In [1]:

```
!mkdir ~/.keras
!mkdir ~/.keras/models
!cp ../input/keras-pretrained-models/*notop* ~/.keras/models/
!cp ../input/keras-pretrained-models/imagenet_class_index.json ~/.keras/models/
!cp ../input/keras-pretrained-models/resnet50* ~/.keras/models/
```

```
The syntax of the command is incorrect.
The syntax of the command is incorrect.
'cp' is not recognized as an internal or external command,
operable program or batch file.
'cp' is not recognized as an internal or external command,
operable program or batch file.
'cp' is not recognized as an internal or external command,
operable program or batch file.
```

In [2]:

```
%matplotlib inline
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
from glob import glob
import matplotlib.pyplot as plt
import os
import pandas as pd
import seaborn as sns
from skimage.util.montage import montage2d
from skimage.io import imread
base_dir = os.path.join('D:/Neural Network/','input', 'pulmonary-chest-xray-abnormalities')
```

In [ ]:

In [3]:

```
mont_paths = glob(os.path.join(base_dir, 'Montgomery', 'MontgomerySet', '*',
'*.*'))
shen_paths = glob(os.path.join(base_dir, 'ChinaSet_AllFiles', 'ChinaSet_AllFil
es', '*', '*.*'))
print('Montgomery Files', len(mont_paths))
print('Shenzhen Files', len(shen_paths))
all_paths_df = pd.DataFrame(dict(path = mont_paths + shen_paths))
all_paths_df['source'] = all_paths_df['path'].map(lambda x: x.split('/')[2])
all_paths_df['file_id'] = all_paths_df['path'].map(lambda x: os.path.splitext(
os.path.basename(x))[0])
all_paths_df['patient_group']  = all_paths_df['file_id'].map(lambda x: x.split
('_')[0])

all_paths_df['file_ext'] = all_paths_df['path'].map(lambda x: os.path.splitext
(x)[1][1:])
all_paths_df = all_paths_df[all_paths_df.file_ext.isin(['png', 'txt'])]
all_paths_df['pulm_state']  = all_paths_df['file_id'].map(lambda x: int(x.spli
t('_')[-1]))
all_paths_df.sample(5)
```

```
Montgomery Files 277
Shenzhen Files 1325
```

Out[3]:

	path	source	file_id	patient_group	file_ext	pul
1467	D:/Neural Network/input\pulmonary-chest-xray-a...	input\pulmonary-chest-xray-abnormalities\China...	CHNCXR_0529_1	CHNCXR	png	
41	D:/Neural Network/input\pulmonary-chest-xray-a...	input\pulmonary-chest-xray-abnormalities\Montg...	MCUCXR_0056_0	MCUCXR	txt	
895	D:/Neural Network/input\pulmonary-chest-xray-a...	input\pulmonary-chest-xray-abnormalities\China...	CHNCXR_0619_1	CHNCXR	txt	
706	D:/Neural Network/input\pulmonary-chest-xray-a...	input\pulmonary-chest-xray-abnormalities\China...	CHNCXR_0430_1	CHNCXR	txt	
455	D:/Neural Network/input\pulmonary-chest-xray-a...	input\pulmonary-chest-xray-abnormalities\China...	CHNCXR_0179_0	CHNCXR	txt	

In [4]:

```
clean_patients_df = all_paths_df.pivot_table(index = ['patient_group', 'pulm_s
tate', 'file_id'],
                                             columns=['file_ext'],
                                             values = 'path', aggfunc='first')
.reset_index()
clean_patients_df.sample(5)
from warnings import warn
def report_to_dict(in_path):
    with open(in_path, 'r') as f:
        all_lines = [x.strip() for x in f.read().split('\n')]
    info_dict = {}
    try:
        if "Patient's Sex" in all_lines[0]:
            info_dict['age'] = all_lines[1].split(':')[-1].strip().replace('Y'
, '')
            info_dict['sex'] = all_lines[0].split(':')[-1].strip()
            info_dict['report'] = ' '.join(all_lines[2:]).strip()
        else:
            info_dict['age'] = all_lines[0].split(' ')[-1].replace('yrs', '').
replace('yr', '')
            info_dict['sex'] = all_lines[0].split(' ')[0].strip()
            info_dict['report'] = ' '.join(all_lines[1:]).strip()

        info_dict['sex'] = info_dict['sex'].upper().replace('FEMALE', 'F').rep
lace('MALE', 'M').replace('FEMAL', 'F')[0:1]
        if 'month' in info_dict.get('age', ''):
            info_dict.pop('age') # invalid
        if 'day' in info_dict.get('age', ''):
            info_dict.pop('age') # invalid
        elif len(info_dict.get('age',''))>0:
            info_dict['age'] = float(info_dict['age'])
        else:
            info_dict.pop('age')
        return info_dict
    except Exception as e:
        print(all_lines)
        warn(str(e), RuntimeWarning)
        return {}
report_df = pd.DataFrame([dict(**report_to_dict(c_row.pop('txt')), **c_row)
              for  _, c_row in clean_patients_df.iterrows()])
report_df.sample(5)
```

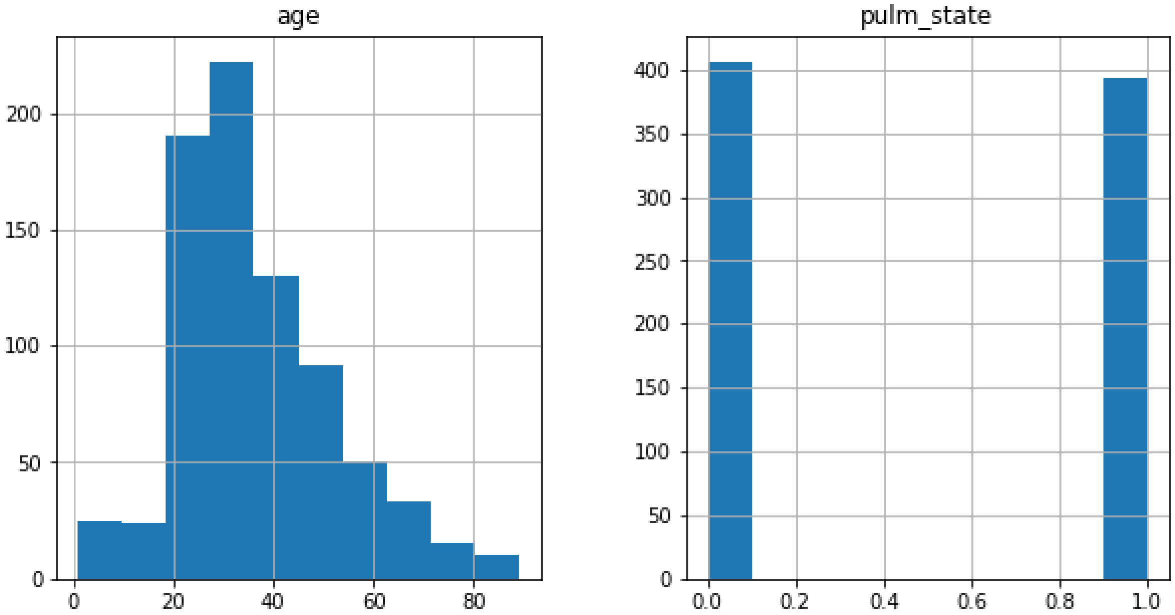
```
['male 16month', 'normal']
['male 16month', 'normal']
['female24yrs', 'normal']

C:\Users\mkahs\Anaconda3\lib\site-packages\ipykernel\__main__.py:32: RuntimeW
arning: 'age'
C:\Users\mkahs\Anaconda3\lib\site-packages\ipykernel\__main__.py:32: RuntimeW
arning: could not convert string to float: 'female24'

['male35yrs', 'PTB in the left upper field']
['male35yrs', 'Bilateral secondary PTB']
['Male , 38yrs,', 'secondary PTB in the bilateral upper and middle fields, ma
inly fibrous  lesions']

C:\Users\mkahs\Anaconda3\lib\site-packages\ipykernel\__main__.py:32: RuntimeW
arning: could not convert string to float: 'male35'
C:\Users\mkahs\Anaconda3\lib\site-packages\ipykernel\__main__.py:32: RuntimeW
arning: could not convert string to float: '38,'
```

Out[4]:

	age	file_id	patient_group	png	pulm_state	report	sex
345	26.0	CHNCXR_0346_1	CHNCXR	D:/Neural Network/input\pulmonary-chest-xray-a...	1	STB tuberculosis pleuritis	F
169	23.0	CHNCXR_0170_0	CHNCXR	D:/Neural Network/input\pulmonary-chest-xray-a...	0	normal	M
520	34.0	CHNCXR_0521_1	CHNCXR	D:/Neural Network/input\pulmonary-chest-xray-a...	1	PTB in the right upper field	M
654	33.0	CHNCXR_0655_1	CHNCXR	D:/Neural Network/input\pulmonary-chest-xray-a...	1	secondary PTB in the right upper field,mainly ...	M
496	45.0	CHNCXR_0497_1	CHNCXR	D:/Neural Network/input\pulmonary-chest-xray-a...	1	bilateral PTB	M

In [5]:
```
report_df[['age', 'patient_group', 'pulm_state', 'sex']].hist(figsize = (10, 5
))
```

Out[5]:
```
array([[<matplotlib.axes._subplots.AxesSubplot object at 0x000001B5BC663828>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000001B5BC66CA58
>]],
      dtype=object)
```



In [6]:
```
from sklearn.model_selection import train_test_split
raw_train_df, valid_df = train_test_split(report_df,
                                   test_size = 0.25,
                                   random_state = 2018,
                                   stratify = report_df[['pulm_state', 'patien
t_group']])
print('train', raw_train_df.shape[0], 'validation', valid_df.shape[0])
raw_train_df.sample(1)
```

```
train 600 validation 200
```

Out[6]:

	age	file_id	patient_group	png	pulm_state	report	sex
628	62.0	CHNCXR_0629_1	CHNCXR	D:/Neural Network/input\pulmonary-chest-xray-a...	1	Bilateral secondary PTB	M

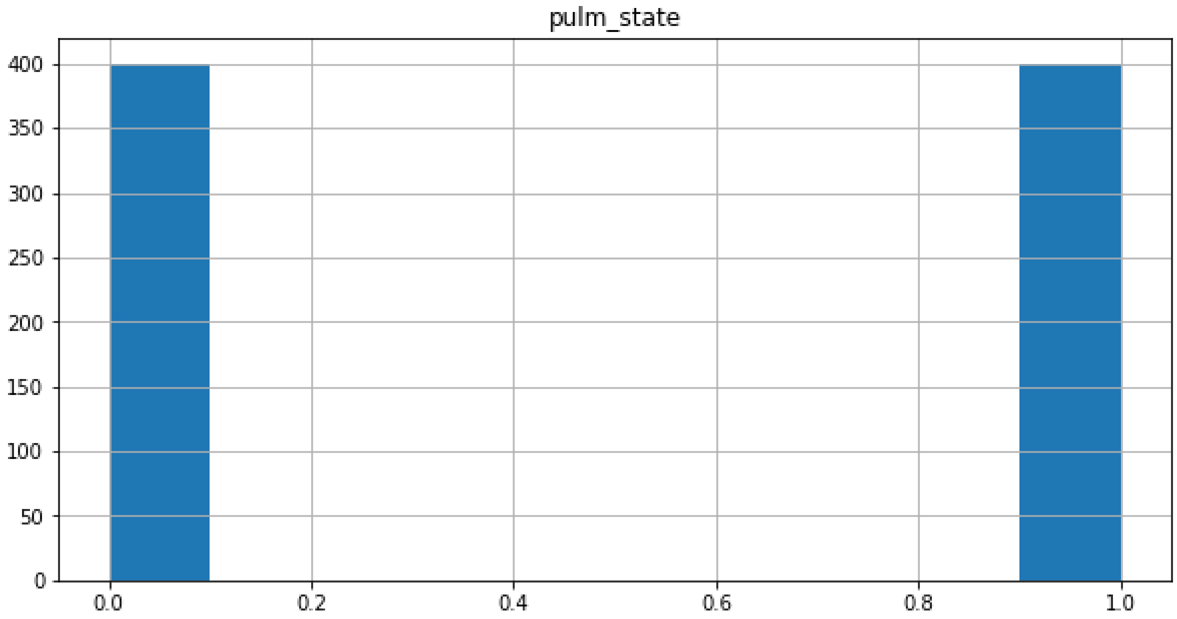
In [7]:

```
train_df = raw_train_df.groupby(['pulm_state', 'patient_group']).apply(lambda
x: x.sample(200, replace = True)
                                                      ).reset_index(drop = Tru
e)
print('New Data Size:', train_df.shape[0], 'Old Size:', raw_train_df.shape[0])
train_df[['pulm_state', 'patient_group']].hist(figsize = (10, 5))
```

```
New Data Size: 800 Old Size: 600
```

Out[7]:

```
array([[<matplotlib.axes._subplots.AxesSubplot object at 0x000001B5BD07B320
>]],
      dtype=object)
```



In [8]:

```
from keras.preprocessing.image import ImageDataGenerator
from keras.applications.imagenet_utils import preprocess_input
from PIL import Image
ppi = lambda x: Image.fromarray(preprocess_input(np.array(x).astype(np.float32
)))
IMG_SIZE = (224, 224) # slightly smaller than vgg16 normally expects
core_idg = ImageDataGenerator(samplewise_center=False,
                              samplewise_std_normalization=False,
                              horizontal_flip = True,
                              vertical_flip = False,
                              height_shift_range = 0.15,
                              width_shift_range = 0.15,
                              rotation_range = 5,
                              shear_range = 0.01,
                              fill_mode = 'nearest',
                              zoom_range=0.2)
```

```
C:\Users\mkahs\Anaconda3\lib\site-packages\h5py\__init__.py:36: FutureWarnin
g: Conversion of the second argument of issubdtype from `float` to `np.floati
ng` is deprecated. In future, it will be treated as `np.float64 == np.dtype(f
loat).type`.
  from ._conv import register_converters as _register_converters
Using TensorFlow backend.
```

In [10]:

```
def flow_from_dataframe(img_data_gen, in_df, path_col, y_col, **dflow_args):
    base_dir = os.path.dirname(in_df[path_col].values[0])
    print('## Ignore next message from keras, values are replaced anyways')
    df_gen = img_data_gen.flow_from_directory(base_dir,
                                     class_mode = 'sparse',
                                    **dflow_args)
    df_gen.filenames = in_df[path_col].values
    df_gen.classes = np.stack(in_df[y_col].values)
    df_gen.samples = in_df.shape[0]
    df_gen.n = in_df.shape[0]
    df_gen._set_index_array()
    df_gen.directory = '' # since we have the full path
    print('Reinserting dataframe: {} images'.format(in_df.shape[0]))
    return df_gen
```

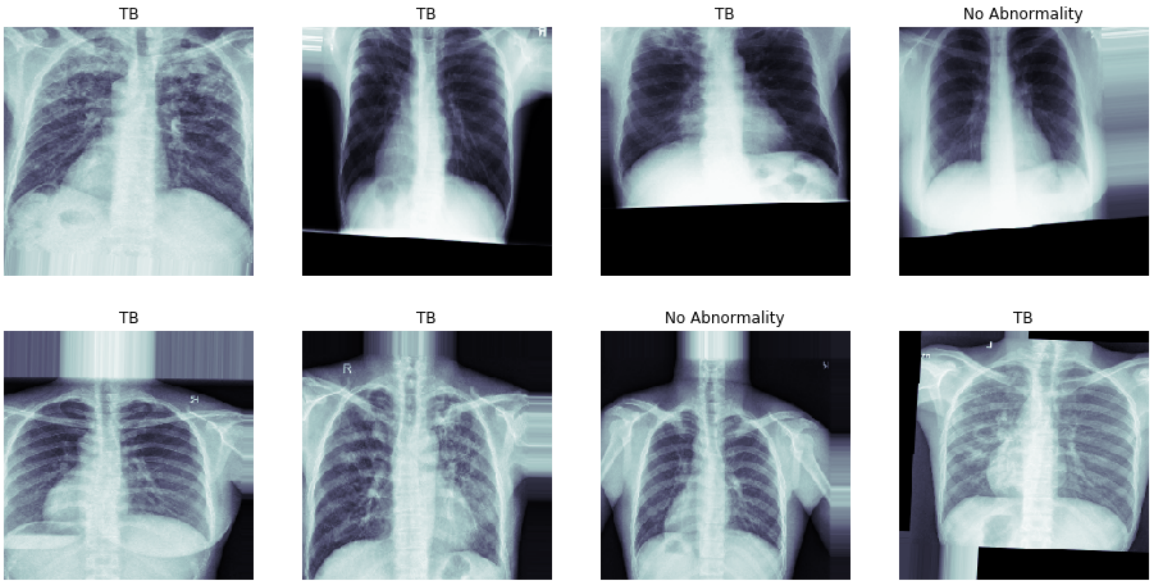
In [11]:

```
train_gen = flow_from_dataframe(core_idg, train_df,
                             path_col = 'png',
                            y_col = 'pulm_state',
                            target_size = IMG_SIZE,
                             color_mode = 'rgb',
                            batch_size = 32)

valid_gen = flow_from_dataframe(core_idg, valid_df,
                             path_col = 'png',
                            y_col = 'pulm_state',
                            target_size = IMG_SIZE,
                             color_mode = 'rgb',
                            batch_size = 256) # we can use much larger batches
for evaluation
# used a fixed dataset for evaluating the algorithm
test_X, test_Y = next(flow_from_dataframe(core_idg,
                               valid_df,
                             path_col = 'png',
                            y_col = 'pulm_state',
                            target_size = IMG_SIZE,
                             color_mode = 'rgb',
                            batch_size = 1024)) # one big batch
```

```
## Ignore next message from keras, values are replaced anyways
Found 0 images belonging to 0 classes.
Reinserting dataframe: 800 images
## Ignore next message from keras, values are replaced anyways
Found 0 images belonging to 0 classes.
Reinserting dataframe: 200 images
## Ignore next message from keras, values are replaced anyways
Found 0 images belonging to 0 classes.
Reinserting dataframe: 200 images
```

In [13]:

```
t_x, t_y = next(train_gen)
fig, m_axs = plt.subplots(2, 4, figsize = (16, 8))
for (c_x, c_y, c_ax) in zip(t_x, t_y, m_axs.flatten()):
    c_ax.imshow(c_x[:,:,0], cmap = 'bone', vmin = 0, vmax = 255)
    c_ax.set_title('%s' % ('TB' if c_y>0.5 else 'No Abnormality'))
    c_ax.axis('off')
```



In [33]:

```
from keras.applications.vgg16 import VGG16
from keras.layers import GlobalAveragePooling2D, Dense, Dropout, Flatten, Inpu
t, Conv2D, multiply, LocallyConnected2D, Lambda
from keras.models import Model
in_lay = Input(t_x.shape[1:])
base_pretrained_model = VGG16(input_shape =  t_x.shape[1:],
                              include_top = False, weights = 'imagenet')
base_pretrained_model.trainable = False
pt_depth = base_pretrained_model.get_output_shape_at(0)[-1]
pt_features = base_pretrained_model(in_lay)
from keras.layers import BatchNormalization
bn_features = BatchNormalization()(pt_features)

# here we do an attention mechanism to turn pixels in the GAP on an off

attn_layer = Conv2D(64, kernel_size = (1,1), padding = 'same', activation = 'r
elu')(bn_features)
attn_layer = Conv2D(16, kernel_size = (1,1), padding = 'same', activation = 'r
elu')(attn_layer)
attn_layer = Conv2D(1,
                                kernel_size = (1,1),
                                padding = 'valid',
                                activation = 'sigmoid')(attn_layer)
# fan it out to all of the channels
up_c2_w = np.ones((1, 1, 1, pt_depth))
up_c2 = Conv2D(pt_depth, kernel_size = (1,1), padding = 'same',
               activation = 'linear', use_bias = False, weights = [up_c2_w])
up_c2.trainable = False
attn_layer = up_c2(attn_layer)

mask_features = multiply([attn_layer, bn_features])
gap_features = GlobalAveragePooling2D()(mask_features)
gap_mask = GlobalAveragePooling2D()(attn_layer)
# to account for missing values from the attention model
gap = Lambda(lambda x: x[0]/x[1], name = 'RescaleGAP')([gap_features, gap_mask
])
gap_dr = Dropout(0.5)(gap)
dr_steps = Dropout(0.25)(Dense(128, activation = 'elu')(gap_dr))
out_layer = Dense(1, activation = 'sigmoid')(dr_steps)
tb_model = Model(inputs = [in_lay], outputs = [out_layer])

tb_model.compile(optimizer = 'adam', loss = 'binary_crossentropy',
                           metrics = ['binary_accuracy'])

# tb_model.summary()
base_pretrained_model.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
input_6 (InputLayer)         (None, 224, 224, 3)       0         
_________________________________________________________________
block1_conv1 (Conv2D)        (None, 224, 224, 64)      1792      
_________________________________________________________________
block1_conv2 (Conv2D)        (None, 224, 224, 64)      36928     
_________________________________________________________________
block1_pool (MaxPooling2D)   (None, 112, 112, 64)      0         
_________________________________________________________________
block2_conv1 (Conv2D)        (None, 112, 112, 128)     73856     
_________________________________________________________________
block2_conv2 (Conv2D)        (None, 112, 112, 128)     147584    
_________________________________________________________________
block2_pool (MaxPooling2D)   (None, 56, 56, 128)       0         
_________________________________________________________________
block3_conv1 (Conv2D)        (None, 56, 56, 256)       295168    
_________________________________________________________________
block3_conv2 (Conv2D)        (None, 56, 56, 256)       590080    
_________________________________________________________________
block3_conv3 (Conv2D)        (None, 56, 56, 256)       590080    
_________________________________________________________________
block3_pool (MaxPooling2D)   (None, 28, 28, 256)       0         
_________________________________________________________________
block4_conv1 (Conv2D)        (None, 28, 28, 512)       1180160   
_________________________________________________________________
block4_conv2 (Conv2D)        (None, 28, 28, 512)       2359808   
_________________________________________________________________
block4_conv3 (Conv2D)        (None, 28, 28, 512)       2359808   
_________________________________________________________________
block4_pool (MaxPooling2D)   (None, 14, 14, 512)       0         
_________________________________________________________________
block5_conv1 (Conv2D)        (None, 14, 14, 512)       2359808   
_________________________________________________________________
block5_conv2 (Conv2D)        (None, 14, 14, 512)       2359808   
_________________________________________________________________
block5_conv3 (Conv2D)        (None, 14, 14, 512)       2359808   
_________________________________________________________________
block5_pool (MaxPooling2D)   (None, 7, 7, 512)         0         
=================================================================
Total params: 14,714,688
Trainable params: 0
Non-trainable params: 14,714,688
_________________________________________________________________
```

In [15]:

```
!rm -rf ~/.keras # clean up the model / make space for other things
```

```
'rm' is not recognized as an internal or external command,
operable program or batch file.
```

In [16]:

```
from keras.callbacks import ModelCheckpoint, LearningRateScheduler, EarlyStopp
ing, ReduceLROnPlateau
weight_path="{}_weights.best.hdf5".format('tb_detector')

checkpoint = ModelCheckpoint(weight_path, monitor='val_loss', verbose=1,
                             save_best_only=True, mode='min', save_weights_onl
y = True)


reduceLROnPlat = ReduceLROnPlateau(monitor='val_loss', factor=0.8, patience=10
, verbose=1, mode='auto', epsilon=0.0001, cooldown=5, min_lr=0.0001)
early = EarlyStopping(monitor="val_loss",
                      mode="min",
                      patience=5) # probably needs to be more patient, but kag
gle time is limited
callbacks_list = [checkpoint, early, reduceLROnPlat]
```

```
C:\Users\mkahs\Anaconda3\lib\site-packages\keras\callbacks.py:1065: UserWarni
ng: `epsilon` argument is deprecated and will be removed, use `min_delta` ins
tead.
  warnings.warn('`epsilon` argument is deprecated and '
```

In [17]:

```
tb_model.fit_generator(train_gen,
                                  steps_per_epoch = 35,
                                  validation_data = (test_X, test_Y),
                                  epochs = 8,
                                  callbacks = callbacks_list)
```

```
Epoch 1/8
35/35 [==============================] - 659s 19s/step - loss: 0.6049 - binar
y_accuracy: 0.6571 - val_loss: 0.4442 - val_binary_accuracy: 0.8000

Epoch 00001: val_loss improved from inf to 0.44423, saving model to tb_detect
or_weights.best.hdf5
Epoch 2/8
35/35 [==============================] - 635s 18s/step - loss: 0.5101 - binar
y_accuracy: 0.7688 - val_loss: 0.4420 - val_binary_accuracy: 0.7800

Epoch 00002: val_loss improved from 0.44423 to 0.44196, saving model to tb_de
tector_weights.best.hdf5
Epoch 3/8
35/35 [==============================] - 633s 18s/step - loss: 0.4517 - binar
y_accuracy: 0.7991 - val_loss: 0.4272 - val_binary_accuracy: 0.7900

Epoch 00003: val_loss improved from 0.44196 to 0.42721, saving model to tb_de
tector_weights.best.hdf5
Epoch 4/8
35/35 [==============================] - 636s 18s/step - loss: 0.4316 - binar
y_accuracy: 0.8036 - val_loss: 0.4249 - val_binary_accuracy: 0.7950

Epoch 00004: val_loss improved from 0.42721 to 0.42488, saving model to tb_de
tector_weights.best.hdf5
Epoch 5/8
35/35 [==============================] - 633s 18s/step - loss: 0.3623 - binar
y_accuracy: 0.8446 - val_loss: 0.4316 - val_binary_accuracy: 0.7900

Epoch 00005: val_loss did not improve from 0.42488
Epoch 6/8
35/35 [==============================] - 635s 18s/step - loss: 0.3687 - binar
y_accuracy: 0.8446 - val_loss: 0.4593 - val_binary_accuracy: 0.7850

Epoch 00006: val_loss did not improve from 0.42488
Epoch 7/8
35/35 [==============================] - 634s 18s/step - loss: 0.3528 - binar
y_accuracy: 0.8473 - val_loss: 0.4411 - val_binary_accuracy: 0.8050

Epoch 00007: val_loss did not improve from 0.42488
Epoch 8/8
35/35 [==============================] - 634s 18s/step - loss: 0.3321 - binar
y_accuracy: 0.8589 - val_loss: 0.4731 - val_binary_accuracy: 0.8000

Epoch 00008: val_loss did not improve from 0.42488
```

Out[17]:

```
<keras.callbacks.History at 0x1b5c88a3b70>
```

In [45]:

```
tb_model.load_weights(weight_path)
tb_model.save('full_tb_model.h5')
```

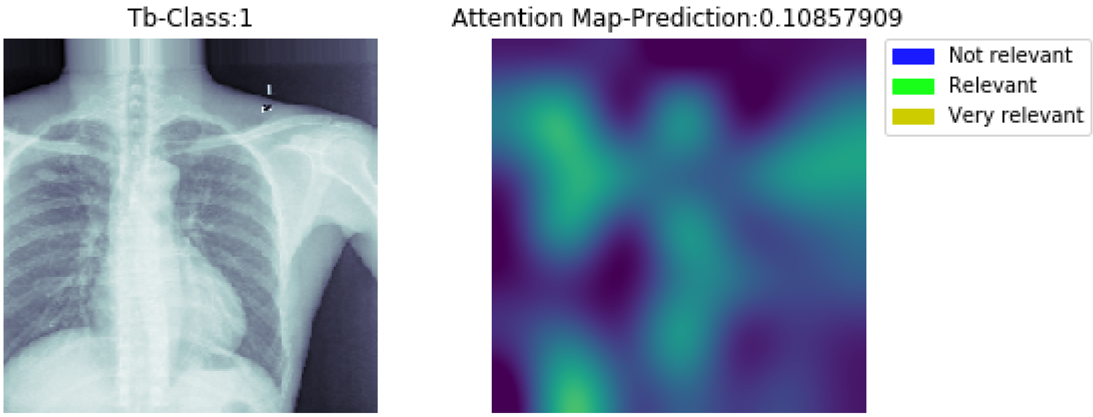
In [46]:

```
# get the attention layer since it is the only one with a single output dim
for attn_layer in tb_model.layers:
    c_shape = attn_layer.get_output_shape_at(0)
    if len(c_shape)==4:
        if c_shape[-1]==1:
            print(attn_layer)
            break
```

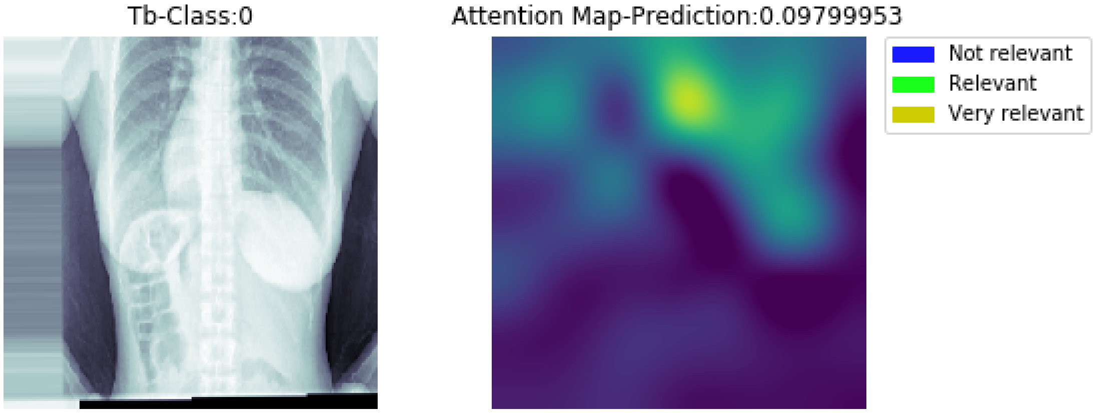
```
<keras.layers.convolutional.Conv2D object at 0x000001B584F35198>
```

In [55]:

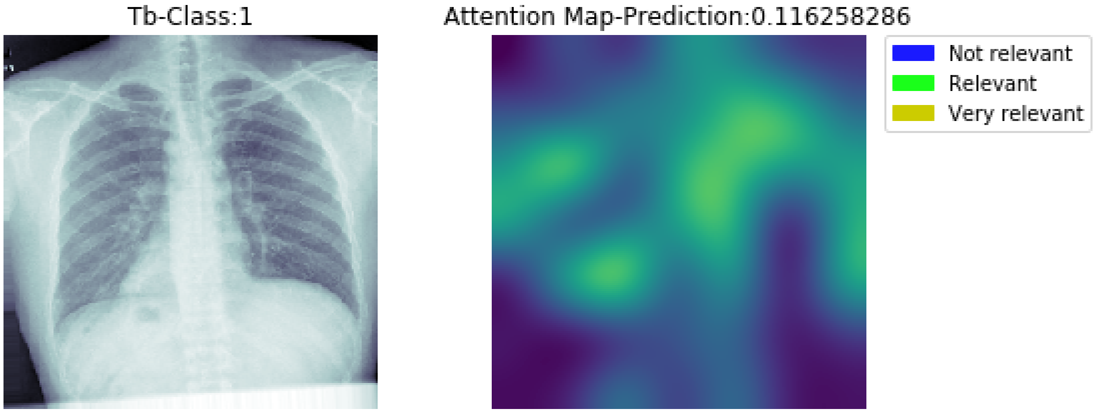
```
import keras.backend as K
import matplotlib.patches as mpatches
rand_idx = np.random.choice(range(len(test_X)), size = 6)
attn_func = K.function(inputs = [tb_model.get_input_at(0), K.learning_phase
()],
           outputs = [attn_layer.get_output_at(0)]
          )
fig, m_axs = plt.subplots(len(rand_idx), 2, figsize = (8, 4*len(rand_idx)))
[c_ax.axis('off') for c_ax in m_axs.flatten()]
for c_idx, (img_ax, attn_ax) in zip(rand_idx, m_axs):
    cur_img = test_X[c_idx:(c_idx+1)]
    attn_img = attn_func([cur_img, 0])[0]
    img_ax.imshow(cur_img[0,:,:,0], cmap = 'bone')
    attn_ax.imshow(attn_img[0, :, :, 0], cmap = 'viridis',
                   vmin = 0, vmax = 1,
                   interpolation = 'lanczos')
    real_label = test_Y[c_idx]
    img_ax.set_title('Tb-Class:%s' % (real_label))
    pred_confidence = tb_model.predict(cur_img)[0]
    t=1
    cmap = {1:[0.1,0.1,1.0,t],2:[0.1,1.0,0.1,t],3:[0.8,0.8,0.0,t]}
    labels = {1:'Not relevant',2:'Relevant',3:'Very relevant'}
    attn_ax.set_title('Attention Map-Prediction:%s' % (pred_confidence[0]))
    patches =[mpatches.Patch(color=cmap[i],label=labels[i]) for i in cmap]
    attn_ax.legend(handles=patches, bbox_to_anchor=(1.05, 1), loc=2, borderaxe
spad=0. )
fig.savefig('attention_map.png', dpi = 300)
```


Tb-Class:1

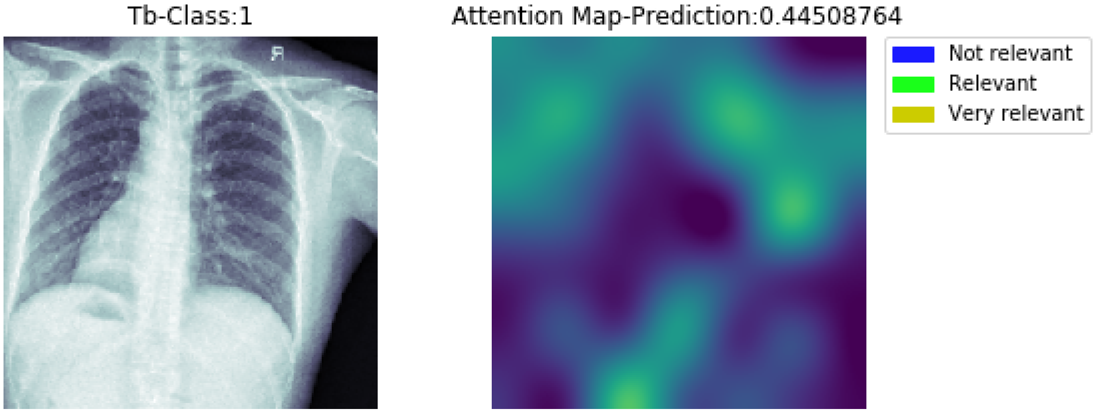
Attention Map-Prediction:0.10857909


Tb-Class:0

Attention Map-Prediction:0.09799953


Tb-Class:1

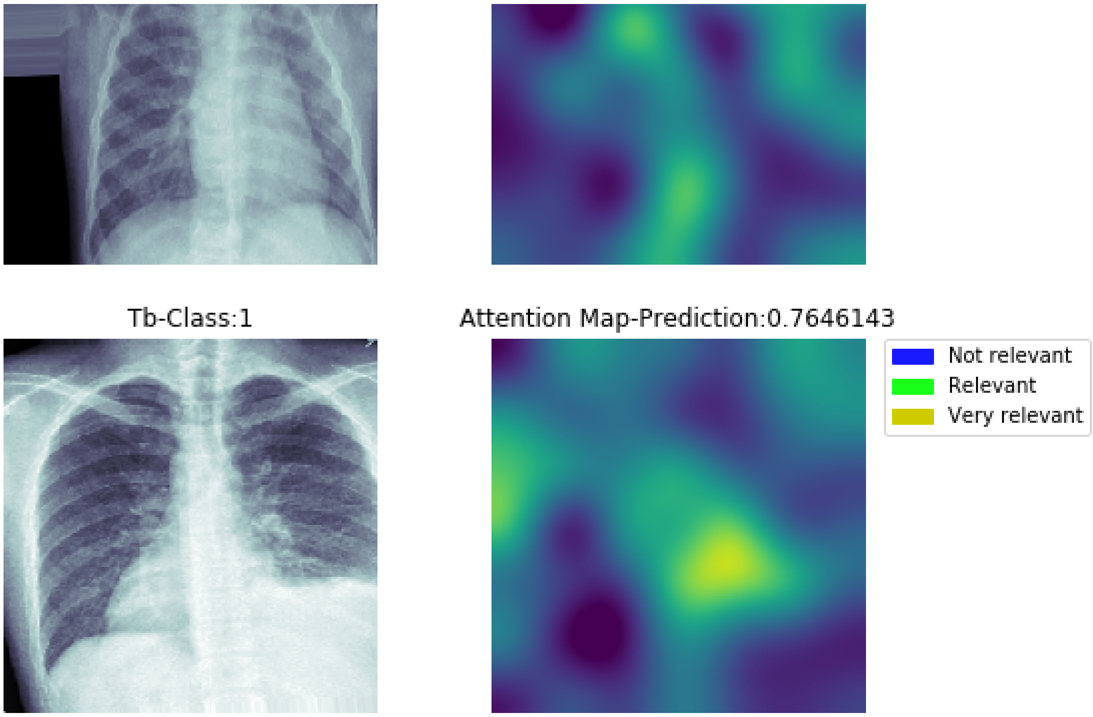
Attention Map-Prediction:0.116258286


Tb-Class:1

Attention Map-Prediction:0.44508764

Tb-Class:0

Attention Map-Prediction:0.82040644



Tb-Class:1

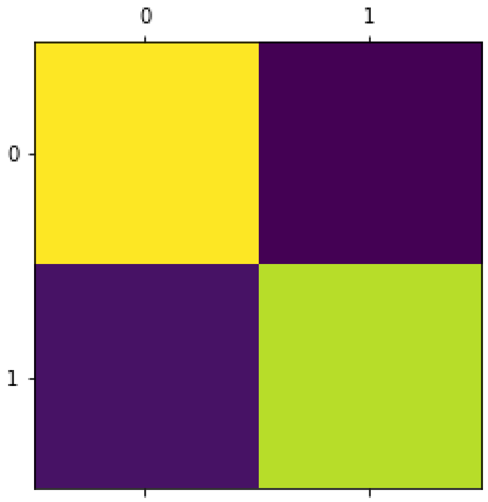
Attention Map-Prediction:0.7646143

In [21]:
```
pred_Y = tb_model.predict(test_X, batch_size = 16, verbose = True)
```

```
200/200 [==============================] - 90s 449ms/step
```

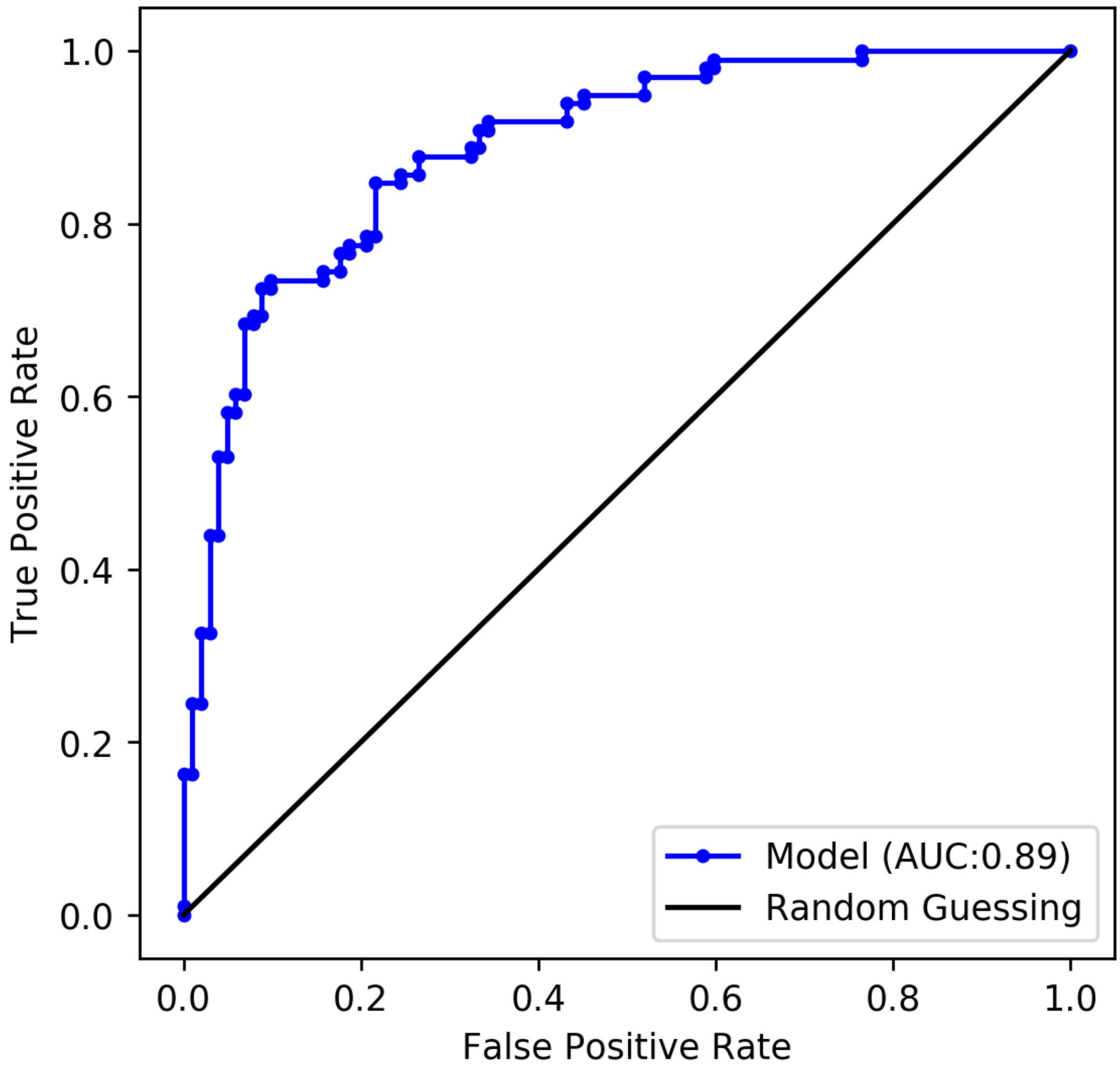
In [22]:
```
from sklearn.metrics import classification_report, confusion_matrix
plt.matshow(confusion_matrix(test_Y, pred_Y>0.5))
print(classification_report(test_Y, pred_Y>0.5, target_names = ['Healthy', 'TB']))
```

```
              precision    recall  f1-score   support

     Healthy       0.79      0.81      0.80       102
          TB       0.80      0.78      0.79        98

   micro avg       0.80      0.80      0.80       200
   macro avg       0.80      0.79      0.79       200
weighted avg       0.80      0.80      0.79       200
```



In [31]:

```python
from sklearn.metrics import roc_curve, roc_auc_score
fpr, tpr, _ = roc_curve(test_Y, pred_Y)
fig, ax1 = plt.subplots(1,1, figsize = (5, 5), dpi = 250)
ax1.plot(fpr, tpr, 'b.-', label = 'Model (AUC:%2.2f)' % roc_auc_score(test_Y,
pred_Y))
ax1.plot(fpr, fpr, 'k-', label = 'Random Guessing')
ax1.legend(loc = 4)
ax1.set_xlabel('False Positive Rate')
ax1.set_ylabel('True Positive Rate');
fig.savefig('roc.pdf')
```



In [29]:

```
import keras
from keras.callbacks import TensorBoard
# keras.callbacks.TensorBoard(log_dir='./Graph', histogram_freq=0,
#           write_graph=True, write_images=True)
# tbCallBack = keras.callbacks.TensorBoard(log_dir='Graph', histogram_freq=0,
#           write_graph=True, write_images=True)
# tbCallback.set_model(tb_model)
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-29-a2d42456def3> in <module>()
      5 tbCallBack = keras.callbacks.TensorBoard(log_dir='Graph', histogram_f
req=0,
      6           write_graph=True, write_images=True)
----> 7 tbCallback.set_model(tb_model)

NameError: name 'tbCallback' is not defined
```