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**Association of ultrafiltration rates and  
intradialytic hypotension in Sohag University  
Hospitals**

***Thesis***

***Submitted for partial fulfillment of the Master's degree in  
Internal Medicine***

***By***

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## Results

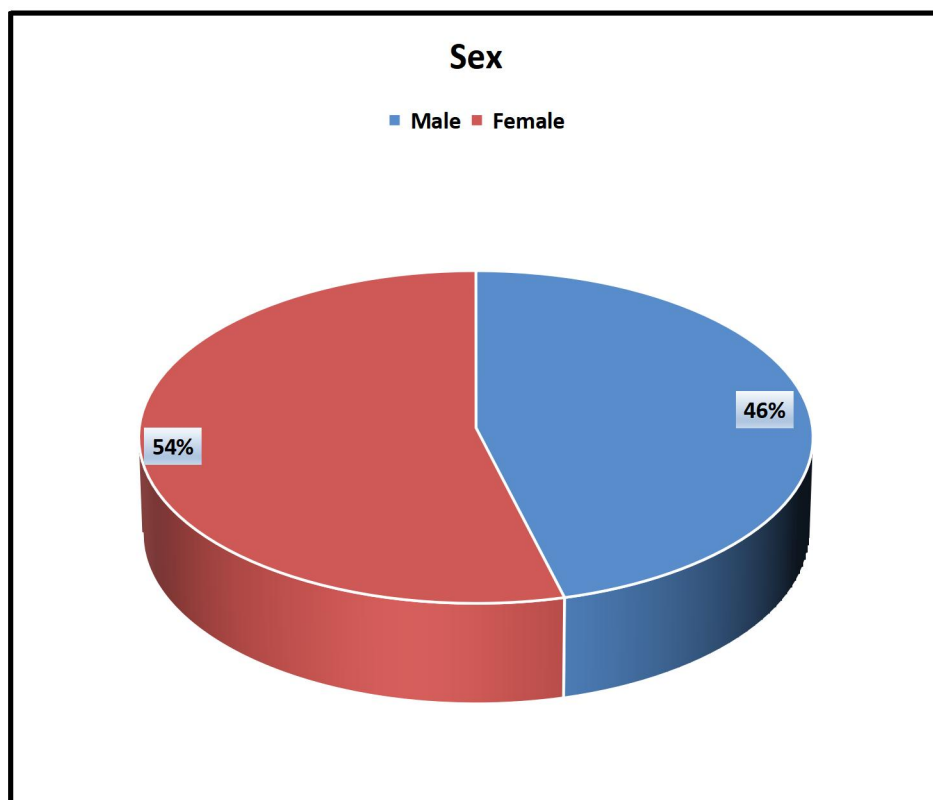
This study was carried out on 50 patients on maintenance hemodialysis receiving 3 sessions weekly at the hemodialysis unit, Sohag University Hospitals.

### A. Demographic characteristics of the studied patients

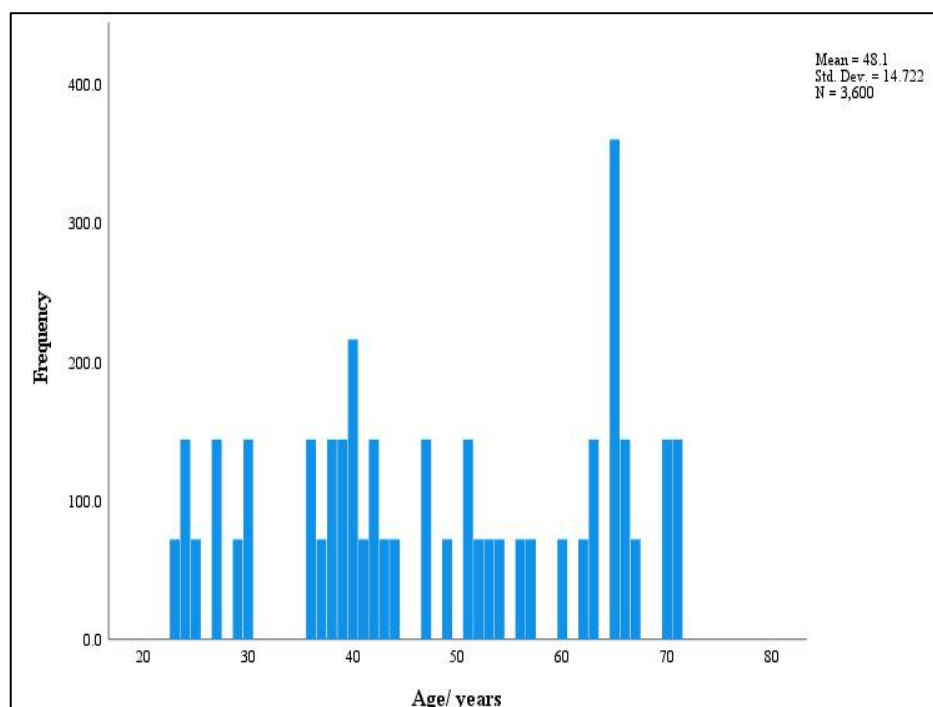
**Table (1): Demographic characteristics among the studied patients.**

		Total patients (N= 50)	
		N	%
Sex	Male	23	46.0%
	Female	27	54.0%
Age (years)	Mean $\pm$ SD	48.59 $\pm$ 14.61	
	Median (Range)	47 (23 – 71)	
BMI (Kg/m <sup>2</sup> )	Mean $\pm$ SD	25.61 $\pm$ 4.89	
	Median (Range)	25.15 (17.5 – 36.7)	

SD: standard deviation, BMI: Body mass index



**Figure (1): Distribution of sex among the study patients.**

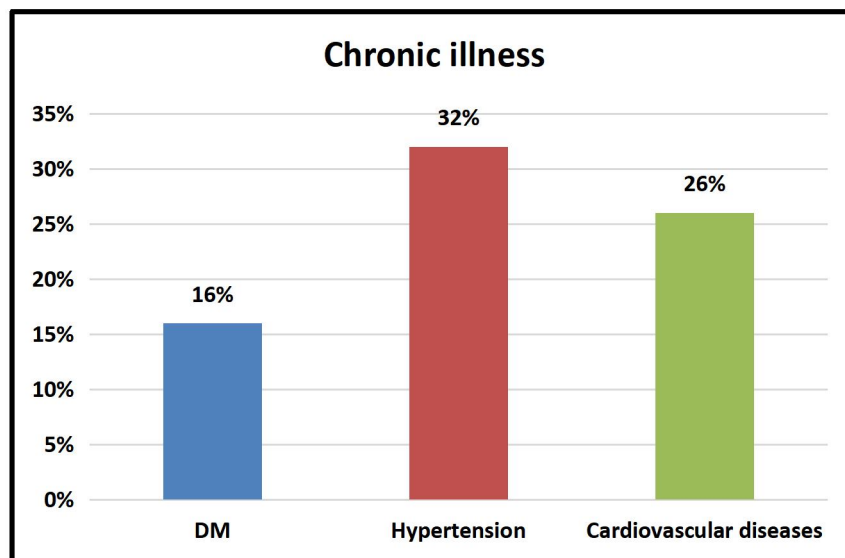


**Figure (2): Distribution of age among the study patients.**

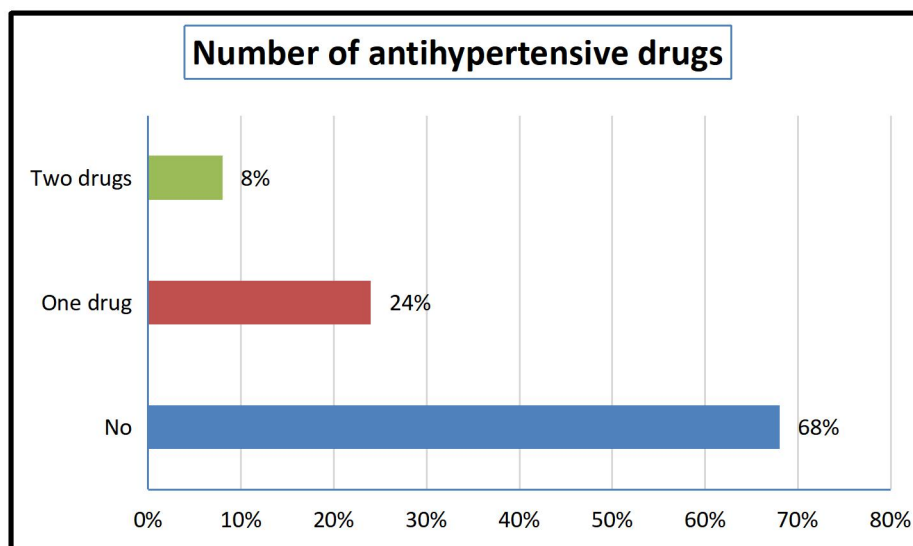
## B. Clinical characteristics of the studied patients

**Table (2): Clinical history among the study patients.**

		Studied patients (N= 50)	
		N	%
Chronic illness	DM	8	16.0%
	Hypertension	16	32.0%
	Cardiovascular diseases	13	26.0%
Number of antihypertensive drugs	No	34	68.0%
	One drug	12	24.0%
	Two drugs	4	8.0%



**Figure (3): Distribution of the studied patients regarding chronic illness.**

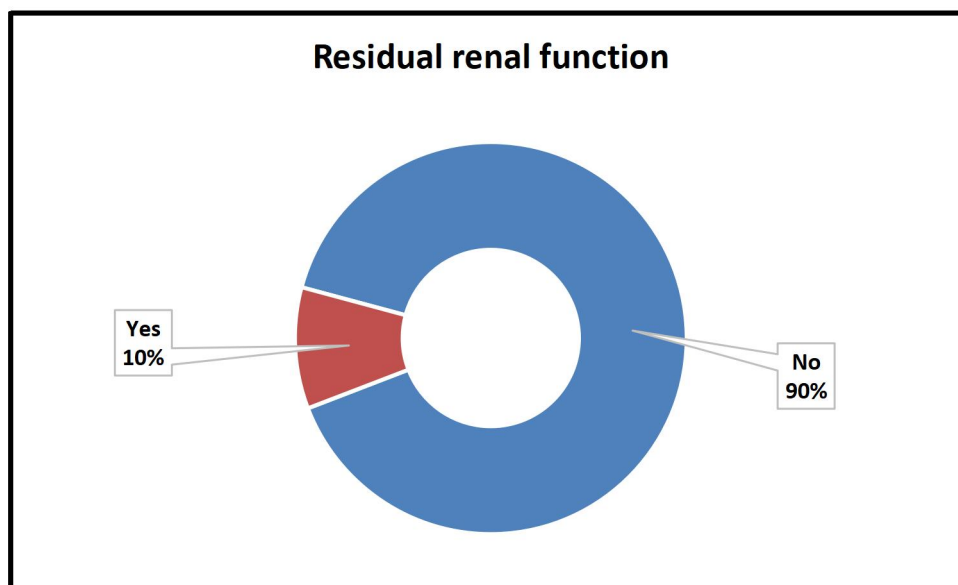


**Figure (4): Distribution of the studied patients regarding the number of antihypertensive drugs.**

**Table (3): Residual renal function & Dialytic age among the studied patients.**

			Total patients (N= 50)	
			N	%
Residual renal function	No		45	90.0%
	Yes		5	10.0%
Dialytic age (months)	Mean $\pm$ SD		89.48 $\pm$ 64.98	
	Median (Range)		73.0 (7 – 240)	

SD: standard deviation



**Figure (5): Distribution of the studied patients regarding residual renal function.**

### C. Laboratory investigation of the studied patients

**Table (4): Laboratory data among the studied cases.**

	Studied cases (N= 50)						
	Mean	± SD	Median	IQR		Range	
Hemoglobin (g/dL)	9.99	± 1.22	9.9	8.9	10.9	8.1	12.9
Hematocrit	31.24	± 4.06	31.5	27.7	34.6	24.0	41.0
Albumin (g/dL)	3.65	± 0.28	3.7	3.4	3.9	3.2	4.2

SD: standard deviation, IQR: Inter-quartile range

#### D. Characteristics of hemodialysis sessions of the studied patients

**Table (5): Hemodialysis sessions criteria among the study patients.**

		Number of hemodialysis sessions (N= 3600)	
		N	%
Time of session	Morning	1512	42.0%
	Noon	1080	30.0%
	Evening	1008	28.0%
Interdialytic day	2	2399	66.6%
	3	1201	33.4%
Hemodialysis day of the week	Day 1	1200	33.33%
	Day 2	1200	33.33%
	Day 3	1200	33.33%
IDWG (L)	Median (IQR)	3 (2.5 - 3.5)	
	Mean $\pm$ SD	3.11 $\pm$ 0.81	
	Range	1 – 6.5	
Pre-dialysis SBP (mm/Hg)	Median (IQR)	115 (110 - 120)	
	Mean $\pm$ SD	116.68 $\pm$ 10.35	
	Range	90 – 150	
Pre-dialysis DBP (mm/Hg)	Median (IQR)	75 (70 - 80)	
	Mean $\pm$ SD	75.60 $\pm$ 7.79	
	Range	50 – 100	
UFR (mL/kg/h)	Median (IQR)	11.3 (10 - 13.2)	
	Mean $\pm$ SD	11.91 $\pm$ 1.88	
	Range	10 – 16	
UFR categories	<10	842	23.4%
	10- 12	1308	36.3%
	12- 14	860	23.9%
	14- 16	427	11.9%
	>16	163	4.5%
IDH	No	2511	69.75%
	Yes	1089	30.25%

SD: standard deviation, IQR: Interquartile range, SBP: Systolic blood pressure,  
DBP: Diastolic blood pressure, IDWG: interdialytic weight gain, UFR: ultrafiltration rate  
IDH: Intradialytic hypotension

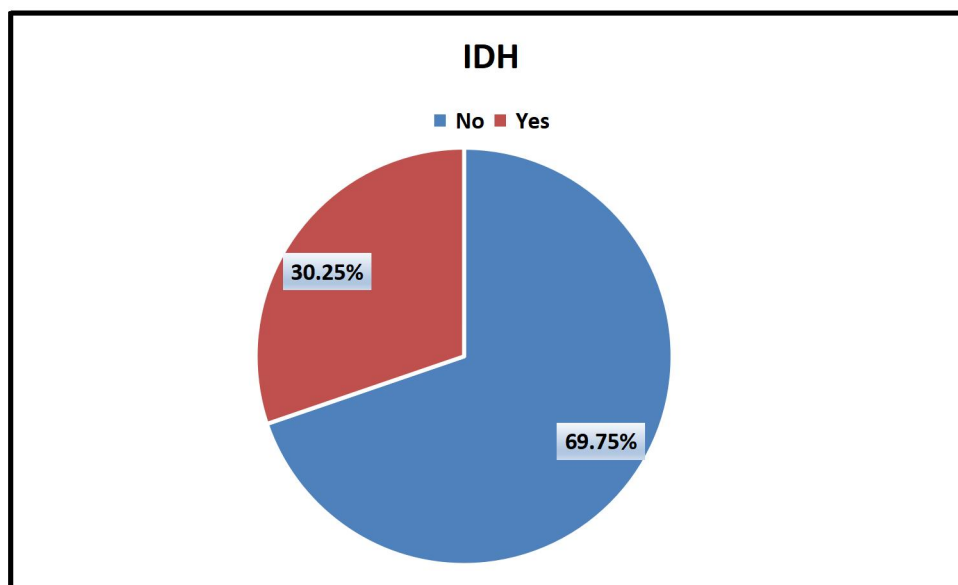


Figure (6): Distribution of the studied HD sessions regarding intradialytic hypotension.

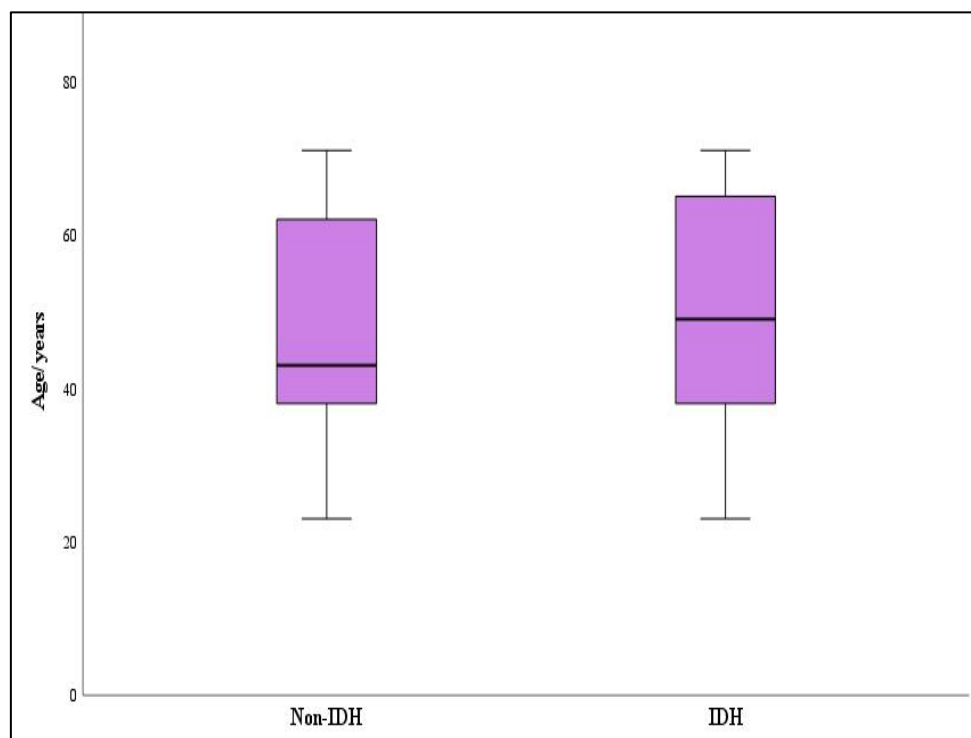
#### E. Relation between IDH and different parameters

Table (6): Relation between IDH and demographic data.

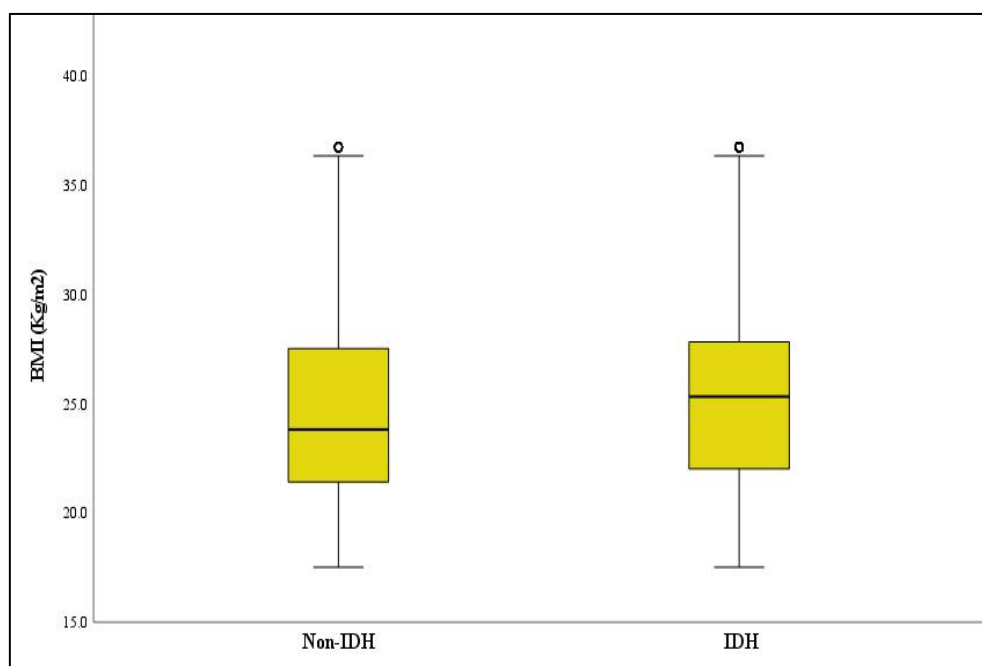
		Non IDH (Number of sessions =2511)		IDH (Number of sessions =1089)		Test value	P- value
		N	%	N	%		
Sex	Male	1166	46.4%	490	45.0%	X <sup>2</sup> =	0.426
	Female	1345	53.6%	599	55.0%	0.634	(NS)
Age (years)	Median (IQR)	43 (38 - 62)		49 (38 - 65)		z <sub>MWU</sub> = 3.291	<0.001 (HS)
	Mean ± SD	46.85 ± 14.32		48.64 ± 14.87			
	Range	23 – 71		23 – 71			
BMI (Kg/m <sup>2</sup> )	Median (IQR)	23.8 (21.4 - 27.5)		25.3 (22 - 27.8)		z <sub>MWU</sub> = 4.325	<0.001 (HS)
	Mean ± SD	25.02 ± 4.79		25.76 ± 4.90			
	Range	17.5 – 36.7		17.5 – 36.7			

P value >0.05: Not significant (NS), P value <0.05 is significant (S), p<0.01 is highly significant (HS)  
SD: standard deviation, IQR: Interquartile range, X<sup>2</sup>: Chi-Square test, z<sub>MWU</sub>: Mann-Whitney U test





**Figure (7): Comparison between IDH & non-IDH regarding age.**



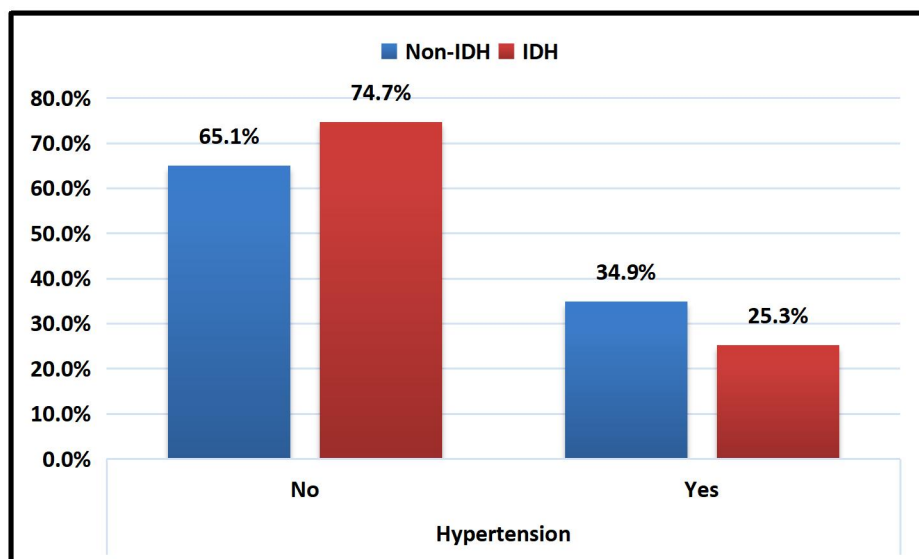
**Figure (8): Comparison between IDH & non-IDH regarding BMI.**

**Table (7): Relation between IDH and clinical data.**

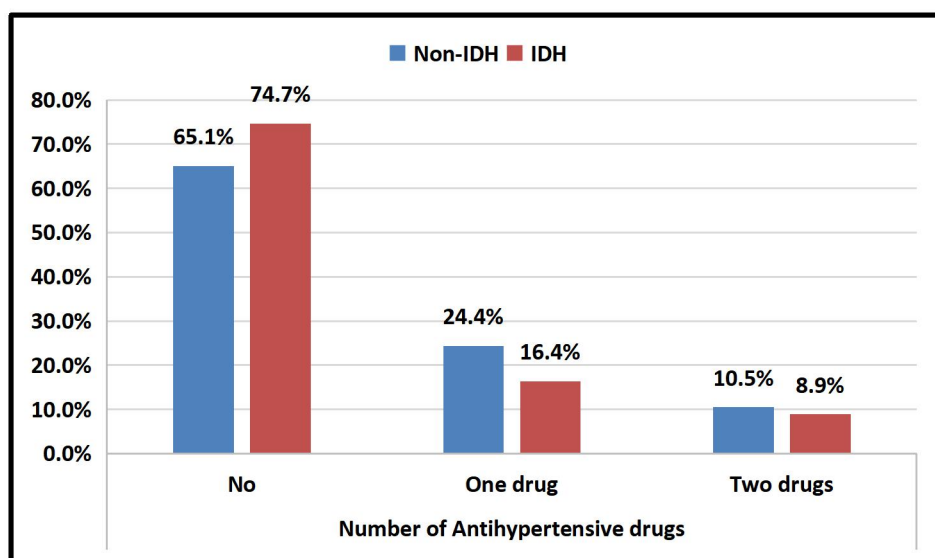
		Non IDH (Number of sessions =2511)		IDH (Number of sessions =1089)		Test value	P-value
		N	%	N	%		
Diabetes	No	2105	83.8%	919	84.4%	X <sup>2</sup> = 0.176	0.675 (NS)
	Yes	406	16.2%	170	15.6%		
Cardiovascular disease	No	1873	74.6%	791	72.6%	X <sup>2</sup> = 1.511	0.219 (NS)
	Yes	638	25.4%	298	27.4%		
Hypertension	No	1635	65.1%	813	74.7%	X <sup>2</sup> = 31.78	<0.001 (HS)
	Yes	876	34.9%	276	25.3%		
Number of antihypertensive drugs	No	1635	65.1%	813	74.7%	X <sup>2</sup> = 33.997	<0.001 (HS)
	One drug	613	24.4%	179	16.4%		
	Two drugs	263	10.5%	97	8.9%		
Residual renal function	No	2251	89.6%	989	90.8%	X <sup>2</sup> = 1.159	0.282 (NS)
	Yes	260	10.4%	100	9.2%		
Dialytic age (months)	Median (IQR)	68 (37 - 112)		72 (37 - 120)		z <sub>MWU</sub> = 2.656	0.008 (HS)
	Mean±SD	83.20 ± 59.0		92.25 ± 68.05			
	Range	7 – 216		7 – 240			

P value >0.05: Not significant (NS), P value <0.05 is significant (S), p<0.01 is highly significant (HS)

SD: standard deviation, IQR: Interquartile range,  $X^2$ : Chi-Square test,  $Z_{MWU}$ : Mann-Whitney U test



**Figure (9): Comparison between IDH & non-IDH regarding hypertension.**



**Figure (10): Comparison between IDH & non-IDH regarding the number of antihypertensive drugs.**

**Table (8): Relation between IDH and laboratory data.**

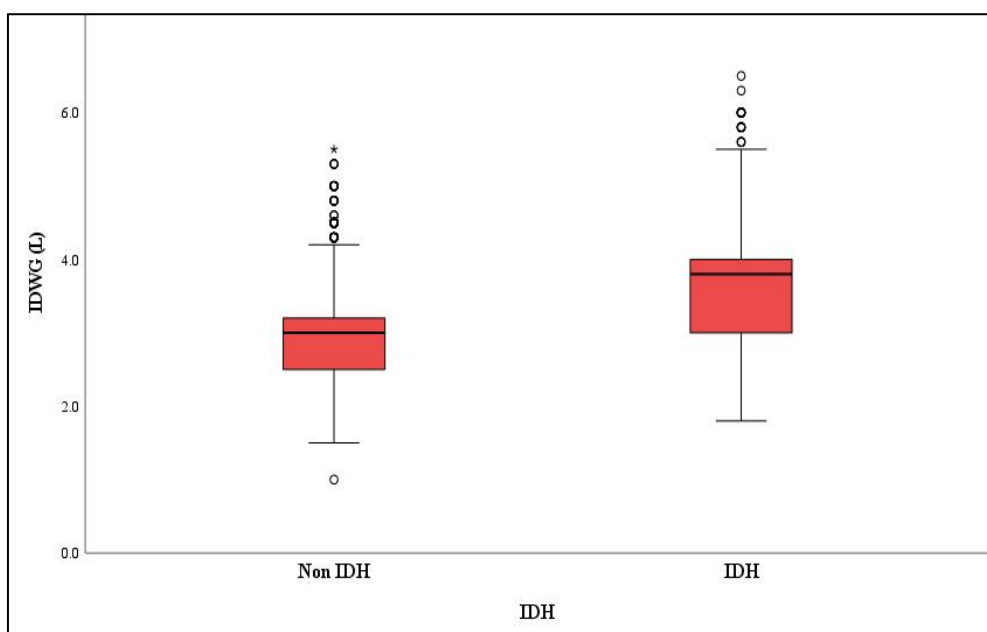
	Non IDH (Number of sessions =2511)					IDH (Number of sessions =1089)					Mann-Whitney U test	
	Median	IQR		Range		Median	IQR		Range		$Z_{MWU}$	P-value
<b>Hemoglobin (g/dL)</b>	10.0	9.1	11.1	8.1	12.9	9.8	8.8	10.8	8.1	12.9	5.225	<0.001 (HS)
<b>Hematocrit</b>	31.6	27.9	35.5	24.0	41.0	31.3	27.7	34.0	24.0	41.0	4.267	<0.001 (HS)
<b>Albumin (g/dL)</b>	3.6	3.4	3.9	3.2	4.2	3.6	3.4	3.9	3.2	4.2	1.550	0.121 (NS)

P value >0.05: Not significant (NS), P value <0.05 is significant (S), p<0.01 is highly significant (HS). SD: standard deviation, IQR: Interquartile range,  $Z_{MWU}$ : Mann-Whitney U test

**Table (9): Relation between IDH and hemodialysis sessions criteria.**

		Non IDH (Number of sessions =2511)		IDH (Number of sessions =1089)		Test value	P-value
		N	%	N	%		
Interdialytic day	2	2190	87.2%	209	19.2%	X <sup>2</sup> = 1581.0	<0.001 (HS)
	3	321	12.8%	880	80.8%		
Day of the week	Day 1	320	12.7%	880	80.8%	X <sup>2</sup> = 1580.0	<0.001 (HS)
	Day 2	1104	44.0%	96	8.8%		
	Day 3	1087	43.3%	113	10.4%		
Time of the day	Morning	1109	44.2%	403	37.0%	X <sup>2</sup> = 20.719	<0.001 (HS)
	Noon	748	29.8%	332	30.5%		
	Evening	654	26.0%	354	32.5%		
IDWG (L)	Median (IQR)	3 (2.5 - 3.2)		3.8 (3 - 4)		z <sub>MWU</sub> = 3.291	<0.001 (HS)
	Mean ± SD	2.84 ± 0.67		3.74 ± 0.75			
	Range	1 – 5.5		1.8 – 6.5			
Pre-dialysis SBP (mm/Hg)	Median (IQR)	115 (110 - 120)		115 (110 - 120)		z <sub>MWU</sub> = 1.411	0.058 (NS)
	Mean ± SD	116.92 ± 10.65		116.113 ± 9.58			
	Range	90 – 150		90 – 150			
Pre-dialysis DBP (mm/Hg)	Median (IQR)	75 (70 - 80)		75 (70 - 80)		z <sub>MWU</sub> = 2.066	0.039 (S)
	Mean ± SD	75.77 ± 7.98		75.19 ± 7.31			
	Range	50 – 100		60 – 95			

P value >0.05: Not significant (NS), P value <0.05 is significant (S), p<0.01 is highly significant (HS)  
SD: standard deviation, IQR: Interquartile range, X<sup>2</sup>: Chi-Square test, z<sub>MWU</sub>: Mann-Whitney U test

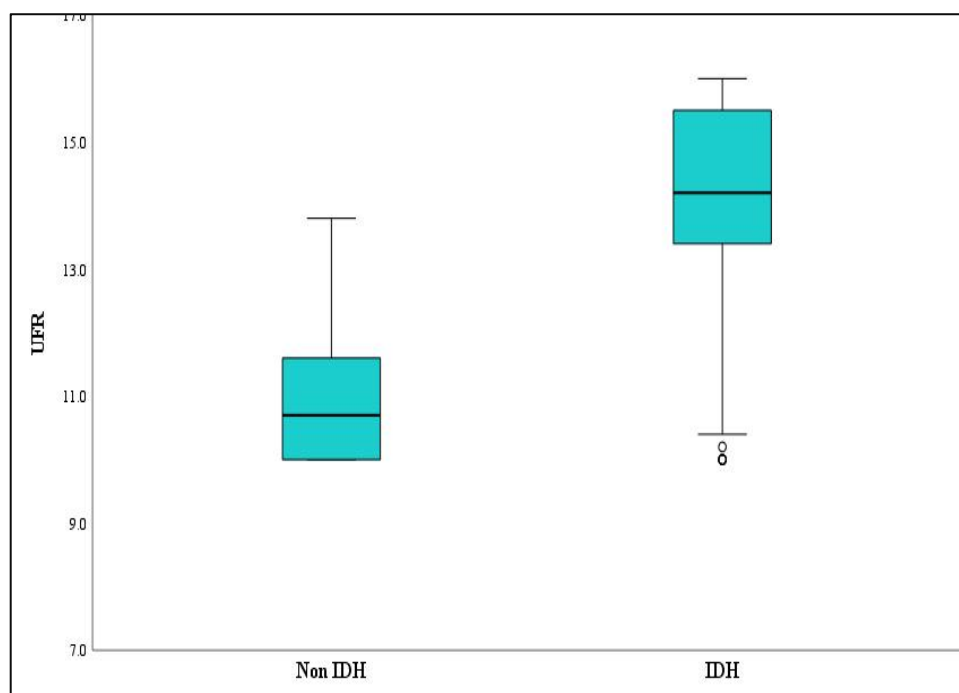


**Figure (11): Comparison between IDH & non-IDH regarding IDWG.**

**Table (10): Relation between IDH and UFRs.**

		Non IDH (Number of sessions =2511)		IDH (Number of sessions =1089)		Mann-Whitney U test	
						Z <sub>MWU</sub>	P-value
UFR	Median (IQR)	10.7 (10 - 11.6)		14.2 (13.4 - 15.5)		Z <sub>MWU</sub> = 44.779	<0.001 (HS)
	Mean ± SD	10.92 ± 1.00		14.20 ± 1.36			
	Range	10 – 13.8		10 – 16			
UFR categories	<10	839	33.4%	3	0.3%	X <sup>2</sup> = 2269.8	<0.001 (HS)
	10- 12	1242	49.5%	66	6.0%		
	12- 14	430	17.1%	430	39.5%		
	14- 16	0	0.0%	427	39.2%		
	>16	0	0.0%	163	15.0%		

P value >0.05: Not significant (NS), P value <0.05 is significant (S), p<0.01 is highly significant (HS)  
SD: standard deviation, IQR: Interquartile range, UFR: ultrafiltration rate



**Figure (12): Comparison between IDH & non-IDH regarding UFR.**

**Table (11): Relation between DM and UFRs in the IDH group.**

		IDH (Number of sessions =1089)				Mann-Whitney U test	
		No DM		DM		Z <sub>MWU</sub>	P-value
UFR	Median (IQR)	14.2 (13.4 - 15.5)		14.3 (13.5 - 15.6)		Z <sub>MWU</sub> = 1.551	0.121 (NS)
	Mean ± SD	14.17 ± 1.37		14.37 ± 1.29			
	Range	10 – 16		11.2 – 16			
UFR categories	<10	3	0.3%	0	0.0%	X <sup>2</sup> = 4.922	0.295 (NS)
	10- 12	58	6.3%	8	4.7%		
	12- 14	367	39.9%	63	37.1%		
	14- 16	362	39.4%	65	38.2%		
	>16	129	14.0%	34	20.0%		

P value >0.05: Not significant (NS), P value <0.05 is significant (S), p<0.01 is highly significant (HS)  
SD: standard deviation, IQR: Interquartile range, UFR: ultrafiltration rate

**Table (12): Relation between cardiovascular diseases and UFRs in the IDH group.**

		IDH group (Number of sessions =1089)				Mann-Whitney U test	
		No cardiovascular diseases		Cardiovascular diseases		Z <sub>MWU</sub>	P-value
UFR	Median (IQR)	14.3 (13.5 - 15.6)		13.8 (12.8 - 15.0)		z <sub>MWU</sub> = 4.883	<0.001 (HS)
	Mean ± SD	14.34 ± 1.27		13.84 ± 1.51			
	Range	10 – 16		10 – 16			
UFR categories	<10	0	0.0%	3	1.0%	X <sup>2</sup> = 34.61	<0.001 (HS)
	10- 12	34	4.3%	32	10.7%		
	12- 14	297	37.5%	133	44.6%		
	14- 16	329	41.6%	98	32.9%		
	>16	131	16.6%	32	10.7%		

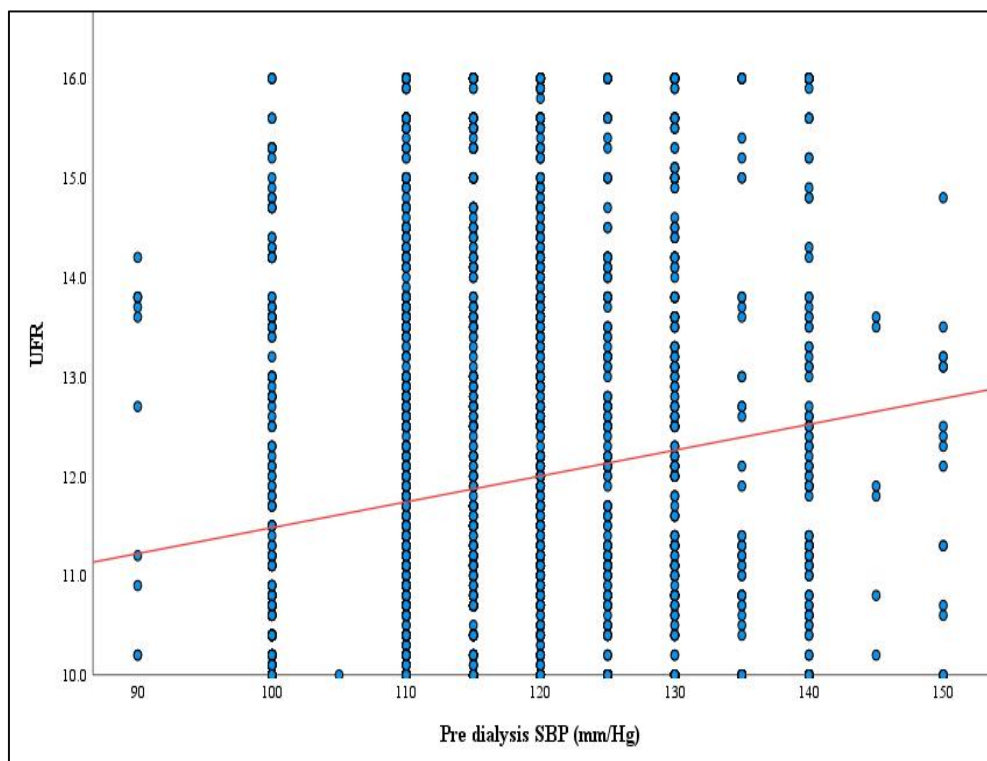
P value >0.05: Not significant (NS), P value <0.05 is significant (S), p<0.01 is highly significant (HS)  
SD: standard deviation, IQR: Interquartile range, UFR: ultrafiltration rate



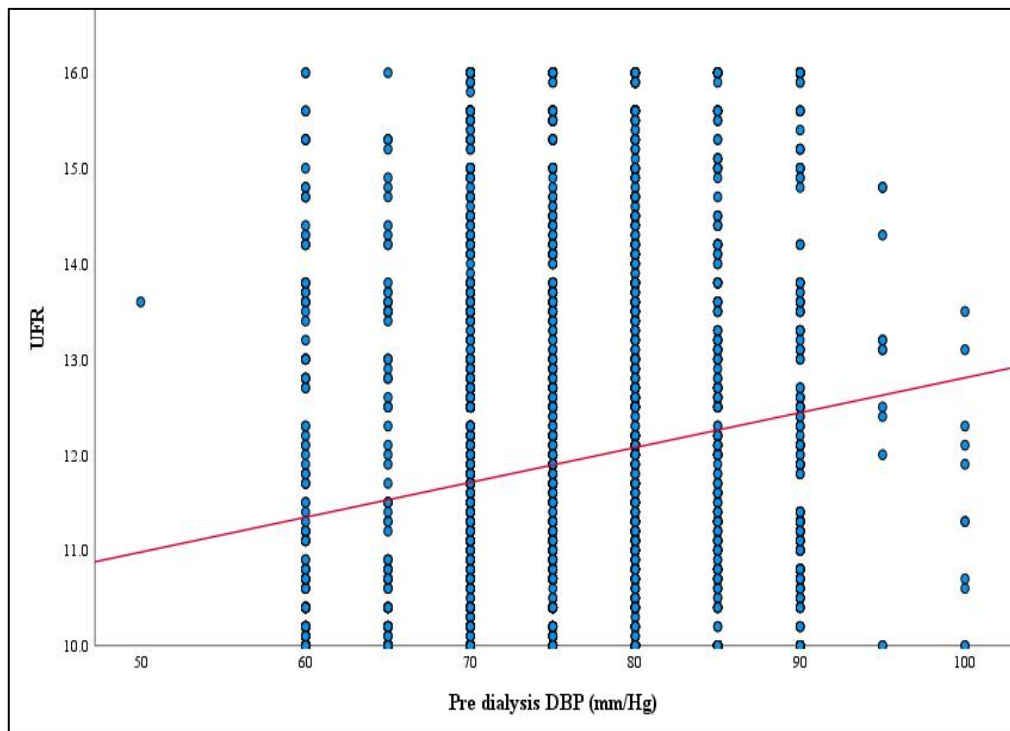
**Table (13): Correlation study between UFR and different numerical variables.**

	UFR	
	(r)	p-value
Age (years)	0.130	<0.001 (HS)
BMI (Kg/m <sup>2</sup> )	0.177	<0.001 (HS)
Dialytic age (m)	0.005	0.772 (NS)
Hemoglobin (g/dL)	-0.076	<0.001 (HS)
Hematocrit	-0.107	<0.001 (HS)
Albumin (g/dL)	0.023	0.168 (NS)
IDWG (L)	0.534	<0.001 (HS)
Pre-dialysis SBP (mm/Hg)	0.166	<0.001 (HS)
Pre-dialysis DBP (mm/Hg)	0.158	<0.001 (HS)

$p \leq 0.05$  is considered statistically significant,  $p \leq 0.01$  is considered highly statistically significant, (r): Spearman correlation coefficient



**Figure (13): Scatter-plot showing a significant positive correlation between total UFR with pre-dialysis SBP.**



**Figure (14): Scatter plot showing a significant positive correlation between total UFR with pre-dialysis DBP.**

**Table (14): Identification of the appropriate cut-off point for ultrafiltration rate (UFR) to prevent the occurrence of intradialytic hypotension via the examination of binary UFR categories.**

Ultrafiltration rate (ml/kg/h)	Adjusted OR	95%CI		Likelihood ratio of positive	Number needed to harm (IDH)
		Lower limit	Upper limit		
≤10 vs. >10	155.82	54.38	446.43	110.52	2.56
≤11 vs. >11	87.36	54.79	139.28	43.88	1.98
≤12 vs. >12	70.99	54.51	92.46	21.92	1.49
≤13 vs. >13	115.59	88.45	151.07	10.61	1.20
≤14 vs. >14	5938.1	370.37	95204.99	6.03	1.20
≤15 vs. >15	2272.23	141.67	36445.13	4.35	1.30
≤16 vs. >16	886.41	55.15	14246.21	3.71	1.37

B: Regression coefficient; OR: Odds ratio, CI: Confidence interval

**Table (15): Logistic regression analysis for factors associated with intradialytic hypotension.**

Parameters	B	S.E.	Wald	P-value	Odds ratio (OR)	95%CI	
						Lower limit	Upper limit
Age	0.007	0.003	7.282	<b>0.007</b>	1.007	1.002	1.013
Sex	-0.382	0.287	1.773	0.183	0.682	0.389	1.198
BMI	0.028	0.008	11.741	<b>0.001</b>	1.029	1.012	1.045
Diabetes	-0.509	0.348	2.142	0.143	0.601	0.304	1.188
Cardiovascular disease	-0.347	0.232	2.239	0.135	0.707	0.449	1.113
Hypertension	-0.456	0.081	31.516	<b>&lt;0.001</b>	0.634	0.540	0.743
Number of antihypertensive drugs	0.260	0.058	20.002	<b>0.025</b>	1.296	1.157	1.453
Dialytic age(m)	-0.002	0.002	0.607	0.436	0.998	0.994	1.002
Hemoglobin (g/dL)	0.094	0.046	4.186	<b>0.041</b>	1.098	1.004	1.201
Hematocrit	0.035	0.014	6.347	<b>0.012</b>	1.036	1.008	1.065
Albumin (g/dL)	-1.781	0.369	23.239	<b>&lt;0.001</b>	0.168	0.082	0.348
IDWG (L)	2.477	0.357	48.082	<b>&lt;0.001</b>	11.907	5.912	23.983
Interdialytic day	1.759	0.450	15.286	<b>&lt;0.001</b>	5.807	2.404	14.024
Day of the week	0.383	0.265	2.094	0.148	1.467	0.873	2.466
Time of the day	0.047	0.131	0.127	0.721	1.048	0.811	1.354
Pre-dialysis SBP	0.006	0.004	2.457	0.117	1.006	0.999	1.013
Pre-dialysis DBP	-0.083	0.036	5.301	<b>0.021</b>	0.920	0.857	0.988
UFR	2.547	0.156	267.531	<b>&lt;0.001</b>	12.772	9.412	17.331

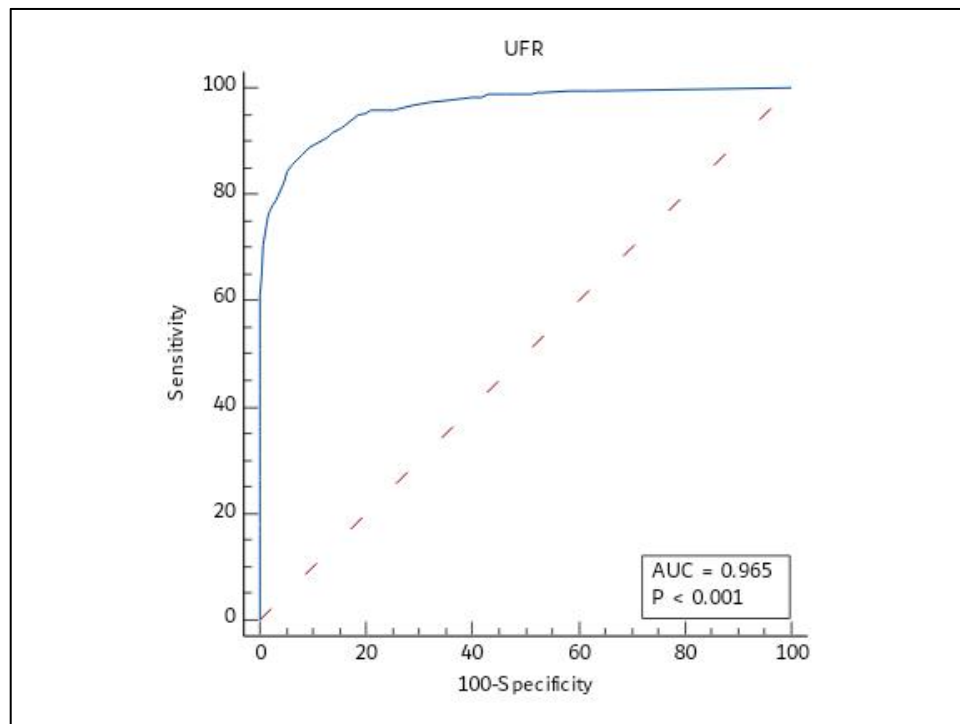
B: Regression coefficient; S.E.: Standard error, CI: Confidence interval

**Table (16): Validity of ultrafiltration rate (UFR) in the identification of the occurrence of intradialytic hypotension.**

	Cutoff	AUC	Sensitivity	Specificity	PPV	NPV	p-value
<b>UFR</b>	12.7	0.965	85.8%	93.9%	85.9%	93.8%	<b>&lt;0.001**</b>

AUC: Area Under a Curve, NPV: Negative predictive value, PPV: Positive predictive value

\*: Statistically significant at  $p \leq 0.05$



**Figure (15): ROC curve of UFR in the identification of the occurrence of intradialytic hypotension.**

**Table (17): Criterion values and coordinates of the ROC curve of ultrafiltration rate (UFR) at different cut-off points to detect intradialytic hypotension.**

<b>Ultrafiltration rate (ml/kg/h)</b>	<b>Sensitivity</b>	<b>Specificity</b>	<b>PPV</b>	<b>NPV</b>
<b>&gt;10</b>	99.63%	36.97%	40.7%	99.6%
<b>&gt;11</b>	98.35%	60.12%	51.7%	98.8%
<b>&gt;12</b>	93.66%	82.87%	70.3%	96.8%
<b>&gt;13</b>	78.88%	96.89%	91.7%	91.4%
<b>&gt;14</b>	74.10%	98.69%	96.1%	89.8%
<b>&gt;15</b>	61.07%	99.72%	99.0%	85.5%
<b>&gt;16</b>	0.0%	100%	100%	0.0%

## Statistical analysis

### Statistical analysis of the data

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0 (**IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp**). Qualitative data were described using numbers and percentages. The Shapiro-Wilk test was used to verify the normality of the distribution. Quantitative data were described using range (minimum and maximum), mean, standard deviation, median, and interquartile range (IQR). The significance of the obtained results was judged at the 5% level. The used tests were:

- **Mann-Whitney Test (U test):** to assess the statistical significance of the difference of a non-parametric variable between two study groups.
- **Correlation analysis (using Spearman/Pearson's method):** to assess the strength of association between two quantitative variables. The correlation coefficient, denoted symbolically "r," defines the strength and direction of the linear relationship between two variables.
- **Logistic regression** is a statistical method used to examine the relationship between one or more independent variables (predictors) and a binary outcome (e.g., yes/no, presence/absence of a disease or death).
- **The ROC Curve (receiver operating characteristic):** provides a useful way to evaluate the Sensitivity and specificity for quantitative diagnostic measures that categorize cases into one of two groups.