Senior Project Random Forest

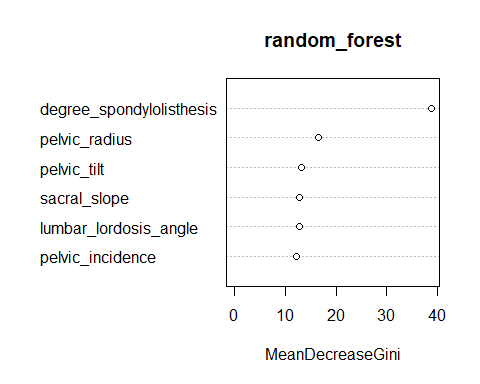
Michael Streyle

October 30th, 2018

# Introduction

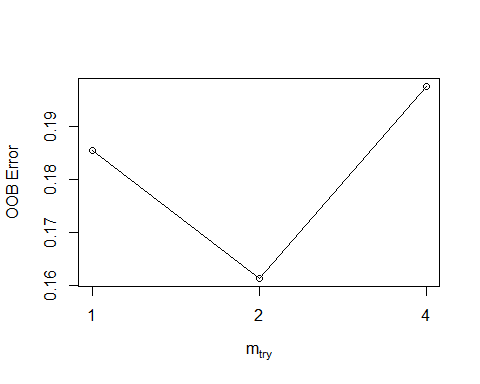
# Initial Model

MeanDecreaseGini  
pelvic\_tilt 13.15211  
pelvic\_incidence 12.14187  
lumbar\_lordosis\_angle 12.68480  
sacral\_slope 12.80926  
pelvic\_radius 16.58574  
degree\_spondylolisthesis 38.84536



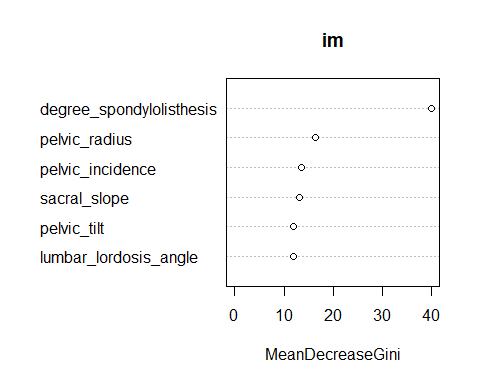
Confusion Matrix and Statistics  
  
 Reference  
Prediction Abnormal Normal  
 Abnormal 38 2  
 Normal 10 12  
   
 Accuracy : 0.8065   
 95% CI : (0.6863, 0.8958)  
 No Information Rate : 0.7742   
 P-Value [Acc > NIR] : 0.33265   
   
 Kappa : 0.5396   
 Mcnemar's Test P-Value : 0.04331   
   
 Sensitivity : 0.7917   
 Specificity : 0.8571   
 Pos Pred Value : 0.9500   
 Neg Pred Value : 0.5455   
 Prevalence : 0.7742   
 Detection Rate : 0.6129   
 Detection Prevalence : 0.6452   
 Balanced Accuracy : 0.8244   
   
 'Positive' Class : Abnormal

mtry = 2 OOB error = 16.13%   
Searching left ...  
mtry = 1 OOB error = 18.55%   
-0.15 0.05   
Searching right ...  
mtry = 4 OOB error = 19.76%   
-0.225 0.05



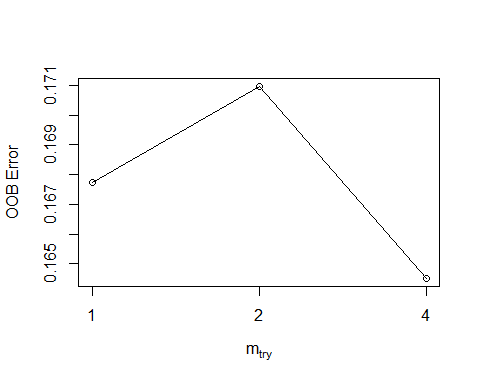
Call:  
 randomForest(x = x, y = y, mtry = res[which.min(res[, 2]), 1])   
 Type of random forest: classification  
 Number of trees: 500  
No. of variables tried at each split: 2  
  
 OOB estimate of error rate: 16.94%  
Confusion matrix:  
 Abnormal Normal class.error  
Abnormal 152 18 0.1058824  
Normal 24 54 0.3076923

MeanDecreaseGini  
pelvic\_incidence 13.60084  
pelvic\_tilt 11.98641  
lumbar\_lordosis\_angle 11.80908  
sacral\_slope 13.10558  
pelvic\_radius 16.39389  
degree\_spondylolisthesis 39.96065



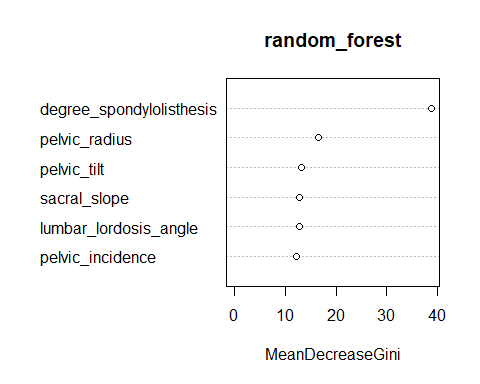
# Cross-Validation Model

mtry = 2 OOB error = 17.1%   
Searching left ...  
mtry = 1 OOB error = 16.77%   
0.01886792 0.05   
Searching right ...  
mtry = 4 OOB error = 16.45%   
0.03773585 0.05

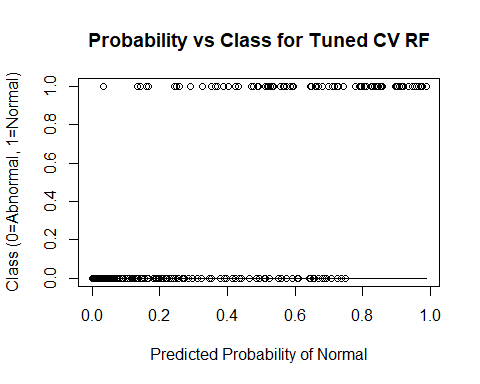


mtry OOBError  
1.OOB 1 0.1677419  
2.OOB 2 0.1709677  
4.OOB 4 0.1645161

MeanDecreaseGini  
pelvic\_tilt 13.15211  
pelvic\_incidence 12.14187  
lumbar\_lordosis\_angle 12.68480  
sacral\_slope 12.80926  
pelvic\_radius 16.58574  
degree\_spondylolisthesis 38.84536

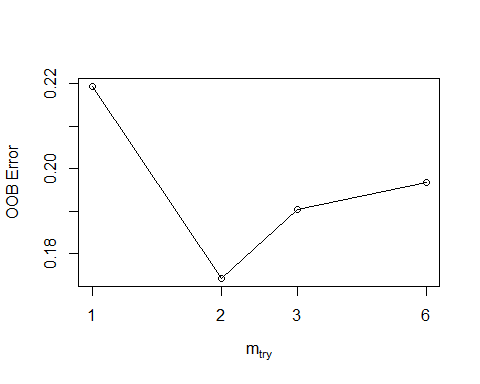


Confusion Matrix and Statistics  
  
 Reference  
Prediction Abnormal Normal  
 Abnormal 187 23  
 Normal 26 74  
   
 Accuracy : 0.8419   
 95% CI : (0.7965, 0.8807)  
 No Information Rate : 0.6871   
 P-Value [Acc > NIR] : 3.261e-10   
   
 Kappa : 0.6355   
 Mcnemar's Test P-Value : 0.7751   
   
 Sensitivity : 0.8779   
 Specificity : 0.7629   
 Pos Pred Value : 0.8905   
 Neg Pred Value : 0.7400   
 Prevalence : 0.6871   
 Detection Rate : 0.6032   
 Detection Prevalence : 0.6774   
 Balanced Accuracy : 0.8204   
   
 'Positive' Class : Abnormal



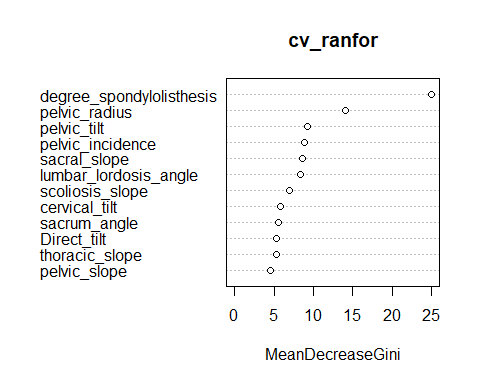
# Add Provided Random Noise

mtry = 3 OOB error = 19.03%   
Searching left ...  
mtry = 2 OOB error = 17.42%   
0.08474576 0.05   
mtry = 1 OOB error = 21.94%   
-0.2592593 0.05   
Searching right ...  
mtry = 6 OOB error = 19.68%   
-0.1296296 0.05

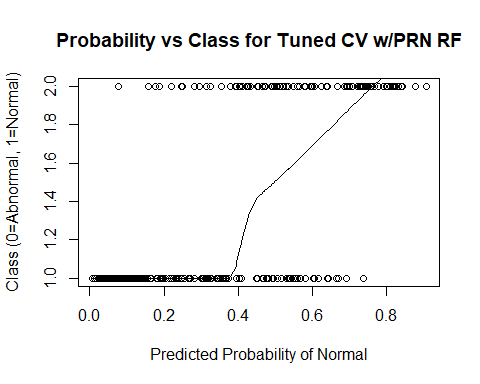


mtry OOBError  
1.OOB 1 0.2193548  
2.OOB 2 0.1741935  
3.OOB 3 0.1903226  
6.OOB 6 0.1967742

MeanDecreaseGini  
pelvic\_incidence 8.859955  
pelvic\_tilt 9.250360  
lumbar\_lordosis\_angle 8.412710  
sacral\_slope 8.561810  
pelvic\_radius 14.124541  
degree\_spondylolisthesis 25.057467  
pelvic\_slope 4.515013  
Direct\_tilt 5.361990  
thoracic\_slope 5.314960  
cervical\_tilt 5.856255  
sacrum\_angle 5.578070  
scoliosis\_slope 6.937531

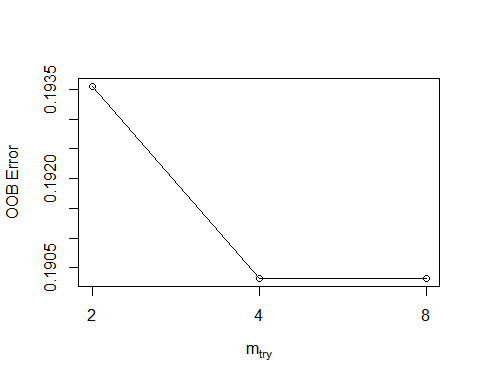


Confusion Matrix and Statistics  
  
 Reference  
Prediction Abnormal Normal  
 Abnormal 188 22  
 Normal 35 65  
   
 Accuracy : 0.8161   
 95% CI : (0.7684, 0.8577)  
 No Information Rate : 0.7194   
 P-Value [Acc > NIR] : 5.282e-05   
   
 Kappa : 0.5645   
 Mcnemar's Test P-Value : 0.112   
   
 Sensitivity : 0.8430   
 Specificity : 0.7471   
 Pos Pred Value : 0.8952   
 Neg Pred Value : 0.6500   
 Prevalence : 0.7194   
 Detection Rate : 0.6065   
 Detection Prevalence : 0.6774   
 Balanced Accuracy : 0.7951   
   
 'Positive' Class : Abnormal



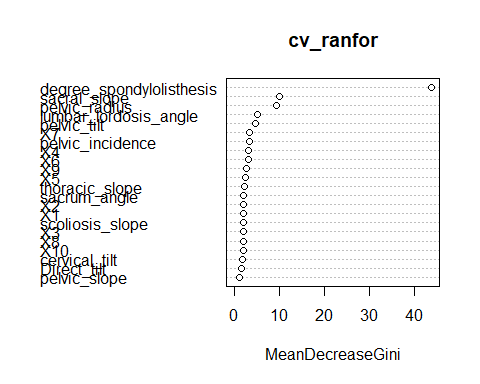
# Add 10 Random Variables

mtry = 4 OOB error = 19.03%   
Searching left ...  
mtry = 2 OOB error = 19.35%   
-0.01694915 0.05   
Searching right ...  
mtry = 8 OOB error = 19.03%   
0 0.05

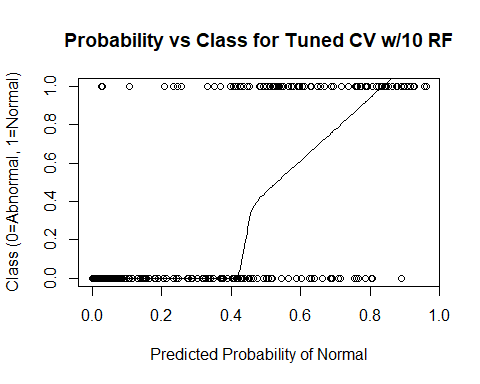


mtry OOBError  
2.OOB 2 0.1935484  
4.OOB 4 0.1903226  
8.OOB 8 0.1903226

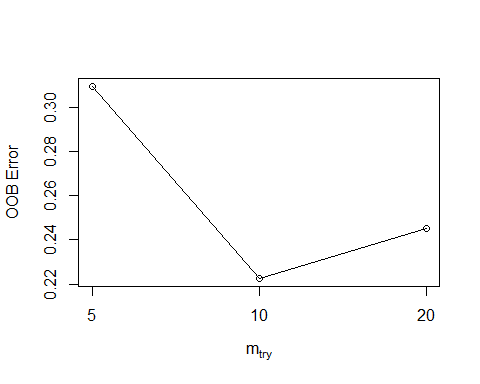
MeanDecreaseGini  
pelvic\_incidence 3.2022659  
pelvic\_tilt 4.5670598  
lumbar\_lordosis\_angle 5.0248268  
sacral\_slope 9.9702033  
pelvic\_radius 9.1985254  
degree\_spondylolisthesis 43.9117143  
pelvic\_slope 0.9751303  
Direct\_tilt 1.4061935  
thoracic\_slope 2.0743864  
cervical\_tilt 1.8274781  
sacrum\_angle 1.9724421  
scoliosis\_slope 1.8839118  
X1 1.9651829  
X2 1.9712072  
X3 1.8640025  
X4 3.1620878  
X5 2.3345345  
X6 3.1114970  
X7 3.3487048  
X8 1.8452842  
X9 2.6035675  
X10 1.8380684



Confusion Matrix and Statistics  
  
 Reference  
Prediction Abnormal Normal  
 Abnormal 185 25  
 Normal 25 75  
   
 Accuracy : 0.8387   
 95% CI : (0.7929, 0.8779)  
 No Information Rate : 0.6774   
 P-Value [Acc > NIR] : 8.779e-11   
   
 Kappa : 0.631   
 Mcnemar's Test P-Value : 1   
   
 Sensitivity : 0.8810   
 Specificity : 0.7500   
 Pos Pred Value : 0.8810   
 Neg Pred Value : 0.7500   
 Prevalence : 0.6774   
 Detection Rate : 0.5968   
 Detection Prevalence : 0.6774   
 Balanced Accuracy : 0.8155   
   
 'Positive' Class : Abnormal

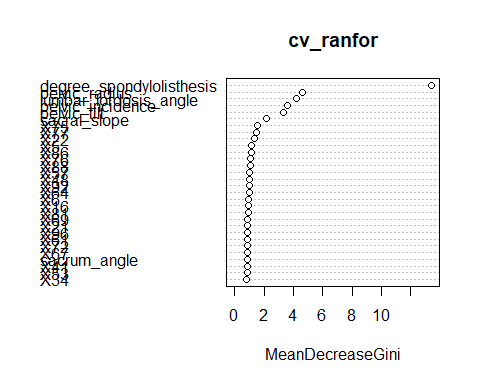
 # Add 100 Random Variables

mtry = 10 OOB error = 22.26%   
Searching left ...  
mtry = 5 OOB error = 30.97%   
-0.3913043 0.05   
Searching right ...  
mtry = 20 OOB error = 24.52%   
-0.1014493 0.05

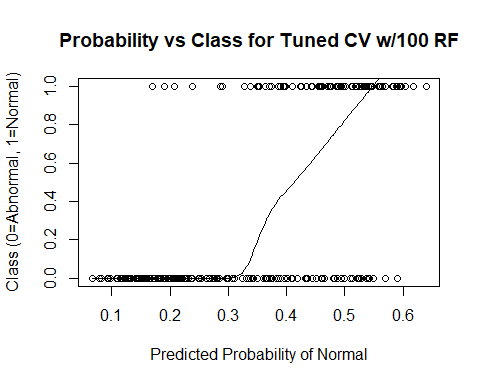


mtry OOBError  
5.OOB 5 0.3096774  
10.OOB 10 0.2225806  
20.OOB 20 0.2451613

MeanDecreaseGini  
pelvic\_incidence 3.5641762  
pelvic\_tilt 3.3364984  
lumbar\_lordosis\_angle 4.1795320  
sacral\_slope 2.1758695  
pelvic\_radius 4.6062258  
degree\_spondylolisthesis 13.4208132  
pelvic\_slope 0.5021879  
Direct\_tilt 0.4562610  
thoracic\_slope 0.6121050  
cervical\_tilt 0.6490038  
sacrum\_angle 0.8462769  
scoliosis\_slope 0.8053812  
X1 0.6778439  
X2 0.7681018  
X3 0.5986865  
X4 0.6395936  
X5 1.1574296  
X6 0.9578584  
X7 0.8195534  
X8 0.5693077  
X9 0.8036344  
X10 0.5131597  
X11 0.6718749  
X12 0.8218499  
X13 0.6936367  
X14 0.8080790  
X15 0.7415135  
X16 0.9315695  
X17 0.8227422  
X18 0.7675297  
X19 0.6834504  
X20 0.5525062  
X21 0.8873626  
X22 1.3218316  
X23 0.4555300  
X24 0.7460673  
X25 0.8135725  
X26 0.8221727  
X27 0.8228608  
X28 0.6093707  
X29 0.8005218  
X30 0.4597668  
X31 0.4503310  
X32 0.5027736  
X33 0.4704129  
X34 0.8271870  
X35 0.6919351  
X36 0.4129119  
X37 0.4176781  
X38 0.4859588  
X39 0.6571532  
X40 0.5607707  
X41 0.8422408  
X42 0.6237343  
X43 0.5391351  
X44 0.6084440  
X45 0.5481742  
X46 0.6294841  
X47 0.5116424  
X48 1.0152811  
X49 0.4335624  
X50 0.4320520  
X51 0.6124192  
X52 0.6786963  
X53 0.8362618  
X54 0.7361601  
X55 0.7630174  
X56 0.5427745  
X57 1.0309441  
X58 0.6285753  
X59 0.4628716  
X60 0.5709009  
X61 0.8848405  
X62 0.6564414  
X63 0.8029348  
X64 0.9675891  
X65 0.4215953  
X66 0.5415668  
X67 0.8627367  
X68 0.6104719  
X69 0.8989694  
X70 0.5206083  
X71 0.4498217  
X72 0.8733714  
X73 0.7831430  
X74 0.5914240  
X75 1.5269245  
X76 1.0941257  
X77 1.4513585  
X78 0.6886498  
X79 0.7448360  
X80 0.5132508  
X81 0.9279296  
X82 0.7091917  
X83 0.5736508  
X84 0.6183928  
X85 0.5801355  
X86 1.1174080  
X87 0.6260272  
X88 1.0469253  
X89 0.6245683  
X90 0.7147637  
X91 0.5763333  
X92 1.0072758  
X93 0.5329751  
X94 0.7784585  
X95 0.7014517  
X96 0.8857833  
X97 0.6277713  
X98 0.6463808  
X99 0.7828845  
X100 0.6499342

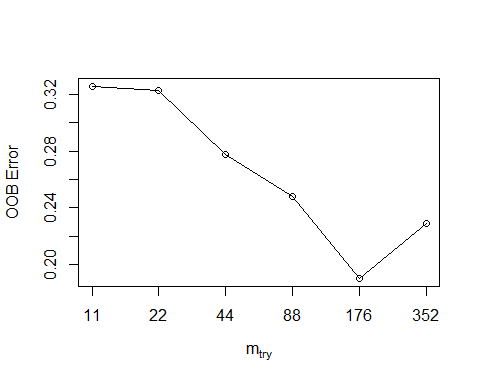


Confusion Matrix and Statistics  
  
 Reference  
Prediction Abnormal Normal  
 Abnormal 192 18  
 Normal 58 42  
   
 Accuracy : 0.7548   
 95% CI : (0.703, 0.8017)  
 No Information Rate : 0.8065   
 P-Value [Acc > NIR] : 0.9896   
   
 Kappa : 0.3734   
 Mcnemar's Test P-Value : 7.691e-06   
   
 Sensitivity : 0.7680   
 Specificity : 0.7000   
 Pos Pred Value : 0.9143   
 Neg Pred Value : 0.4200   
 Prevalence : 0.8065   
 Detection Rate : 0.6194   
 Detection Prevalence : 0.6774   
 Balanced Accuracy : 0.7340   
   
 'Positive' Class : Abnormal



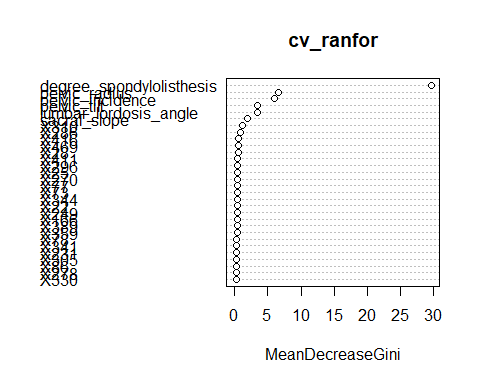
# Add 500 Random Variables

mtry = 22 OOB error = 32.26%   
Searching left ...  
mtry = 11 OOB error = 32.58%   
-0.01 0.05   
Searching right ...  
mtry = 44 OOB error = 27.74%   
0.14 0.05   
mtry = 88 OOB error = 24.84%   
0.1046512 0.05   
mtry = 176 OOB error = 19.03%   
0.2337662 0.05   
mtry = 352 OOB error = 22.9%   
-0.2033898 0.05

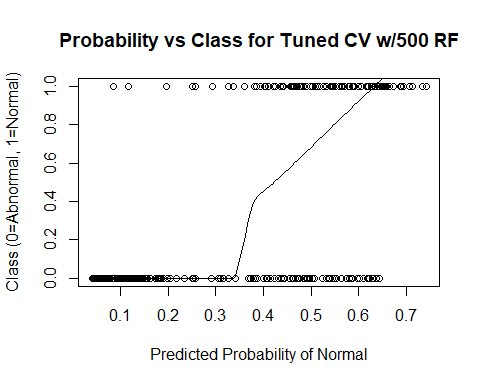


mtry OOBError  
11.OOB 11 0.3258065  
22.OOB 22 0.3225806  
44.OOB 44 0.2774194  
88.OOB 88 0.2483871  
176.OOB 176 0.1903226  
352.OOB 352 0.2290323

MeanDecreaseGini  
pelvic\_incidence 6.01100462  
pelvic\_tilt 3.38621535  
lumbar\_lordosis\_angle 3.38204323  
sacral\_slope 1.84095368  
pelvic\_radius 6.61375200  
degree\_spondylolisthesis 29.69157311  
pelvic\_slope 0.04516613  
Direct\_tilt 0.05921861  
thoracic\_slope 0.28618526  
cervical\_tilt 0.10897747  
sacrum\_angle 0.05223586  
scoliosis\_slope 0.06663832  
X1 0.02960129  
X2 0.07636687  
X3 0.16661184  
X4 0.04863451  
X5 0.10742465  
X6 0.26578690  
X7 0.17616101  
X8 0.08328187  
X9 0.19831939  
X10 0.04033133  
X11 0.11273203  
X12 0.06154676  
X13 0.12715521  
X14 0.21590919  
X15 0.01675745  
X16 0.07298429  
X17 0.09978005  
X18 0.07644006  
X19 0.04767568  
X20 0.01928116  
X21 0.22156802  
X22 0.36132039  
X23 0.03678497  
X24 0.07818254  
X25 0.40941571  
X26 0.19638778  
X27 0.09877176  
X28 0.55740077  
X29 0.04900979  
X30 0.09326776  
X31 0.05102179  
X32 0.06179487  
X33 0.10394346  
X34 0.19932217  
X35 0.04293341  
X36 0.05409918  
X37 0.08539927  
X38 0.11589262  
X39 0.03693409  
X40 0.07416488  
X41 0.17868996  
X42 0.05328176  
X43 0.04976898  
X44 0.05743946  
X45 0.04320375  
X46 0.06791816  
X47 0.04224700  
X48 0.22214187  
X49 0.10783932  
X50 0.06129321  
X51 0.11258447  
X52 0.07751939  
X53 0.07971532  
X54 0.09749348  
X55 0.05284229  
X56 0.06923572  
X57 0.13788549  
X58 0.07596851  
X59 0.15465781  
X60 0.07671116  
X61 0.12330184  
X62 0.01923306  
X63 0.15183106  
X64 0.07857717  
X65 0.02756508  
X66 0.03266193  
X67 0.03617204  
X68 0.05365864  
X69 0.09030315  
X70 0.07436254  
X71 0.08809051  
X72 0.05169864  
X73 0.37302217  
X74 0.03099392  
X75 0.19216087  
X76 0.26427187  
X77 0.37414607  
X78 0.33110780  
X79 0.11133380  
X80 0.05611238  
X81 0.11583623  
X82 0.05931341  
X83 0.06050782  
X84 0.20131448  
X85 0.02110258  
X86 0.29794029  
X87 0.04191640  
X88 0.08738797  
X89 0.06984945  
X90 0.07378192  
X91 0.12342942  
X92 0.09392362  
X93 0.09396828  
X94 0.13264929  
X95 0.04590794  
X96 0.08765083  
X97 0.16594496  
X98 0.12797302  
X99 0.05731357  
X100 0.06706657  
X101 0.06487321  
X102 0.14071207  
X103 0.28628130  
X104 0.15972425  
X105 0.13511206  
X106 0.11035306  
X107 0.06045395  
X108 0.05526211  
X109 0.06618923  
X110 0.03146295  
X111 0.07414700  
X112 0.04467685  
X113 0.18689112  
X114 0.06654089  
X115 0.11832695  
X116 0.08729151  
X117 0.10837718  
X118 0.05961255  
X119 0.14412188  
X120 0.12519334  
X121 0.05411145  
X122 0.05773627  
X123 0.09112382  
X124 0.13259947  
X125 0.08274779  
X126 0.10798220  
X127 0.08246826  
X128 0.17160849  
X129 0.15822923  
X130 0.03380575  
X131 0.14833513  
X132 0.23223608  
X133 0.12910473  
X134 0.20058092  
X135 0.09472974  
X136 0.04045340  
X137 0.03387976  
X138 0.09871264  
X139 0.04250720  
X140 0.24841844  
X141 0.17066478  
X142 0.16477167  
X143 0.11492612  
X144 0.12261287  
X145 0.04582035  
X146 0.05321394  
X147 0.25491069  
X148 0.17117766  
X149 0.06540284  
X150 0.13580258  
X151 0.06538597  
X152 0.04333726  
X153 0.15595083  
X154 0.07085186  
X155 0.12545881  
X156 0.02565294  
X157 0.21200909  
X158 0.04324198  
X159 0.02431852  
X160 0.18846197  
X161 0.27907309  
X162 0.12915179  
X163 0.12056938  
X164 0.10879677  
X165 0.06715881  
X166 0.35606259  
X167 0.02377555  
X168 0.14604953  
X169 0.05987168  
X170 0.17339194  
X171 0.08943269  
X172 0.05921203  
X173 0.18621241  
X174 0.04205375  
X175 0.09606354  
X176 0.13001952  
X177 0.03165576  
X178 0.05092353  
X179 0.06941343  
X180 0.07277669  
X181 0.11646062  
X182 0.10026587  
X183 0.04626869  
X184 0.22276236  
X185 0.11399451  
X186 0.15885405  
X187 0.08940498  
X188 0.06152393  
X189 0.07765397  
X190 0.05527593  
X191 0.16615003  
X192 0.08298090  
X193 0.09599317  
X194 0.06504682  
X195 0.02164871  
X196 0.09316481  
X197 0.06078110  
X198 0.08758853  
X199 0.11519842  
X200 0.09797695  
X201 0.14539931  
X202 0.05804286  
X203 0.12115162  
X204 0.26841086  
X205 0.06941323  
X206 0.01097693  
X207 0.05700664  
X208 0.04869068  
X209 0.12228680  
X210 0.11556243  
X211 0.12659351  
X212 0.04111852  
X213 0.05109449  
X214 0.03895095  
X215 0.05380040  
X216 0.04959300  
X217 0.13305732  
X218 0.04277244  
X219 0.09767859  
X220 0.05890807  
X221 0.16070062  
X222 0.06015762  
X223 0.13874404  
X224 0.03599820  
X225 0.06227555  
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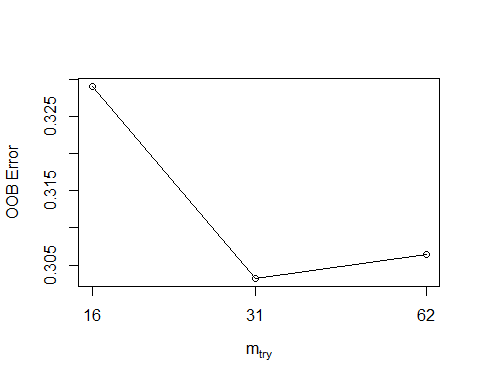


Confusion Matrix and Statistics  
  
 Reference  
Prediction Abnormal Normal  
 Abnormal 182 28  
 Normal 37 63  
   
 Accuracy : 0.7903   
 95% CI : (0.7407, 0.8343)  
 No Information Rate : 0.7065   
 P-Value [Acc > NIR] : 0.0005294   
   
 Kappa : 0.5087   
 Mcnemar's Test P-Value : 0.3210620   
   
 Sensitivity : 0.8311   
 Specificity : 0.6923   
 Pos Pred Value : 0.8667   
 Neg Pred Value : 0.6300   
 Prevalence : 0.7065   
 Detection Rate : 0.5871   
 Detection Prevalence : 0.6774   
 Balanced Accuracy : 0.7617   
   
 'Positive' Class : Abnormal



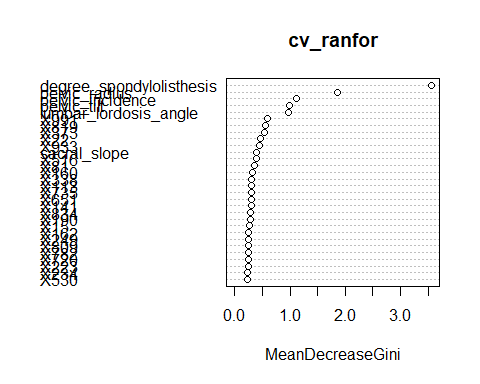
# Add 1000 Random Variables

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Searching left ...  
mtry = 16 OOB error = 32.9%   
-0.08510638 0.05   
Searching right ...  
mtry = 62 OOB error = 30.65%   
-0.0106383 0.05



mtry OOBError  
16.OOB 16 0.3290323  
31.OOB 31 0.3032258  
62.OOB 62 0.3064516

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lumbar\_lordosis\_angle 0.975049651  
sacral\_slope 0.395121701  
pelvic\_radius 1.849761856  
degree\_spondylolisthesis 3.565151873  
pelvic\_slope 0.043054130  
Direct\_tilt 0.112771258  
thoracic\_slope 0.036546526  
cervical\_tilt 0.048519792  
sacrum\_angle 0.084515479  
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Confusion Matrix and Statistics  
  
 Reference  
Prediction Abnormal Normal  
 Abnormal 210 0  
 Normal 100 0  
   
 Accuracy : 0.6774   
 95% CI : (0.6223, 0.7292)  
 No Information Rate : 1   
 P-Value [Acc > NIR] : 1   
   
 Kappa : 0   
 Mcnemar's Test P-Value : <2e-16   
   
 Sensitivity : 0.6774   
 Specificity : NA   
 Pos Pred Value : NA   
 Neg Pred Value : NA   
 Prevalence : 1.0000   
 Detection Rate : 0.6774   
 Detection Prevalence : 0.6774   
 Balanced Accuracy : NA   
   
 'Positive' Class : Abnormal

