ROC (Receiver Operating Characteristic) Curve Analysis

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Agenda

- Introduction
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Introduction

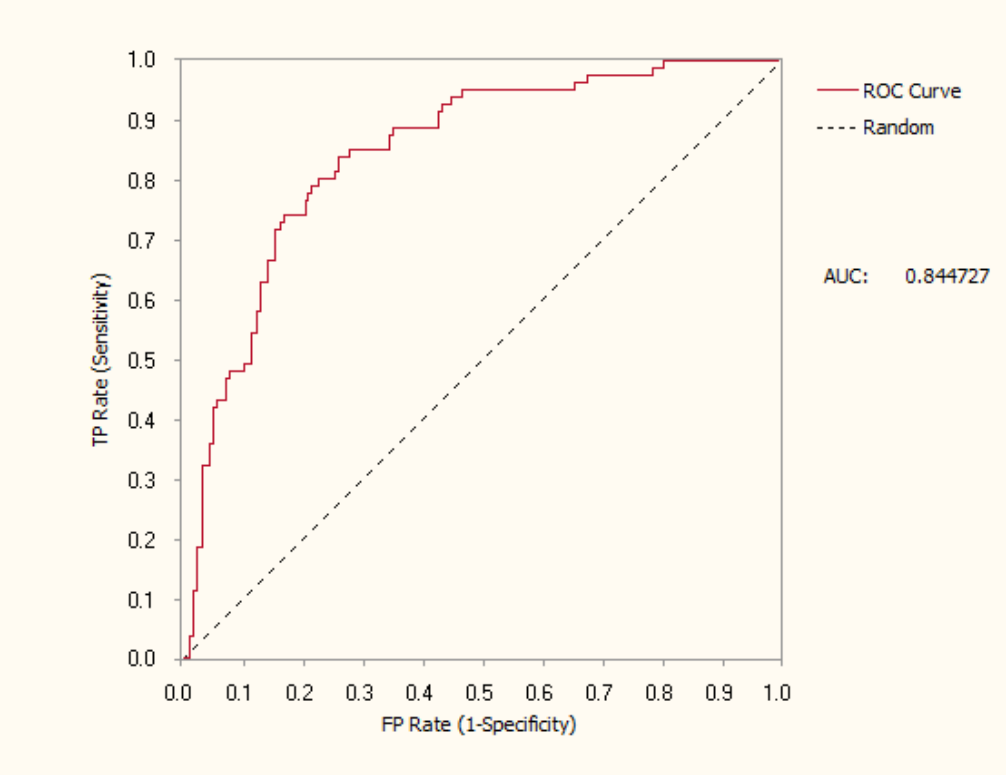
- ROC (Receiver Operating Characteristic) curve is a fundamental tool for diagnostic test evaluation. It is increasingly used in many fields, such as data mining, financial credit scoring, weather forecasting etc.

- ROC curve plots the true positive rate (sensitivity) of a test versus its false positive rate (1-specificity) for different cut-off points of a parameter

- ROC curve is graphically to display the trade-off relationship between sensitivity and specificity for all possible thresholds

- SAS/STAT Procedures: FREQ, LOGISTIC, MIXED and NLMIXED can be used to perform ROC curve analysis

ROC (Receiver Operating Characteristic) Curve[1]



Definition[2]

- Sensitivity is the probability of a test will be positive given a patient with the disease
- Specificity is the probability of a test will be negative given a patient without the disease

	Disease				
Test	**Present**	**n**	**Absent**	**n**	**Total**
Positive	True Positive (TP)	*a*	False Positive (FP)	*c*	*a + c*
Negative	False Negative (FN)	*b*	True Negative (TN)	*d*	*b + d*
Total		*a + b*		*c + d*	

Sensitivity = TP/(TP+FN) = a/(a+b)

Specificity = TN/(TN+FP) = d/(c+d)

Positive predictive value (PPV) = TP/(TP+FP) = a/(a+c)

Negative predictive value (NPV) = TN/(TN+FN) = d/(b+d)

Accuracy

- The accuracy of a test is measured by the area under the ROC curve (AUC).
- AUC is the area between the curve and the x axis.
- An area of 1 represents a perfect test, while an area of .5 represents a worthless test.
- The closer the curve follows the left-upper corner of the plot, the more accurate the test.

Application in SAS[3]

- PROC FREQ: 2×2 contingency table in PET (Positron Emission Tomography) scan for detecting cancer

- data cancer;

```
input   Diagnosed $ Observed $   patients;
datalines;
     Cancer          Cancer          25
     Caner           No_Cancer        3
     No_Cancer       Cancer          42
     No_Cancer       No_Cancer      111
     ;
run;
```

- Proc freq data=cancer;

```
     table diagnosis*observed;
     weight patients;
run;
```

Table of Diagnosed by Observed

		Observed		
		Cancer	No_Cancer	Total
Diagnosed				
Cancer	Frequency	25	3	28
	Percent	13.81	1.66	15.47
	Row Pct	89.29	10.71	
	Col Pct	37.31	2.63	
No_Cancer	Frequency	42	111	153
	Percent	23.20	61.33	84.53
	Row Pct	27.45	72.55	
	Col Pct	62.69	97.37	
Total	Frequency	67	114	181
	Percent	37.02	62.98	100.00

Sensitivity = 37.31%

Specificity = 97.37%

PPV = 89.29%

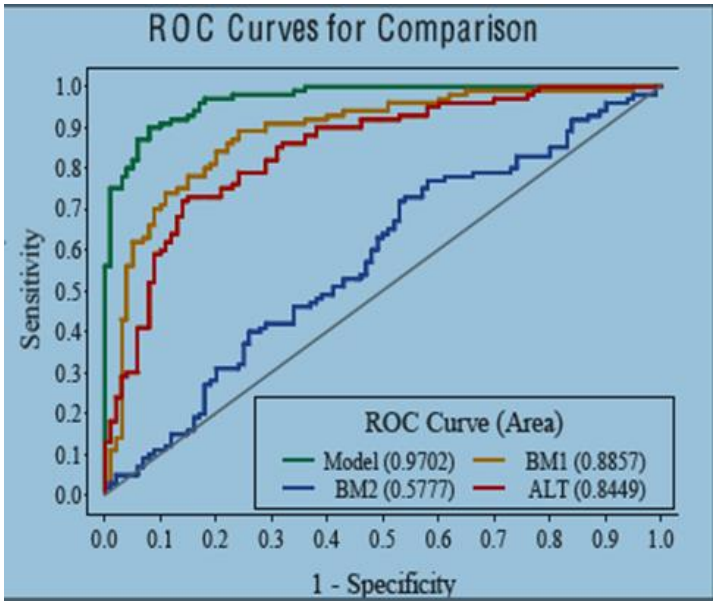
NPV = 72.55%

Diagnosed cancer if SUV (Standardized Uptake Value) > 7;
Observed cancer determined by gold standard

Application in SAS[4]

- Developing new biomarkers (BM) that are more specific in detecting drug induced liver injury (DILI) than the commonly used test [elevated alanine transaminase (ALT)]
- ods graphics on;

```
proc logistic data = biom plots = roc;
model status (event='1') = alt bm1 bm2;
        roc "BM1' bm1;
        roc "BM2" bm2;
        roc "ALT" alt;
        roccontrast reference('ALT')/estimate e;
 run;
 ods graphics off;
```



AUC equals to C-statistics

Conclusion

- Threshold Selection
  - To choose the most appropriate cut-off for a test. The best cut-off has the highest true positive rate together with the lowest false positive rate
- Assessment of Diagnostic Accuracy
  - To evaluate the accuracy of a diagnostic test using AUC value to discriminate the diseased cases from normal cases
- Multiple Tests Comparison
  - To compare the performance of two or more tests via a visual method

Reference

- 1. https://www.gepsoft.com/images/GeneXproTools5/LogisticRegressionMeasuresOfFit.png
- 2. https://www.medcalc.org/manual/roc-curves.php
- 3. http://www2.sas.com/proceedings/sugi31/210-31.pdf
- 4. Gonen, Mithat. 2007. Analyzing Receiver Operating Characteristic Curves with SAS. Cary, NC: SAS Institute Inc.

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