*Receiver Operating Characteristic (ROC)*

The ROC curve is defined as the LOCUS of True Positive Rate (*TPR*) and False Positive Rate (*FPR*) for *all possible choices of cutoff thresholds* as shown in Fig 1. The color bar to the right of the ROC curve represents the threshold levels. Another term for TPR is sensitivity or recall. Another term for FPR is 1-Specificity or 1-True Negative Rate (TNR). The Y-axis (TPR) is the proportion of True Dead over all observed Dead. The x-axis (FPR) is one minus the proportion of True SURV over the total of observed SURV. In other words, ROC looks at the performance of a classifier in prediction of both of classes, Dead and SURV. The *overall* performance, for *all* threshold values, can be assessed by computing the Area Under the Curve of ROC (AUC-ROC).

The shape of the ROC curve depends on the overlap between the distributions of predicted probabilities of the two classes. A perfect classifier with no overlapping will have an L-shape ROC curve (dashed line in Fig 1) with AUC-ROC equal to one and will pass through the point of (FPR=0, TPR=1), as indicated with the gray dot, corresponding to the threshold where all patients are correctly identified by the classifier. The closer the ROC curve gets to the diagonal "line of unity" (representing random chance) such as the solid curve in Fig 1 the worse the performance of classifier. The purple and red dots correspond to the upper and lower bounds of the threshold: > 1 and 0, respectively. At the lower bound (threshold = 0), the classifier identifies all patients as SURV (FPR= 0% or specificity=100%). At the upper bound, the classifier identifies all patients as DEAD (sensitivity= 100%).

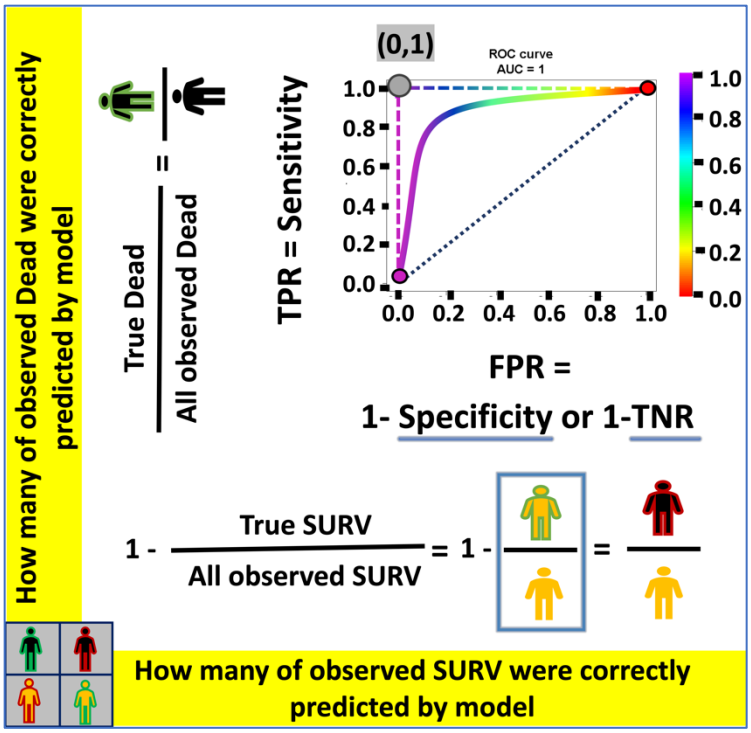


Fig.1 ROC- The example of ROC curves for a perfect classifier (L-shape dashed-curve), an imperfect classifier (solid curve), and a random classifier (diagonal dotted-line).

*Precision-Recall Curve (PRC)*

The PRC is a plot the LOCUS of *Precision* and *Recall* for *all possible choices of cutoff threshold* as pictured in Fig 2. The X-axis in the PRC (recall) is the same as the Y-axis in the ROC. Other terms for recall are sensitivity and TPR, equal to True DEAD over all observed Dead. The Y-axis (precision) is also known as positive predictive value (PPV), equal to True DEAD over all predicted DEAD by the model. The color bar to the right of the PRC curve represents the threshold levels of the classifier. It is important to note that the formulas for precision and recall have the same numerator (True DEAD) and both include True DEAD in their denominator. Their only difference is one element in their denominators: False DEAD in precision and False SURV in

recall. Thus, PRC focuses on the quantity of True DEAD over various cutoff thresholds considering errors of both classes: False DEAD and False SURV. Therefore, PRC is beneficial when dealing with imbalanced data as it focuses on the performance of model in only the minority class (DEAD) and it is sensitive to skewness in the imbalance data. Similar to ROC, the PRC can be summarized by computing the Area Under Curve of PRC (AUC-PRC). In PRC, the random classifier would be a horizontal line with precision equal to proportion of minority class; for instance, 8% for 90-day post-LVAD mortality.

A perfect classifier will have an L-shape PRC curve (dashed line in Fig 2) with the AUC-PRC of 1, and will include the point (recall= 1, precision= 1), as indicated with the gray dot in the figure, corresponding to the cutoff threshold where all patients are correctly identified by the classifier. However, when there is overlap between predicted probabilities of classes the PRC curve approaches the dotted horizontal line corresponding to a random classifier. The red and purple dots in Fig 2 corresponds to the two extreme thresholds. The red dot (threshold = 0.0) indicates the point where recall = 0, and precision =0/0, indicated by 1.0. The purple dot corresponds to the threshold 1.0 wherein the classifier identified all patients as DEAD; hence the recall = 1.0 (no False SURV) and the precision = overall proportion of the minority (DEAD) class.

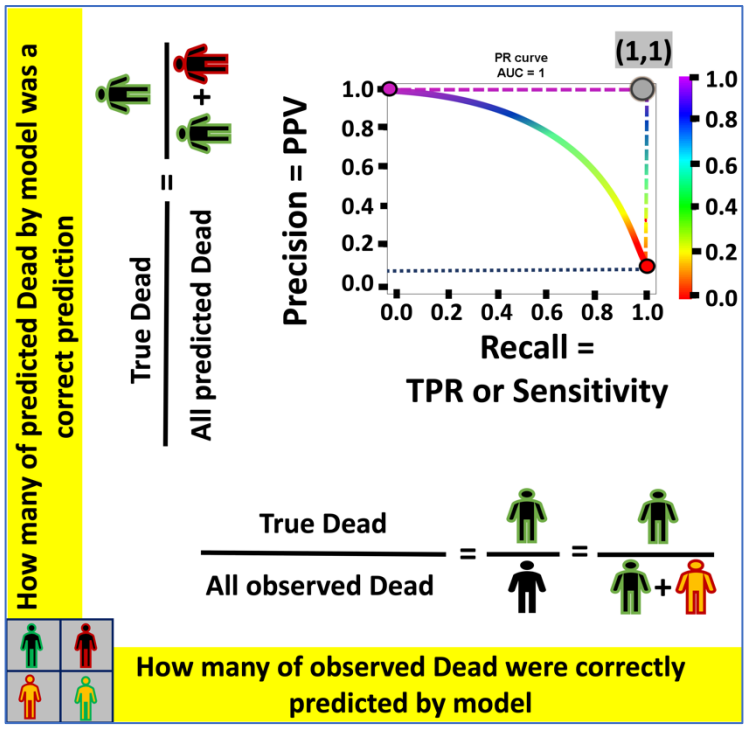


Fig.2 PRC-The example of PRC curves for a perfect classifier (L-shape dashed-curve), an imperfect classifier (solid curve), and a random classifier (horizontal dotted-line).