Semester project

Hemodynamics (BMEGEVGNX26)

Statistical Analysis of Hemodynamic Metrics in Aneurysms

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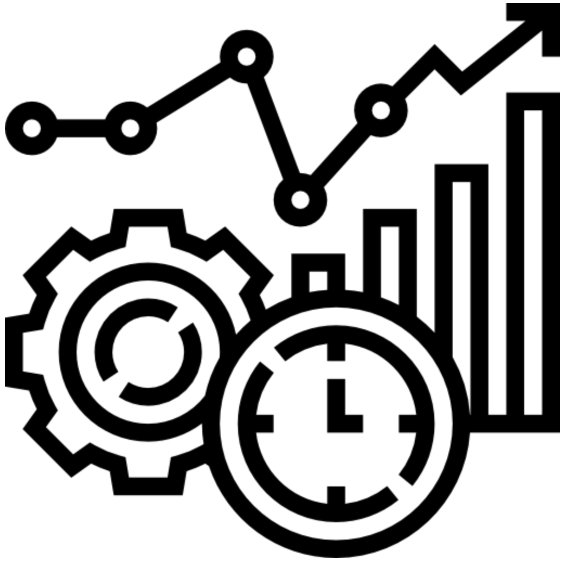
Relevance of Statistical Analysis

Why is statistical analysis important?

1. **Reproductibility :** In the medical field, statistical analysis ensures that findings are consistent and hypotheses can be validated based on robust data.
2. **Evidence-based decision:** Provides a foundation for informed, data-driven medical decision-making.

Application in Hemodynamics

- **Evaluating Stent Effectiveness:** Analyzing performance under varying conditions (e.g., nominal vs oversized stents).
- **Identifying Critical Relationships:** Detecting patterns and relationships in key metrics like AMVR.
- **Risk Assessment:** Quantifying the likelihood of device failure or incomplete occlusion to guide improvements.



Statistical Tests Presence in Literature I.

Ali Sarrami-Foroushani's article

- 164 virtual anatomies modeled using **CFD** to simulate hemodynamic changes.
- Evaluated success with **AMVR >35%** as a predictor of aneurysm occlusion.
- **Statistical analysis**
  - → **Student's t-Test:** Compared continuous variables.
  - → **χ^2 Test:** Analyzed categorical data.
  - → **RRs & CIs:** Identified risk factors for failure.

Table 6 Subgroup analysis: RRs of incomplete occlusion associated with the presence of a side branch, aneurysm size, aspect ratio and hypertension.

	Normotensive		Hypertensive			
	Relative risk (95% CI)	*p* value	Relative risk (95% CI)	*p* value	Relative risk (95% CI)	*p* value
Side branch presence	3.53 (1.21–10.32)	0.021	2.05 (1.09–3.85)	0.025		
Size (>10 mm)	2.15 (0.84–5.51)	0.109	2.00 (1.10–3.62)	0.022		
Aspect ratio (>1.6)	1.42 (0.50–4.00)	0.504	1.49 (0.79–2.83)	0.216		
Hypertension					1.93 (1.09–3.40)	0.023

Statistical Tests Presence in Literature II.

Table 6 Subgroup analysis: RRs of incomplete occlusion associated with the presence of a side branch, aneurysm size, aspect ratio and hypertension.

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1. **Side Branch Presence:** Consistently increases occlusion failure risk in both normotensive and hypertensive groups and is statistically significant.
2. **Aneurysm Size (>10 mm):** Significant risk factor for hypertensive patients but not for normotensive patients.
3. **Aspect Ratio (>1.6):** Not a significant risk factor in either group.
4. **Hypertension:** Independently increases occlusion failure risk (RR = 1.93, p = 0.023).

Types of Statistical Tests I.

1

ANOVA

ANOVA: Analysis of Variance

Objective: Compares group means by partitioning total variability into within-group and between-group variances.

Test Statistic:

$$F = \frac{MS_{between}}{MS_{within}}, \quad MS = \frac{SS}{df}$$

Where MS is mean square.

2

Student's t-test

Objective: Compares two means to test if they are significantly different.

Test Statistic:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s_p^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$$s_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$$

3

χ2 Test (Chi-Square):

Objective: Tests association between categorical variables.

Test Statistic:

$$\chi^2 = \sum \frac{(O - E)^2}{E},$$

Where:

- O is the observed frequency
- E is the expected frequency

Types of Statistical Tests II.

4

Two-way ANOVA

Objective: Tests main effects and interaction effects between 2 factors.

Used to:

1. **Test the main effects** of two independent factors on a dependent variable (e.g., stent type and stent size on AMVR).
2. **Evaluate interaction effects** between the factors to see if one factor's influence depends on the level of the other.

1. **Partition total variability:** Calculate the sum of squares for Factor A, B, interaction effect and for the error. SS
2. **Degrees of Freedom:** Calculate the DoF for each component. $\mathrm{d}f$
3. **Variance:** Calculate the variance for each component. σ^2
4. **Test Hypotheses:** Calculate F for each effect and the corresponding p-value to decide the null hypothesis.

$$F \rightarrow p < 0.05 \ ?$$

Statistical analysis I. - Setup

4	Two-way ANOVA	**Factors:** Stent type, Stent size **Dependent variable:** Aneurysm Mean Velocity Reduction (AMVR)

H0 Hypotheses

1. There is a significant difference between the **stent types** in case of **AMVR** values.
2. There is a significant difference between the **stent sizes** in case of **AMVR** values.
3. The **stent type** has an influence on the effect of the **stent size** in case of **AMVR** values.

Assumptions

1. The data within the groups should be **normally distributed**.
2. The **variance** of data in groups should be equal.
3. The measurements should be **independent**.
4. The dependent variable should have a metric scale level.

Question

1. Does **Factor A** have an effect on the dependent variable?
2. Does **Factor B** have an effect on the dependent variable?
3. Is there an **interaction** between Factor A and Factor B?

Statistical analysis II. - Setup

4	**Two-way ANOVA**	**Factors:** Stent type, Stent size **Dependent variable:** Aneurysm Mean Velocity Reduction (AMVR)

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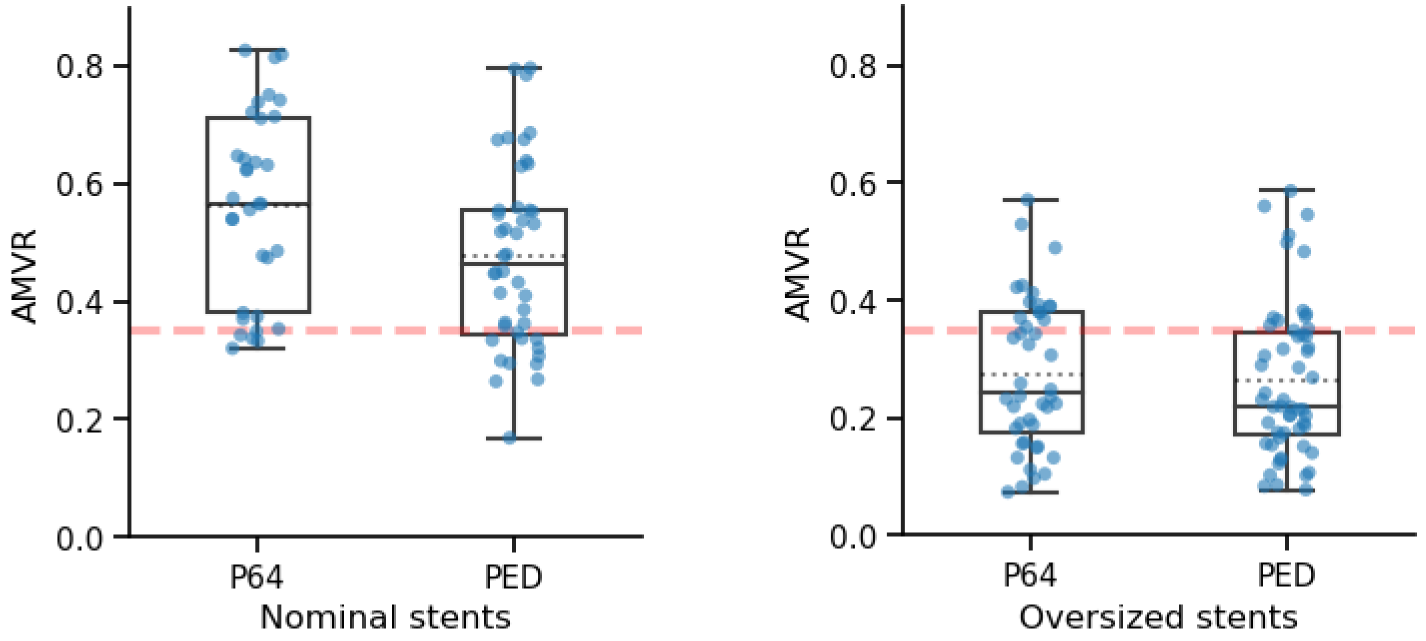
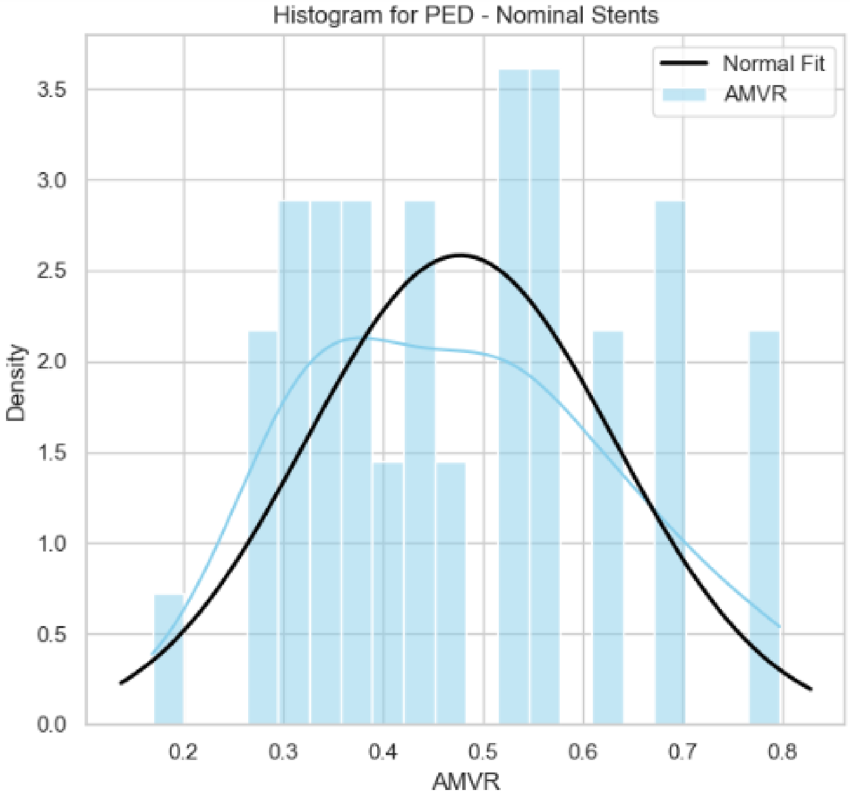


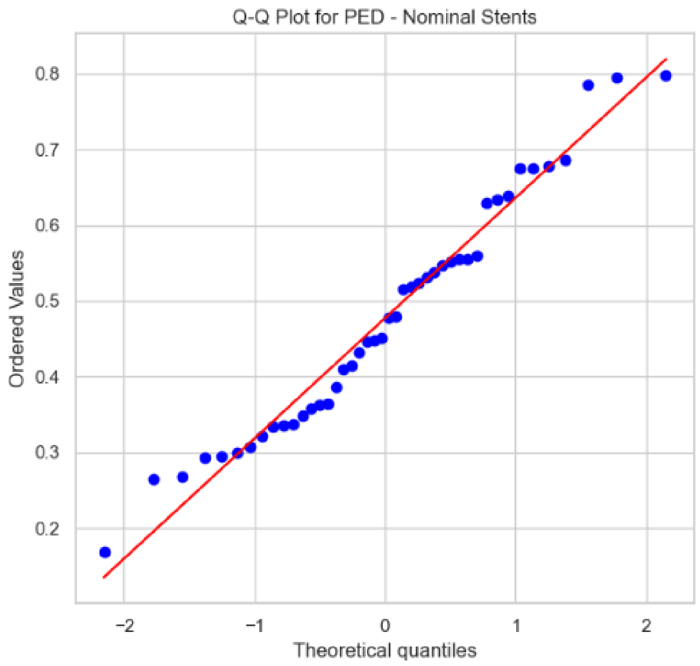
Statistical analysis III. - Results

4	Two-way ANOVA	**Factors:** Stent type, Stent size **Dependent variable:** Aneurysm Mean Velocity Reduction (AMVR)

Assumptions

1. The data within the groups should be **normally distributed**. ✔
2. The **variance** of data in groups should be equal. ✔
3. The measurements should be **independent**. ✔
4. The dependent variable should have a metric scale level. ✔





Statistical analysis IV. - Results

4	Two-way ANOVA	**Factors:** Stent type, Stent size **Dependent variable:** Aneurysm Mean Velocity Reduction (AMVR)

Question

1. Does **Factor A** have an effect on the dependent variable?
2. Does **Factor B** have an effect on the dependent variable?
3. Is there an **interaction** between Factor A and Factor B?

Answers

1. **Yes.**
2. **Yes**, undoubtingly.
3. **No,** since p-value almost doubles the necessary value, its not certain enough.

	p-value
Stent type	3.897e-2
Stent size	6.689e-23
Interaction	9.467e-2

Thank you for your attention!

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