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Research Article

Investigating the Relationship Between Changes in Cerebral Oximetry and Area Under the Curve with Short-Term Complications after Cardiac Surgery

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Abstract

Background: The availability of monitoring equipment is increasing today. These devices range from invasive to non-invasive. The selection of appropriate monitoring is based on their advantages, disadvantages and costs. In general, the role of non-invasive brain monitoring is expanding due to its performance accuracy as well as greater output stability. Annually, nearly half of one million patients who undergo heart surgery commonly experience neurological complications such as cognitive disorders, neuropsychological disorders, etc. In this study we aimed to investigate the relationship between short-term complications after heart surgery with cerebral oximetry changes and the space under the curve (duration of rSo2 drop) so that this monitoring may be used for heart surgery in the future.

Methods: This prospective cross-sectional study was performed on 101 patients in the cardiac surgery room of Imam Khomeini Hospital in Tehran during 2019-2020. After entering the operating room, patients underwent routine monitoring such as: NIBP, ECG, HR, Spo2, ETCo2 will be placed. Then, before induction of anesthesia, they are monitored by INVOS 5100c cerebral oximeter rSo2. Patients will be followed up for 7 days, the duration of intubation and hospitalization in the ICU and complications such as renal failure, CVA and death will be recorded for them. P-value less than 0.05 was significant.

Result: There is a significant relationship between the AUC left and IHD (P-value=0.034), CVA (P-value=0.05), multivalve surgery (P-value=0.05), CABG surgery (P-value=0.001), dissection surgery (P-value=0.009), ICU stay (left P-value=0.01, right P-value=0.005), intubation time (P-value=0.023), people who die within a week (P-value=0.036). There is a significant relationship between the amount of rSO2Left and the EF variable before the operation (P-value=0.014), stage 3 kidney failure and mortality rate after one week (P-value=0.001). the Cross lamp duration is the highest for patients whose rSO2Left was in the region of (10-20) and the lowest Cross lamp duration for patients who did not have drop in rSO2Left (P-value=0.002). There is a significant difference in pump time between people who did not have a drop in rSO2 and people who had a drop of more than 20 minutes (P-value=0.032). The cross lamp duration of patients in the first group of rSO2 has a significant relationship with the other three groups (P-value<0.001).

Conclusion: The mean level below the cerebral oximetry chart (AUC) in patients with IHD and CVA was significant. This means that the disease affects the amount of oxygenation during the operation.
In patients undergoing CABG surgery, the data recorded on the right forehead showed a lower area under the curve. Also, patients with dissection of the aorta have more significant data on the right side.
Also, the left data of patients had a significant relationship with the EF variable before surgery and this variable affects the patient's brain oxygen level.

Kew Words: cerebral oximetry, complications of cardiac surgery

Introduction

Today, the availability of monitoring devices is expanding. These devices range from invasive to non-invasive. Choosing the right monitoring is based on their advantages, disadvantages and costs. In general, the role of non-invasive brain monitoring is expanding due to the accuracy in performance and more stable output. Every year, nearly half of one million patients who undergo heart surgery commonly experience neurological complications such as cognitive disorders, neuropsychological disorders, etc., in a quarter of them these changes remain stable and the main cause of these complications is brain tissue ischemia (2-5). Neurological complications are one of the most important complications after heart surgery, and POCD (postoperative cognitive dysfunction) is usually seen in 23-81% of these patients (28). Other complications of the central nervous system after cardiovascular surgery can be mentioned as cerebral embolism, decreased perfusion of all parts of the brain, inflammation, cerebral hyperthermia, cerebral edema, and dysfunction of the blood-brain barrier. In addition to the above, it seems that the processes that damage the CNS can also affect other vital organs of the body and lead to damage in them as well (2). Cerebral oximetry and jugular bulb oximetry are used to evaluate brain oxygenation, which jugular bulb oximetry measures jugular oxygen saturation (Sjvo2) through the vein directly and invasively. Cerebral oximetry can measure the oxygen saturation of the cerebral vessels (rSo2) even in those with a diameter of less than one mm. It can measure the oxygen saturation locally and non-invasively through infrared light that sensors are placed on the forehead and one of its most important advantages compared with jugular bulb oximetry is that cerebral oximetry can also measure rSo2 in nonpulsatile times, such as when the patient is on cardiopulmonary bypass or cardiopulmonary arrest (1). It has been shown in some studies that interventions based on cerebral oximetry monitoring have been effective in improving the outcome of patients (1).

Considering the above, in this study, we decided to investigate the relationship between short-term complications after heart surgery with changes in cerebral oximetry and the space under the curve (duration of rSo2 drop), so that perhaps this monitoring can be used for heart surgery in the future.

Methods and materials

This is a prospective cross-sectional study on 101 eligible patients undergoing heart surgery in Imam Khomeini Hospital from March 2018 to March 2020. All patients aged 20-80 years after obtaining informed consent and meeting the entry criteria (age 20-80 years, non-emergency cardiac surgery) will be monitored by the INVOS cerebral oximetry device and their data will be entered into a questionnaire and the amount and type of complications will be evaluated during hospitalization.

Using the sample size formula plus 10% additional sample, about 90 patients were calculated, but in the present study, 101 patients were evaluated, which is a positive point in our work. In this study, after entering the operating room, patients will be subjected to routine monitoring such as: NIBP, ECG, HR, Spo2, ETCo2. Then, before the induction of anesthesia, they are monitored by the INVOS 5100c cerebral oximetry device of Medtronic company, made in the United States of America, in such a way that two self-adhesive patches will be attached to both sides of the forehead (left and right side). These two patches have LEDs and infrared sensors that can measure rSo2 and show it on the monitor, after which the basic rSo2 amount will be recorded. After the injection of 0.5-1 µg/kg of fentanyl, an arterial line will be inserted for the patients and they will also undergo IBP monitoring. For the induction of anesthesia, Midazolam 0.1 mg/kg + Fentanyl 5-10µg/kg + 1-2 mg/kg propofol, 0.6 mg/kg atracurium is injected to the patients along with 500 cc of Ringer's serum and after that the patient will be intubated and for the maintenance of the patients propofol 20-100 g/kg/min, Fentanyl 0.5µg/kg/h + Midazolam o.25-0.5µg/kg/h + Atracurium 2-4µg/kg/min were prescribed (29). The rSo2 of the two hemispheres of the brain will be recorded after induction, before cardiopulmonary bypass and after it, and the data of the space under the curve will be interpreted by the software related to the device, and the patients will be followed up for 7 days, and the complications caused by them will be recorded. Inclusion criteria is age 20-80 years and non-emergency cardiac surgery. Exclusion criteria is age over 80 years old and under 20 years old, dialysis patients, end-stage renal disease (ESRD), blood creatinine above 2 units, infective endocarditis, emergency heart surgery, BMI<18 and BMI>30.

Mean, standard deviation, median, range, frequency and percentage were used to describe the data. Chi-score, Fisher's exact test and Spearman's correlation coefficient were used to find the relationship between Ki67 and p16 levels and different degrees of CIN. Finally, we will use the statistical indicators of sensitivity, specificity, positive and negative predictive value, kappa coefficient and positive and negative accuracy ratio to determine the differentiation of these indicators. All analyzes will be done by SPSS 25.0 statistical software.

Results

101 patients aged 20-80 underwent heart surgery at Imam Khomeini Hospital and entered this prospective cross-sectional study. After obtaining informed consent, they were examined by the INVOS cerebral oximetry device, and their data were entered into a questionnaire, and the amount and type of complications were evaluated during the hospitalization period.

The demographic information of 101 patients of this study is analyzed in Table No.1

		N (%)
Gender	Male	64 (63.4%)
	Female	37 (36.6%)
BMI	18 - 25	44 (43.6%)
	25 - 30	57 (56.4%)
Smoker	No	83 (82.2%)

	Yes	18 (17.8%)
Age	Mean ± SD	52.92 ± 16.68
	Median (Range)	55 (19,79)

Table 1: demographic information of patients

In table number 2, we examine the clinical information of the patients.

		N (%)
IHD	No	66 (65.3%)
	Yes	35 (34.7%)
CHF	No	76 (75.2%)
	Yes	25 (24.8%)
CKD	No	94 (93.1%)
	Yes	7 (6.9%)
DM	No	85 (84.2%)
	Yes	16 (15.8%)
HTN	No	57 (56.4%)
	Yes	44 (43.6%)
CVA	No	89 (88.1%)
	Yes	12 (11.9%)
CABG	No	88 (87.1%)
	Yes	13 (12.9%)
Valve surgery	No	60 (59.4%)
	Yes	41 (40.6%)
CABG + Valve surgery	No	85 (84.2%)
	Yes	16 (15.8%)
Multivalve surgery	No	88 (87.1%)
	Yes	13 (12.9%)
Dissection	No	83 (82.2%)
	Yes	18 (17.8%)
EF	**<30%**	**18 (17.8%)**
	>30%	**83 (82.2%)**

Table 2: Clinical information of patients

Cerebral oximetry changes and the area under the drop time curve (rSo2) have been analyzed in Table No. 3.

		N (%)	***P-value****
LEFT rSO2<30%(min)	0	39 (38.6%)	
	<10	29 (28.7%)	
	10 – 20	18 (17.8%)	
	>20	15 (14.9%)	
RIGHT rSO2<30%(min)	0	41 (40.6%)	
	<10	30 (29.7%)	
	10 – 20	15 (14.9%)	<0.001
	>20	15 (14.9%)	
		Mean ± SD	***Median (Range)***

LEFT AUC	339.77 ± 331.15	230 (100,1930)
RIGHT AUC	383.47 ± 471.4	200 (100,2350)

Table 3: Examining changes in cerebral oximetry and the area under the curve of the drop time

In table number 4, we examine the average and standard deviation of variables calculated during the operation.

		N (%)	
Duration of ICU add(days)	**Death in the operating room**	**2 (2.0%)**	
	<3	35 (34.7%)	
	3 – 5	51 (50.5%)	
	>5	13 (12.9%)	
Extubation time(hrs)	**Death in the operating room &Icu**	**7 (6.9%)**	
	<8	24 (23.8%)	
	8 – 24	56 (55.4%)	
	>24	14 (13.9%)	
		Mean ± SD	***Median (Range)***
Pomp time(min)		148.62 ± 65.67	137 (20,350)
Cross Clamp time(min)		91.58 ± 36.29	90 (30,208)

Table 4: Checking the mean and standard deviation of each Variable

In table number 5, we examine the complications that occurred in the first week after the operation.

		N (%)
AKI stage1 W1	No	87 (86.1%)
	Yes	14 (13.9%)
AKI stage2 W1	No	86 (85.1%)
	Yes	15 (14.9%)
AKI stage3 W1	No	93 (92.1%)
	Yes	8 (7.9%)
Dialysis W1	No	99 (98.0%)
	Yes	2 (2.0%)
Death W1	No	84 (83.2%)
	Yes	17 (16.8%)

Table 5: Complications that occurred during the first week after the operation

In table number 6, we examine the relationship between changes in cerebral oximetry and area under the curve with demographic and clinical information of people.

		LEFT AUC		RIGHT AUC	
		Mean ± SD	P-value*	Mean ± SD	P-value*
Gender	Male	365.33 ± 360.62	0.358	387 ± 475.95	0.933
	Female	293.21 ± 269.21		377.43 ± 472.1	
BMI	18 - 25	375.19 ± 370.27	0.388	369.64 ± 453.97	0.81
	25 - 30	310.12 ± 295.68		395.93 ± 491.98	
Smoker	No	335.02 ± 303.95	0.802	380.71 ± 489.8	0.925
	Yes	358.5 ± 433.47		393.06 ± 414.55	
IHD	No	384.26 ± 378.31	0.034	451.47 ± 556.37	0.015

	Yes	249.08 ± 178.03		244.76 ± 140.23	
CHF	No	340.81 ± 350.53	0.962	417.74 ± 515.45	0.275
	Yes	336.7 ± 274.01		280.68 ± 290.6	
CKD	No	347.97 ± 336.94	0.085	391.07 ± 482.78	0.099
	Yes	186 ± 132.59		246.75 ± 113.88	
DM	No	346.09 ± 347.65	0.691	402.12 ± 508.41	0.429
	Yes	304.5 ± 225.43		284 ± 147.98	
HTN	No	306.09 ± 282.78	0.289	370.32 ± 463.79	0.759
	Yes	386.73 ± 388.51		404.79 ± 491	
CVA	No	353.38 ± 340.74	0.05	400.68 ± 490.94	0.009
	Yes	199.86 ± 163.2		213.86 ± 95.26	
CABG	No	351.37 ± 348.02	0.087	413.65 ± 498.08	0.001
	Yes	249.56 ± 119.23		184.3 ± 96.42	
Valvular	No	346.98 ± 377.02	0.834	342.51 ± 404.37	0.391
	Yes	331.17 ± 271.43		436.85 ± 548.64	
cabg-valv	No	350.12 ± 343.91	0.493	395.66 ± 492.12	0.542
	Yes	275.82 ± 240.17		292.78 ± 273.49	
Multivalve	No	309.13 ± 252.93	0.05	366.94 ± 461.47	0.461
	Yes	510.83 ± 596.73		481.18 ± 539.84	
dissection	No	319.57 ± 337.58	0.321	309.02 ± 317.76	0.009
	Yes	408.22 ± 307.42		641.88 ± 764.35	
Age.c	20 - 40	388.52 ± 408.77	0.474	439.76 ± 546.72	0.26
	40 - 60	282.21 ± 247.94		252.26 ± 163.34	
	60 +	317.17 ± 256.95		419.81 ± 537.95	

*Based on T-test

Table 6: Examining the relationship between the space under the curve and demographic information, diseases and type of operation

In Table No. 7, we examine the average AUC during the operation against the variables of operation time and complications one week after the operation.

		LEFT AUC		RIGHT AUC	
		Mean ± SD	P-value*	Mean ± SD	P-value*
Duration of ICU add(days)	No	1122 ± .	0.01	1917 ± .	0.005
	<3	444 ± 462.5		426.79 ± 514.05	
	(3 - 5)	273.95 ± 195.4		359.74 ± 443.38	
	>5	236.73 ± 111.89		223.83 ± 103.4	
Extubation time(hrs)	No	820.75 ± 656.86	0.023	1260 ± 1007.54	0.008
	<8	346.84 ± 413.91		285.42 ± 309.62	
	(8 - 24)	310.02 ± 261.66		364.7 ± 447.81	
	>24	274.36 ± 122.29		389.4 ± 445.22	
EF	<30%	359.93 ± 265.59	0.804	289 ± 297.91	0.431
	>30%	335.43 ± 345.27		402.97 ± 499.37	
AKI stage1 W1	No	341.1 ± 340.69	0.933	399.91 ± 499.82	0.464
	Yes	332.33 ± 284.77		286.36 ± 235.79	
AKI stage2 W1	No	353.09 ± 356.06	0.424	413.72 ± 501.2	0.176
	Yes	272.15 ± 141.89		204.73 ± 133.53	
AKI stage3 W1	No	344.51 ± 345.37	0.686	382.47 ± 473.11	0.957

	Yes	291 ± 104.93		392 ± 488.2	
Dialysis W1	No	339.51 ± 333.28	0.951	384.72 ± 474.44	0.843
	Yes	360 ± .		290 ± .	
Death W1	No	303.63 ± 283.07	0.036	334.97 ± 391.61	0.048
	Yes	507.57 ± 476.05		618.54 ± 724.06	

*Based on T-Test

Table 7: Examining the average AUC against the variables of operation time and complications one week after the operation

In table number 8, we examine the amount of rSO2 of patients based on demographic characteristics, diseases and type of operation.

		LEFT rSO2<30%(min)					RIGHT rSO2<30%(min)				
		0	<10	10 - 20	>20	P-value*	0	<10	10 - 20	>20	P-value*
Gender	Male	26 (66.7%)	17 (58.6%)	14 (77.8%)	7 (46.7%)	0.275	27 (65.9%)	19 (63.3%)	11 (73.3%)	7 (46.7%)	0.466
	Female	13 (33.3%)	12 (41.4%)	4 (22.2%)	8 (53.3%)		14 (34.1%)	11 (36.7%)	4 (26.7%)	8 (53.3%)	
BMI	18 - 25	17 (43.6%)	13 (44.8%)	5 (27.8%)	9 (60.0%)	0.322	19 (46.3%)	13 (43.3%)	6 (40.0%)	6 (40.0%)	0.963
	25 - 30	22 (56.4%)	16 (55.2%)	13 (72.2%)	6 (40.0%)		22 (53.7%)	17 (56.7%)	9 (60.0%)	9 (60.0%)	
smoker	No	34 (87.2%)	24 (82.8%)	12 (66.7%)	13 (86.7%)	0.285	36 (87.8%)	26 (86.7%)	8 (53.3%)	13 (86.7%)	0.018
	Yes	5 (12.8%)	5 (17.2%)	6 (33.3%)	2 (13.3%)		5 (12.2%)	4 (13.3%)	7 (46.7%)	2 (13.3%)	
IHD	No	28 (71.8%)	18 (62.1%)	13 (72.2%)	7 (46.7%)	0.316	29 (70.7%)	19 (63.3%)	7 (46.7%)	11 (73.3%)	0.346
	Yes	11 (28.2%)	11 (37.9%)	5 (27.8%)	8 (53.3%)		12 (29.3%)	11 (36.7%)	8 (53.3%)	4 (26.7%)	
CHF	No	33 (84.6%)	21 (72.4%)	14 (77.8%)	8 (53.3%)	0.117	34 (82.9%)	20 (66.7%)	12 (80.0%)	10 (66.7%)	0.353
	Yes	6 (15.4%)	8 (27.6%)	4 (22.2%)	7 (46.7%)		7 (17.1%)	10 (33.3%)	3 (20.0%)	5 (33.3%)	
CKD	No	38 (97.4%)	27 (93.1%)	17 (94.4%)	12 (80.0%)	0.159	39 (95.1%)	28 (93.3%)	15 (100.0%)	12 (80.0%)	0.147
	Yes	1 (2.6%)	2 (6.9%)	1 (5.6%)	3 (20.0%)		2 (4.9%)	2 (6.7%)	0 (0.0%)	3 (20.0%)	
DM	No	33 (84.6%)	26 (89.7%)	15 (83.3%)	11 (73.3%)	0.574	36 (87.8%)	27 (90.0%)	12 (80.0%)	10 (66.7%)	0.186
	Yes	6 (15.4%)	3 (10.3%)	3 (16.7%)	4 (26.7%)		5 (12.2%)	3 (10.0%)	3 (20.0%)	5 (33.3%)	
HTN	No	20 (51.3%)	17 (58.6%)	13 (72.2%)	7 (46.7%)	0.412	24 (58.5%)	18 (60.0%)	8 (53.3%)	7 (46.7%)	0.833
	Yes	19 (48.7%)	12 (41.4%)	5 (27.8%)	8 (53.3%)		17 (41.5%)	12 (40.0%)	7 (46.7%)	8 (53.3%)	
CVA	No	34 (87.2%)	25 (86.2%)	17 (94.4%)	13 (86.7%)	0.837	35 (85.4%)	27 (90.0%)	14 (93.3%)	13 (86.7%)	0.845
	Yes	5 (12.8%)	4 (13.8%)	1 (5.6%)	2 (13.3%)		6 (14.6%)	3 (10.0%)	1 (6.7%)	2 (13.3%)	
CABG	No	33 (84.6%)	26 (89.7%)	17 (94.4%)	12 (80.0%)	0.588	34 (82.9%)	28 (93.3%)	12 (80.0%)	14 (93.3%)	0.412
	Yes	6 (15.4%)	3 (10.3%)	1 (5.6%)	3 (20.0%)		7 (17.1%)	2 (6.7%)	3 (20.0%)	1 (6.7%)	
valvular	No	18 (46.2%)	16 (55.2%)	10 (55.6%)	11 (73.3%)	0.354	20 (48.8%)	14 (46.7%)	11 (73.3%)	10 (66.7%)	0.229
	Yes	21 (53.8%)	13 (44.8%)	8 (44.4%)	4 (26.7%)		21 (51.2%)	16 (53.3%)	4 (26.7%)	5 (33.3%)	
cabg-valv	No	34 (87.2%)	23 (79.3%)	16 (88.9%)	12 (80.0%)	0.735	36 (87.8%)	24 (80.0%)	12 (80.0%)	13 (86.7%)	0.786

	Yes	5 (12.8%)	6 (20.7%)	2 (11.1%)	3 (20.0%)		5 (12.2%)	6 (20.0%)	3 (20.0%)	2 (13.3%)	
multivalv	No	34 (87.2%)	27 (93.1%)	14 (77.8%)	13 (86.7%)	0.507	36 (87.8%)	27 (90.0%)	12 (80.0%)	13 (86.7%)	0.821
	Yes	5 (12.8%)	2 (6.9%)	4 (22.2%)	2 (13.3%)		5 (12.2%)	3 (10.0%)	3 (20.0%)	2 (13.3%)	
dissection	No	31 (79.5%)	23 (79.3%)	12 (66.7%)	12 (80.0%)	0.707	33 (80.5%)	25 (83.3%)	12 (80.0%)	8 (53.3%)	0.121
	Yes	8 (20.5%)	6 (20.7%)	6 (33.3%)	3 (20.0%)		8 (19.5%)	5 (16.7%)	3 (20.0%)	7 (46.7%)	
Age.c	20 - 40	10 (25.6%)	4 (13.8%)	6 (35.3%)	4 (26.7%)	0.564	10 (24.4%)	5 (16.7%)	2 (14.3%)	7 (46.7%)	0.339
	40 - 60	11 (28.2%)	14 (48.3%)	5 (29.4%)	5 (33.3%)		13 (31.7%)	12 (40.0%)	5 (35.7%)	5 (33.3%)	
	60 +	18 (46.2%)	11 (37.9%)	6 (35.3%)	6 (40.0%)		18 (43.9%)	13 (43.3%)	7 (50.0%)	3 (20.0%)	

*P-value based on Chi-Square And fisher Exact test

In table number 9, we examine the rSO2 level of patients against the variables of operation time and complications one week after the operation.

Table 8: Examination of the rSO2 level of patients based on demographic characteristics, diseases and type of operation

		LEFT rSO2<30%(min)						**RIGHT rSO2<30%(min)**					
		0	**<10**	**10 - 20**	**>20**	**P-value***	**Pairwise comparison**	**0**	**<10**	**10 - 20**	**>20**	**P-value***	**Pairwise comparison**
Duration of ICU add(days)	**No**	**1 (2.6%)**	**0 (0.0%)**	**0 (0.0%)**	**1 (6.7%)**	**0.081**		**1 (2.4%)**	**0 (0.0%)**	**0 (0.0%)**	**1 (6.7%)**	**0.124**	
	< 3	**17 (43.6%)**	**10 (34.5%)**	**3 (16.7%)**	**5 (33.3%)**			**20 (48.8%)**	**7 (23.3%)**	**5 (33.3%)**	**3 (20.0%)**		
	3 - 5	**21 (53.8%)**	**12 (41.4%)**	**11 (61.1%)**	**7 (46.7%)**			**19 (46.3%)**	**16 (53.3%)**	**8 (53.3%)**	**8 (53.3%)**		
	> 5	**0 (0.0%)**	**7 (24.1%)**	**4 (22.2%)**	**2 (13.3%)**			**1 (2.4%)**	**7 (23.3%)**	**2 (13.3%)**	**3 (20.0%)**		
Extubation time(hrs)	**No**	**2 (5.1%)**	**2 (6.9%)**	**1 (5.6%)**	**2 (13.3%)**	**0.136**		**1 (2.4%)**	**3 (10.0%)**	**2 (13.3%)**	**1 (6.7%)**	**0.005**	
	< 8	**13 (33.3%)**	**8 (27.6%)**	**1 (5.6%)**	**2 (13.3%)**			**17 (41.5%)**	**4 (13.3%)**	**2 (13.3%)**	**1 (6.7%)**		
	8 - 24	**21 (53.8%)**	**15 (51.7%)**	**14 (77.8%)**	**6 (40.0%)**			**20 (48.8%)**	**21 (70.0%)**	**8 (53.3%)**	**7 (46.7%)**		
	> 24	**3 (7.7%)**	**4 (13.8%)**	**2 (11.1%)**	**5 (33.3%)**			**3 (7.3%)**	**2 (6.7%)**	**3 (20.0%)**	**6 (40.0%)**		
EF W1	**< 30%**	**4 (10.3%)**	**5 (17.2%)**	**2 (11.1%)**	**7 (46.7%)**	**0.014**		**3 (7.3%)**	**6 (20.0%)**	**5 (33.3%)**	**4 (26.7%)**	**0.092**	
	> 30%	**35 (89.7%)**	**24 (82.8%)**	**16 (88.9%)**	**8 (53.3%)**			**38 (92.7%)**	**24 (80.0%)**	**10 (66.7%)**	**11 (73.3%)**		
AKI stage1 W1	**No**	**37 (94.9%)**	**22 (75.9%)**	**15 (83.3%)**	**13 (86.7%)**	**0.159**		**36 (87.8%)**	**25 (83.3%)**	**12 (80.0%)**	**14 (93.3%)**	**0.702**	
	Yes	**2 (5.1%)**	**7 (24.1%)**	**3 (16.7%)**	**2 (13.3%)**			**5 (12.2%)**	**5 (16.7%)**	**3 (20.0%)**	**1 (6.7%)**		

		36	24	13	13		40	22	11	13		
AKI	N	(92.3	(82.8	(72.2	(86.7	0.2	(97.6	(73.3	(73.3	(86.7	0.0	
stage2 W1	o	%)	%)	%)	%)	49	%)	%)	%)	%)	19	
		3	5	5	2		1	8	4	2		
	Y	(7.7	(17.2	(27.8	(13.3		(2.4	(26.7	(26.7	(13.3		
	es	%)	%)	%)	%)		%)	%)	%)	%)		
		39	27	17	10		41	29	12	11		
AKI	N	(100.	(93.1	(94.4	(66.7	0.0	(100.	(96.7	(80.0	(73.3	0.0	
stage3 W1	o	0%)	%)	%)	%)	01	0%)	%)	%)	%)	02	
		0	2	1	5		0	1	3	4		
	Y	(0.0	(6.9	(5.6	(33.3		(0.0	(3.3	(20.0	(26.7		
	es	%)	%)	%)	%)		%)	%)	%)	%)		
		39	28	18	14		41	29	15	14		
Dialysis	N	(100.	(96.6	(100.	(93.3	0.3	(100.	(96.7	(100.	(93.3	0.3	
W1	o	0%)	%)	0%)	%)	66	0%)	%)	0%)	%)	75	
		0	1	0	1		0	1	0	1		
	Y	(0.0	(3.4	(0.0	(6.7		(0.0	(3.3	(0.0	(6.7		
	es	%)	%)	%)	%)		%)	%)	%)	%)		
		37	26	15	6		40	26	9	9		
	N	(94.9	(89.7	(83.3	(40.0	<0.	(97.6	(86.7	(60.0	(60.0	<0.	
Death W1	o	%)	%)	%)	%)	001	%)	%)	%)	%)	001	
		2	3	3	9		1	4	6	6		
	Y	(5.1	(10.3	(16.7	(60.0		(2.4	(13.3	(40.0	(40.0		
	es	%)	%)	%)	%)		%)	%)	%)	%)		
		137.6	143.5	156.2	177.9	0.2		157.5	159.3	179.2	0.0	
Pomp		4 ±	2 ±	2 ±	3 ±	14*	127 ±	±	3 ±	7 ±	32*	
time(min)		63.11	50.24	70.7	86.52	*	59.95	49.95	60.91	94.79	*	(1-4)
Cross		76.26	95.03	112.8	99.27	0.0	71.66	101.3	102.4	115.6	<0.	
Clamp		±	±	3 ±	±	02*	±	3 ±	7 ±	7 ±	001	(1-2,1-
time(min)		26.55	32.8	38.87	46.73	* (1-3)	25.88	29.51	40.4	44.06	**	3,1-4)

*P-value based On Chi-Square and Fisher Exact Test

** P-value Based on ANOVA (Bonferoni pairwise comparison)

Table 9: Examining the rSO2 level of patients against the variables of operation time and complications one week after the operation

Discussion

In this study 64 (63.4%) were male and the rest were female. 44 (43.6%) of the patients are in the normal range of BMI (18-25) and the rest are in the abnormal range, and 18 (17.8%) of the patients are smokers. Of the total number of patients, 34 (34.7%) had IHD, 25 (24.8%) had CHF, 7 (6.9%) had CKD, 16 (15.8%) had DM, 44 (43.6%) had HTN, 12 (11.9%) had CVA, and 13 (12.9%) had CABG, 16 (15.8%) had CABG-Valve operation, 46 (45.5%) were treated with Valve operation, 13 (12.9%) with Multivalve operation and finally 23 (22.8%) had Dissection.

Based on the baseline rSo2 recorded by pressure self-adhesive on the left forehead, 39 (38.6%) of the patients had no drop oxygen below 30%, 29 (28.7%) of the patients had a drop oxygen below 30% for less than 10 minutes, 18 (17.8%) of the patients had a drop oxygen below 30% between 10 and 20 minutes, and finally 15 (14.9%) of the patients had a drop oxygen below 30% for more than 20 minutes. The drop oxygen below 30% has been related to the values received from the left forehead, the values are 41(40.6%), 30(29.7%), 15(14.9%) and finally 15(14.9%) respectively. The information on the left and right sides are completely consistent with each other and the correlation coefficient is equal to 0.8.

The average area under the cerebral oximetry chart (AUC) based on the information of the left forehead is equal to 331.15 ± 339.77 with a range of 100 to 1930 min% and the information based on the right forehead is equal to 471.4 ± 383.47 with a range of 100 to 2350 min%.

The average Pomp time of the patients was 65.67 ± 148.62 with a range of 20 to 350 minutes, and the average Cross Clamp time was 36.29 ± 91.58 with a range of 30 to 208 minutes.

The average level under the graph in people with IHD is 178.03 ± 249.08 and in the rest is 378.31 ± 384.26, which is statistically significant. Also, this rate is significant among people who have had a history of CVA. The average level under the chart in people with a history of CVA is 163.2 ± 199.86 and in the rest is 340.74 ± 353.38. The patients who underwent multivalve surgery have the average of 596.73 ± 510.83 and others 252.93 ± 309.13 and it was statistically significant.

These values have also been evaluated in comparison with the average level of the diagram of the right frontal section. The result for patients with a history of CVA was similar to the left side. Similarly, patients who underwent CABG surgery have a lower area under the curve of the right side than the rest of the patients.

AUC right for people who had dissection surgery is significantly higher than people who do not have this complication. (However, patients with lower AUC have a longer duration of hospitalization in the ICU. In fact, with a decrease in AUC, the duration of a person's hospitalization in the ICU increases. The average of this value for people who are hospitalized in the ICU for more than 5 days is equal to 111.89 ± 236.73 (P-value=0.01). Also, with the decrease of the area under the curve, the duration of intubation of the patient increases. This amount for patients with a duration of more than 24 hours is equal to 274. 122.29 ± 36 (P-value=0.023) among the people who die within a week, the level under the curve during the operation is also significant.

There is a significant relationship between the amount of rSO2Left and EF variable before the operation. Patients with EF above 30% have lower rSO2Left. There is a significant relationship between rSO2Left with stage 3 renal failure and mortality after one week. Cross clamp duration is the

highest for patients whose rSO2Left was in the region (10-20) and for patients whose rSO2Left was zero, the duration of Cross lamp is the lowest. And this difference between these two groups is statistically significant. The duration of Cross lamp and Pomp time was evaluated for patients with rSO2right and a significant correlation was obtained between the groups. There is a significant difference in pump time between people who did not have rSO2 drop greater than 20 minutes. The cross lamp duration of patients in the first group of rSO2 has a significant relationship with the other three groups.

Conclusion

Among the patients aged 19 to 79 years who underwent open-heart surgery, the rSO2 level was checked using the INVOS cerebral oximetry device from the right and left side of the forehead and the data was recorded once during the operation and the area under the curve was checked. The right and left data records were almost the same except for special cases that will be announced later.

The mean area under the cerebral oximetry graph (AUC) in patients with IHD and CVA was statistically significant. This means that the disease affects the amount of oxygen in the blood during the operation.

In patients who have undergone CABG surgery, the data on the right side of the forehead recorded showed a lower area under the curve. Also, patients with DISSECTION surgery have more significant data of the area under the curve on the right.

Also, the data of the left subcurve level of the patients has a significant relationship with the EF variable before the operation, and this variable has an effect on the patient's blood oxygen level.

Due to the one-week examination of patients to check the complications caused by the reduction of oxygen during the operation, the level under the curve is also significant for those who have been under care in the ICU for more than 5 days.

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