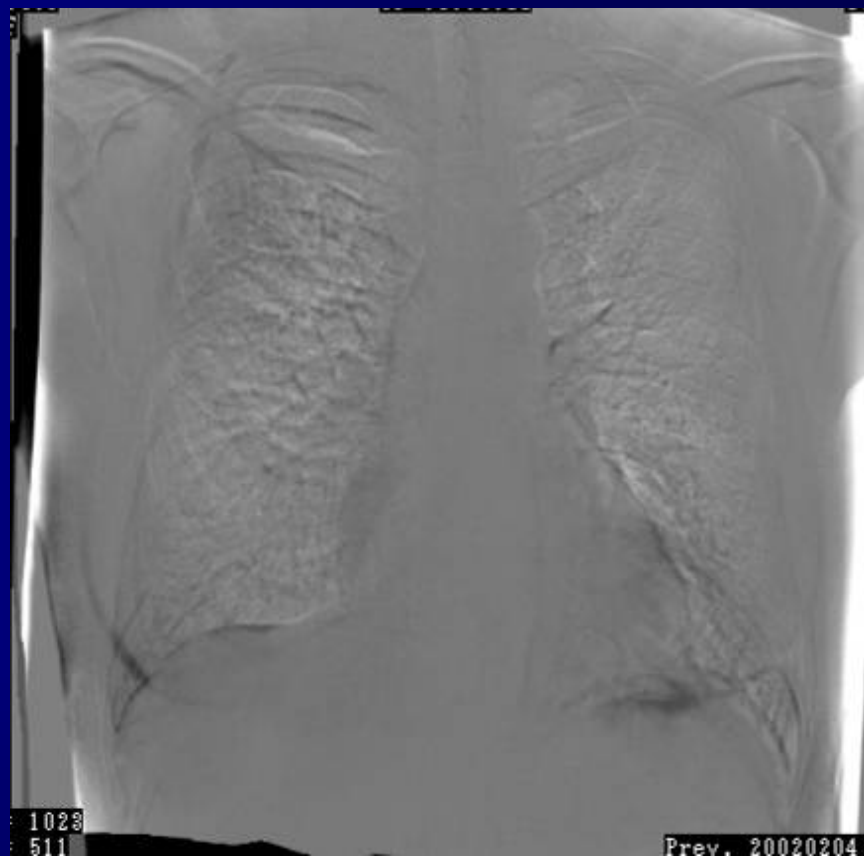
Bottom Status Bar:
Technical details for the CT scan:
CE 120 kVp
230mA
500 0msec Thick 5.0mm
2007.05.24/14:27:14.000
2007.05.05/09:48:40.000000
4995/2048
500/100
可逆圧縮



In this case, original chest radiographs were obtained with CXDI-11. These matrix sizes were different according to the collimation size. Image quality of temporal subtraction image was improved with by use of an upgraded computer algorithm.

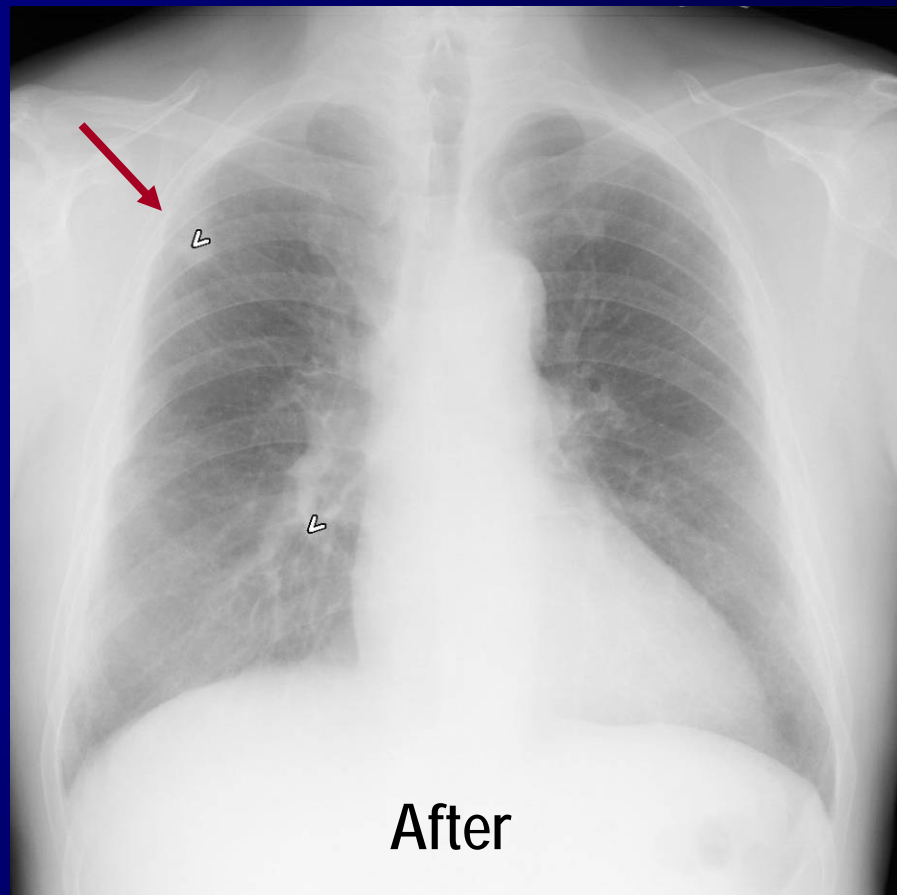
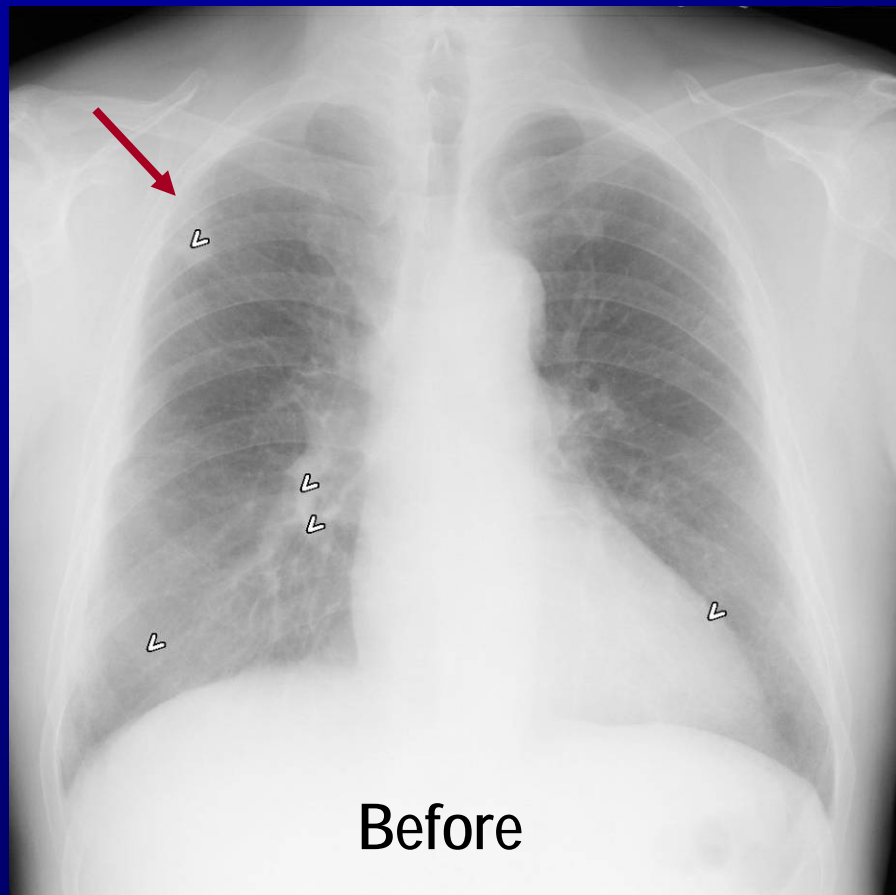


Before



After

Image quality of temporal subtraction image was improved with by use of an upgraded computer algorithm.



In this case, nodule detection image with the previous version showed five candidate for pulmonary nodule. Among them, a candidate is true positive for lung cancer (**red arrow**). After improving the computer algorithm, the number of false positive was decreased from four to one .

Conclusion

- We had integrated temporal subtraction and nodule detection systems into hospital's PACS.
- We faced some problems to integrate the CAD system to hospital's PACS.
- We had changed loading style of CAD images from conventional DICOM protocol to web browser type.
- In the upright position, temporal subtraction images were acceptable quality for clinical use.
- The overall detectability of the nodule detection system was 74% and the false-positive rate was 2.1 false positives per case.

Thank You very much for Your Attention !