In [1]:
```
import os
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn import metrics
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.tree import DecisionTreeClassifier
```

In [2]:
```
diab=pd.read_csv(r"/Users/apple/Downloads/diabetes.csv")
```

In [3]:
```
diab
```

Out[3]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Outco
0	6	148	72	35	0	33.6	0.627	50	
1	1	85	66	29	0	26.6	0.351	31	
2	8	183	64	0	0	23.3	0.672	32	
3	1	89	66	23	94	28.1	0.167	21	
4	0	137	40	35	168	43.1	2.288	33	
...	...	...	...	...	...	...	...	...	
763	10	101	76	48	180	32.9	0.171	63	
764	2	122	70	27	0	36.8	0.340	27	
765	5	121	72	23	112	26.2	0.245	30	
766	1	126	60	0	0	30.1	0.349	47	
767	1	93	70	31	0	30.4	0.315	23	

768 rows × 9 columns

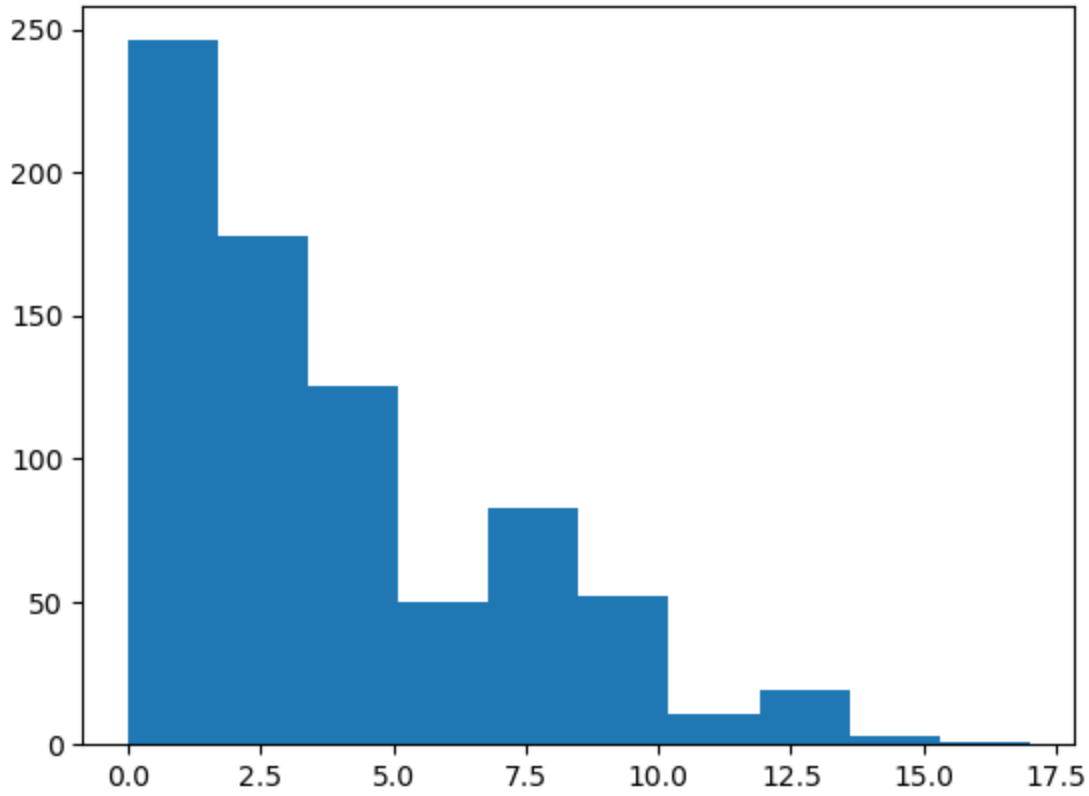
EDA

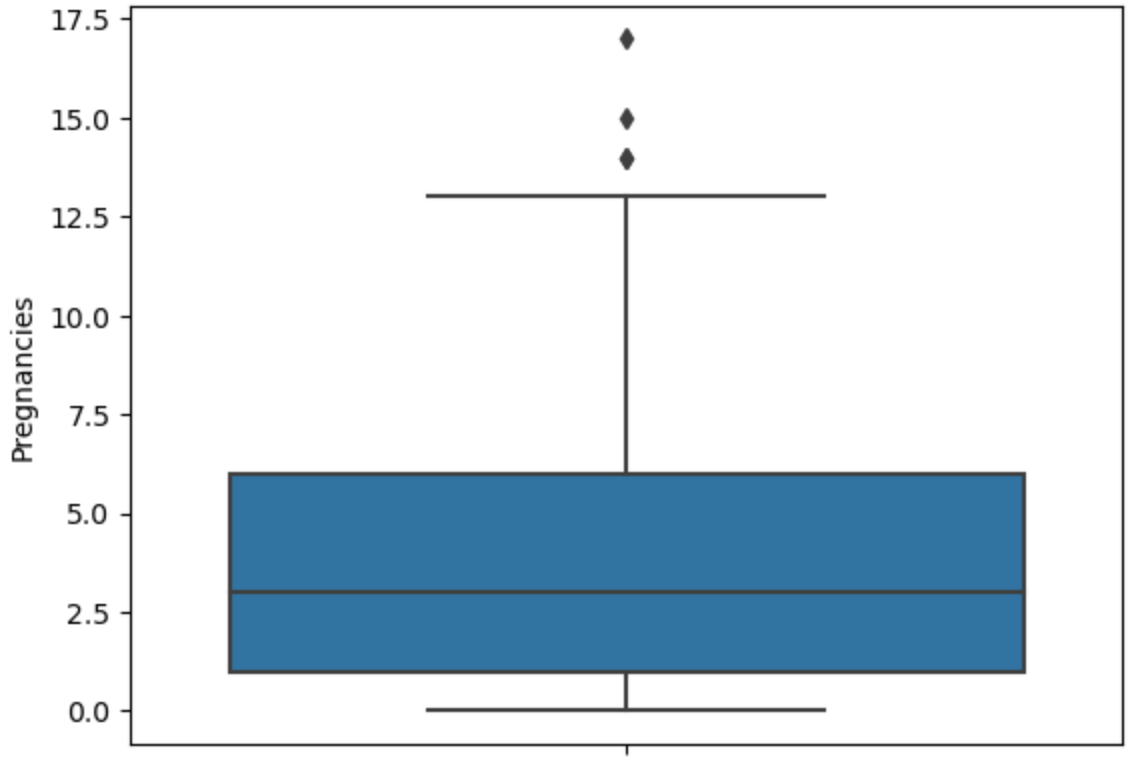
In [4]:
```
def univariate_num(data,x):
    missing=data[x].isnull().sum()
    min1=round(data[x].min(), 2)
    max1=round(data[x].max(), 2)
    mean=round(data[x].mean(), 2)
    var=round(data[x].var(), 2)
    std=round(data[x].std(),2)
    range1=round(max1-min1, 2)
    q1=round(data[x].quantile(.25), 2)
    q2=round(data[x].quantile(.5),2)
    q3=round(data[x].quantile(.75), 2)
    skew=round(data[x].skew(), 2)
    kurt=round(data[x].kurt(), 2)
    myvalue={"missing":missing, "min":min1, "max":max1, "mean":mean,
             "var":var,"std":std, "range":range1,"q1":q1, "q2":q2,"q3":q3,
            "skewness":skew, "kurtosis":kurt}
    plt.hist(data[x])
    plt.show()
    sns.boxplot(data=data, y=data[x])
    plt.show()
    return myvalue
```

In [5]:
```
diab.columns
```

Out[5]:
```
Index(['Pregnancies', 'Glucose', 'BloodPressure', 'SkinThickness', 'Insulin',
       'BMI', 'DiabetesPedigreeFunction', 'Age', 'Outcome'],
      dtype='object')
```

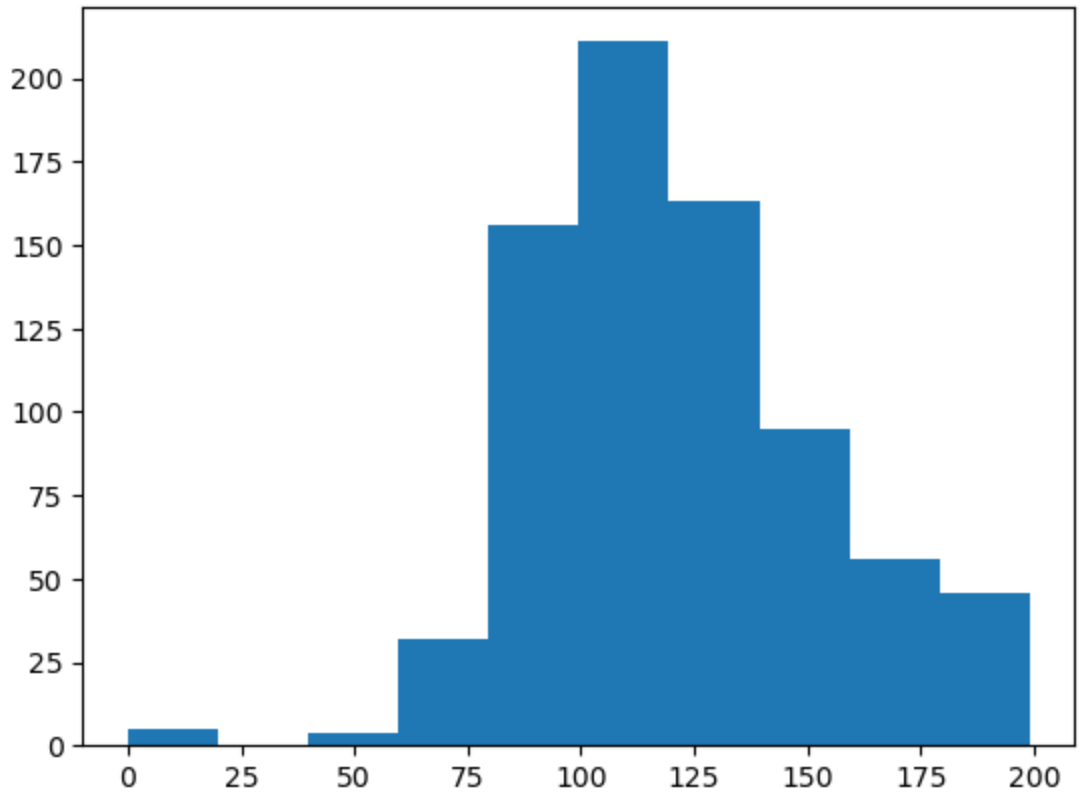
In [6]:
```
#['Pregnancies', 'Glucose', 'BloodPressure', 'SkinThickness', 'Insulin',
       #'BMI', 'DiabetesPedigreeFunction', 'Age', 'Outcome'],
univariate_num(diab,'Pregnancies')                                  # has ouliers but very
```

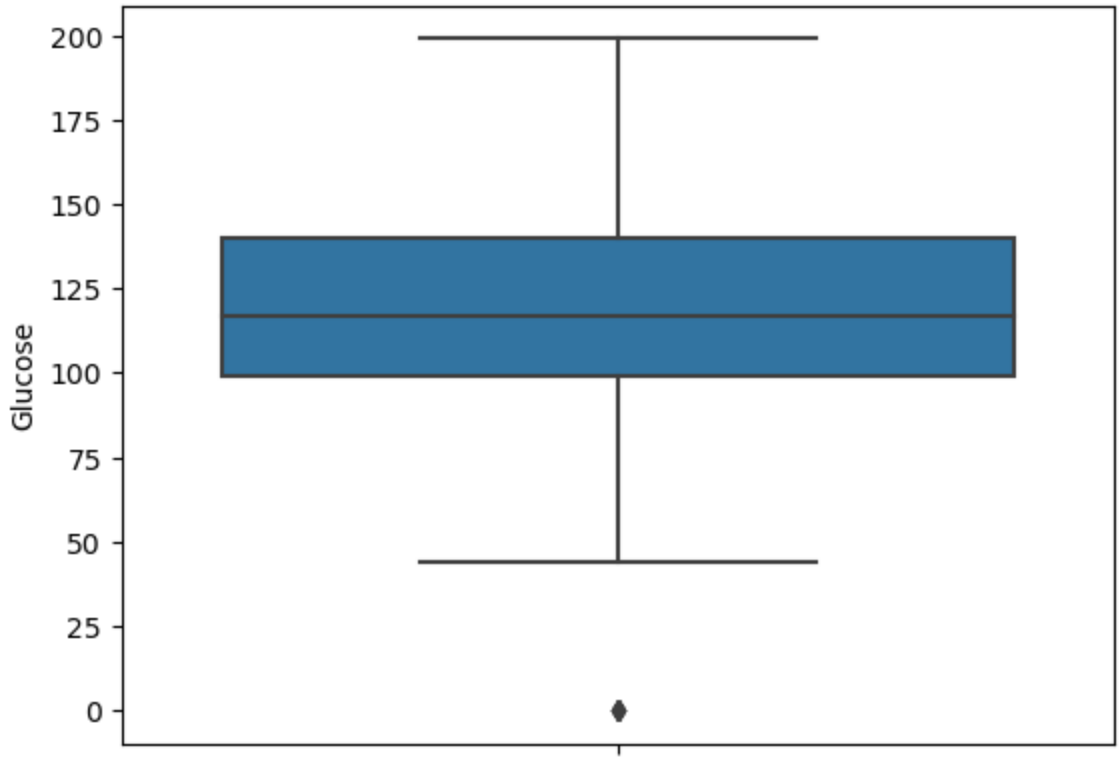




Out[6]:
```
{'missing': 0,
 'min': 0,
 'max': 17,
 'mean': 3.85,
 'var': 11.35,
 'std': 3.37,
 'range': 17,
 'q1': 1.0,
 'q2': 3.0,
 'q3': 6.0,
 'skewness': 0.9,
 'kurtosis': 0.16}
```

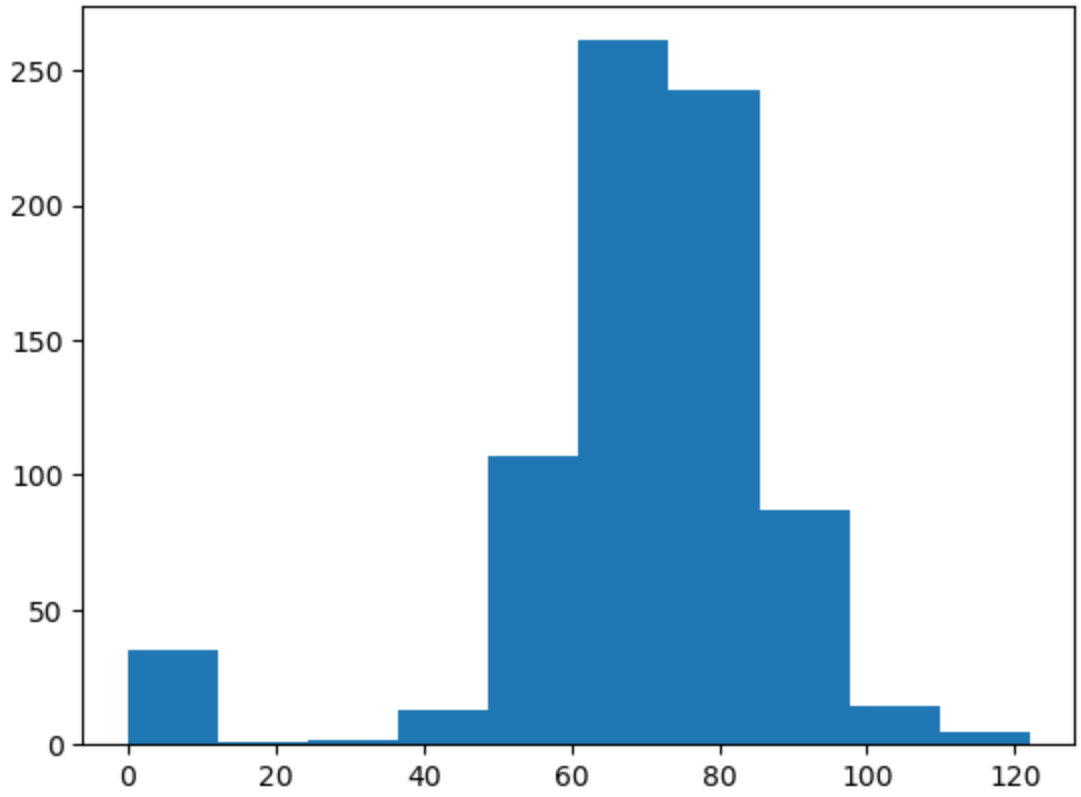
In [7]:
```
#['Pregnancies', 'Glucose', 'BloodPressure', 'SkinThickness', 'Insulin',
      #'BMI', 'DiabetesPedigreeFunction', 'Age', 'Outcome'],
univariate_num(diab,'Glucose')                                    # no outliers
```

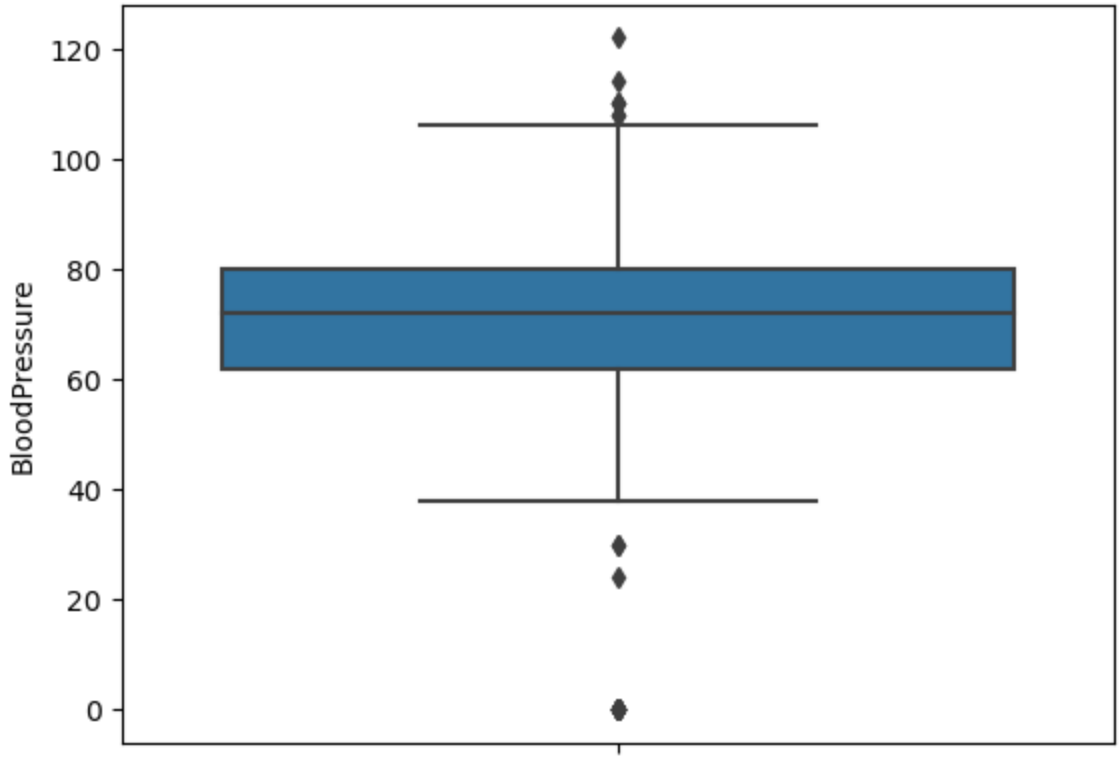




Out[7]:
```
{'missing': 0,
 'min': 0,
 'max': 199,
 'mean': 120.89,
 'var': 1022.25,
 'std': 31.97,
 'range': 199,
 'q1': 99.0,
 'q2': 117.0,
 'q3': 140.25,
 'skewness': 0.17,
 'kurtosis': 0.64}
```

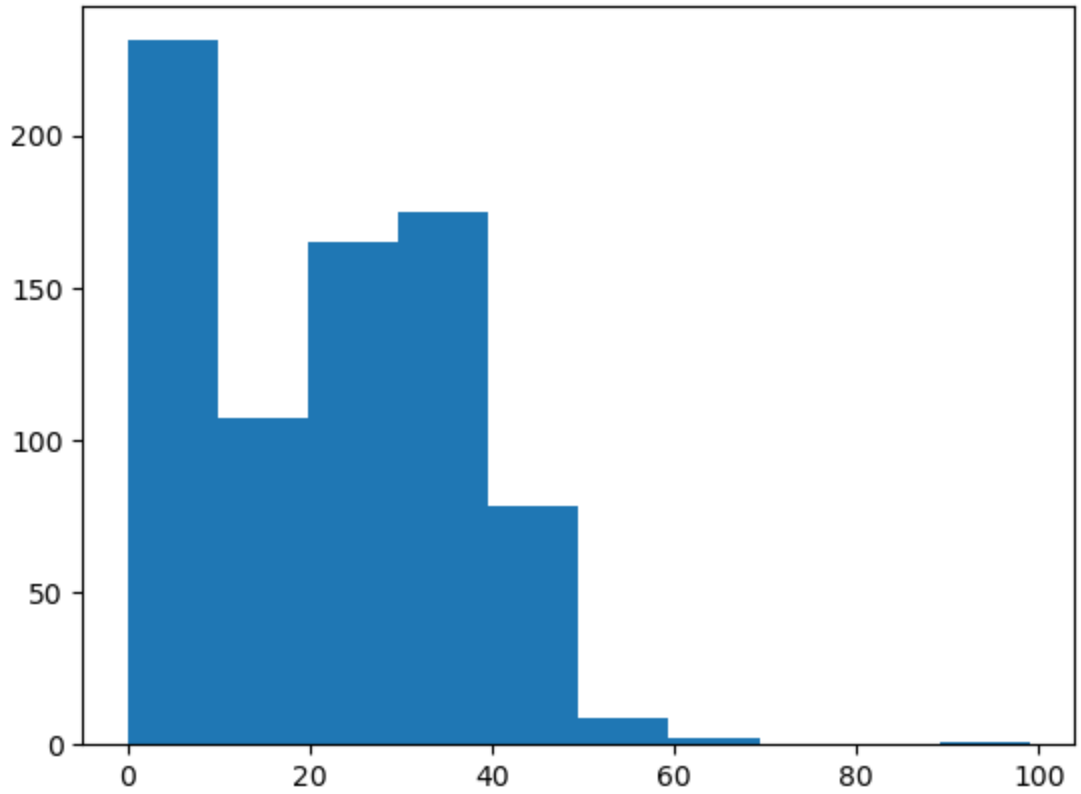
In [8]:
```
#['Pregnancies', 'Glucose', 'BloodPressure', 'SkinThickness', 'Insulin',
       #'BMI', 'DiabetesPedigreeFunction', 'Age', 'Outcome'],
univariate_num(diab,"BloodPressure")                    # less ouliers
```

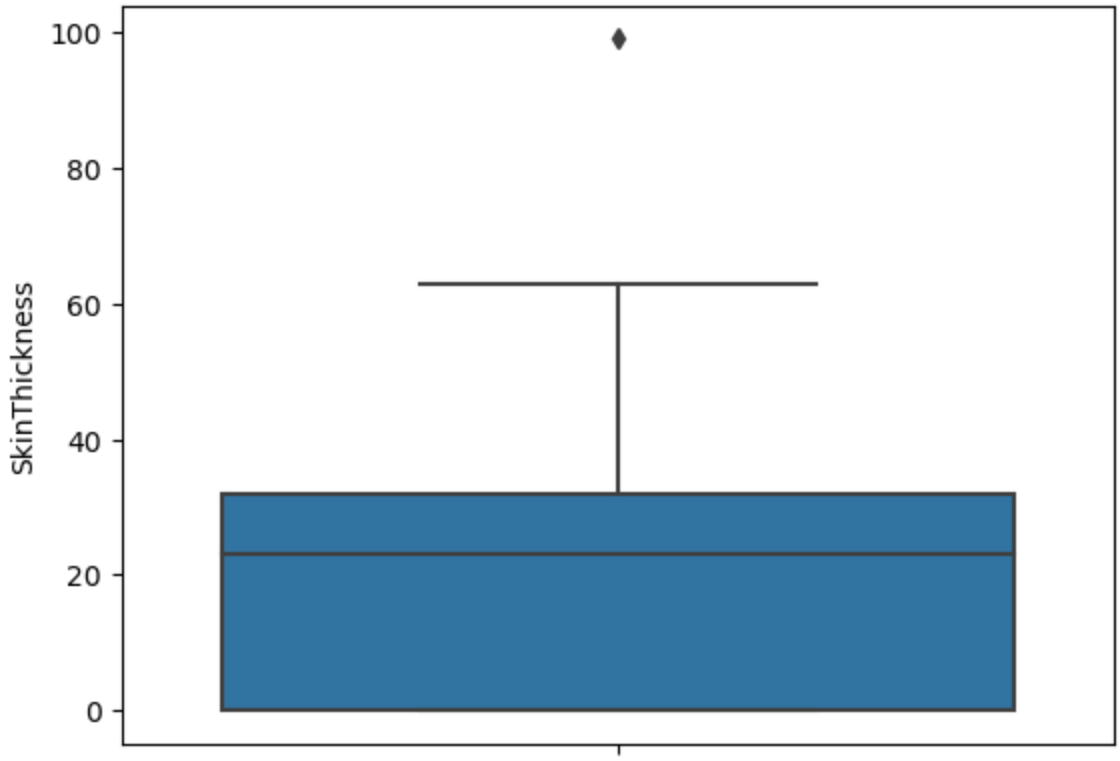




Out[8]:
```
{'missing': 0,
 'min': 0,
 'max': 122,
 'mean': 69.11,
 'var': 374.65,
 'std': 19.36,
 'range': 122,
 'q1': 62.0,
 'q2': 72.0,
 'q3': 80.0,
 'skewness': -1.84,
 'kurtosis': 5.18}
```

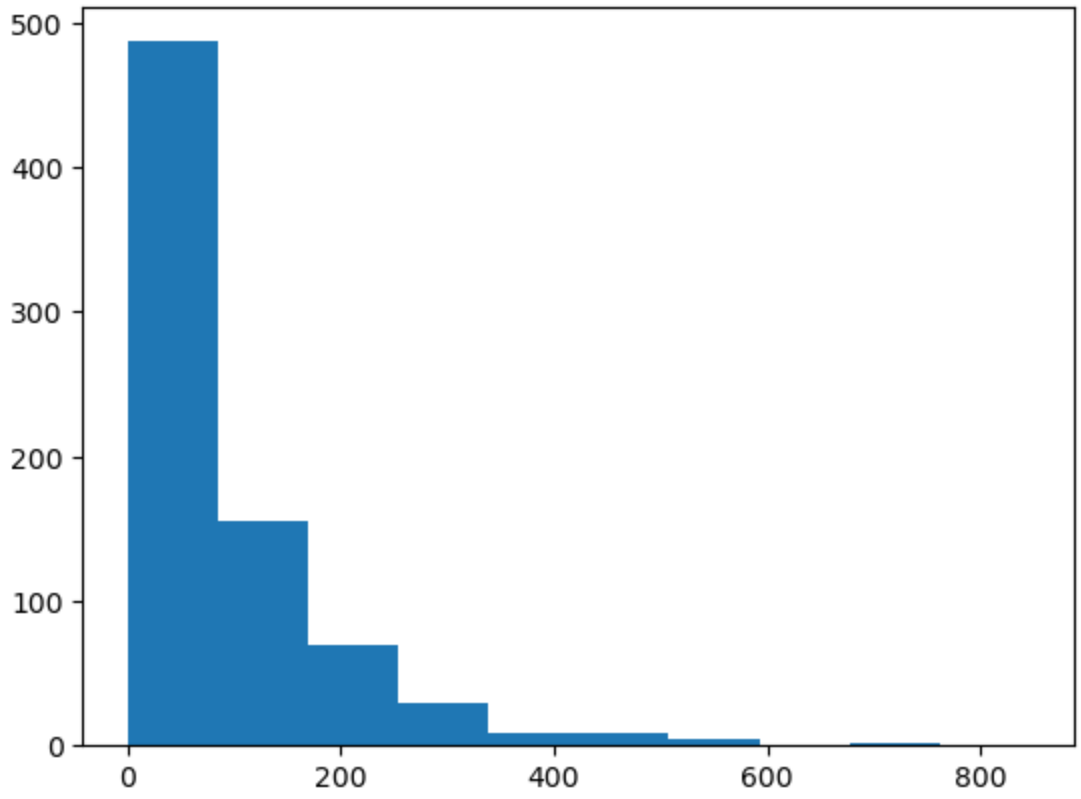
In [10]:
```
#['Pregnancies', 'Glucose', 'BloodPressure', 'SkinThickness', 'Insulin',
       #'BMI', 'DiabetesPedigreeFunction', 'Age', 'Outcome'],
univariate_num(diab,"SkinThickness")                                  # no outliers
```

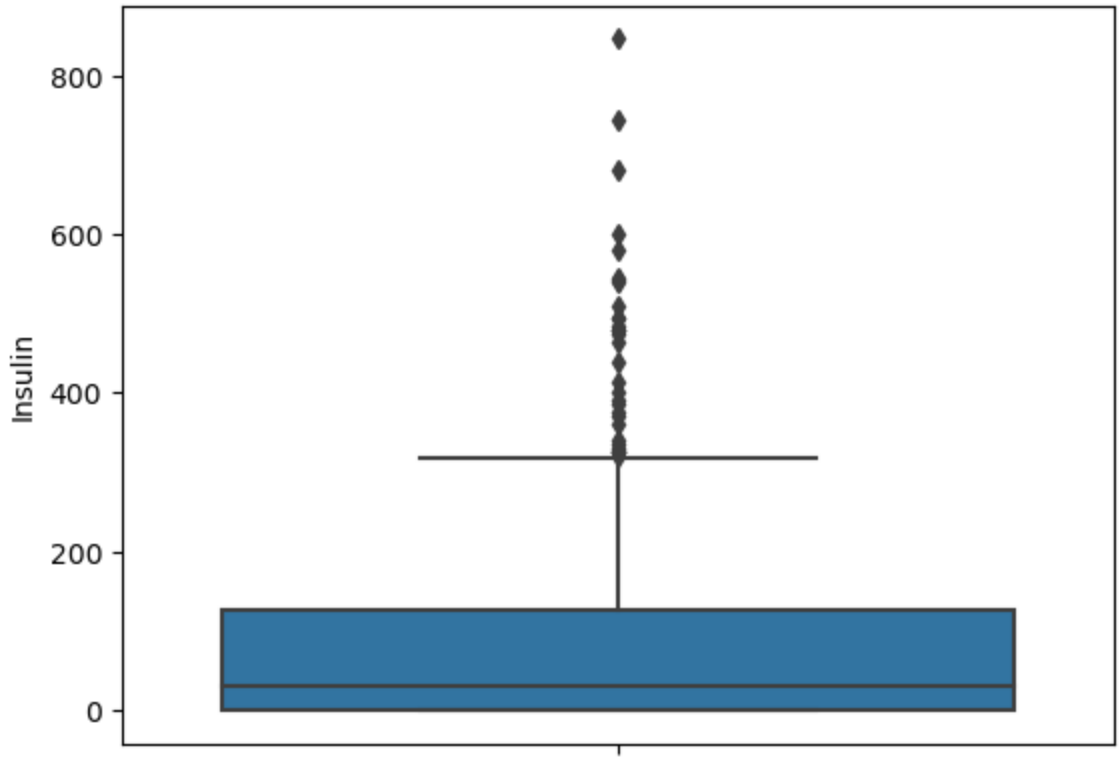




Out[10]:
```
{'missing': 0,
 'min': 0,
 'max': 99,
 'mean': 20.54,
 'var': 254.47,
 'std': 15.95,
 'range': 99,
 'q1': 0.0,
 'q2': 23.0,
 'q3': 32.0,
 'skewness': 0.11,
 'kurtosis': -0.52}
```

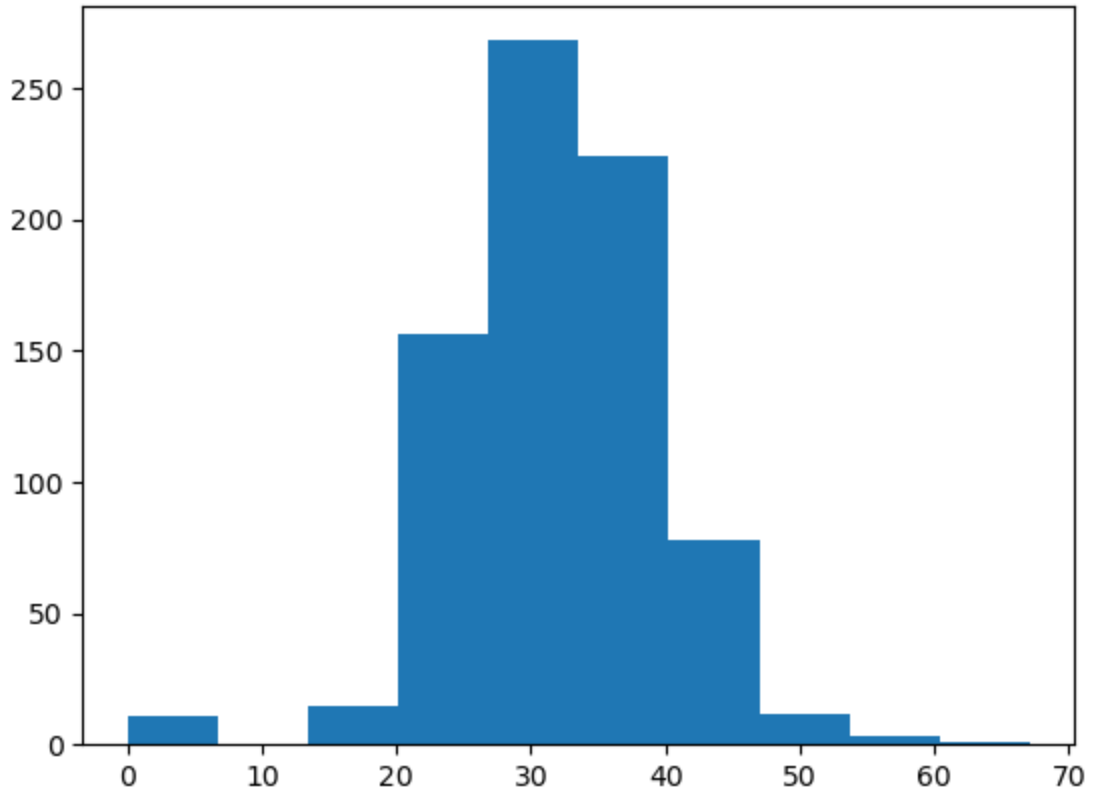
In [11]:
```
#['Pregnancies', 'Glucose', 'BloodPressure', 'SkinThickness', 'Insulin',
      #'BMI', 'DiabetesPedigreeFunction', 'Age', 'Outcome'],
univariate_num(diab,"Insulin")                              # has outliers
```

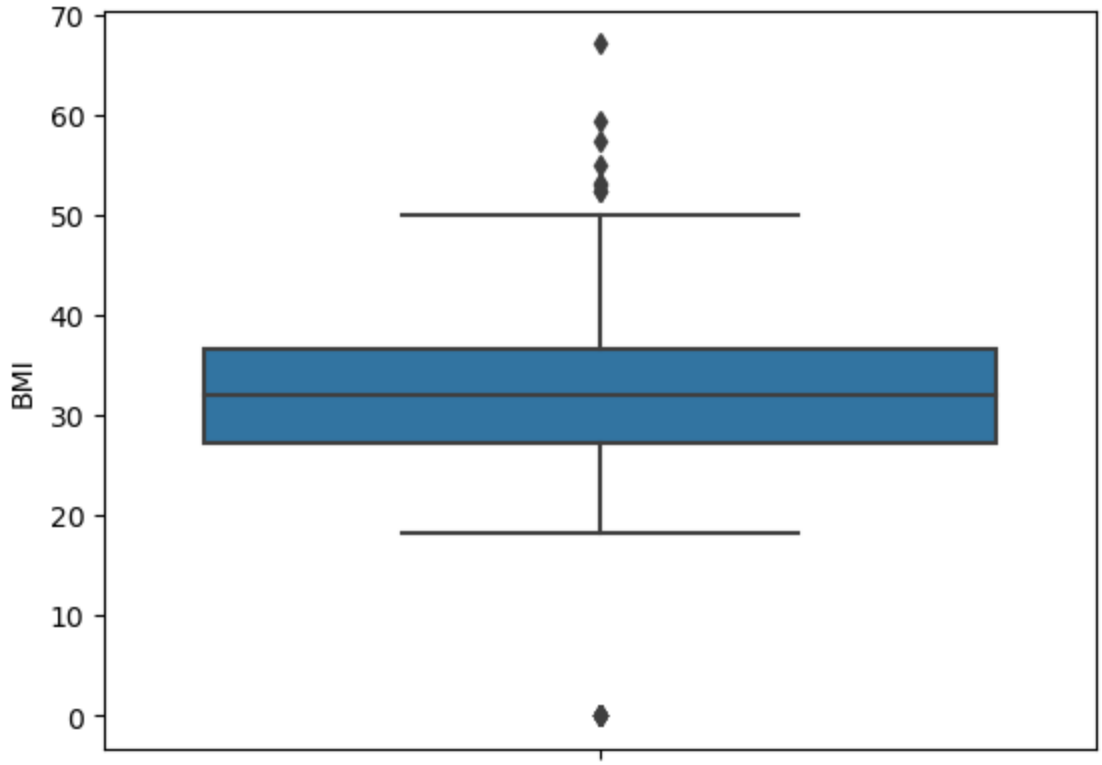




Out[11]:
```
{'missing': 0,
 'min': 0,
 'max': 846,
 'mean': 79.8,
 'var': 13281.18,
 'std': 115.24,
 'range': 846,
 'q1': 0.0,
 'q2': 30.5,
 'q3': 127.25,
 'skewness': 2.27,
 'kurtosis': 7.21}
```

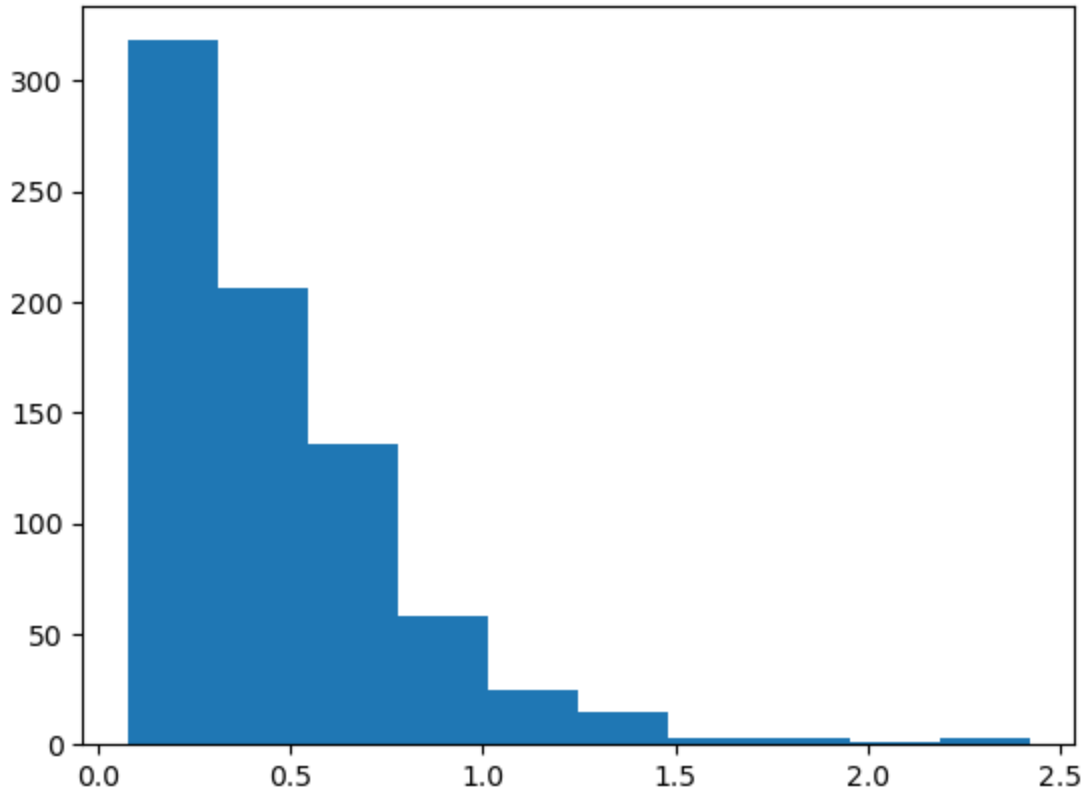
In [12]:
```
#['Pregnancies', 'Glucose', 'BloodPressure', 'SkinThickness', 'Insulin',
       #'BMI', 'DiabetesPedigreeFunction', 'Age', 'Outcome'],
univariate_num(diab,"BMI")                                    # has outliers
```

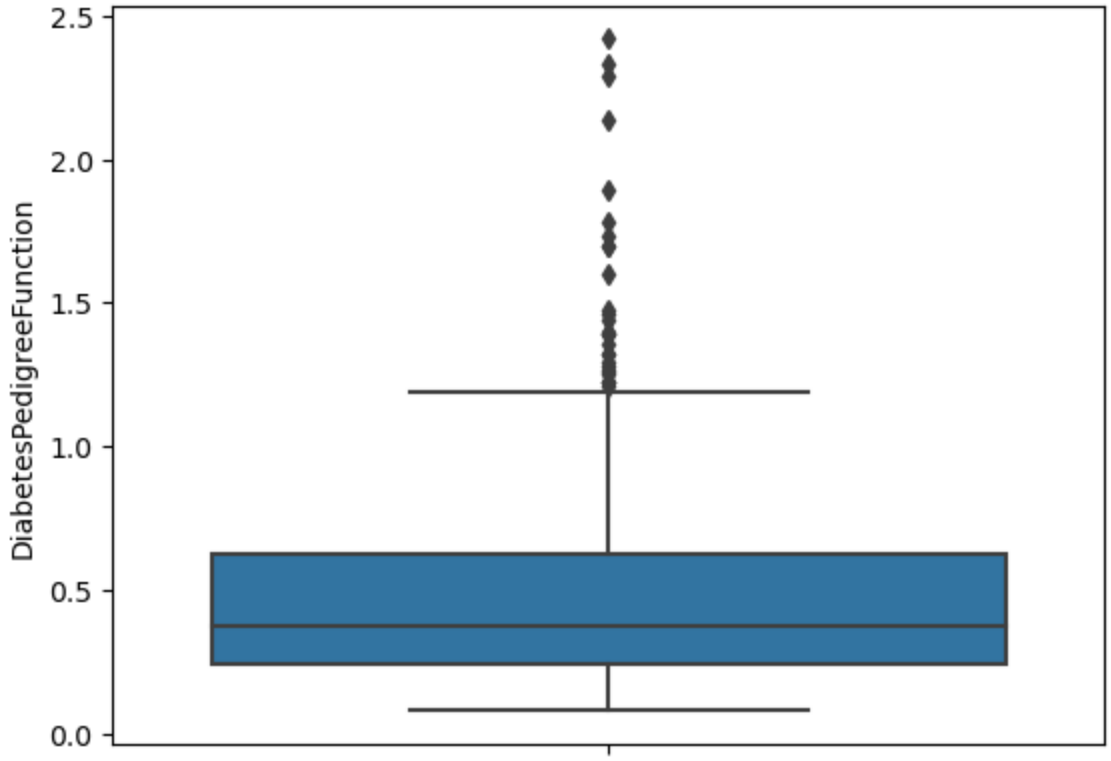




Out[12]:
```
{'missing': 0,
 'min': 0.0,
 'max': 67.1,
 'mean': 31.99,
 'var': 62.16,
 'std': 7.88,
 'range': 67.1,
 'q1': 27.3,
 'q2': 32.0,
 'q3': 36.6,
 'skewness': -0.43,
 'kurtosis': 3.29}
```

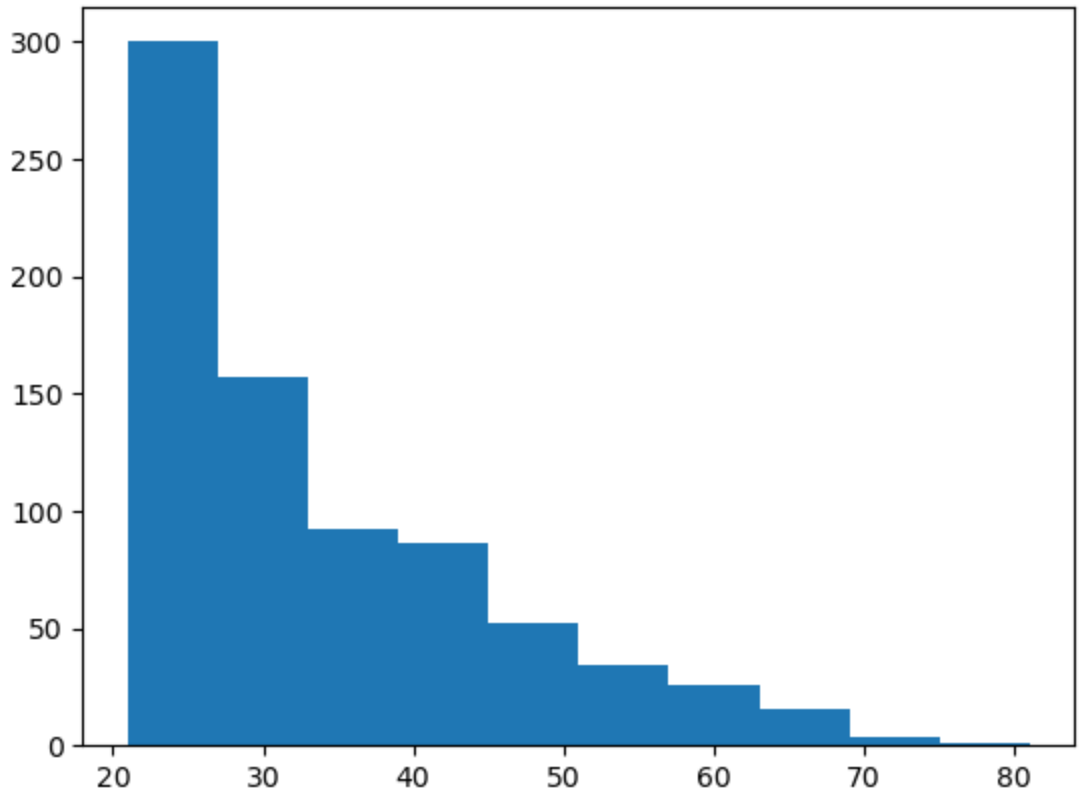
In [13]:
```
#['Pregnancies', 'Glucose', 'BloodPressure', 'SkinThickness', 'Insulin',
       #'BMI', 'DiabetesPedigreeFunction', 'Age', 'Outcome'],
univariate_num(diab,"DiabetesPedigreeFunction")                    #has outliers
```

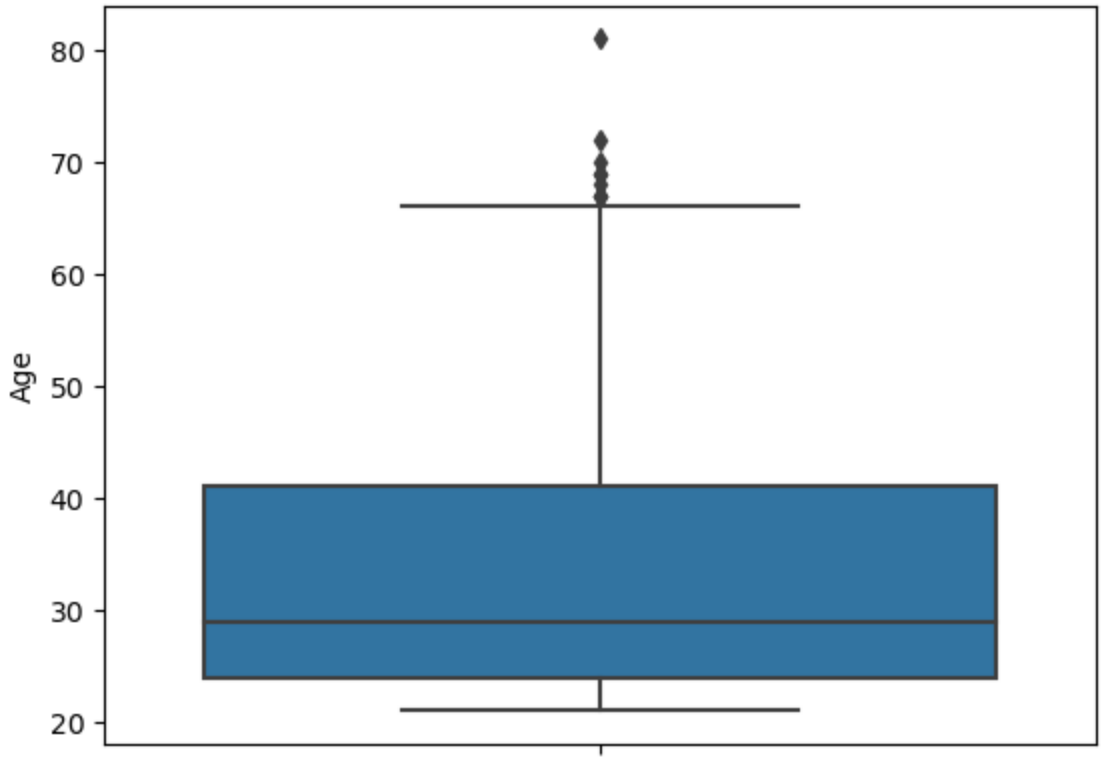




Out[13]:
```
{'missing': 0,
 'min': 0.08,
 'max': 2.42,
 'mean': 0.47,
 'var': 0.11,
 'std': 0.33,
 'range': 2.34,
 'q1': 0.24,
 'q2': 0.37,
 'q3': 0.63,
 'skewness': 1.92,
 'kurtosis': 5.59}
```

In [17]:
```
#['Pregnancies', 'Glucose', 'BloodPressure', 'SkinThickness', 'Insulin',
       #'BMI', 'DiabetesPedigreeFunction', 'Age', 'Outcome'],
univariate_num(diab,"Age")                                    # has outliers
```





Out[17]:
```
{'missing': 0,
 'min': 21,
 'max': 81,
 'mean': 33.24,
 'var': 138.3,
 'std': 11.76,
 'range': 60,
 'q1': 24.0,
 'q2': 29.0,
 'q3': 41.0,
 'skewness': 1.13,
 'kurtosis': 0.64}
```

missing value treatment

In [19]:
```
diab.isnull().sum()                    # no missing value
```

Out[19]:
```
Pregnancies                 0
Glucose                     0
BloodPressure               0
SkinThickness               0
Insulin                     0
BMI                         0
DiabetesPedigreeFunction    0
Age                         0
Outcome                     0
dtype: int64
```

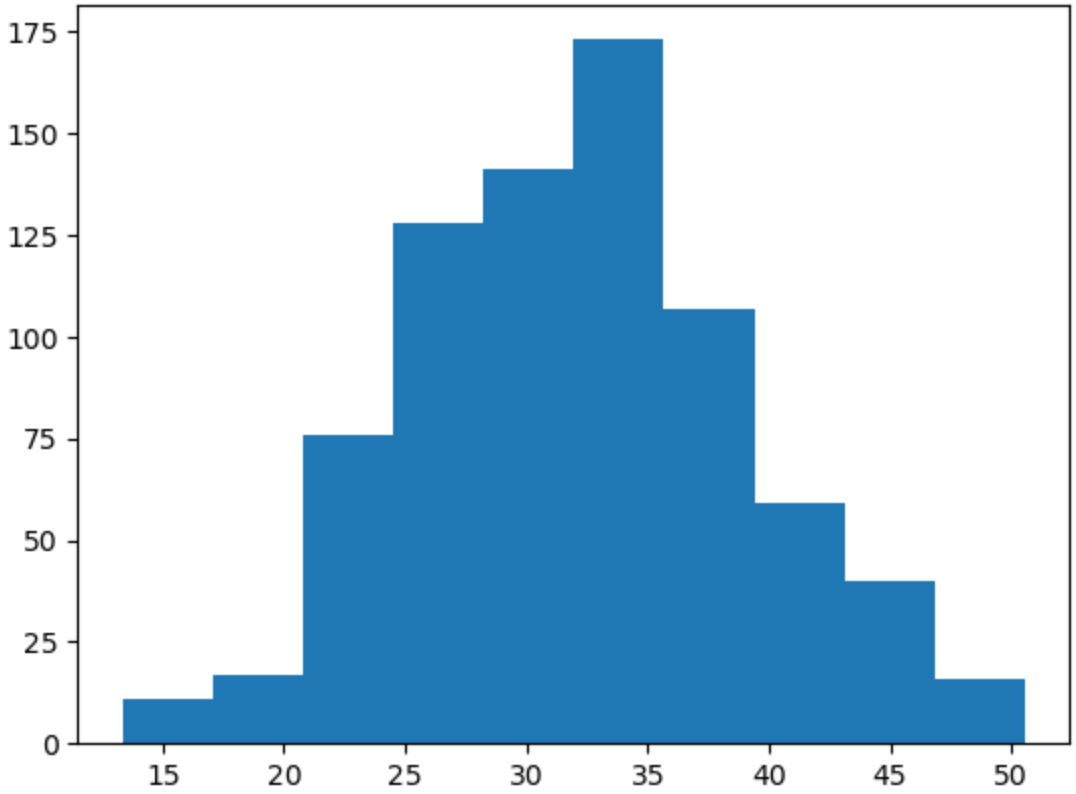
outliers treatment

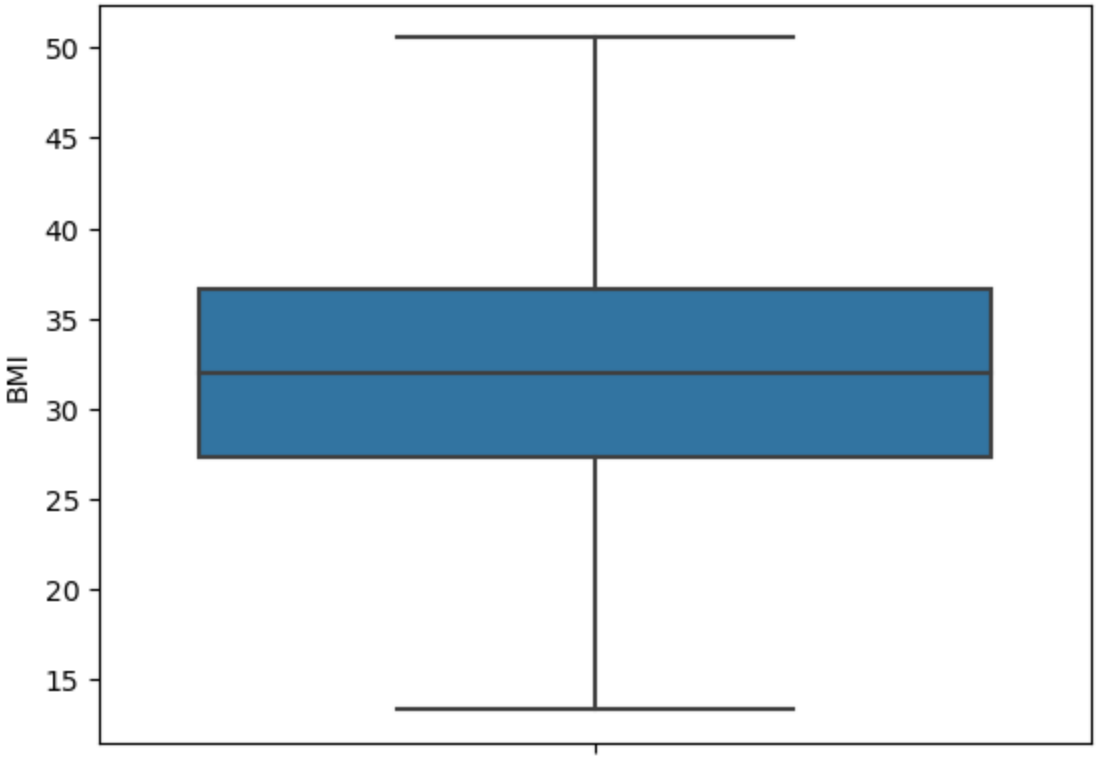
In [20]:
```
var="BMI"

q1=diab[var].quantile(.25)
q3=diab[var].quantile(.75)
lower_cap=q1-1.5*(q3-q1)
```

```
diab[var]=np.where(diab[var]>=upper_cap, upper_cap,diab[var] )
diab[var]=np.where(diab[var]<=lower_cap, lower_cap, diab[var])
```

In [22]:
```
univariate_num(diab,"BMI")
```





Out[22]:
```
{'missing': 0,
 'min': 13.35,
 'max': 50.55,
 'mean': 32.13,
 'var': 49.7,
 'std': 7.05,
 'range': 37.2,
 'q1': 27.3,
 'q2': 32.0,
 'q3': 36.6,
 'skewness': 0.14,
 'kurtosis': 0.05}
```

In [23]:
```
diab.columns
```

Out[23]:
```
Index(['Pregnancies', 'Glucose', 'BloodPressure', 'SkinThickness', 'Insulin',
       'BMI', 'DiabetesPedigreeFunction', 'Age', 'Outcome'],
      dtype='object')
```

In [25]:
```
var="Pregnancies"

q1=diab[var].quantile(.25)
q3=diab[var].quantile(.75)
lower_cap=q1-1.5*(q3-q1)
upper_cap=q3+1.5*(q3-q1)

diab[var]=np.where(diab[var]>=upper_cap, upper_cap,diab[var] )
diab[var]=np.where(diab[var]<=lower_cap, lower_cap, diab[var])
```

In [26]:
```
var="BloodPressure"

q1=diab[var].quantile(.25)
q3=diab[var].quantile(.75)
lower_cap=q1-1.5*(q3-q1)
upper_cap=q3+1.5*(q3-q1)

diab[var]=np.where(diab[var]>=upper_cap, upper_cap,diab[var] )
diab[var]=np.where(diab[var]<=lower_cap, lower_cap, diab[var])
```

In [27]:
```
var="Insulin"

q1=diab[var].quantile(.25)
q3=diab[var].quantile(.75)
lower_cap=q1-1.5*(q3-q1)
upper_cap=q3+1.5*(q3-q1)

diab[var]=np.where(diab[var]>=upper_cap, upper_cap,diab[var] )
diab[var]=np.where(diab[var]<=lower_cap, lower_cap, diab[var])
```

In [28]:
```
var="DiabetesPedigreeFunction"

q1=diab[var].quantile(.25)
q3=diab[var].quantile(.75)
lower_cap=q1-1.5*(q3-q1)
upper_cap=q3+1.5*(q3-q1)

diab[var]=np.where(diab[var]>=upper_cap, upper_cap,diab[var] )
diab[var]=np.where(diab[var]<=lower_cap, lower_cap, diab[var])
```

In [30]:
```
var="Age"

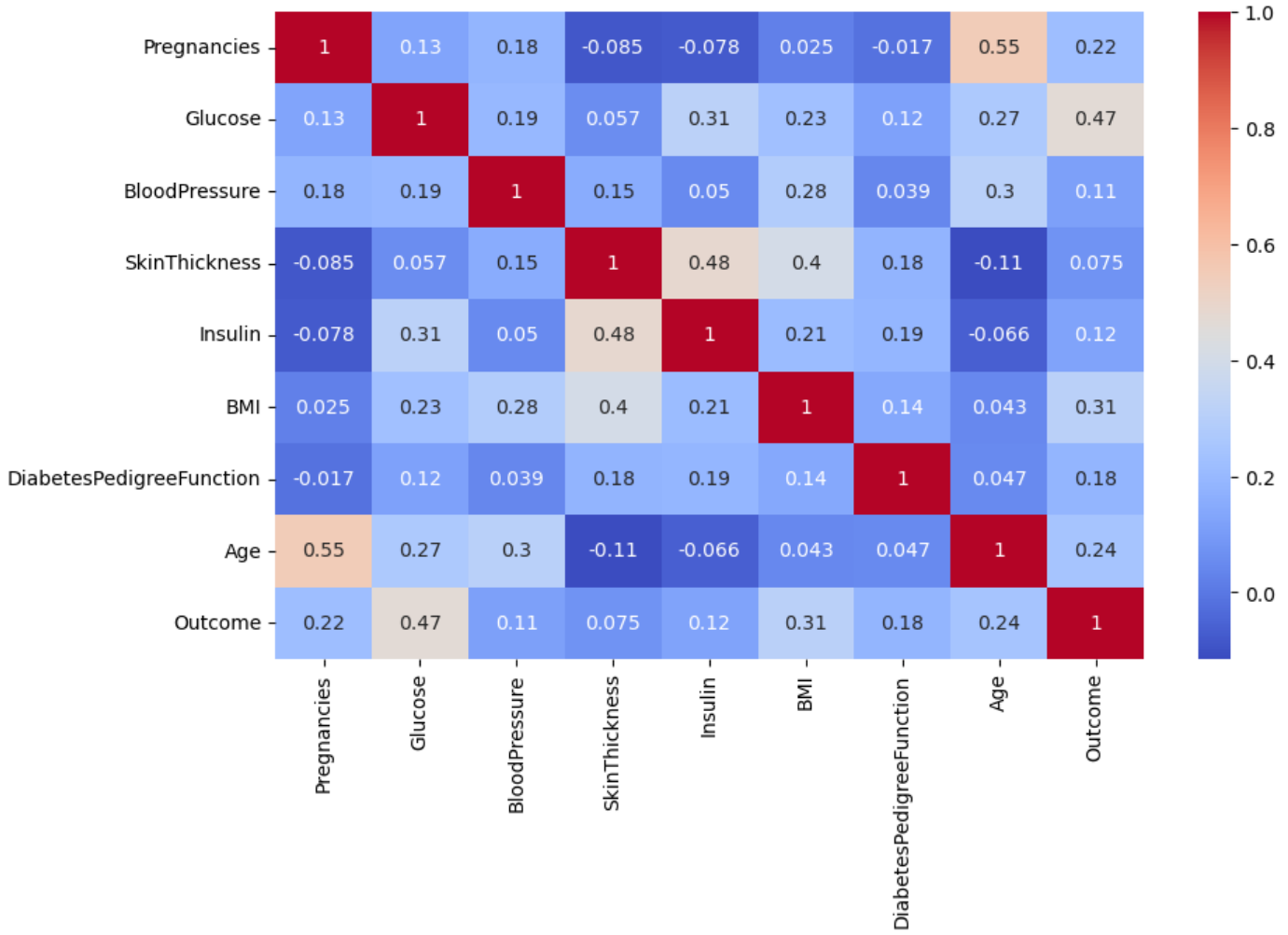
q1=diab[var].quantile(.25)
q3=diab[var].quantile(.75)
```

```
lower_cap=q1-1.5*(q3-q1)
upper_cap=q3+1.5*(q3-q1)

diab[var]=np.where(diab[var]>=upper_cap, upper_cap,diab[var] )
diab[var]=np.where(diab[var]<=lower_cap, lower_cap, diab[var])
```

multicolinearity

In [37]:
```
cr=diab.corr()
plt.figure(figsize=(10,6))
sns.heatmap(cr,annot=True,cmap="coolwarm")
plt.show()
```



model devlopment

In [52]:
```
diab1=pd.get_dummies(diab, drop_first=True)
```

In [55]:
```
x=diab1.drop(columns=["Outcome"])
y=diab1["Outcome"]
```

In [57]:
```
x_train, x_test, y_train, y_test=train_test_split(x,y, test_size=.3, random_state=0)
```

In [56]:
```
from sklearn.tree import DecisionTreeClassifier
```

In [58]:
```
dt=DecisionTreeClassifier()
```

```
print("Train Accuracy :", round(dt.score(x_train, y_train),3))
print("Test Accuracy :", round(dt.score(x_test, y_test),3))
```

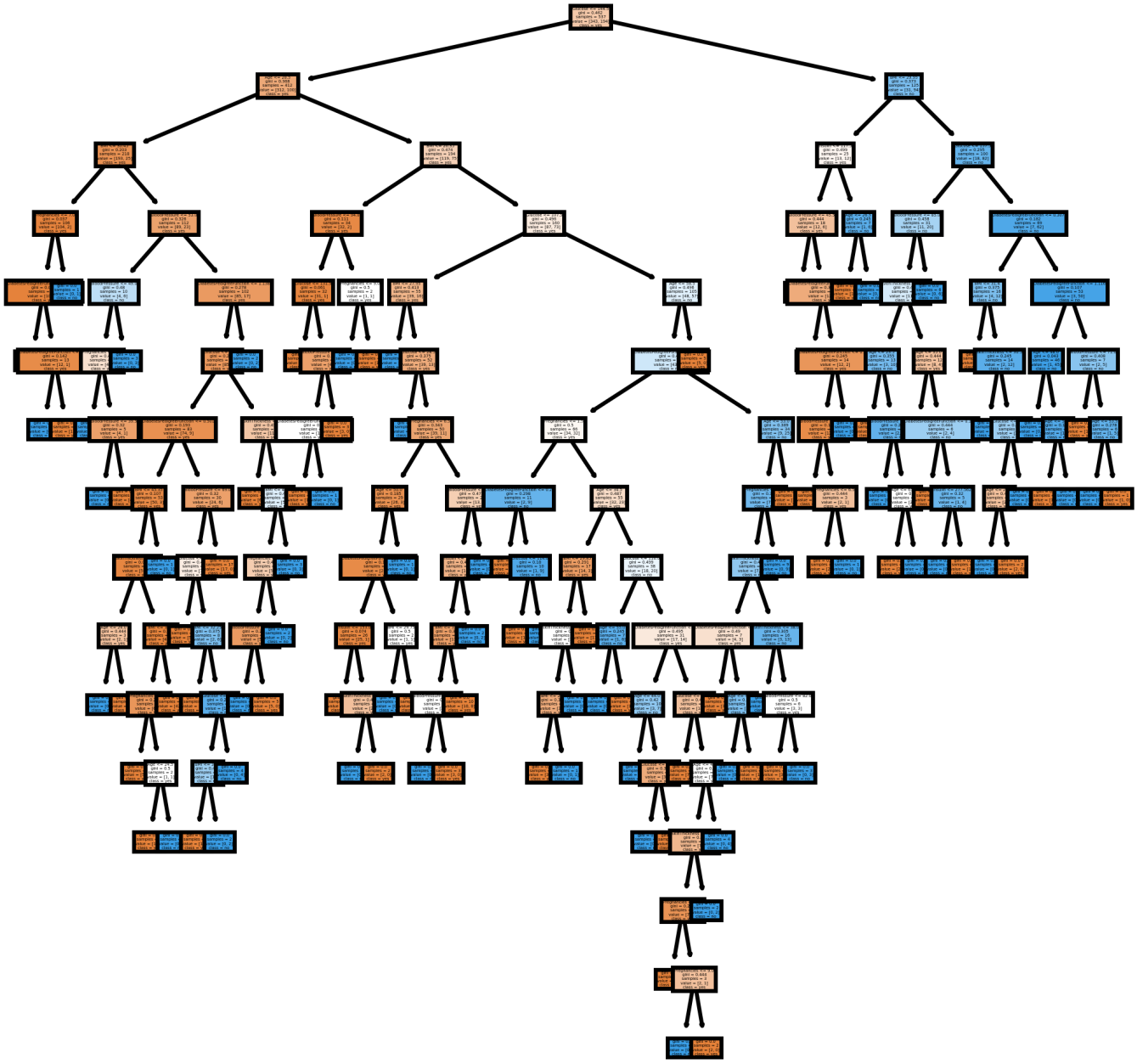
```
Train Accuracy : 1.0
Test Accuracy : 0.749
```

In [59]:

```
from sklearn.tree import plot_tree
fn=x_train.columns
cn=["yes","no"]

# Setting dpi = 300 to make image clearer than default
fig, axes = plt.subplots(nrows = 1,ncols = 1,figsize = (5,5), dpi=500)

dt_plot=plot_tree(dt,
           feature_names = fn,
           class_names=cn,
           filled = True);
```



Grid search

In [60]:
```
param={"criterion":["gini","entropy"],
      "max_depth":[5,7,9,11],
      "min_samples_split":[20,50,100,120,150],
      "min_samples_leaf":[10,20,50,80,100]}

dtg=DecisionTreeClassifier(random_state=0)

gd=GridSearchCV(estimator=dtg,param_grid=param,cv=10,n_jobs=-1,verbose=2)
gd.fit(x_train, y_train)
```

```
Fitting 10 folds for each of 200 candidates, totalling 2000 fits
[CV] END criterion=gini, max_depth=5, min_samples_leaf=10, min_samples_split=20; total t
ime=   0.0s
[CV] END criterion=gini, max_depth=5, min_samples_leaf=10, min_samples_split=20; total t
ime=   0.0s
[CV] END criterion=gini, max_depth=5, min_samples_leaf=10, min_samples_split=20; total t
ime=   0.0s
[CV] END criterion=gini, max_depth=5, min_samples_leaf=10, min_samples_split=50; total t
ime=   0.0s
[CV] END criterion=gini, max_depth=5, min_samples_leaf=10, min_samples_split=50; total t
ime=   0.0s
[CV] END criterion=gini, max_depth=5, min_samples_leaf=10, min_samples_split=50; total t
ime=   0.0s
[CV] END criterion=gini, max_depth=5, min_samples_leaf=10, min_samples_split=100; total
time=   0.0s
[CV] END criterion=gini, max_depth=5, min_samples_leaf=10, min_samples_split=120; total
time=   0.0s
[CV] END criterion=gini, max_depth=5, min_samples_leaf=10, min_samples_split=120; total
time=   0.0s
[CV] END criterion=gini, max_depth=5, min_samples_leaf=10, min_samples_split=150; total
time=   0.0s
[CV] END criterion=gini, max_depth=5, min_samples_leaf=20, min_samples_split=20; total t
ime=   0.0s
[CV] END criterion=gini, max_depth=5, min_samples_leaf=20, min_samples_split=20; total t
ime=   0.0s
[CV] END criterion=gini, max_depth=5, min_samples_leaf=20, min_samples_split=100; total
time=   0.0s
[CV] END criterion=gini, max_depth=5, min_samples_leaf=20, min_samples_split=100; total
time=   0.0s
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[CV] END criterion=gini, max_depth=11, min_samples_leaf=100, min_samples_split=150; tota
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Out[60]:

```
▸ GridSearchCV
▸ estimator: DecisionTreeClassifier
  ▸ DecisionTreeClassifier
```

```
ples_split=120; total time=   0.0s
[CV] END criterion=entropy, max_depth=5, min_samples_leaf=100, min_samples_split=120; to
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[CV] END criterion=entropy, max_depth=7, min_samples_leaf=10, min_samples_split=50; tota
l time=   0.0s
```

In [61]:
```
gd.best_params_
```

Out[61]:
```
{'criterion': 'entropy',
 'max_depth': 5,
 'min_samples_leaf': 10,
 'min_samples_split': 100}
```

In [62]:
```
gd.best_estimator_
```

Out[62]:

```
DecisionTreeClassifier(criterion='entropy', max_depth=5, min_samples_leaf=10,
                       min_samples_split=100, random_state=0)
```

In [63]:

```
dt_new=DecisionTreeClassifier(max_depth=5, min_samples_leaf=10, min_samples_split=100, r

dt_new.fit(x_train, y_train)
```

Out[63]:

```
DecisionTreeClassifier(max_depth=5, min_samples_leaf=10, min_samples_split=100,
                       random_state=0)
```

In [64]:

```
dt_new.score(x_test, y_test)
```

Out[64]:

```
0.7489177489177489
```

In [66]:

```
dt_new.score(x_train,y_train)
```

Out[66]:

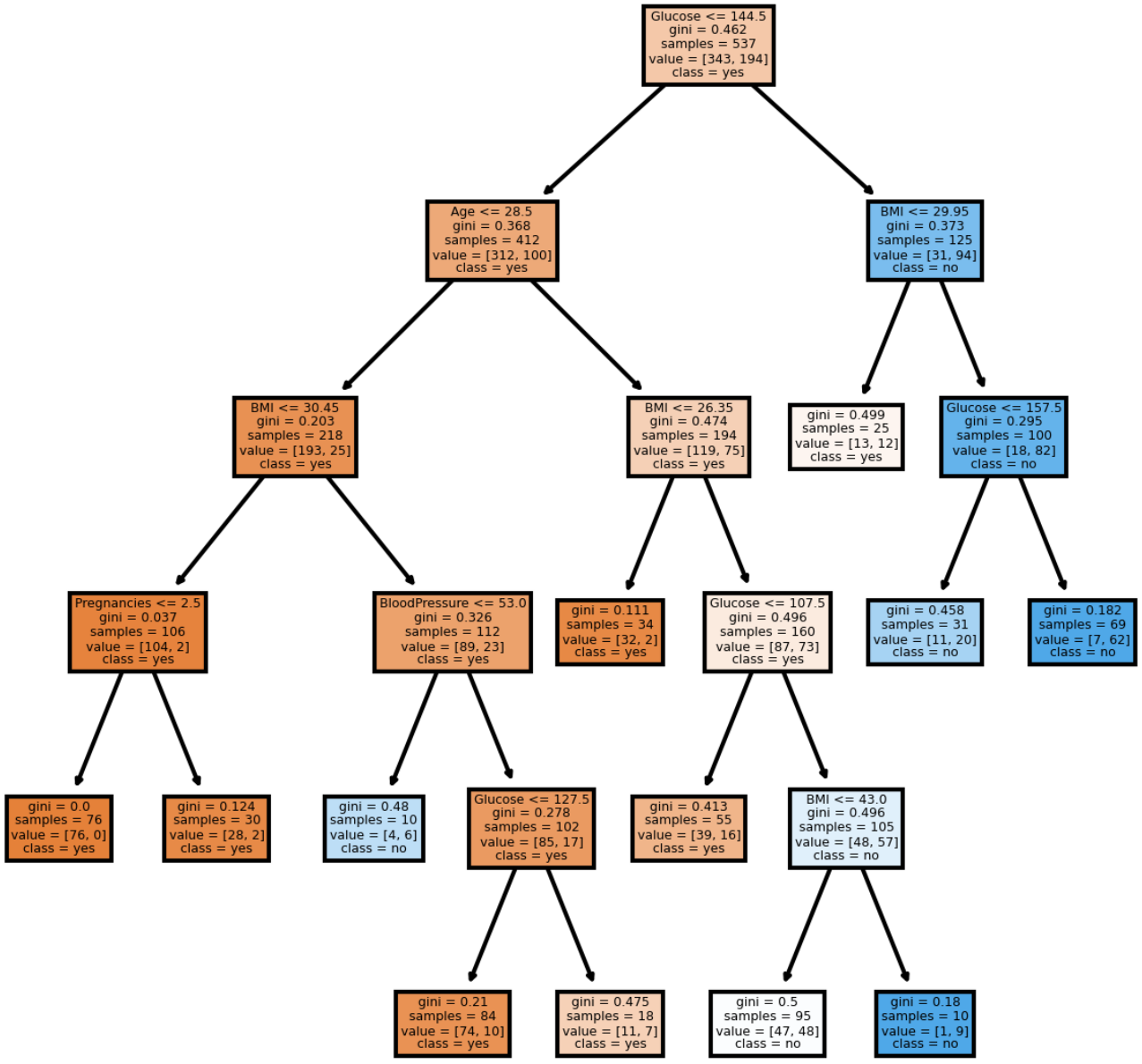
```
0.7783985102420856
```

In [67]:

```
from sklearn.tree import plot_tree
fn=x.columns
cn=["yes","no"]

fig,axes=plt.subplots(nrows=1, ncols=1, figsize=(5,5), dpi=300)

dt_plot=plot_tree(dt_new, feature_names=fn, class_names=cn, filled=True)
```



In [68]:
```
featImp=pd.DataFrame({"Variables":x_train.columns,
                      "imp":dt_new.feature_importances_}).sort_values(by=["imp"], ascendi
featImp
```

Out[68]:

	Variables	imp
1	Glucose	0.603729
5	BMI	0.204751
7	Age	0.154712
2	BloodPressure	0.034859
0	Pregnancies	0.001949
3	SkinThickness	0.000000
4	Insulin	0.000000
6	DiabetesPedigreeFunction	0.000000

In [69]:
```
dt1=DecisionTreeClassifier(max_depth=5, min_samples_leaf=10, min_samples_split=100, rand

x_train1=x_train[["Glucose","BMI","Age","Pregnancies"]]
x_test1=x_test[["Glucose","BMI","Age","Pregnancies"]]

dt1.fit(x_train1, y_train)
```

Out[69]:

▼ DecisionTreeClassifier

```
DecisionTreeClassifier(max_depth=5, min_samples_leaf=10, min_samples_split=100,
                       random_state=0)
```

In [70]:
```
dt1.score(x_train1, y_train)
```

Out[70]:
```
0.7746741154562383
```

```
[CV] END criterion=entropy, max_depth=7, min_samples_leaf=80, min_samples_split=100; tot
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```

In [72]:
```
dt1.score(x_test1,y_test)
```

Out[72]:
```
0.7489177489177489
```

In [73]:
```
from sklearn.tree import export_text

rules=export_text(dt1, feature_names=x_train1.columns.to_list())
print(rules)
```

```
|--- Glucose <= 144.50
|   |--- Age <= 28.50
|   |   |--- BMI <= 30.45
|   |   |   |--- Pregnancies <= 2.50
|   |   |   |   |--- class: 0
|   |   |   |--- Pregnancies >  2.50
|   |   |   |   |--- class: 0
|   |   |--- BMI >  30.45
|   |   |   |--- Glucose <= 127.50
|   |   |   |   |--- class: 0
|   |   |   |--- Glucose >  127.50
|   |   |   |   |--- class: 0
|   |--- Age >  28.50
|   |   |--- BMI <= 26.35
|   |   |   |--- class: 0
|   |   |--- BMI >  26.35
|   |   |   |--- Glucose <= 107.50
|   |   |   |   |--- class: 0
|   |   |   |--- Glucose >  107.50
|   |   |   |   |--- BMI <= 43.00
|   |   |   |   |   |--- class: 1
|   |   |   |   |--- BMI >  43.00
|   |   |   |   |   |--- class: 1
|--- Glucose >  144.50
|   |--- BMI <= 29.95
|   |   |--- class: 0
|   |--- BMI >  29.95
|   |   |--- Glucose <= 157.50
|   |   |   |--- class: 1
|   |   |--- Glucose >  157.50
|   |   |   |--- class: 1
```

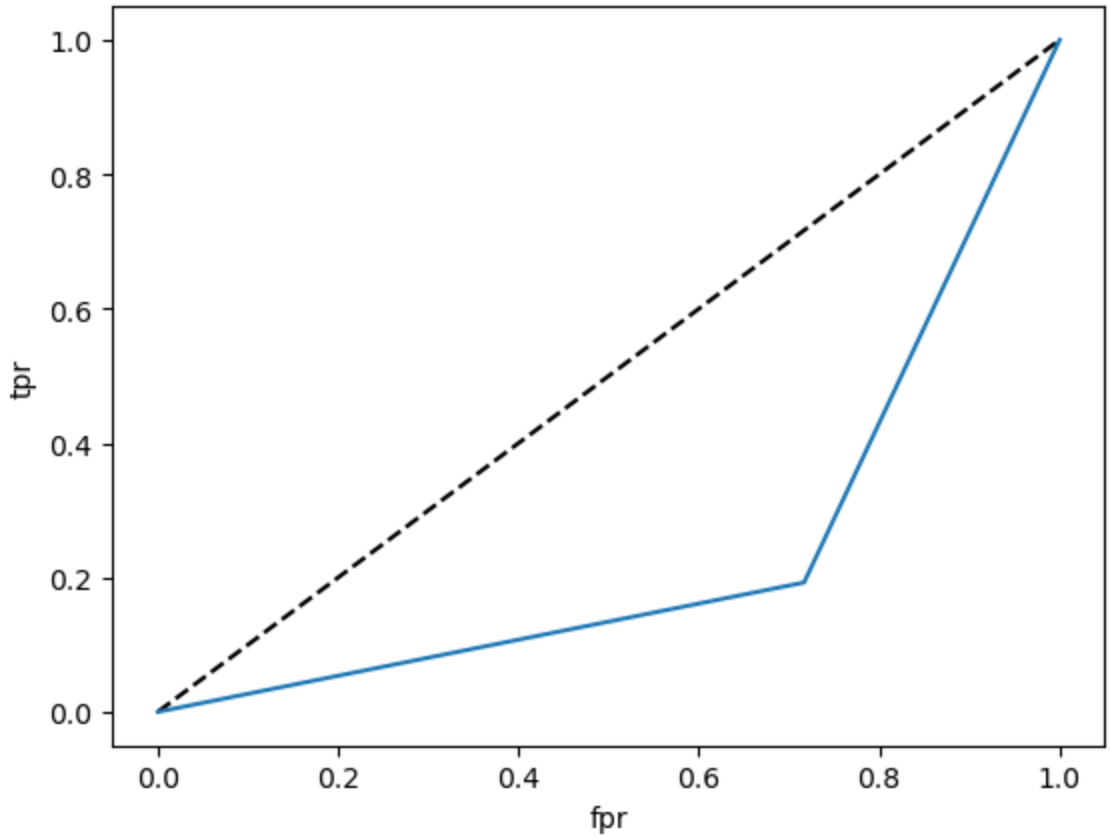
In [74]:
```
pred_train=dt1.predict(x_train1)
pred_test=dt1.predict(x_test1)
```

In [75]:
```
prob_train1=dt1.predict_proba(x_train1)[:,1]
prob_test1=dt1.predict_proba(x_test1)[:,1]
```

In [76]:
```
def class_metrics(act, pred, probs):
    ac1=metrics.accuracy_score(act, pred)
    rc1=metrics.recall_score(act, pred)
    pc1=metrics.precision_score(act, pred)
    f1=metrics.f1_score(act, pred)
    auc1=metrics.roc_auc_score(act, pred)
    result={"Accuracy":ac1, "Recall":rc1, "Precision":pc1, "F1 Score":f1, "AUC":auc1}

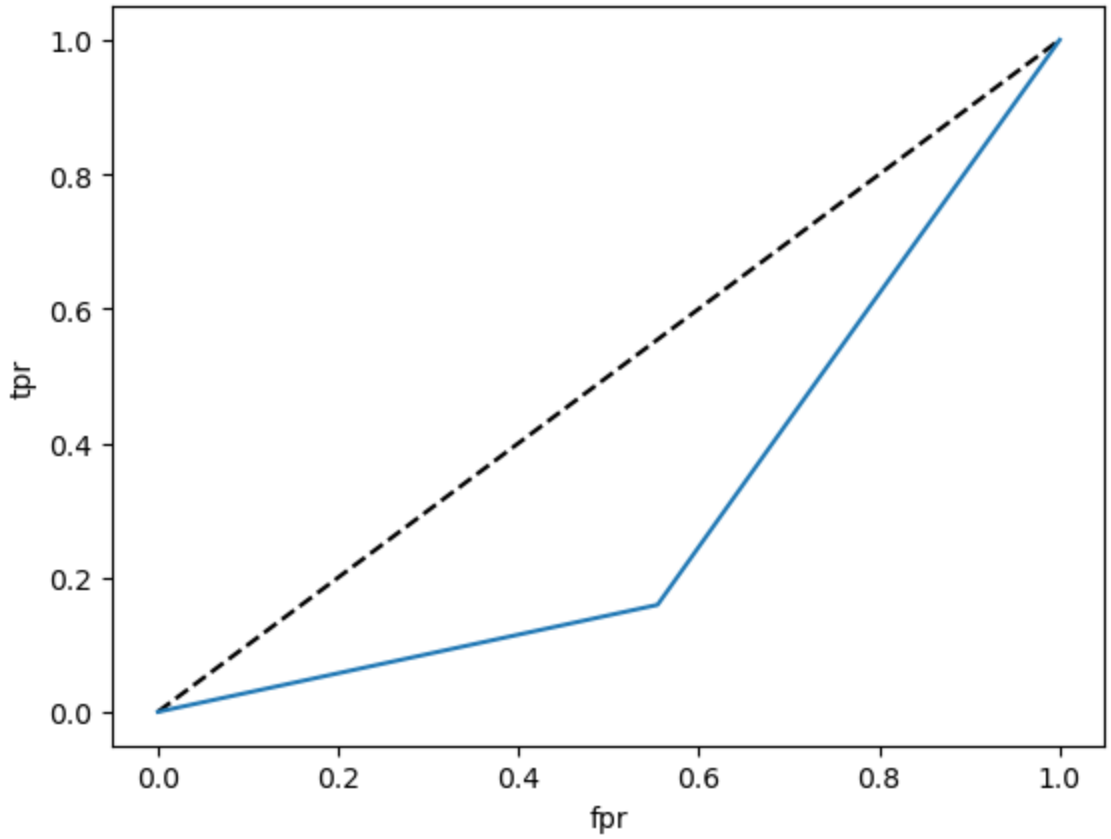
    tpr, fpr, threshold=metrics.roc_curve(act, pred)
    plt.plot([0,1],[0,1],"k--")
    plt.plot(fpr,tpr)
    plt.xlabel("fpr")
    plt.ylabel("tpr")
    plt.show()
    return result
```

In [77]:
```
class_metrics(y_train, pred_train, prob_train1)
```



Out[77]:
```
{'Accuracy': 0.7746741154562383,
 'Recall': 0.7164948453608248,
 'Precision': 0.6780487804878049,
 'F1 Score': 0.6967418546365914,
 'AUC': 0.7620375101439693}
```

In [78]:
```
class_metrics(y_test, pred_test, prob_test1)
```



Out[78]:
```
{'Accuracy': 0.7489177489177489,
 'Recall': 0.5540540540540541,
 'Precision': 0.6212121212121212,
 'F1 Score': 0.5857142857142857,
 'AUC': 0.6974091926321225}
```

In [ ]: