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PEARLS OF LABORATORY MEDICINE

Sensitivity, Specificity, and Predictive Values in Diagnostic Testing

Yachana Kataria, PhD

Boston Children's Hospital

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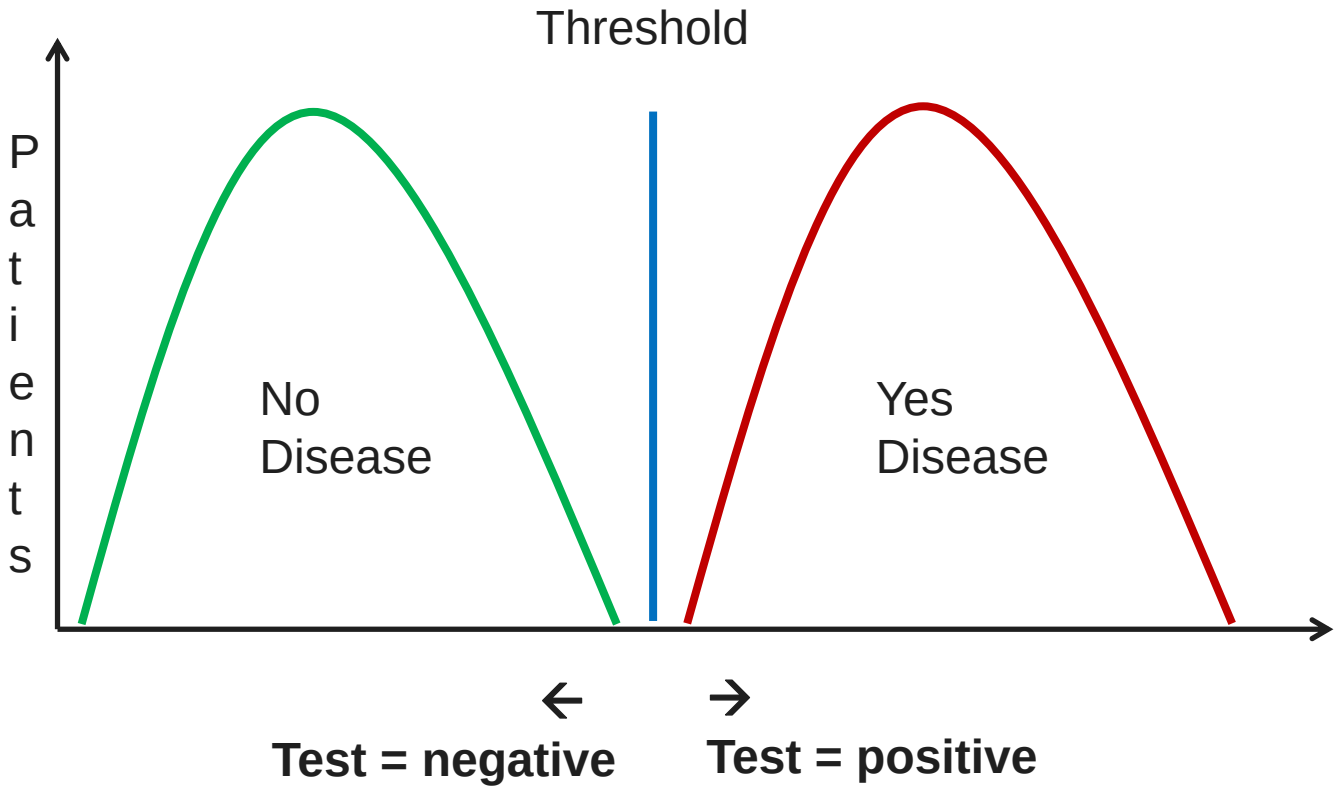
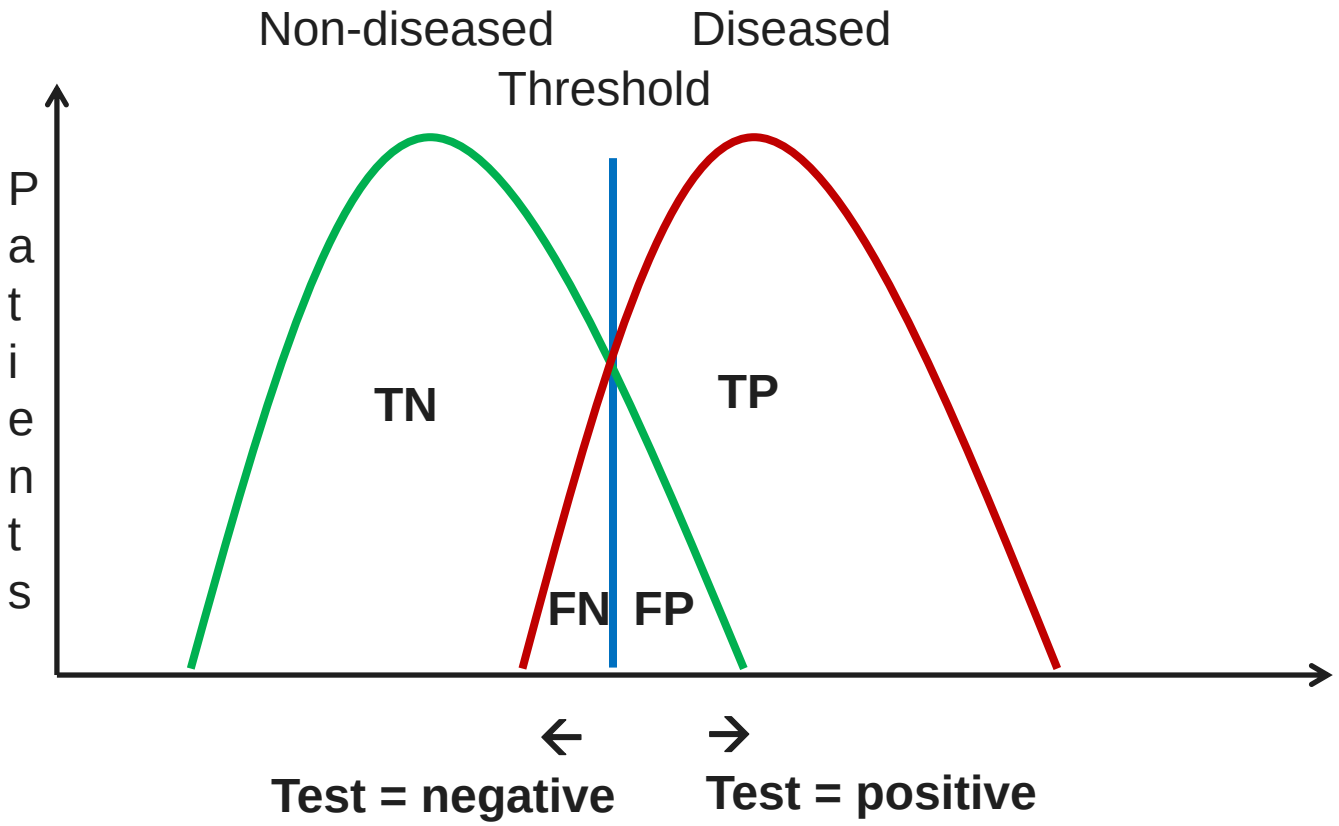
Diagnostic Testing



There is no perfect test



Interpretation of BNP as a test

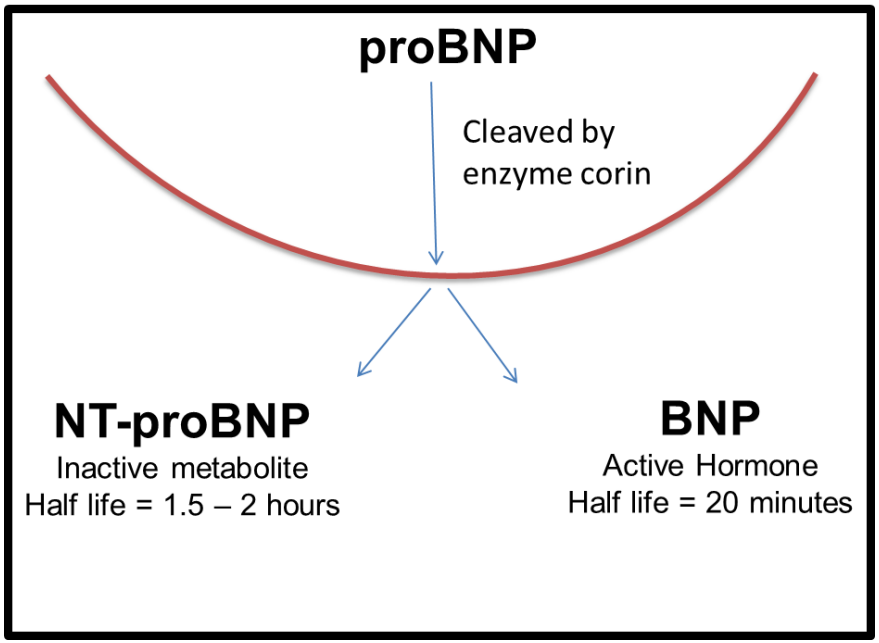
- B-type natriuretic peptide (BNP) is utilized in the emergency department to help establish the diagnosis of congestive heart failure (CHF)
- Diagnostic accuracy:
  - Sensitivity
  - Specificity
  - Positive predictive value and negative predictive value
  - Receiver operating characteristic (ROC) curve

Congestive heart failure (CHF)

- Approximately 5.1 million people in the US have CHF
- Prevalence and incidence increases with age
- 50% of people who develop CHF die within 5 years of diagnosis
- BNP has gained attention for patients with suspected CHF

B-type natriuretic peptide (BNP)

- Secreted by the ventricles of the heart in response to excessive stretching of heart muscle cells
- Blood levels increase with CHF symptoms



Shortness of breath in the emergency department

TABLE 2. MULTIPLE LOGISTIC-REGRESSION ANALYSIS OF FACTORS USED FOR DIFFERENTIATING BETWEEN PATIENTS WITH AND THOSE WITHOUT CONGESTIVE HEART FAILURE.

PREDICTOR	P VALUE	ODDS RATIO (95% CI)*
Age	0.04	1.02 (1.00–1.03)
History of congestive heart failure	<0.001	11.08 (6.55–18.77)
History of myocardial infarction	<0.001	2.72 (1.63–4.54)
Rales	<0.001	2.24 (1.41–3.58)
Cephalization of vessels	<0.001	10.69 (5.32–21.47)
Edema	<0.001	2.88 (1.81–4.57)
Jugular venous distention	0.04	1.87 (1.04–3.36)
B-type natriuretic peptide ≥100 pg/ml	<0.001	29.60 (17.75–49.37)

*The odds ratio reflects the odds for patients with the characteristic in question, as compared with those without the characteristic. The odds ratio for age represents the exponent for each year of age in the logistic equation. CI denotes confidence interval.

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Diagnostic performance of BNP

BNP (100 pg/mL)	Congestive Heart Failure +	Congestive Heart Failure -
BNP+	672 (TP)	198 (FP)
BNP-	72 (FN)	644 (TN)
	TP + FN = 744	FP + TN = 842

Maisel et al. 2002

Sensitivity of BNP

BNP (100 p /mL)	Congestive Heart Failure +	Congestive Heart Failure -
+	672 (TP)	198 (FP)
-	72 (FN)	644 (TN)
	TP + FN = 744	FP + TN = 842

$$\textbf{Sensitivity} = \frac{TP}{TP+FN} = \frac{672}{744} = \textbf{90\%}$$

- **Sensitivity** is the proportion of patients with the disease who will get a positive test result

Maisel et al. 2002

Specificity of BNP

BNP (100 pg /mL)	Congestive Heart Failure +	Congestive Heart Failure -
+	672 (TP)	198 (FP)
-	72 (FN)	644 (TN)
	TP + FN = 744	FP + TN = 842

$$\textbf{Specificity} = \frac{TN}{TN+FP}$$

$$= \frac{644}{842}$$

$$= \textbf{76 \%}$$

- **Specificity** is the proportion of patients who do not have the disease and will test negative

Maisel et al. 2002

Predictive values of BNP

BNP (100 pg /mL)	Congestive Heart Failure +	Congestive Heart Failure -	
+	672 (TP)	198 (FP)	Positive Predictive Value (PPV) = $\frac{TP}{TP+FP}$ = **77** %
-	72 (FN)	644 (TN)	Negative Predictive Value (NPV) = $\frac{TN}{TN+FN}$ = **90** %

Maisel et al. 2002

Diagnostic performance of BNP

BNP (100 pg /mL)	Congestive Heart Failure +	Congestive Heart Failure -	
+	672 (TP)	198 (FP)	PPV = 77%
-	72 (FN)	644 (TN)	NPV = 90%

Sensitivity = 90% Specificity = 76%

Disease Prevalence = 47%

Maisel et al. 2002

Changing the prevalence of disease

BNP (100 pg /mL)	Congestive Heart Failure +	Congestive Heart Failure -	
+	71 (TP)	362 (FP)	PPV = 16%
-	8 (FN)	1145 (TN)	NPV = 99%
	TP + FN = 79	FP + TN = 1507	

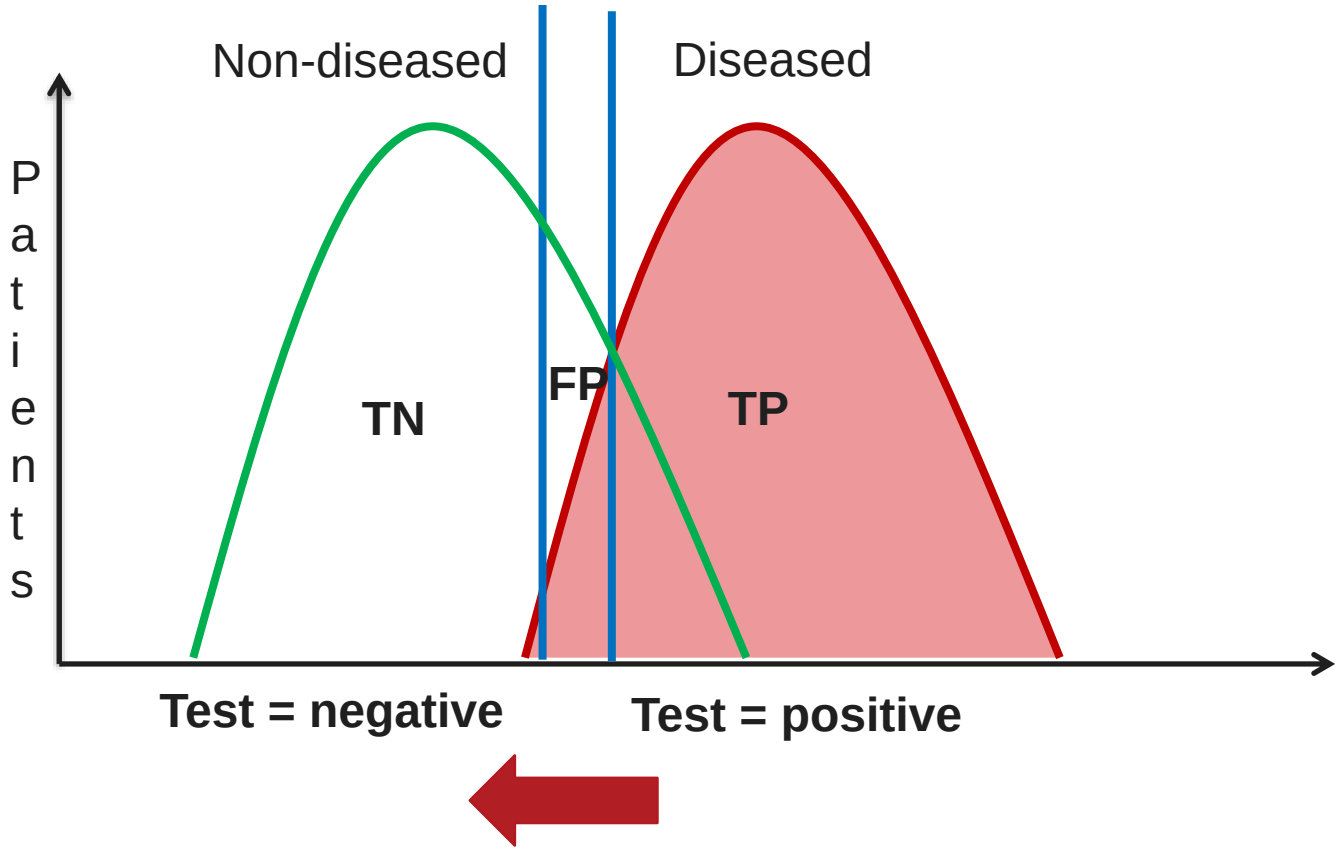
Sensitivity = 90% Specificity = 76%

Disease Prevalence = 5%

Predictive values

- Predictive values are related to prevalence of disease
- Lower prevalence will yield lower positive predictive value
- Clinicians care about predictive values
- Negative predictive value excludes a diagnosis, whereas a positive predictive value confirms a diagnosis

Lowering the threshold



Different BNP cutoff value

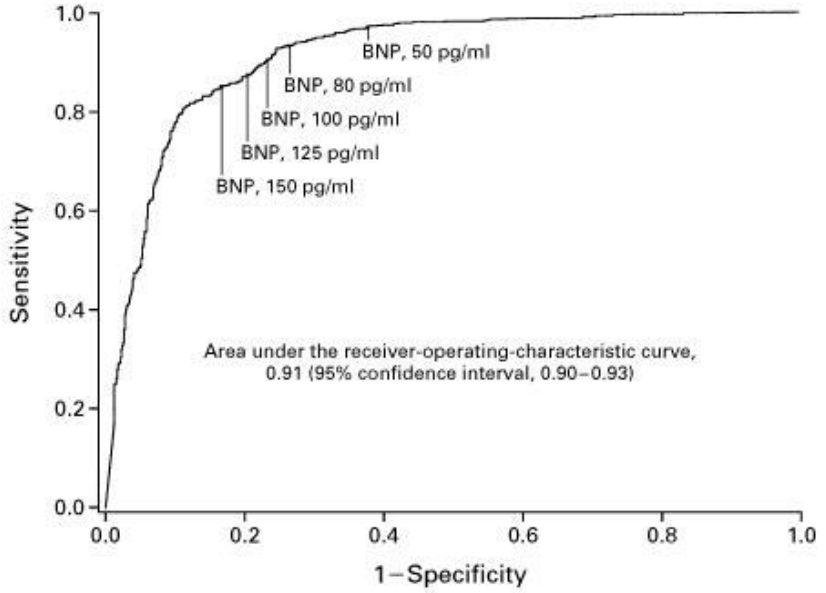
BNP (pg/mL)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
50	97	62	71	96
100	90	76	79	89
150	85	83	83	85

Maisel et al. 2002

Diagnostic Accuracy

- Sensitivity & specificity are not absolute
  - Might differ in different populations
  - At different spectrum of disease
- Gold standard
- How do you define a positive and negative result?

Receiver operating characteristic (ROC) curve



BNP pg/ml	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Accuracy
	(95 percent confidence interval)				
50	97 (96–98)	62 (59–66)	71 (68–74)	96 (94–97)	79
80	93 (91–95)	74 (70–77)	77 (75–80)	92 (89–94)	83
100	90 (88–92)	76 (73–79)	79 (76–81)	89 (87–91)	83
125	87 (85–90)	79 (76–82)	80 (78–83)	87 (84–89)	83
150	85 (82–88)	83 (80–85)	83 (80–85)	85 (83–88)	84

- Visualization of the performance of potential cutoff values in the same graph
- Measure area under curve

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Reference

1. Maisel AS, Krishnaswamy P, Nowak RM, McCrod J, Hollander JE, Duc P, Omland T, et al. Rapid measurement of B-type natriuretic peptide in the emergency diagnosis of heart failure.

   N Eng J Med 2002; 347: 161-7.

Disclosures/Potential Conflicts of Interest

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