Identification of Right Ventricular Dysfunction

In patients with acute pulmonary embolism

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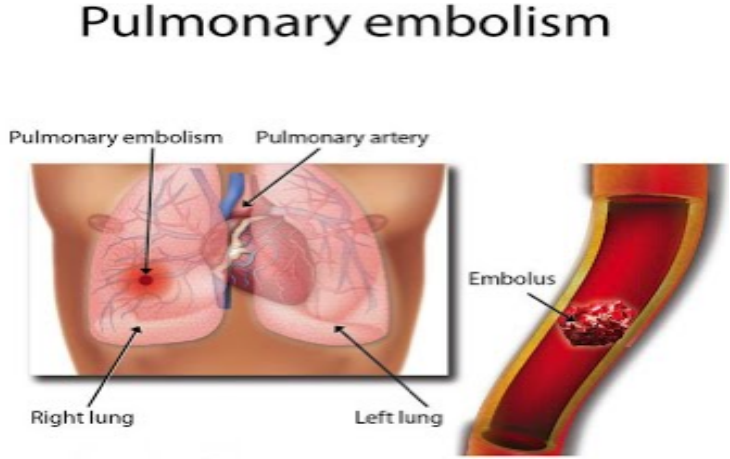
Introduction

Acute Pulmonary Embolism

Acute: short duration, rapidly progressive, and in need of urgent care

Pulmonary: lung

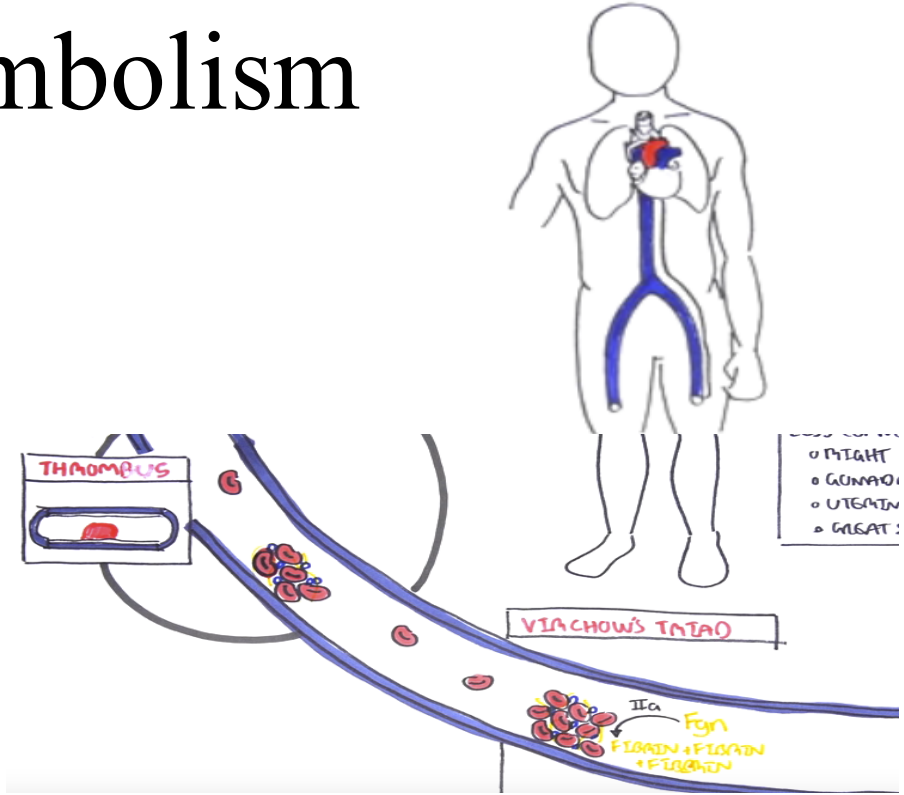
Embolism: blood clot in the arteries or in the veins



Acute Pulmonary Embolism

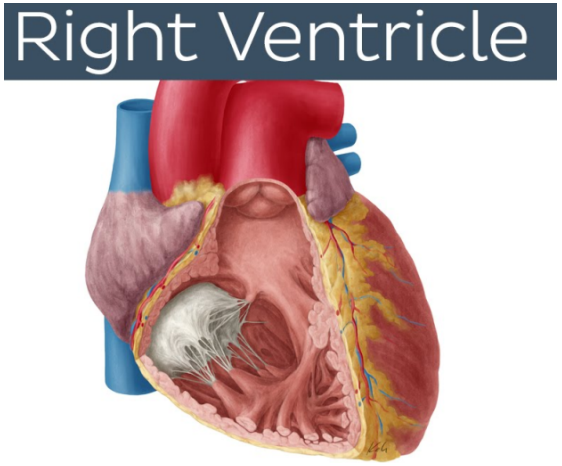
Signs and Symptoms

- ❖ Dyspnea
- ❖ Pleuritic chest pain
- ❖ Tachycardia
- ❖ Hypotension
- ❖ Signs of DVT(Deep vein thrombosis)
  - ➢ Swollen leg
  - ➢ Pain in leg



Right Ventricular Dysfunction

Right ventricle is a volume pump



Right Ventricular Dysfunction

Characterized by the RVEDD > 3 cm and the RV FAC < 25%

Most notably:

Acute increases in afterload (pulmonary hypertension)

RVEDD (Right Ventricular End-Diastolic Diameter) FAC (Fractional Area Change)

Objectives

- Create a logistic regression model
- Identify Right Ventricular Dysfunction (RVD) in patients with PE reliably
- Use computed tomography pulmonary angiography (CTPA)

Material & Methods

Patients Characteristics

Identified 97 patients

Age: 22-92

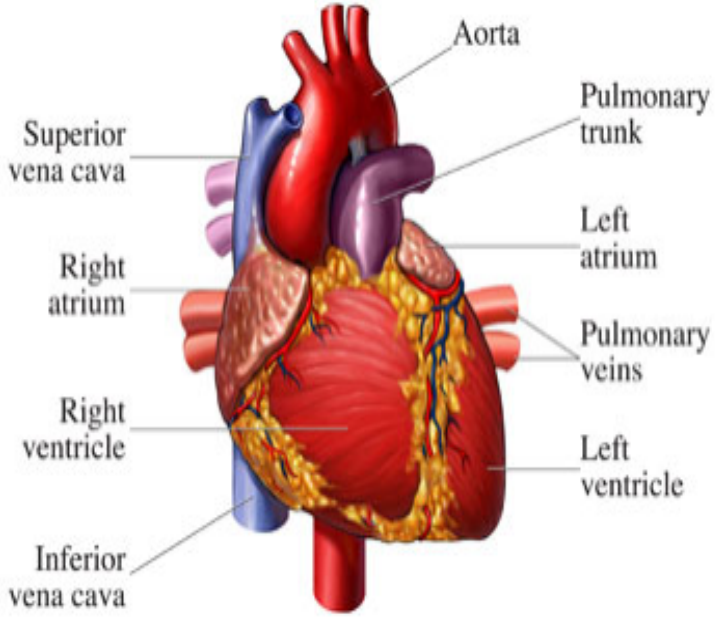
RVD(-) = 46 patients

RVD(+) = 51 patients

	RVD(−) PASP ≤ 30 mmHg; $n = 46$	RVD(+) PASP > 30 mmHg; $n = 51$	p
Age [years]	71.5 (27–91)	67 (22–92)	NS
BMI	26.79 (23.23–38.51)	26.57 (19.15–34.29)	NS
Systolic BP [mmHg]	119 (85–168)	124 (70–163)	NS
Heart rate [bpm]	94 (60–125)	96 (48–144)	NS
PASP [mmHg]	25 (18–30)	45 (32–95)	<0.001
Length of hospitalization [days]	9 (1–31)	12 (1–44)	0.03
ICU admission (*)	21 (46%)	34 (67%)	0.04
Mortality (*)	4 (8.7%)	7 (13.7%)	NS

Measurements

1. Maximum short axis of the Right (RV) and Left (LV) Ventricle
2. Diameter of the pulmonary artery (PA)
3. Diameter of superior vena cava (SVC)
4. Diameter of inferior vena cava (IVC)
5. Diameter of coronary sinus (CS)



Methods – Logistic Regression

SPSS

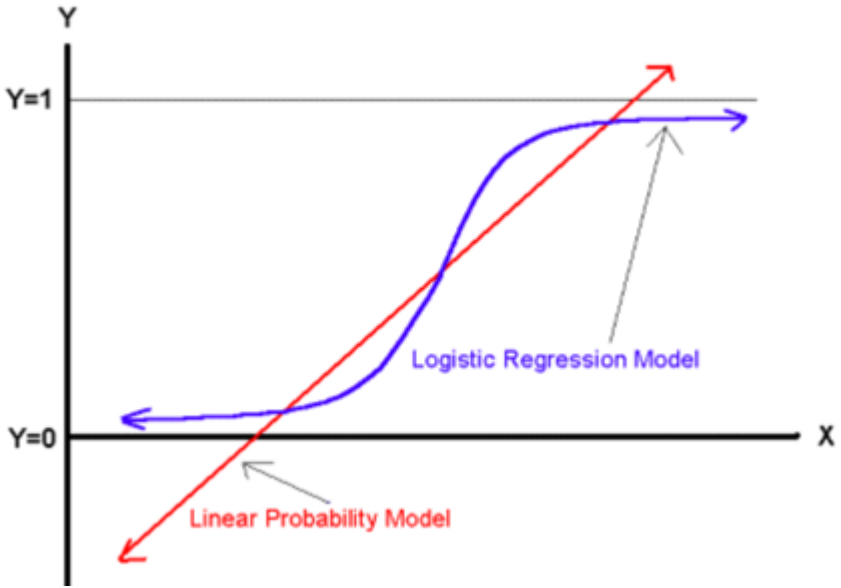
95% confidence limits

P value ≤ 0.05

$$p = \frac{1}{1 + e^{-z}},$$

Multivariate logistic regression model

$$z = b_0 + b_1 x_1 + b_2 x_2 + \ldots + b_n x_n.$$



Accessed Parameters

	RVD (−) PASP ≤ 30mmHg	RVD (+) PASP > 30mmHg	*p*
Regression model probability	0.22 (0.44–0.94)	0.79 (0.12–0.99)	<0.001
Obstruction score [points]	7 (2–31)	22 (2–38)	<0.001
RV [mm]	41 (22–68)	48.63 (30.07–69.13)	<0.001
RV/LV	0,95 (0,56–2,38)	1.25 (0.49–3.02)	<0.001
PA [mm]	29 (20–47)	32 (21–48)	0.007
SVC [mm]	23 (12–31)	25 (17–36)	0.002
IVC [mm]	30 (19–44)	32 (22–45)	0.003
CS[mm]	13 (5,15–29)	15 (5.77–28)	0.008
Lung infarction	22 (47.8%)	33 (64.7%)	ns
IVS bowing (%)	4 (9%)	17 (33%)	<0.01
IVC reflux (%)	17 (37%)	26 (51%)	ns

Determine Best Parameters

Backward conditional stepwise method was used to select the parameters

Results of logistic regression analysis.

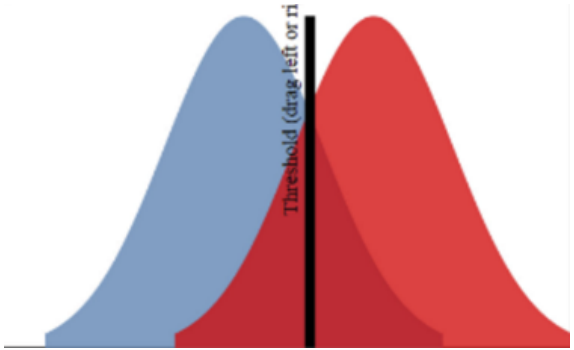
		Estimate	SE	*T* test	*P* level	OR	95.0% C.I.	
							Lower	Upper
b_0	Intercept log. reg.	−8.361	1.92	18.85	<0.001	0.001	–	–
b_1	Obstruction score	0.132	0.02	29.75	<0.001	1.141	1.088	1.196
b_2	RV	0.078	0.03	8.48	0.004	1.082	1.025	1.140
b_3	IVC	0.094	0.05	3.61	0.012	1.098	0.997	1.211

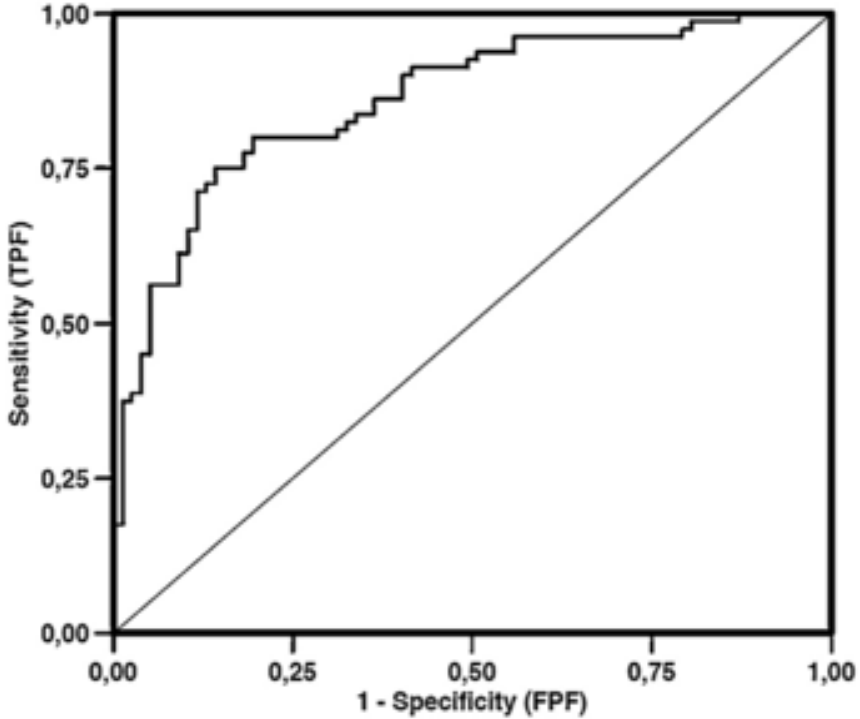
Obtained Model

Z = -8.361 + 0.132 x Obstruction score

+ 0.078 x RV +0.094 x IVC

AUC = 0.860, 95% Confidence Interval





How well does the model fit the data?

Hosmer-Lemeshow test

A statistical test for goodness of fit for logistic regression models

- Frequently used in risk prediction models

Result

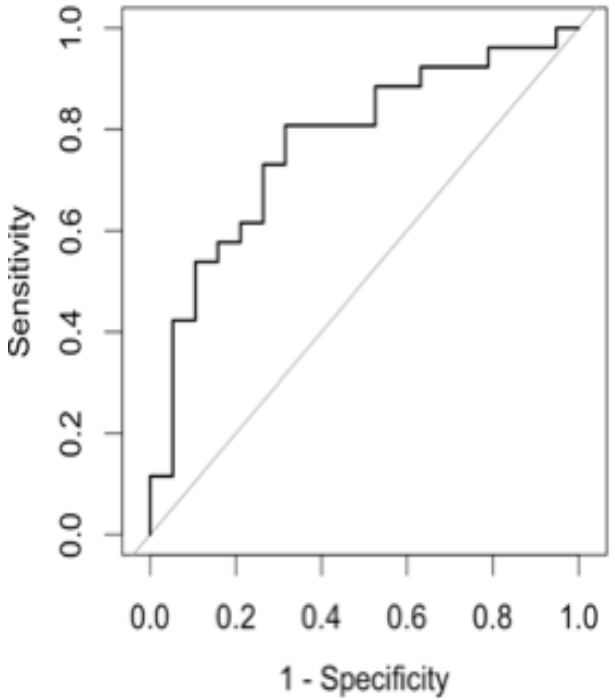
- P = 0.930
- Shows a good fit of model

$$H = \sum_{g=1}^{G} \frac{(O_g - E_g)^2}{N_g \pi_g (1 - \pi_g)}.$$

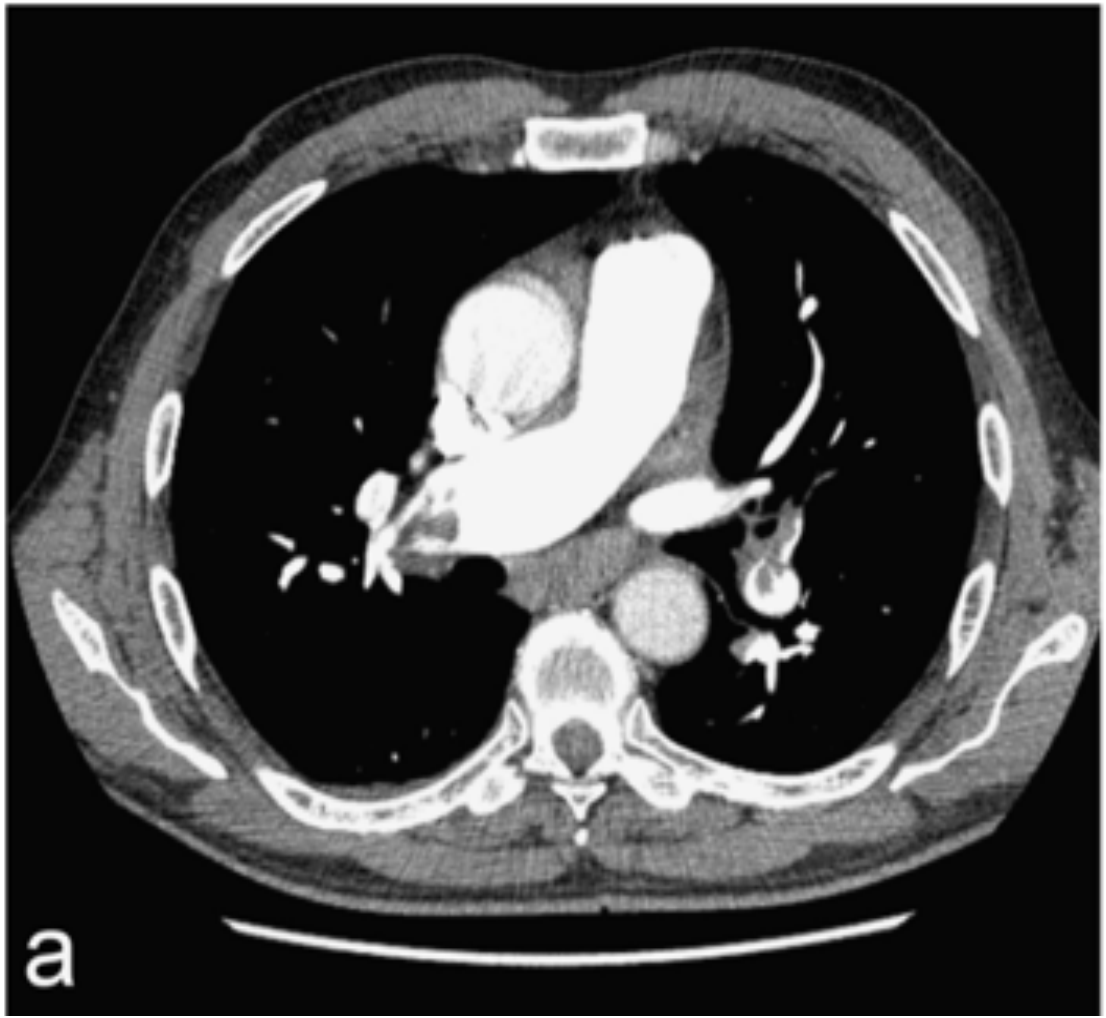
Here Og, Eg, Ng, and πg denote the observed events, expected events, observations, predicted risk for the gth risk decile group, and G is the number of groups.

Simulation - R Code

```
library(pROC)
library(ResourceSelection)
setwd('/Users/wang/Desktop')
data = read.csv('project.csv')

mod <- glm(data$Z~data$Obstruction+data$RV+data$IVC, family="binomial")
summary(mod)
predpr <- predict(mod)

roccurve <- roc(data$Z ~ predpr)
plot(roccurve,legacy.axes=TRUE)

hoslem.test(mod$y, fitted(mod), g=10)
```

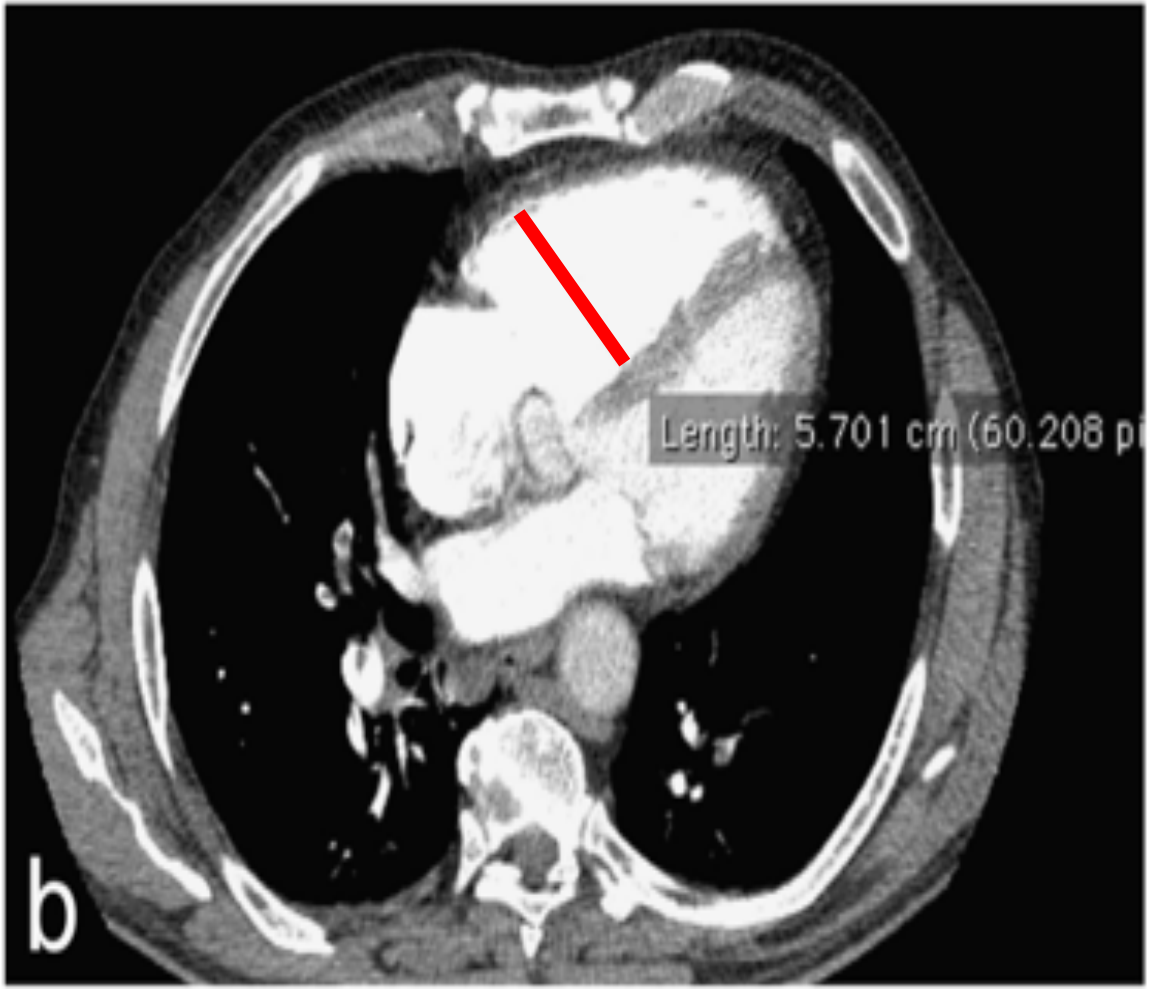


Example

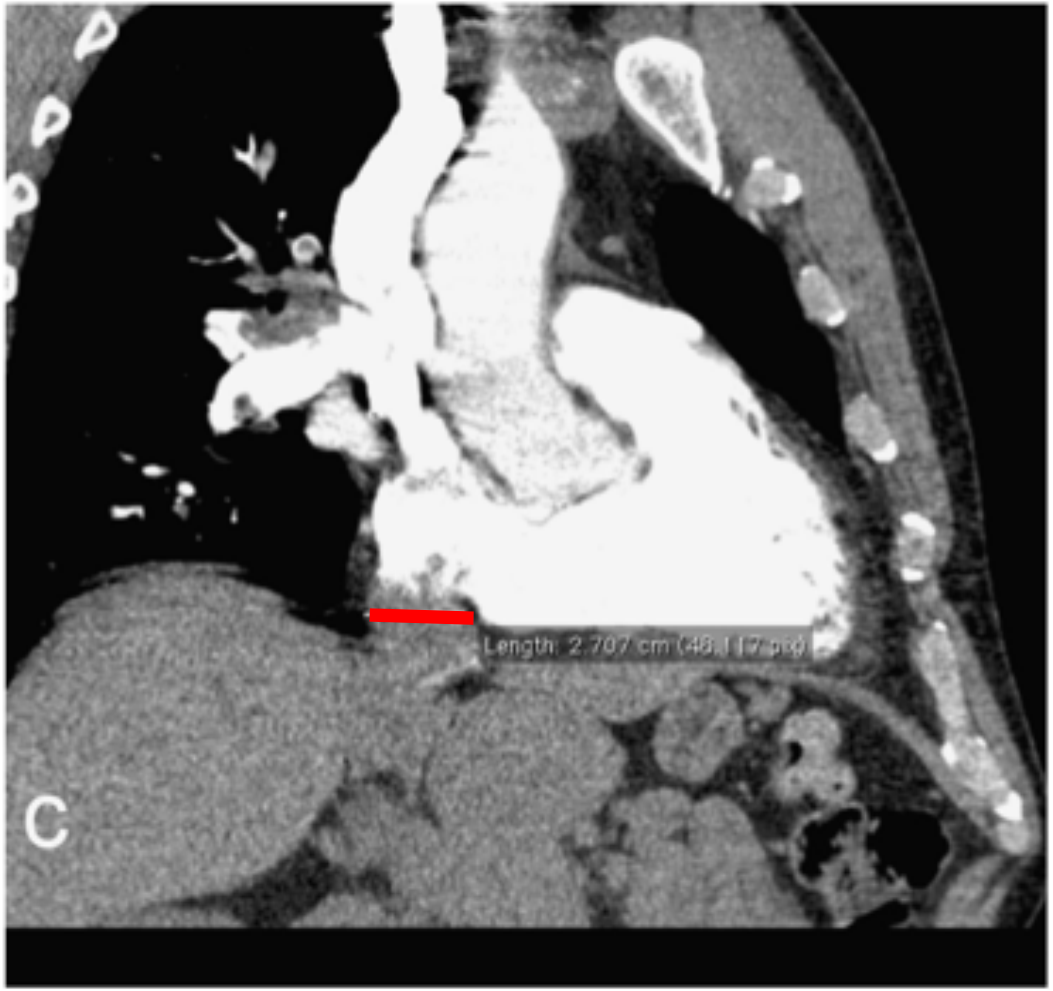


Pulmonary Severity was graded with the pulmonary obstruction score

Obstruction score = 20



Short axis diameter of right ventricle (RV) = 57 mm



Diameter of Inferior Vena Cava (IVC) = 27 mm

Probability of right ventricular dysfunction (RVD) = 0.78

$$z = b_0 + b_1 x_1 + b_2 x_2 + \ldots + b_n x_n.$$

-8.361 + 0.132 x 20 + 0.078 x 57 +0.094 x 27 = 1.263

$$p = \frac{1}{1 + e^{-z}},$$

1/(1+e^-1.263) = 0.7795

Challenges

- Substantial overlap in symptoms and signs of both disorders
- Dyspnea (breathing difficulty) is commonly reported symptom in both disorders
- Heart failure patients often demonstrate signs of right ventricular dysfunction in the absence of PE
- Pulmonary vascular congestion or systemic hypertension should be stabilized before undergoing chest CT

Limitation

- Retrospective study
- Only use existing data
- Continue with Prospective Study

Contribution to Healthcare

- Reliable Assessment of RVD in the course of the acute PE
- Performed better than single CT-based measurements

Question And Answer