Business Problem

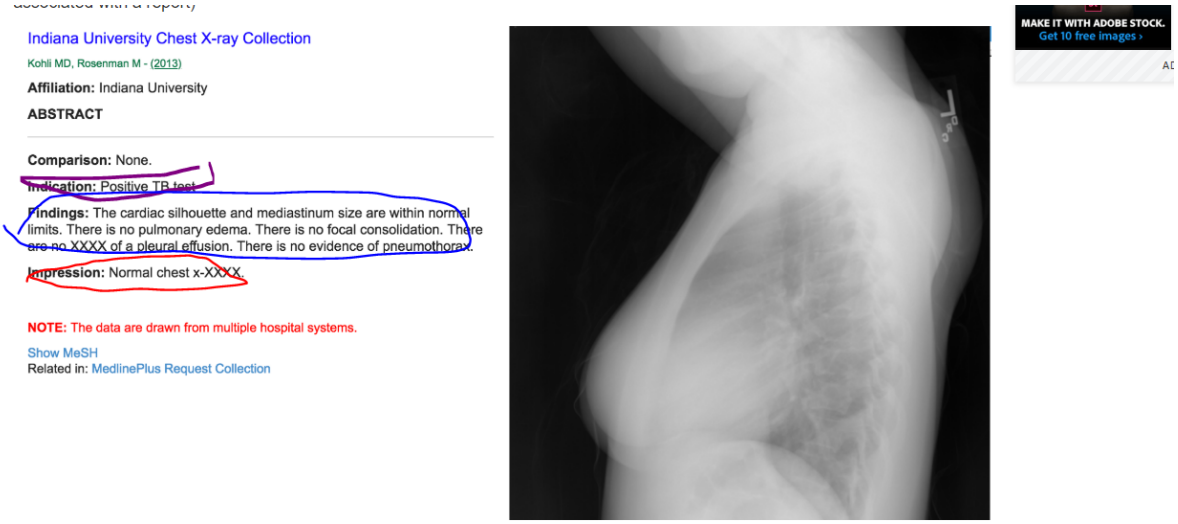
1.Description

The automatic generation of medical reports given x-ray images has a significant chance of improving the patients treatment and care. Although there have been instances of using deep learning for detection and classification of medical images,generating the report based on images would be of great help for medical practioners.

For this case study we propose a new encoder-decoder architecture. In this model we will use deep learning models to extract features and process the data. The experimental results are conducted on the Indiana University Chest -X Ray dataset which is provided to us in the raw format for non commercial use. It has around 7k images and around 3.5k reports.

2. Overview of the data

Data is provided to us in an xml format. Each xml file contains id of the image, descrption of the condition of the patient , finding and Indication. Below we give a sample screen shot of an sample data point.



3. Performance Metric

- We will be using Bleu score to match the reports generated with the original report.
- Training loss will be Sparse Categorical cross Entropy.

EDA

In [74]:
```
import xml.etree.ElementTree as ET
from bs4 import BeautifulSoup
import pandas as pd
import numpy as np
from tqdm import tqdm
import os
import re
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
import seaborn as sns
```

In [46]:
```
columns = ["image_name","image_captions","comparison","indication","findings","im
df = pd.DataFrame(columns=columns)
#list of files in the directory
for file in tqdm(os.listdir("ecgen-radiology/")):
    if file.endswith(".xml"):
        # parsing the  xml files
        tree = ET.parse("ecgen-radiology/"+file)
        img_list = set()
        caption_list = set()
        # finding all the subelements
        for parent in tree.findall('parentImage'):
            img = parent.attrib['id'] + ".png"
            caption_list.add(''if parent.find('caption').text is None else parent
            img_list.add(img)
        # finds all the
        comparison = tree.findtext(".//AbstractText[@Label='COMPARISON']")
        indication = tree.findtext(".//AbstractText[@Label='INDICATION']")
        findings   = tree.findtext(".//AbstractText[@Label='FINDINGS']")
        impression = tree.findtext(".//AbstractText[@Label='IMPRESSION']")

        # adding reports to the dataframe
        df = df.append(pd.Series([','.join(img_list),','.join(caption_list),compa
```

```
100%|██████████████████████████████████████████████████████████████████████
███| 3955/3955 [00:11<00:00, 336.54it/s]
```

In [47]:
```
df.head()
```

Out[47]:

	image_name	image_captions	comparison	indication	findings	impressi
0	CXR1_1_IM-0001-3001.png,CXR1_1_IM-0001-4001.png	Xray Chest PA and Lateral	None.	Positive TB test	The cardiac silhouette and mediastinum size ar...	Normal chest XX
1	CXR10_IM-0002-1001.png,CXR10_IM-0002-2001.png	PA and lateral chest x-XXXX XXXX.	Chest radiographs XXXX.	XXXX-year-old male, chest pain.	The cardiomediastinal silhouette is within nor...	No acu cardiopulmona proce
2	CXR100_IM-0002-1001.png,CXR100_IM-0002-2001.png	CHEST 2V FRONTAL/LATERAL XXXX, XXXX XXXX PM	None.		Both lungs are clear and expanded. Heart and m...	No act disea
3	CXR1000_IM-0003-1001.png,CXR1000_IM-0003-3001....	PA and lateral chest x-XXXX XXXX.	XXXX PA and lateral chest radiographs	XXXX-year-old male, XXXX.	There is XXXX increased opacity within the rig...	1. Increas opacity in t right upper lo v
4	CXR1001_IM-0004-1001.png,CXR1001_IM-0004-1002.png	CHEST 2V FRONTAL/LATERAL XXXX, XXXX XXXX PM	None	dyspnea, subjective fevers, arthritis, immigra...	Interstitial markings are diffusely prominent ...	Diffuse fibros No visible fo acute disea

In [49]:
```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
# <br /><br /> ==> after the above steps, we are getting "br br"
# we are including them into stop words list
# instead of <br /> if we have <br/> these tags would have revmoved in the 1st st

stopwords= set(['br', 'the', 'i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'our
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he',
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itsel
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'th
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than',
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "di
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma',
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn'
            'won', "won't", 'wouldn', "wouldn't"])
```

In [50]:
```
def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)

    # general
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
    phrase = re.sub(r"\'m", " am", phrase)
    return phrase
```

In [52]:
```
def preprocess(data):
    preprocessed_reviews = []
    review_length  = []

    for sentance in tqdm(data.values):
        sentance = re.sub(r"http\S+", "", sentance)
        sentance = BeautifulSoup(sentance, 'lxml').get_text()
        sentance = decontracted(sentance)
        sentance = re.sub("\S*\d\S*", "", sentance).strip()
        sentance = re.sub('[^A-Za-z]+', ' ', sentance)
        sentance = re.sub(r'XXXX', ' ', sentance)
        sentance = re.sub(r'XXXX XXXX', ' ', sentance)
        sentance = re.sub(r'XXXX-year-old', ' ', sentance)


        sentance = ' '.join(e.lower() for e in sentance.split() if e.lower() not
        preprocessed_reviews.append(sentance.strip())
    return preprocessed_reviews
```

In [53]:
```
df['image_captions'] = preprocess(df['image_captions'])
```

```
100%|████████████████████████████████████████████████████████████████
██| 3955/3955 [00:00<00:00, 4421.66it/s]
```

In [54]:
```
df['comparison'] = preprocess(df['comparison'])
```

```
 39%|████████████████████████▌
| 1556/3955 [00:00<00:00, 4884.14it/s]C:\Users\user\Anaconda3\envs\tf-gpu\lib\s
ite-packages\bs4\__init__.py:333: MarkupResemblesLocatorWarning: "." looks like
a filename, not markup. You should probably open this file and pass the filehan
dle into Beautiful Soup.
  MarkupResemblesLocatorWarning
100%|████████████████████████████████████████████████████████████████
██| 3955/3955 [00:00<00:00, 4931.77it/s]
```

In [55]:
```
df['indication'] = preprocess(df['indication'])
```

```
100%|██████████████████████████████████████████████████████████████
██| 3955/3955 [00:00<00:00, 4432.34it/s]
```

In [56]:
```
df['findings'] = preprocess(df['findings'])
```

```
100%|██████████████████████████████████████████████████████████████
██| 3955/3955 [00:01<00:00, 3952.60it/s]
```

In [57]:
```
df['impression'] = preprocess(df['impression'])
```

```
100%|██████████████████████████████████████████████████████████████
██| 3955/3955 [00:00<00:00, 4201.51it/s]
```

In [58]:
```
df.head()
```

Out[58]:

	image_name	image_captions	comparison	indication	findings	impression
0	CXR1_1_IM-0001-3001.png,CXR1_1_IM-0001-4001.png	xray chest pa lateral	none	positive tb test	cardiac silhouette mediastinum size within nor...	normal chest x
1	CXR10_IM-0002-1001.png,CXR10_IM-0002-2001.png	pa lateral chest x	chest radiographs	year old male chest pain	cardiomediastinal silhouette within normal lim...	no acute cardiopulmonary process
2	CXR100_IM-0002-1001.png,CXR100_IM-0002-2001.png	chest frontal lateral pm	none		lungs clear expanded heart mediastinum normal	no active disease
3	CXR1000_IM-0003-1001.png,CXR1000_IM-0003-3001....	pa lateral chest x	pa lateral chest radiographs	year old male	increased opacity within right upper lobe poss...	increased opacity right upper lobe associated ...
4	CXR1001_IM-0004-1001.png,CXR1001_IM-0004-1002.png	chest frontal lateral pm	none	dyspnea subjective fevers arthritis immigrant ...	interstitial markings diffusely prominent thro...	diffuse fibrosis no visible focal acute disease

In [61]:
```
# creating a word count column for findings and impression columns
df['findings_count'] = df['findings'].astype(str).str.split().apply(lambda x: 0 i
df['impressions_count'] = df['impression'].astype(str).str.split().apply(lambda x
```

In [62]:
```
df.head()
```

Out[62]:

	image_name	image_captions	comparison	indication	findings	impression
0	CXR1_1_IM-0001-3001.png,CXR1_1_IM-0001-4001.png	xray chest pa lateral	none	positive tb test	cardiac silhouette mediastinum size within nor...	normal chest x
1	CXR10_IM-0002-1001.png,CXR10_IM-0002-2001.png	pa lateral chest x	chest radiographs	year old male chest pain	cardiomediastinal silhouette within normal lim...	no acute cardiopulmonary process
2	CXR100_IM-0002-1001.png,CXR100_IM-0002-2001.png	chest frontal lateral pm	none		lungs clear expanded heart mediastinum normal	no active disease
3	CXR1000_IM-0003-1001.png,CXR1000_IM-0003-3001....	pa lateral chest x	pa lateral chest radiographs	year old male	increased opacity within right upper lobe poss...	increased opacity right upper lobe associated ...
4	CXR1001_IM-0004-1001.png,CXR1001_IM-0004-1002.png	chest frontal lateral pm	none	dyspnea subjective fevers arthritis immigrant ...	interstitial markings diffusely prominent thro...	diffuse fibrosis no visible focal acute disease

In [66]:
```
# number of images per row
df['image_count'] = df['image_name'].astype(str).str.split(',').apply(len)
```

In [67]:
```
df.head()
```

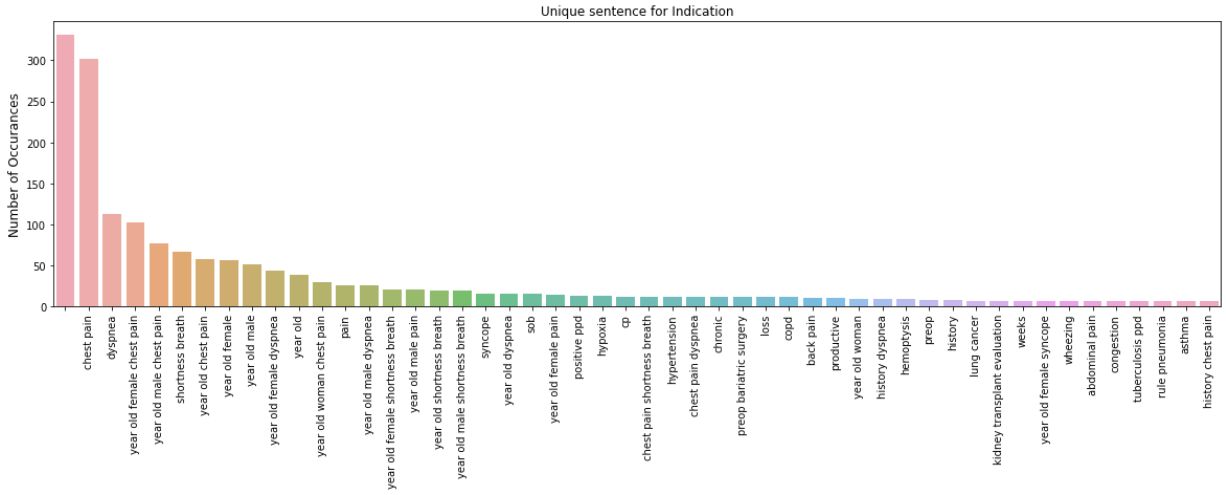
Out[67]:

	image_name	image_captions	comparison	indication	findings	impression
0	CXR1_1_IM-0001-3001.png,CXR1_1_IM-0001-4001.png	xray chest pa lateral	none	positive tb test	cardiac silhouette mediastinum size within nor...	normal chest x
1	CXR10_IM-0002-1001.png,CXR10_IM-0002-2001.png	pa lateral chest x	chest radiographs	year old male chest pain	cardiomediastinal silhouette within normal lim...	no acute cardiopulmonary process
2	CXR100_IM-0002-1001.png,CXR100_IM-0002-2001.png	chest frontal lateral pm	none		lungs clear expanded heart mediastinum normal	no active disease
3	CXR1000_IM-0003-1001.png,CXR1000_IM-0003-3001....	pa lateral chest x	pa lateral chest radiographs	year old male	increased opacity within right upper lobe poss...	increased opacity right upper lobe associated ...
4	CXR1001_IM-0004-1001.png,CXR1001_IM-0004-1002.png	chest frontal lateral pm	none	dyspnea subjective fevers arthritis immigrant ...	interstitial markings diffusely prominent thro...	diffuse fibrosis no visible focal acute disease

In [69]:
```
df.to_csv('Medical.csv',index=False)
```

Most occuring sentences

In [70]:
```
indications = df.indication.value_counts()[0:50]
plt.figure(figsize=(20,5))
sns.barplot(indications.index,indications.values,alpha=0.8)
plt.title("Unique sentence for Indication")
plt.ylabel("Number of Occurances",fontsize=12)
plt.xticks(rotation=90)
plt.show()
```

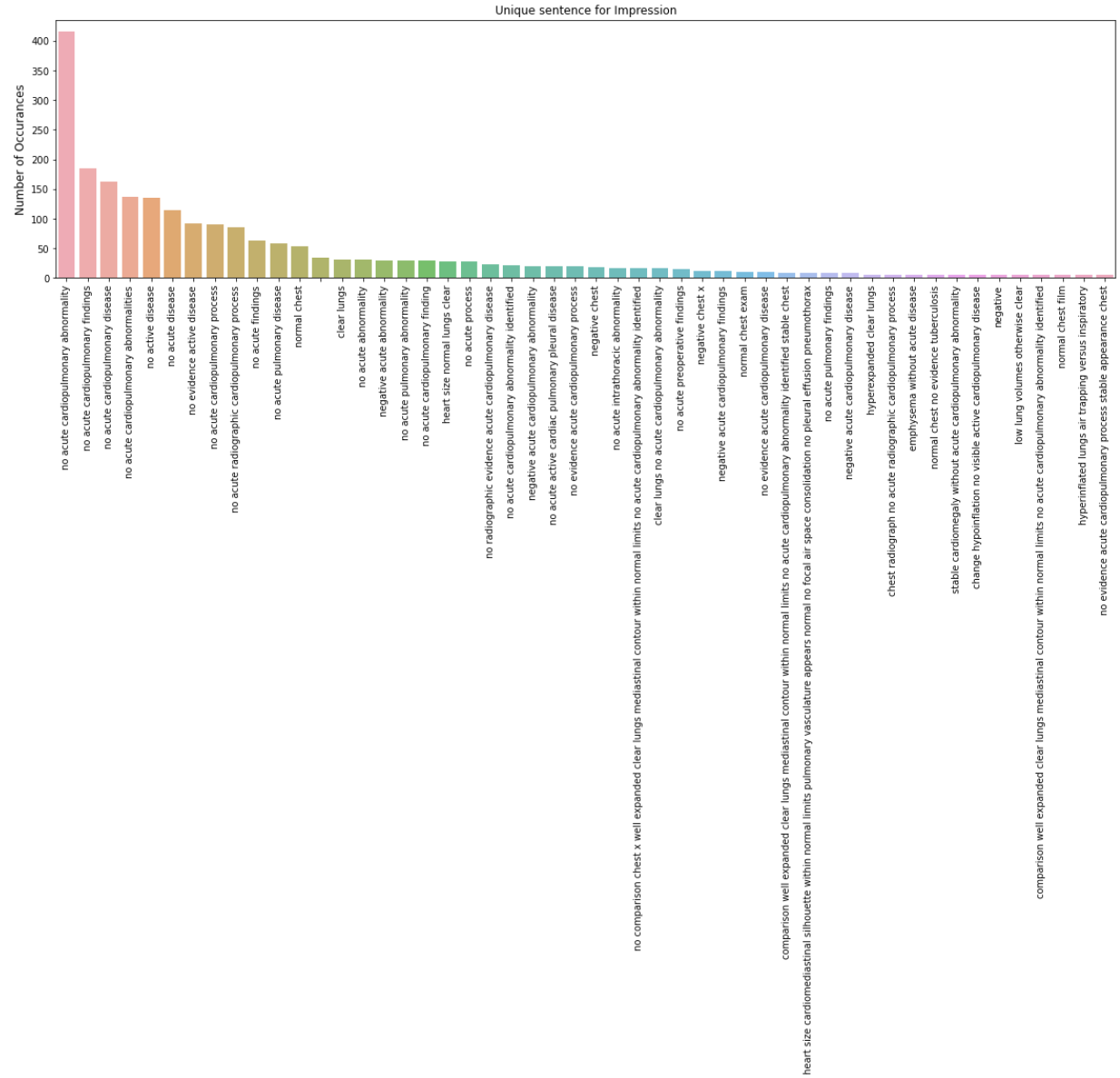


chest pain in different form seem to be really common indication followed by dyspenea which is a form of breathlessness.

In [71]:
```
findings = df.findings.value_counts()[0:50]
plt.figure(figsize=(20,5))
sns.barplot(findings.index,findings.values,alpha=0.8)
plt.title("Unique sentence for Findings")
plt.ylabel("Number of Occurances",fontsize=12)
plt.xticks(rotation=90)
plt.show()
```

There are more than 500 rows without any findings. The remaining findings occured between 50 to 60 times.

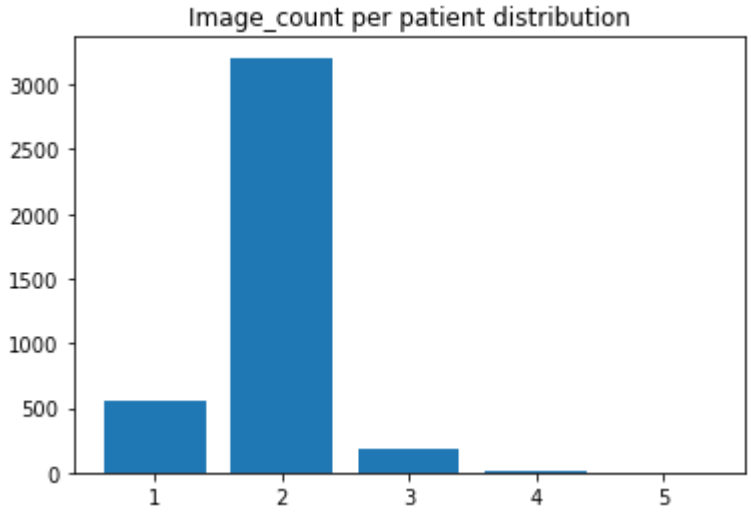
In [72]:
```
impression = df.impression.value_counts()[0:50]
plt.figure(figsize=(20,5))
sns.barplot(impression.index,impression.values,alpha=0.8)
plt.title("Unique sentence for Impression")
plt.ylabel("Number of Occurances",fontsize=12)
plt.xticks(rotation=90)
plt.show()
```



from the above distribution we can see that "No accute cardiopulmanory abnormality" occured 600 times.

EDA of Images

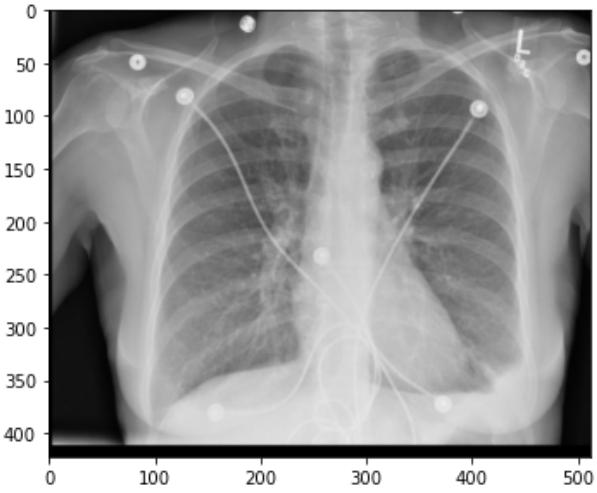
In [73]:
```
plt.bar(df['image_count'].value_counts().index,df['image_count'].value_counts().v
plt.title("Image_count per patient distribution")
plt.show()
```



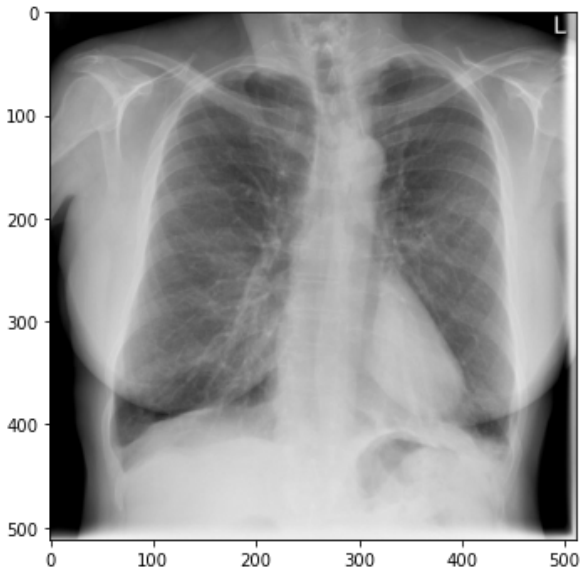
The above graph shows clearly that 2 images per patient is the maximum count value.

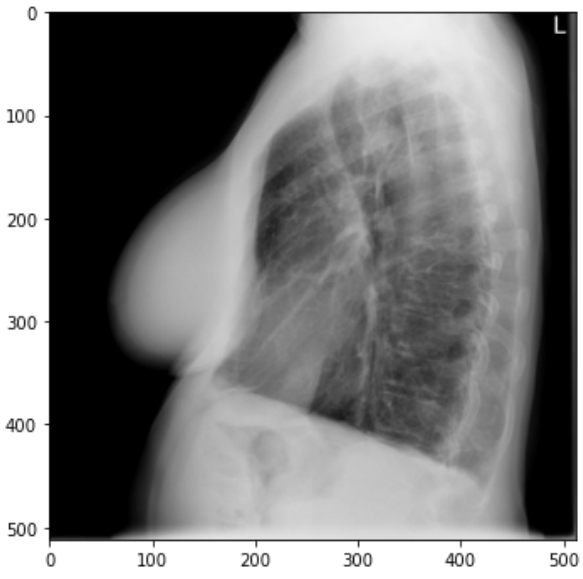
In [78]:
```
def patient_record(data):
    for i,row in data.iterrows():
        imgs = row['image_name'].split(",")
        fig,axs = plt.subplots(1,len(imgs),figsize=(10,10),tight_layout=True)
        count = 0
        for img,subplot in zip(imgs,axs.flatten()):
            img_ = mpimg.imread("NLMCXR_png/"+img)
            implot = axs[count].imshow(img_,cmap='bone')
            count += 1
        plt.show()

        print("Total Images present for the patient:",len(imgs))
        print("="*100)
        print("Findings:Total number of words{}".format(row['findings_count']))
        print(row['findings'])
        print("="*100)
        print("Impressions:Total number of words{}".format(row['impressions_count
        print(row['impression'])
        print("="*100)
```

In [79]:
```
patient_record(df[50:52])
```




```
Total Images present for the patient: 2
================================================================================
====================
Findings:Total number of words29
normal cardiomediastinal silhouette interval improvement lung volumes bilateral
ly improved aeration right left lung bases bilateral small pleural effusions le
ft base atelectatic change interval improvement visualized chest within normal
limits
================================================================================
====================
Impressions:Total number of words16
interval improvement aeration lung bases pleural effusions residual small left
effusion questionable small right pleural effusion
================================================================================
====================
```





```
Total Images present for the patient: 2
================================================================================
====================
Findings:Total number of words26
heart size pulmonary vascularity appear within normal limits clearing left base
airspace opacities lungs appear clear no pneumothorax pleural effusion seen lun
gs appear hyperexpanded consistent emphysema
================================================================================
====================
Impressions:Total number of words8
hyperexpanded lungs consistent emphysema no evidence acute disease
================================================================================
====================
```

Conclusion

- All the data was presented to us was in the xml format which we parsed and saved into a dataframe.
- Each patient has multiple x-ray images, from the data analysis we found out that we have 2 x-ray images per patient is the most common.
- In the text part we found out that the reports had many unknown values like xxxx which we got rid of by applying some data cleaning.

In [ ]: