# AIM OF THE WORK

The aim of the work was to compare the effect of hyperbaric to normobaric hyperoxia on the functional outcome in patients with traumatic brain injury.

# PATIENTS

The study was carried out on 75 adult patients of both sexes, who were admitted to the intensive care unit with the diagnosis of moderate traumatic bran injury (GCS 9-12).

Approval of the medical ethics committee of Alexandria Faculty of medicine was obtained. An informed consent was taken from every patient included in the study or from the next of kin before conducting the study.

Patients were randomly classified into 3 groups:

1) Group I ($HBO_2$): including 25 patients, received conventional treatment of traumatic brain injury plus 20 sessions of hyperbaic oxygen at 1.5 atmospheric pressure. The duration of each session was 60 minutes.

2) Group II (NBH): including 25 patients, received conventional treatment of traumatic brain injury plus 20 sessions of normobaric hyperoxia. The patients received 100% oxygen at normal atmospheric pressure daily for 3 consecutive hours.

3) Group III (control): including 25 patients, received conventional treatment of traumatic brain injury only.

Treatment was started as soon as the patients were clinically stable and all patients were followed up till the end of treatment.

## Inclusion criteria:

1. Isolated moderate traumatic brain injury patients (GCS 9-12)
2. Age ≥ 18 years.

## Exclusion criteria:

1. GCS ≤ 8 and > 12.
2. History of severe pulmonary disease (e.g. chronic obstructive pulmonary disease).
3. Polytraumatic patients.
4. Cardiac patients with impaired systolic function of the heart (EF <45%).
5. Pregnancy.
6. Severe mental retardation or prior severe brain injury or stroke.
7. High-velocity penetrating injury to the head.
8. Multiple organ failure.
9. Convulsions.
10. Need for surgical interference.

# METHODS

All the patients included in the study were subjected to the following:

1. Complete history taking including age, sex, past medical history, and drug distory.
2. Complete clinical examination and vital signs including blood pressure, heart rate, respiratory rate, and temperature.
3. Neurological assessment was done on admission and daily during the period of the study using Glasgow coma scale (GCS).
4. Routine laboratory investigations including: complete blood count, serum sodium, serum potassium, serum creatinine, blood urea, and random blood sugar were done on admission and every other day for correction of any changes in their values.
5. Electrocardiogram (ECG) on admission and when needed.
6. Chest x-ray on admission and when needed.
7. Arterial blood gas analysis was done on admission and daily.
8. Continuous arterial oxygen saturation ($SpO_2$) monitoring by pulse oxymetry to detect any acute changes in oxygen saturation.
9. Jugular venous bulb catheter was inserted to all patients via Seldinger technique. Retrograde catheterization of the internal jugular vein was done, the catheter was introduced percutanously and advanced to the jugular bulb at the base of the skull. The postion was verified by lateral skull x-ray film. Jugular venous and radial arterial blood sampels from which Areterio – Venous oxygen content difference ($AVDO_2$) and Venous – Arterial lactate difference (VADlactate) were calculated before the start of treatment, after the $5^{th}$ day, fter the $10^{th}$ day, and after the end of treatment. Assessment f changes in brain metabolism was done using lactate oxygen index (LOI) which will be calculated as follows:

$$\frac{(\text{Lactate})\text{jv} - (\text{lactate})\text{art}}{(\text{Hbx1.34xSaO2})(0.003\text{xPaO2}) - (\text{Hbx1.34xSvO2})(0.003\text{xPvO2})}$$

Where: Hb: hemoglobin, (lactate)jv: lactate concentration in the juglar venous bulb, (lactate)art: lactate concentration in the arterial blood, $SaO_2$: arterial oxygen saturation, $SvO_2$: jugular bulb oxygen saturation, $PaO_2$ : arterial oxygen tension, $PvO_2$ : jugular bulb oxygen tension

10. Hyperbaric sessions were carried on in the Naval Hyperbaric Medical Institute, Alxandria – Naval forces using a multiplace chamber. Patients were transported by an equipped intensive care ambulance to receive the hyperbaric sessions then transported back after each session to the ICU. Each session was composed of three phases:
    a) Compression phase: (10 minutes) in which the chamber was compressed with air from the ambient pressure to the target pressure.

b) Therapeutic phase: (60 minutes) in which the patient breathed 100% oxygen through an air tight face mask or through special connection in cases with tracheostomy and endotracheal tubes.
c) Decompression phase: (10 minutes) in which the chamber was decompressed to the ambient pressure, the patient continued to breathe oxygen during this phase.

11. Normobaric hyperoxia is breathing high oxygen concentration at normal atmospheric pressure. This will be achieved using non rebreathing oxygen mask with reservoir at high flow of oxygen which supplies 90-100% of oxygen.
12. Glasgow outcome scale (GOS) was assessed at the end of the study.

## Statistical analysis of the data[(151)]

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0.[(152)] Qualitative data were described using number and percent. Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Comparison between different groups regarding categorical variables was tested using Chi-square test. When more than 20% of the cells have expected count less than 5, correction for chi-square was conducted using Fisher's Exact test or Monte Carlo correction. The distributions of quantitative variables were tested for normality using Kolmogorov-Smirnov test, Shapiro-Wilk test and D'Agstino test, also Histogram and QQ plot were used for vision test. If it reveals normal data distribution, parametric tests was applied. If the data were abnormally distributed, non-parametric tests were used. For normally distributed data, comparison between more than two population were analyzed using F-test (ANOVA) and Post Hoc test (Scheffe) , comparison between different periods using ANOVA with repeated measures and Post Hoc test was assessed using Bonferroni adjusted. Significance test results are quoted as two-tailed probabilities. Significance of the obtained results was judged at the 5% level.

# RESULTS

The present study was carried out on 75 adult patients of both sex who suffered from moderate traumatic brain injury (TBI). Patients were categorized into three groups. Group I: 25 patients who received hyperbaric oxygen therapy (HBO) in addition to the conventional therapy. Group II: 25 patients who received normobaric hyperoxia (NBH) in addition to the conventional therapy. Group III: 25 patients who received only the conventional therapy of TBI.

## Demographic characteristics

### Age and gender

The age in group I ranged from 18-41years with a mean age of 30.48 ± 7.86 years, the age in group II ranged from 18-45 years with a mean age of 31.88 ± 8.24 years while the age in group III ranged from 18-46 years with mean age of 29.92 ± 8.92 years. There was no statistically significant difference between the three studied groups regarding age (P=0.696).

As regarding gender, males constituted 17 patients (68%) of group I, 15 patients (60%) of group II, and 17 patients (68%) of group III, while females constituted 8 patients (32%) of group I, 10 patients (40%) of group II and 8 patients (32%) of group III. There was no statistically significant difference between the three groups regarding gender (p=0.866).

**Table (9): Comparison between the studied groups according to demographic data**

| | Group I | | Group II | | Group III | | Test of Significance. | P |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | | |
| **Age (years)** | | | | | | | | |
| Min. – Max. | 18.0 – 41.0 | | 18.0 – 45.0 | | 18.0 – 46.0 | | | |
| Mean ± SD. | 30.48 ± 7.86 | | 31.88 ± 8.24 | | 29.92 ± 8.92 | | F=0.365 | 0.695 |
| Median | 29.0 | | 30.0 | | 30.0 | | | |
| **Gender** | | | | | | | | |
| Male | 17 | 68.0 | 15 | 60.0 | 17 | 68.0 | $\chi^2$=0.471 | 0.866 |
| Female | 8 | 32.0 | 10 | 40.0 | 8 | 32.0 | | |

p: p value for comparing between the studied groups, $\chi^2$: Chi square test, F: F test (ANOVA)
Min: minimum, Max: maximum, No: number.

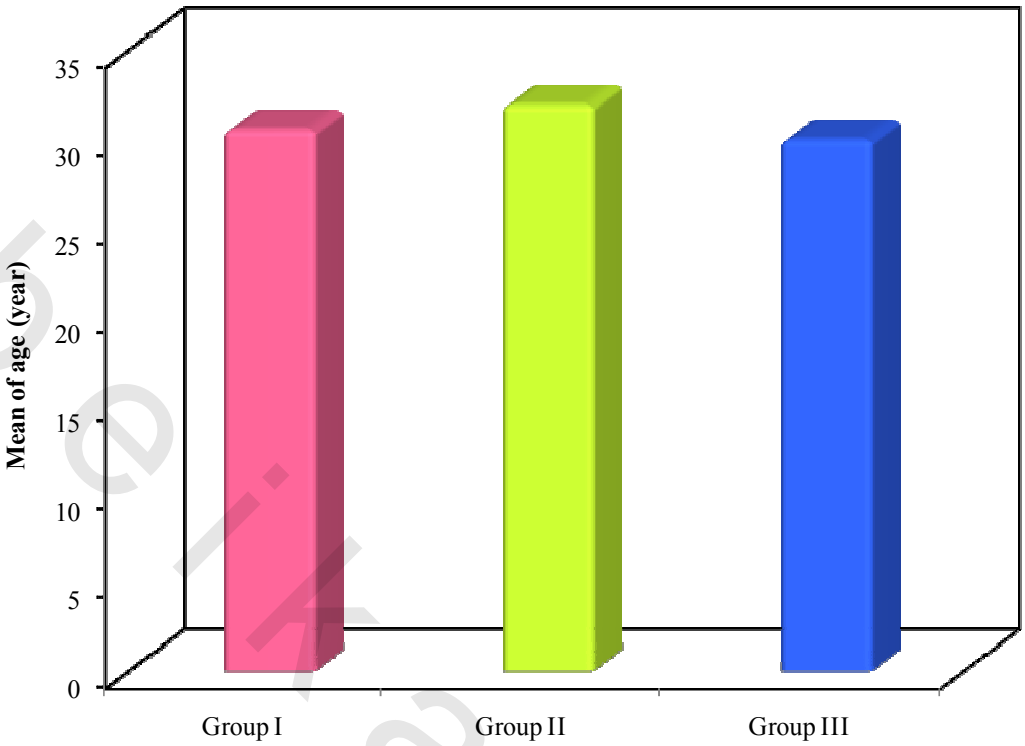


**Figure (10): Comparison between the studied groups according to age.**

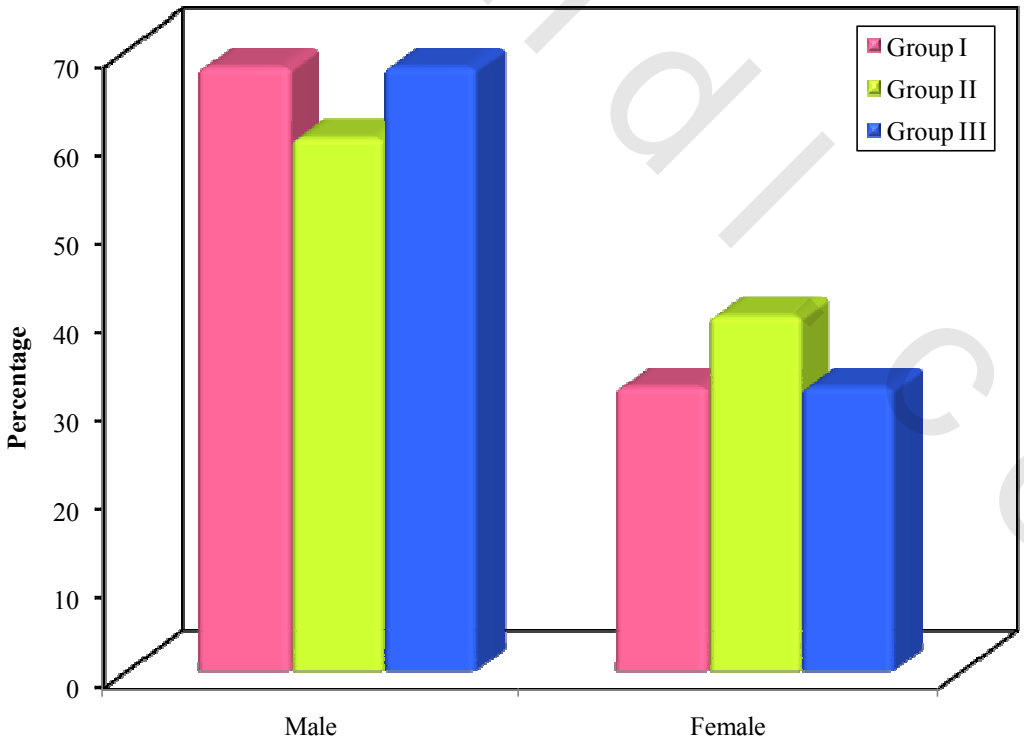


**Figure (11): Comparison between the three studied groups regarding sex.**

## Comparison between the three studied groups regarding past medical history.

The past medical history was similar in the three studied groups. Hypertension (HTN) was the commonest medical history representing 9 patients ( 36%) in group I, 10 patients (40%) in group II, and 12 patients (48%) in group III with no statistically difference between the three groups (P=0.681).

Diabetes mellitus was the second common medical history in all groups representing 7 patients (28%) in group I, 4 patients (16%) in group II, and 6 patients (24%) in group III with no statistically significant difference between the three groups (P=0.137).

Hepatitis C represents 4 patients (16%) in in group I, 1 patient (4%) in group II, and 2 patients (8%) in group III with no statistically significant difference between the three groups (P=0.274).

Bronchial asthma represents 3 patients (12%) in group I, 3 patients (12%) in group II, and 2 patients (8%) in group III with no statistically significant difference between the three groups (P=1.000).

Ischemic heart disease (IHD) represents 1 patient (4%) in both group I and group II, while no patients in group III had IHD with no significant difference between the three groups (P=1.000).

History of peptic ulcer represents only 1 patient (4%) in group II,while both group I and group III had no patients with history of peptic ulcer. There was no statistically significant difference between the three groups (P=1.000).

**Table (10): Comparison between studied groups according to past medical history**

| | Group I | | Group II | | Group III | | $\chi^2$ | p |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | | |
| **DM** | 7 | 28.0 | 4 | 16.0 | 6 | 24.0 | 3.969 | 0.137 |
| **HTN** | 9 | 36.0 | 10 | 40.0 | 12 | 48.0 | 0.770 | 0.681 |
| **IHD** | 1 | 4.0 | 1 | 4.0 | 0 | 0.0 | 1.269 | $^{MC}$p=1.000 |
| **HCV +ve** | 4 | 16.0 | 1 | 4.0 | 2 | 8.0 | 2.591 | 0.274 |
| **Bronchial asthma** | 3 | 12.0 | 3 | 12.0 | 2 | 8.0 | 0.614 | $^{MC}$p=1.000 |
| **Peptic ulcer** | 0 | 0.0 | 1 | 4.0 | 0 | 0.0 | 2.027 | $^{MC}$p=1.000 |

p: p value for comparing between the studied groups , $\chi^2$: value for Chi square, MC: Monte Carlo test, HTN: hypertension, DM: Diabetes mellitus, IHD: ischemic heart disease, HCV: hepatitis C virus, No: number.

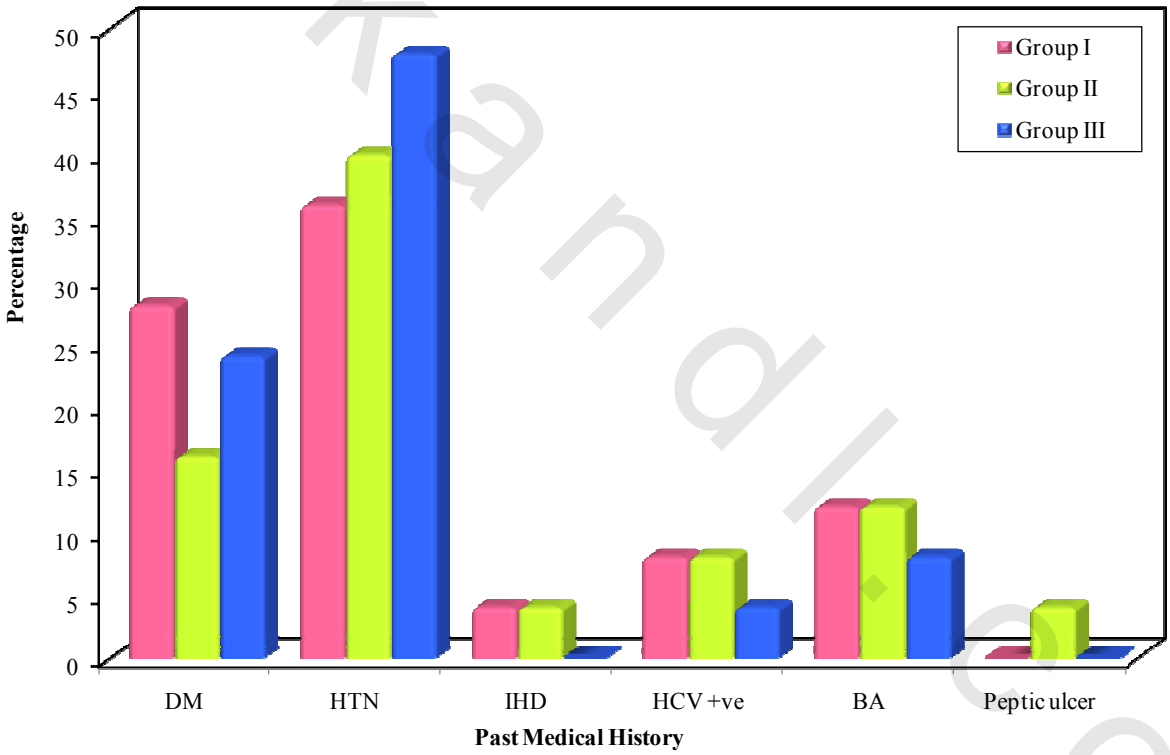


**Figure (12): Comparison between studied groups according to past medical history.**

## Comparison between the three studied groups regarding the mechanism of trauma.

Road traffic accident (RTA) was the commonest mechanism of trauma in the three studied groups representing 17 patients (68%) in group I, 15 patients (60%) in group II, and 16 patients (64%) in group III with no statistically significant difference between the three studied groups (P=0.841).

Falling from height (FFH) was the second common mechanism of trauma representing 4 patients (16%) in group I, 7 patients (28%) in group II, and 8 patients (32%) in group III with no statistically significant difference between the three studied groups (P=0.400).

Alleged assault represents 3 patients (16%) in both group I and group II and represents 1 patient (4%) in group with no statistically significant difference between the three studied groups (P=0.681).

Sport injuries was the least common mechanism of injury representing only one patient (4%) in group I and no patients (0%) in both group II and group III with no statistically significant difference between the three studied groups (P=1.000).

**Table (11): Comparison between studied groups regarding the mechanism of trauma**

| | Group I | | Group II | | Group III | | $\chi^2$ | P |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | | |
| **FFH (failing from height)** | 4 | 16.0 | 7 | 28.0 | 8 | 32.0 | 1.833 | 0.400 |
| **RTA (road traffic accident )** | 17 | 68.0 | 15 | 60.0 | 16 | 64.0 | 0.347 | 0.841 |
| **Alleged Assault** | 3 | 12.0 | 3 | 12.0 | 1 | 4.0 | 1.341 | $^{MC}$p=0.681 |
| **Sport injuries** | 1 | 4.0 | 0 | 0.0 | 0 | 0.0 | 2.027 | $^{MC}$p=1.000 |

p: p value for comparing between the studied groups , $\chi^2$: value for Chi square, MC: Monte Carlo test, No: number

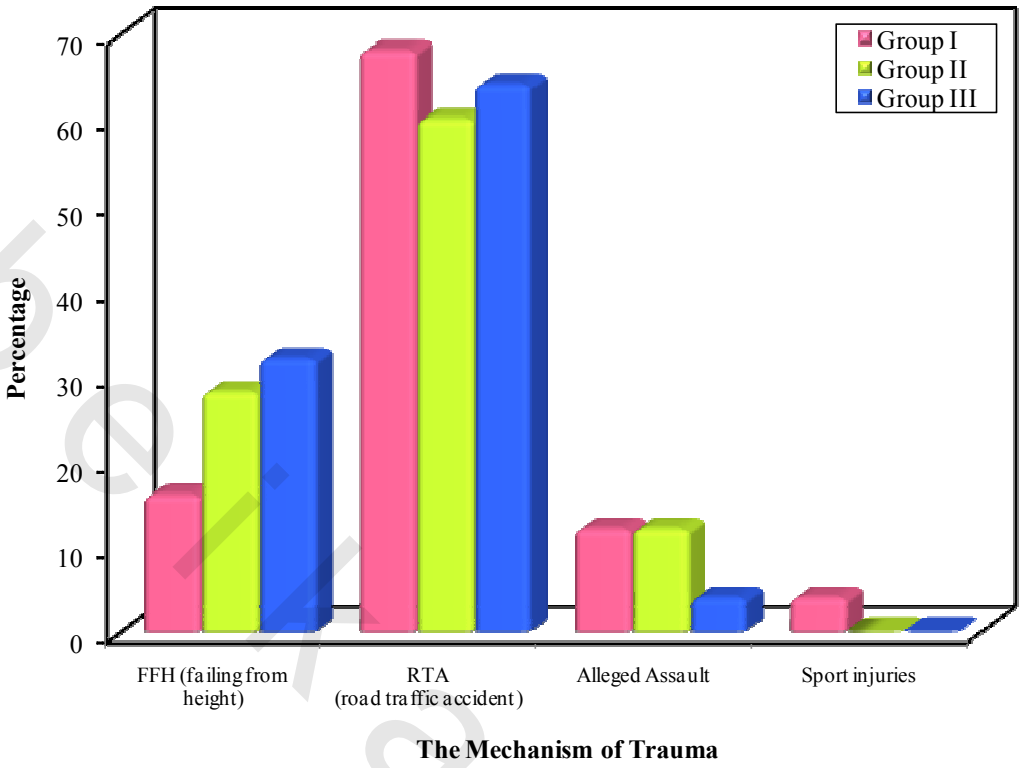


**Figure (13): Comparison between the three studied groups regarding the mechanism of trauma.**

## Comparison between the three studied groups regarding CT brain findings on admission.

Brain edema was the commonest CT brain finding on admission in all groups representing 21 patients (84%) in group I, and 23 patients (92%) in both group II and group III with no statistically significant difference between the three groups (P=0.719).

Multiple hemorrhagic contusions was the second common CT finding representing 12 patients (48%) in group I, 9 patients (36%) in group II, and 7 patients (28%) in group III with no statistically significant difference between the three groups (P=0.339).

Thin rim subdural hemorrhage represents 9 patients (36%) in group I, 7 patients (28%) in group II, and 6 patients (24%) in group III with no statistically significant difference between the three groups (P=0.778).

Thin rim extradural hemorrhage represents 5 patients (20%) in both group I and group II and 6 patients (24%) in group III with no statistically significant difference between the three groups (P=0.778).

Unremarkable CT findings on admission was found in 4 patients (16%) in group I, 2 patients (8%) in group II, and 2 patients in group III with no statistically significant difference between the three groups (P=0.722).

**Table (12): Comparison between the three studied groups regarding CT brain findings on admission**

| | Group I | | Group II | | Group III | | $\chi^2$ | p |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | | |
| **Unremarkable** | 4 | 16.0 | 2 | 8.0 | 2 | 8.0 | 1.119 | $^{MC}$p= 0.722 |
| **Brain edema** | 21 | 84.0 | 23 | 92.0 | 23 | 92.0 | 1.119 | $^{MC}$p= 0.719 |
| **Multiple hemorrhagic conctusions** | 12 | 48.0 | 9 | 36.0 | 7 | 28.0 | 2.166 | 0.339 |
| **Thin rim subdural hemorrhage** | 9 | 36.0 | 7 | 28.0 | 6.0 | 24.0 | 0.502 | 0.778 |
| **Thin rim extradural hemorrhage** | 5 | 20.0 | 5 | 20.0 | 6 | 24.0 | 0.159 | 0.924 |

p: p value for comparing between the studied groups , $\chi^2$: value for Chi square, MC: Monte Carlo test

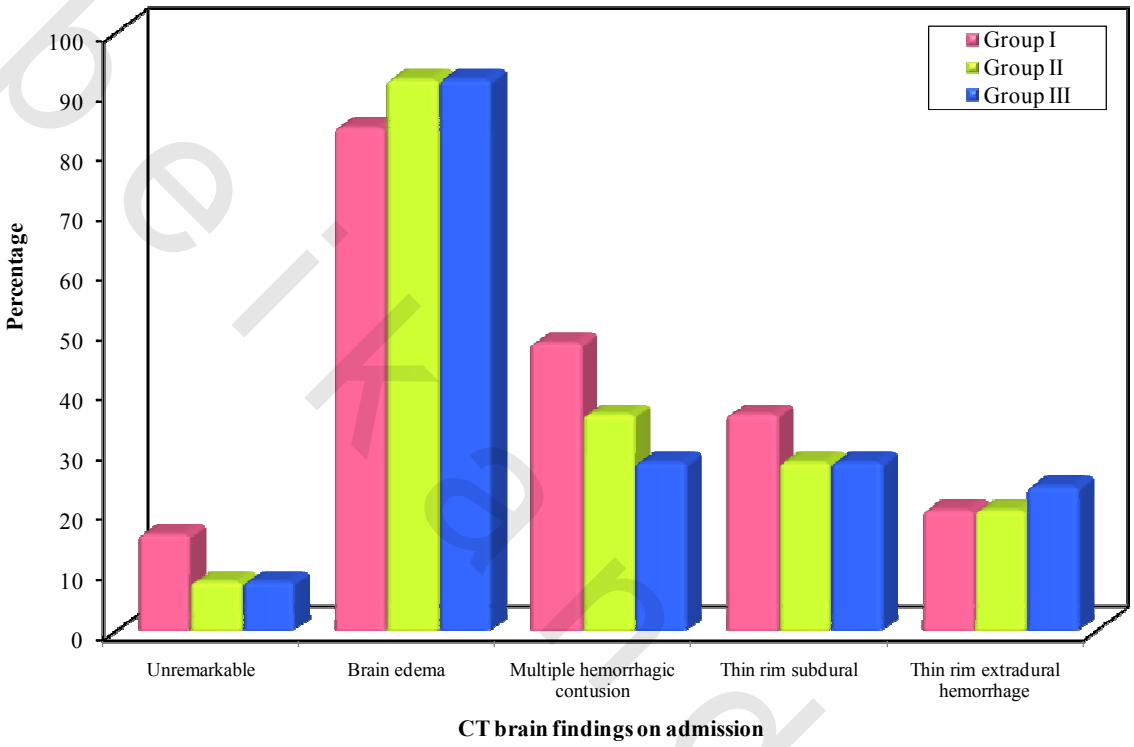


**Figure (14): Comparison between studied groups regarding CT brain findings on admission.**

## Comparison between the three studied groups regarding vital signs.

Heart rate in group I ranged from 79.0–92.0 beats/minute with a mean heart rate of 86.5 ± 3.57 beats/min , in group II ranged from 76.0–93.0 beats/minute with a mean heart rate of 85.5 ± 3.74 beats/minute while in group III ranged from 77.0–95.0 beats/minute with a mean heart rate of 84.5 ± 4.07 beats/minute. There was no statistically significant difference between the three studied groups regarding the heart rate (P=0.157).

Respiratory rate in group I ranged from 14.0–16.0 breaths/minute with a mean respiratory rate of 15.02 ± 0.64 breaths/minute, in group II it ranged from 14.0–17.0 breaths/minute with a mean respiratory rate of 14.86 ± 0.55 breaths/minute , while in group III it ranged from 13.0–17.0 breaths/minute with a mean respiratory rate of 15.02 ± 0.57 breaths/minute. There was no statistically significant difference between the three groups regarding the respiratory rate (P=0.540).

Temperature in group I ranged from 37.0–37.40 c with a mean temperature of 37.23 ± 0.10 c, in group II it ranged from 36.8 – 37.5 c with a mean temperature of 37.25 ± 0.11 c and in group III it ranged from 37.0–37.50 c with a mean temperature of 37.24 ± 0.13 c. there was no statistically significant difference between the three studied groups regarding temperature (P=0.912).

Mean arterial blood pressure (MABP) in group I ranged from 96.0 – 118.0 mmHg with a mean MABP of 106.0 ± 6.64 mmHg, in group II it ranged from 94.0 – 112.0 mmHg with a mean MABP of 104.5 ± 5.42 mmHg and in group III it ranged from 90.0 – 114.0 mmHg with a mean MABP of 106.46 ± 4.74 mmHg. There was no statistically significant difference between the three studied groups regarding MABP (P=0.482).

**Table (13): Comparison between the studied groups regarding vital signs**

| | Group I | Group II | Group III | F | p |
|---|---|---|---|---|---|
| **Heart Rate** | | | | | |
| Min. – Max. | 79.0 – 92.0 | 76.0 – 93.0 | 77.0 – 95.0 | | |
| Mean ± SD. | 86.56 ± 3.57 | 85.74 ± 3.74 | 84.48 ± 4.07 | 1.900 | 0.157 |
| Median | 87.0 | 85.0 | 850.0 | | |
| **Respiratory Rate** | | | | | |
| Min. – Max. | 14.0 – 16.0 | 14.0 – 17.0 | 13.0 – 17.0 | | |
| Mean ± SD. | 15.02 ± 0.64 | 14.86 ± 0.55 | 15.50 ± 0.57 | 0.621 | 0.540 |
| Median | 15.0 | 15.0 | 15.0 | | |
| **Temperature** | | | | | |
| Min. – Max. | 37.00 – 37.40 | 36.80 – 37.50 | 37.0 – 37.50 | | |
| Mean ± SD. | 37.23 ± 0.10 | 37.25 ± 0.11 | 37.24 ± 0.13 | 0.092 | 0.912 |
| Median | 37.20 | 37.10 | 37.30 | | |
| **MABP** | | | | | |
| Min. – Max. | 96.0 – 118.0 | 94.0 – 112.0 | 90.0 – 114.0 | | |
| Mean ± SD. | 106.0 ± 6.64 | 104.59 ± 5.42 | 106.46 ± 4.74 | 0.737 | 0.482 |
| Median | 105.80 | 105.65 | 106.85 | | |

p: p value for comparing between the studied groups, F: F test (ANOVA)

## Comparison between the three studied periods regarding Glasgow coma scale (GCS).

Glasgow coma scale (GCS) in all the three studied groups before the onset of treatment ranged from 9-12 with a mean GCS of 10.08 ± 1.12 in group I, 10.48 ± 1.16 in group II, and 10.13 ± 0.95 in group III with no statistically significant difference between the three groups (P=0.364).

During the period of the study, GCS in group I ranged from 9-15 with a mean GCS of 11.89 ± 1.28 , in group II it ranged from 9-14 with a mean GCS of 11.52 ± 1.32 while in group III it ranged from 8-14 with a mean GCS of 10.92 ± 1.23. There was a statistically significant improvement in group I as compared to group II and group III (P=0.021), while there was no statistically significant difference between group II and group III (P>0.05).

At the end of the study, GCS in group I ranged from 10.0 – 15.0 with a mean GCS of 13.24 ± 1.61, in group II it ranged from 9.0-15.0 with a mean GCS of 12.28 ± 1.81, while in group III it ranged from 9.0-15.0 with a mean GCS of 11.08 ± 1.80. There was a statistically significant improvement in group I as compared to both groups II and III. Also there was a statistically significant improvement in group II as compared to group III (P<0.05).

**Table (14): Comparison between the studied groups regarding GCS**

| | Group I | Group II | Group III | $F_1$ | p |
|---|---|---|---|---|---|
| **Before the onset of treatment** | | | | | |
| Min. – Max. | 9.0 – 12.0 | 9.0 – 12.0 | 9.0 – 12.0 | | |
| Mean ± SD. | 10.08 ± 1.12 | 10.48 ± 1.16 | 10.13 ± 0.95 | 1.026 | 0.364 |
| Median | 10.0 | 11.0 | 10.0 | | |
| **Significance between groups** | NS | | | | |
| **During the period of the study** | | | | | |
| Min. – Max. | 9.67 – 13.94 | 9.78 – 13.72 | 8.67 – 12.78 | | |
| Mean ± SD. | 11.89 ± 1.28 | 11.72 ± 1.32 | 10.92 ± 1.23 | 4.080* | 0.021* |
| Median | 12.0 | 11.56 | 11.0 | | |
| **Significance between groups** | I-II* ,I-III* | | | | |
| **After 20 days** | | | | | |
| Min. – Max. | 10.0 – 15.0 | 8.0 – 15.0 | 9.0 – 15.0 | | |
| Mean ± SD. | 13.24 ± 1.61 | 12.28 ± 1.81 | 11.08 ± 1.80 | 9.607* | <0.001* |
| Median | 13.0 | 12.0 | 11.0 | | |
| **Significance between groups** | I-II* ,I-III***, II- III* | | | | |
| **$F_2$** | 176.888* | 54.824* | 4.524* | | |
| **P** | <0.001* | <0.001* | 0.016* | | |

$F_1$: F test (ANOVA), Sig. bet. grps was done using Post Hoc Test (Scheffe), $F_2$: F test (ANOVA) with repeated measures, P: Stands for adjusted Bonferroni p-value for ANOVA with repeated measures for comparison between different period, *: Statistically significant at p ≤ 0.05, **: Statistically significant at p ≤ 0.01, ***: Statistically significant at p ≤ 0.001

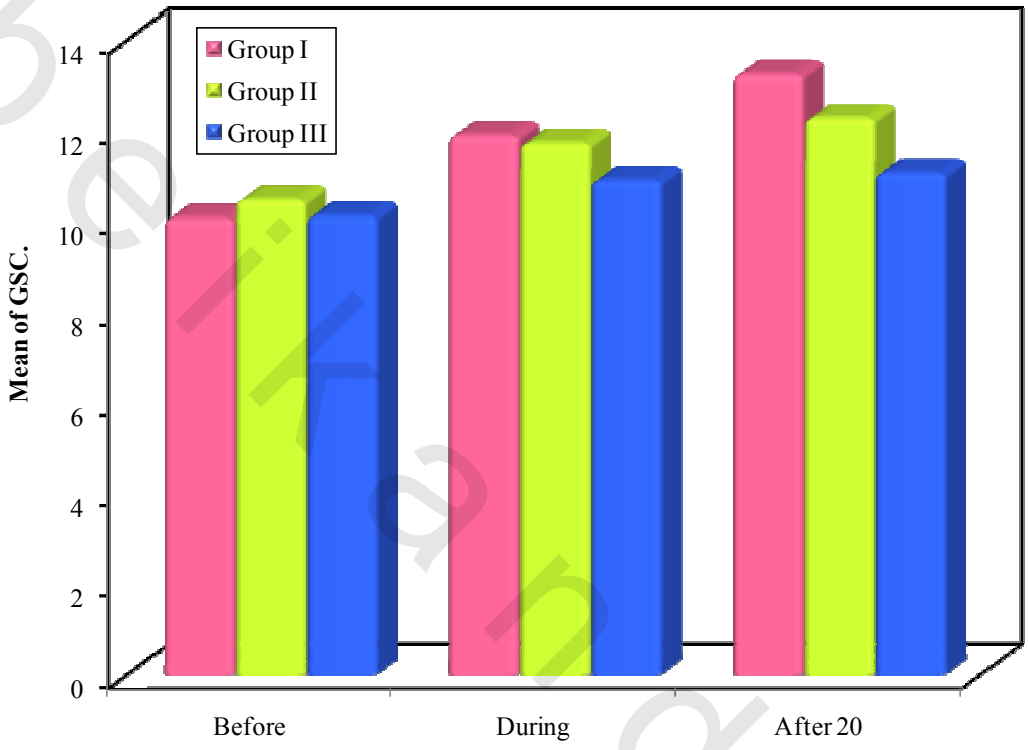


**Figure (15): Comparison between the studied groups according to GCS.**

## Comparison between the three studied groups according to laboratory investigations.

Hemoglobin (Hb) in group I ranged from 11.50 – 13.75 gm/dl with a mean Hb of 13.70 ± 0.39 gm/dl, in group II it ranged from 12.0 – 14.0 gm/dl with a mean Hb of 13.18 ± 0.59 gm/dl while in group III it ranged from 12.50 – 14.65 gm/dl with a mean Hb of 13.21 ± 0.61 gm/dl .

White blood cells (WBCs) in group I ranged from 7.740 - 9.990 cells/dl with mean WBCs of 8.95 ± 0.73, in group II it ranged from 8.000 – 10.50 cells/dl with mean WBCs of 8.860 ± 0.73 cells/dl while in group III it ranged from 7.400 - 11.30 cells/dl with mean WBCs of 9.100 ± 0.70 cells/dl.

Platelets in group I ranged from 214.0 - 420.0 with mean value of 309.5 ± 52.10, in group II it ranged from 164.0 - 407.50 with mean value 307.3 ± 57.87 and in group III ranged 206.5 - 399.50 with mean value of 312.6 ± 58.17.

Blood urea in group I ranged from 29.50 – 51.0 mg/dl with a mean urea of 37.12 ± 5.81 mg/dl, in group II it ranged from 26.50 – 66.0 mg/dl with a mean urea of 41.02 ± 10.72 mg/dl while in group III it ranged from 26.0 – 55.0 mg/dl with a mean urea of 39.82 ± 8.20 mg/dl.

Serum creatinine in group I ranged from 0.50 – 1.25 mg/dl with a mean creatinine of 1.03 ± 0.12 mg/dl, in group II it ranged from 0.65 – 1.30 mg/dl with a mean creatinine of 1.04 ± 0.12 mg/dl, while in group III it ranged from 0.6 – 1.20 mg/dl with a mean creatinine of 0.9 ± 0.10mg/dl.

Serum sodium in group I ranged from 138.0 – 142.0 mEq/L with a mean serum sodium of 139.66 ± 1.04 mEq/L, in group II it ranged from 136.50 – 145.0 mEq/L with a mean serum sodium of 140.98 ± 1.28 mEq/L while in group III it ranged from 136.0 – 141.0 mEq/L with a mean serum sodium of 138.24 ± 1.50 mEq/L.

Serum potassium in group I ranged from 3.65 – 4.45 mEq/L with a mean serum potassium of 4.14 ± 0.21 mEq/L , in group II it ranged from 3.70 – 4.70 mEq/L with a mean serum potassium of 4.23 ± 0.25 mEq/L , while in group III it ranged from 3.50 – 5.15 mEq/L with a mean serum potassium of 4.06 ± 0.48 mEq/L.

Random blood sugar (RBS) in group I ranged from 73.0 – 140.0 mg/dl with mean RBS of 81.78 ± 12.90 mg/dl, in group II it ranged from 82.0 – 170.0 mg/dl with mean RBS of 92.44 ± 16.99 mg/dl while in group III it ranged from 80.0 – 176.0 mg/dl with mean RBS of 88.08 ± 18.55mg/dl.

There was no statistical significant difference between the studied groups according to laboratory investigations ($P > 0.05$).

**Table (15): Comparison between the studied groups according to laboratory investigations**

| | Group I (n=25) | Group II (n=25) | Group III (n=25) | F | p |
|---|---|---|---|---|---|
| **Hemoglobin** | | | | | |
| Min. – Max. | 11.50 – 13.75 | 12.0 – 14.0 | 12.50 – 14.65 | | |
| Mean ± SD. | 13.08 ± 0.39 | 13.18 ± 0.59 | 13.70 ± 0.61 | 0.400 | 0.672 |
| Median | 13.25 | 13.25 | 13.25 | | |
| **Leucocytic count** | | | | | |
| Min. – Max. | 7.74 - 9.99 | 7.40 - 10.26 | 8.04 - 10.30 | | |
| Mean ± SD. | 8.95 ± 0.69 | 8.86 ± 0.73 | 9.10 ± 0.70 | 0.774 | 0.465 |
| Median | 8.96 | 9.04 | 8.99 | | |
| **Platelets** | | | | | |
| Min. – Max. | 214.0 - 420.0 | 164.0 - 407.50 | 206.5 - 399.50 | | |
| Mean ± SD. | 309.5 ± 52.10 | 307.3 ± 57.87 | 312.6 ± 58.17 | 0.056 | 0.946 |
| Median | 317.50 | 322.00 | 320.50 | | |
| **Blood Urea** | | | | | |
| Min. – Max. | 29.50 – 51.0 | 26.50 – 66.0 | 26.0 – 55.0 | | |
| Mean ± SD. | 37.12 ± 5.81 | 41.02 ± 10.72 | 39.82 ± 8.20 | 1.386 | 0.257 |
| Median | 36.50 | 40.50 | 40.50 | | |
| **Serum Creatinine** | | | | | |
| Min. – Max. | 0.50 – 1.25 | 0.65 – 1.30 | 0.6 – 1.20 | | |
| Mean ± SD. | 1.03 ± 0.12 | 1.04 ± 0.12 | 1.05 ± 0.10 | 0.099 | 0.906 |
| Median | 1.05 | 1.05 | 1.05 | | |
| **Serum Sodium** | | | | | |
| Min. – Max. | 138.0 – 142.0 | 136.50 – 142.0 | 136.0 – 142.0 | | |
| Mean ± SD. | 139.66 ± 1.04 | 138.98 ± 1.28 | 139.24 ± 1.50 | 1.778 | 0.176 |
| Median | 140.0 | 139.0 | 139.50 | | |
| **Serum Potassium** | | | | | |
| Min. – Max. | 3.65 – 4.45 | 3.70 – 4.70 | 3.50 – 5.15 | | |
| Mean ± SD. | 4.14 ± 0.21 | 4.23 ± 0.25 | 4.06 ± 0.48 | 1.630 | 0.203 |
| Median | 4.15 | 4.25 | 4.0 | | |
| **Random Blood Sugar** | | | | | |
| Min. – Max. | 73.0 – 140.0 | 82.0 – 170.0 | 80.0 – 176.0 | | |
| Mean ± SD. | 81.78 ± 12.90 | 92.44 ± 16.99 | 88.08 ± 18.55 | 2.695 | 0.074 |
| Median | 80.0 | 87.50 | 84.50 | | |

p: p value for comparing between the studied groups, F: F test (ANOVA)

## Comparison between the three studied groups according to arterial blood gases (ABG)

PH in group I ranged from 7.37 - 7.47 with a mean value of 7.42 ± 0.02, in group II it ranged from 7.39 - 7.46 with a mean value of 7.43 ± 0.02 while in group III it ranged from 7.34 - 7.49 with a mean value of 7.43 ± 0.02. There was no statistically significant difference between the three studied groups regarding PH (P=0.253)

$PaCO_2$ in group I ranged from 37.0 - 42.50 mmHg with a mean $PaCO_2$ of 39.40 ± 1.27 mmHg, in group II it ranged from 36.30 – 40.50 mmHg with a mean $PaCO_2$ of 38.40 ± 1.04 mmHg, while in group III it ranged from 36.0 - 43.0 mmHg with a mean $PaCO_2$ of 39.74 ± 1.18 mmHg. There was no statistically significant difference between the three studied groups regarding $PaCO_2$. There was no statistically significant difference regarding $PaCO_2$ (P=0.060)

$PaO_2$ in group I ranged from 416.0 – 603.0 mmHg with a mean $PaO_2$ of 508.1 ± 48.9 mmHg, in group II it ranged from 288.5 – 391.0 with a mean $PaO_2$ of 325.1 ± 31.7 mmHg while in group III it ranged from 130.0 – 192.0 with a mean $PaO_2$ of 156.6 ± 21.8 mmHg . There was a statistically significant difference between group I and both groups II, III. Also there was a statistically significant difference between group II and group III (P<0.001).

$HCO_3$ in group I ranged from 21.0 - 25.0 mEq/L with mean $HCO_3$ of 23.24 ± 1.06 mEq/L, in group II it ranged from 20.0 – 26.0 mEq/L with a mean $HCO_3$ of 22.70 ± 1.30 mEq/L, while in group III it ranged from 21.0 - 26.0 mEq/L with a mean $HCO_3$ of 23.42 ± 1.29 mEq/L. There was no statistically significant difference between the three studied groups regarding $HCO_3$ (P=0.102).

$SaO_2$ in group I ranged from 100.0 – 100.0 % with a mean $SaO_2$ of 100.0±0.0 %, in group II it ranged from 99.0 – 100.0 % with a mean $SaO_2$ of 99.04 ± 0.20 % , while in group III it ranged from 96.50 – 99.0 % with a mean $SaO_2$ of 97.86 ± 0.70. There was a statistically significant difference between group I and group II, between group I and group III, and between group II and group III while there was no statistically significant difference between group I and group II.

**Table (16): Comparison between the studied groups regarding arterial blood gases (ABG)**

| | Group I (n=25) | Group II (n=25) | Group III (n=25) | F | p |
|---|---|---|---|---|---|
| **pH** | | | | | |
| Min. – Max. | 7.37 - 7.47 | 7.39 - 7.46 | 7.34 - 7.49 | 1.401 | 0.253 |
| Mean ± SD. | 7.42 ± 0.02 | 7.42 ± 0.02 | 7.41 ± 0.02 | | |
| Median | 7.42 | 7.42 | 7.40 | | |
| **$PaCO_2$** | | | | | |
| Min. – Max. | 37.0 - 42.50 | 36.50 – 40.50 | 36.0 - 43.0 | 2.931 | 0.060 |
| Mean ± SD. | 39.40 ± 1.27 | 38.68 ± 1.04 | 38.74 ± 1.18 | | |
| Median | 39.0 | 38.50 | 39.0 | | |
| **$PaO_2$** | | | | | |
| Min. – Max. | 416.0 – 603.0 | 288.5 – 391.0 | 130.0 – 192.0 | 599.232 | <0.001* |
| Mean ± SD. | 508.1 ± 48.9 | 325.1 ± 31.7 | 156.6 ± 21.8 | | |
| Median | 504.0 | 316.0 | 150.0 | | |
| **$HCO_3$** | | | | | |
| Min. – Max. | 21.0 - 25.0 | 20.5 – 26.0 | 21.0 - 25.0 | 2.353 | 0.102 |
| Mean ± SD. | 23.24 ± 1.06 | 22.70 ± 1.30 | 23.42 ± 1.29 | | |
| Median | 23.50 | 23.0 | 23.50 | | |
| **$SaO_2$** | | | | | |
| Min. – Max. | 100.0 – 100.0 | 99.0 – 100.0 | 96.50 – 99.0 | | |
| Mean ± SD. | 100.0 ± 0.0 | 99.04 ± 0.20 | 97.86 ± 0.70 | 162.585* | <0.001* |
| Median | 100.0 | 99.0 | 98.0 | | |

p: p value for comparing between the studied groups , F: F test (ANOVA)
*: Statistically significant at $p \leq 0.05$

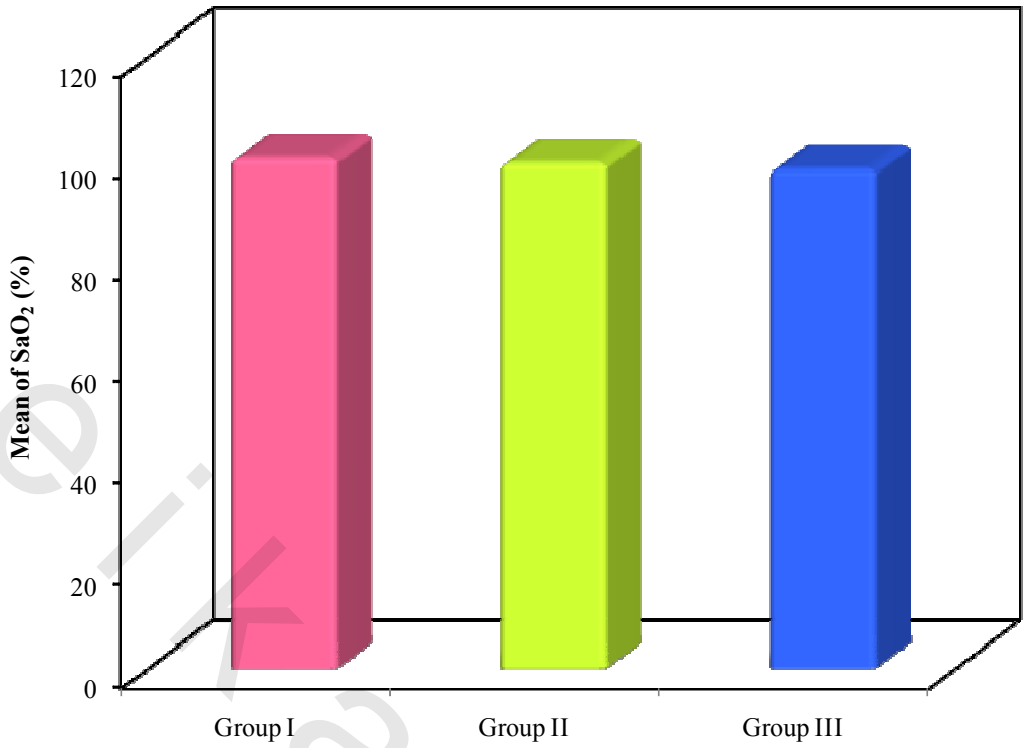


**Figure (16): Comparison between the studied groups according to $SaO_2$**

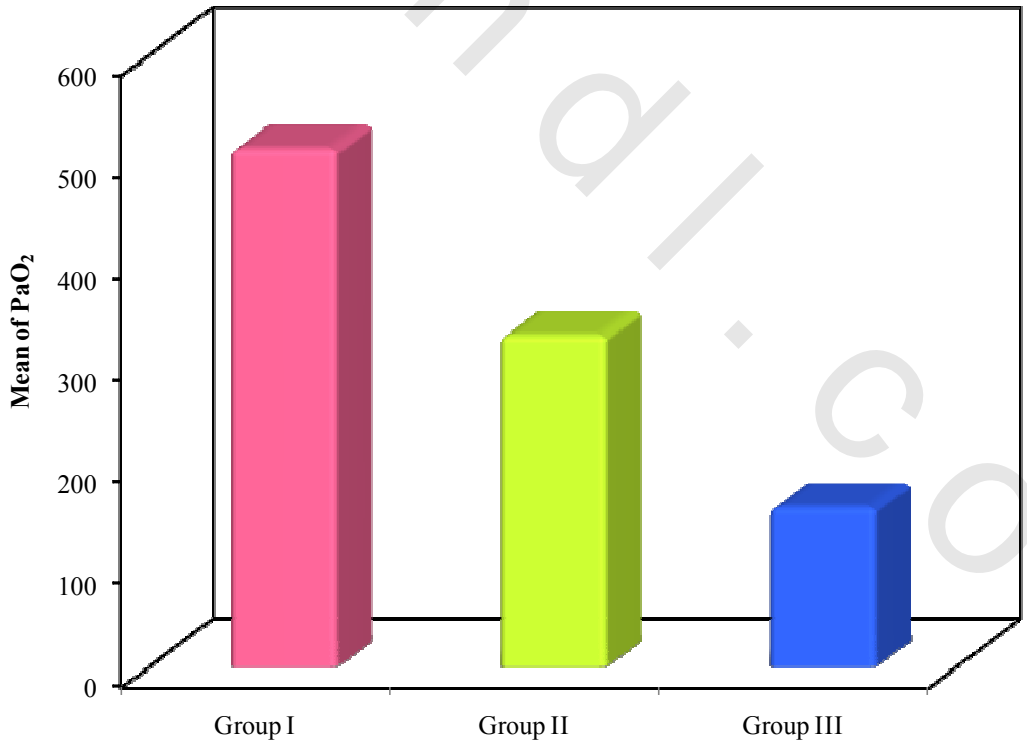


**Figure (17): Comparison between the studied groups according to $PaO_2$**

## Comparison between the three studied groups regarding jugular venous oxygen saturation ($SjvO_2$)

Before the onset of treatment, $SjvO_2$ in group I ranged from 57-73 with a mean $SjvO_2$ of 67.88 ± 4.18, in group II it ranged from 60-74 with a mean $SjvO_2$ of 69.08 ± 3.84, while in group III it ranged from 59-76 with a mean $SjvO_2$ of 68.40 ± 4.92. there was no statistically significant difference between the three studied groups (P=0.620).

There was a statistically significant improvement in $SjvO_2$ at the end of the study in both group I and group II (P<0.001) while there was no statistically significant difference in group III (P=0.349).

After the end of treatment, $SjvO_2$ in group I ranged from 69-84 with a mean $SjvO_2$ of 74.80 ± 3.94, in group II it ranged from 73-78 with a mean $SjvO_2$ of 75.48 ± 1.78, while in group III it ranged from 60-78 with a mean $SjvO_2$ of 69.76 ± 4.65. There was a statistical significant improvement in both group I and group II as compared to group III (P< 0.05), but there was no statistically significant difference between group I and group II (P>0.05)

**Table (17): Comparison between the studied groups according to $SjvO_2$**

| $SjvO_2$ | Group I | Group II | Group III | F | p |
|---|---|---|---|---|---|
| **Before the start of treatment** | | | | | |
| Min – Max. | 58.0 – 74.0 | 61.0 – 75.0 | 58.0 – 75.0 | | |
| Mean ± SD. | 67.88 ± 4.18 | 69.08 ± 3.84 | 68.40 ± 4.92 | 0.482 | 0.620 |
| Median | 69.0 | 70.0 | 70.0 | | |
| **After the end of treatment** | | | | | |
| Min – Max. | 69.0 – 84.0 | 73.0 – 78.0 | 60.0 – 78.0 | | |
| Mean ± SD. | 74.80 ± 3.94 | 75.48 ± 1.78 | 69.76 ± 4.65 | 18.178* | <0.001* |
| Median | 75.0 | 76.0 | 70.0 | | |
| **Significance between groups** | I-III***,II-III*** | | | | |
| **$p_1$** | <0.001* | <0.001* | 0.349 | | |

F: F test (ANOVA), Sig. bet. grps was done using Post Hoc Test (Scheffe), $p_1$: p value for Paired t-test for comparing between before and after the end of treatment , *: Statistically significant at p ≤ 0.05, ***: Statistically significant at p ≤ 0.001

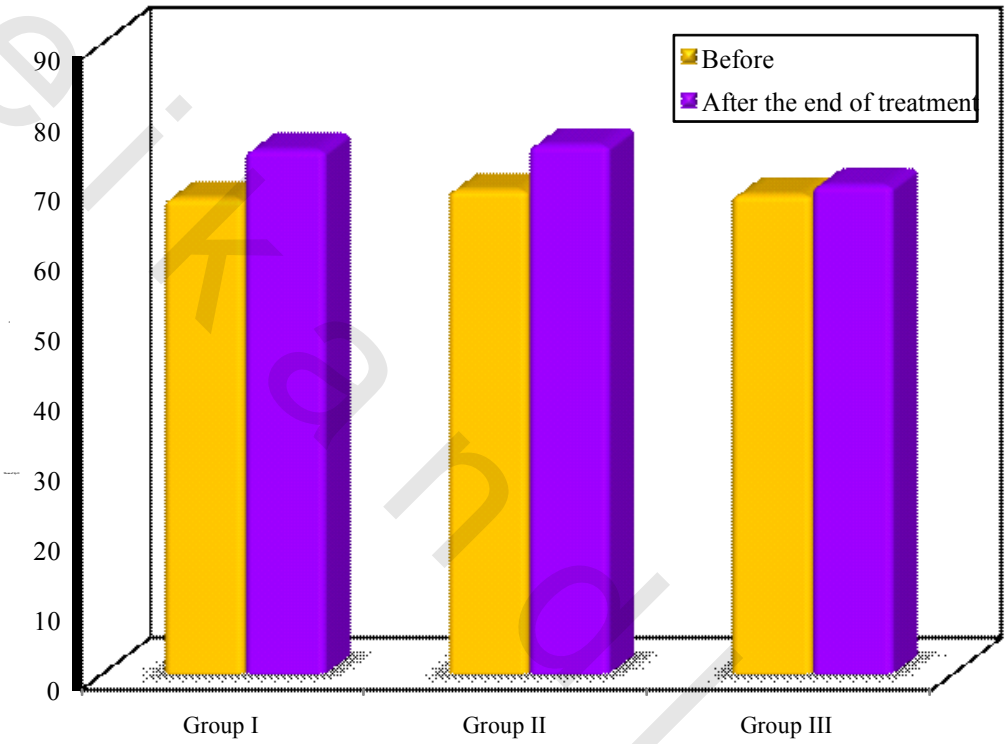


**Figure (18): Comparison between the three studied groups regarding SjvO2.**

## Comparison between the three studied groups regarding lactate level.

There was no statistically significant difference between the three groups regarding arterial lactate level (art. Lactate) either before the onset of treatment (P=0.865) or at the end of the study (P=0.576). Also there was no statistically significant difference of arterial lactate level before and after treatment in each group (P>0.05).

Before the onset of treatment, jugular venous lactate (J.V lactate) in group I ranged from 25.0 – 45.0 mg/dl with a mean J.V lactate of 35.44 ± 6.84, in group II it ranged from 26.0 – 48.0 with a mean J.V lactate of 34.04 ± 6.43, while in group III it ranged from 27.0 – 46.0 with a mean J.V lactate of 33.52 ± 5.58. There was no statistically significant difference between the three studied groups regarding J.V lactate before the onset of treatment (P=0.541).

At the end of the study, J.V lactate in group I ranged from 17.0 – 29.0 with a mean J.V lactate of 21.86 ± 2.73, in group II it ranged from 21.0 –34.0 with a mean J.V lactate of 25.80 ± 4.96, while in group III it ranged from 23.0 – 38.0 with a mean J.V lactate of 28.56 ± 4.03. There was a statistically significant decrease in J.V lactate in group I as compared to both groups II and III. Also there was a statistically significant decrease in J.V lactate in group II as compared to group III (P<0.05).

**Table (18): Comparison between the three studied groups regarding lactate level**

| | | Group I | Group II | Group III | F | p |
|---|---|---|---|---|---|---|
| **Arterial Lactate** | **Before onset of treatment** | | | | | |
| | Min. – Max. | 4.50 – 8.20 | 4.30 – 7.90 | 4.90 – 8.90 | | |
| | Mean ± SD. | 6.43 ± 1.08 | 6.36 ± 1.04 | 6.65 ± 1.22 | 0.464 | 0.631 |
| | Median | 6.50 | 6.50 | 7.0 | | |
| | **After the end of treatment** | | | | | |
| | Min. – Max. | 4.50 – 10.50 | 5.0 – 8.50 | 4.20 – 8.0 | | |
| | Mean ± SD. | 6.64 ± 1.34 | 6.80 ± 0.88 | 6.87 ± 0.86 | 0.311 | 0.734 |
| | Median | 6.50 | 7.0 | 7.0 | | |
| | **$p_1$** | 0.425 | 0.056 | 0.415 | | |
| **Jugular venous Lactate** | **Before onset of treatment** | | | | | |
| | Min. – Max. | 25.0 – 45.0 | 26.0 – 48.0 | 27.0 – 46.0 | | |
| | Mean ± SD. | 35.44 ± 6.84 | 34.04 ± 6.43 | 33.52 ± 5.58 | 0.620 | 0.541 |
| | Median | 35.0 | 33.0 | 31.0 | | |
| | **After the end of treatment** | | | | | |
| | Min. – Max. | 17.0 – 29.0 | 21.0 – 34.0 | 23.0 – 38.0 | | |
| | Mean ± SD. | 21.86 ± 2.73 | 25.80 ± 3.56 | 28.56 ± 4.03 | 23.367* | <0.001* |
| | Median | 22.0 | 25.0 | 27.0 | | |
| | **Significance between Groups** | I-II***, I-III***, II-III* | | | | |
| | **$p_1$** | <0.001* | <0.001* | <0.001* | | |

F: F test (ANOVA), Significance between groups was done using Post Hoc Test (Scheffe), $p_1$: p value for Paired t-test for comparing between before and after the end of treatment , *: Statistically significant at $p \leq 0.05$ , **: Statistically significant at $p \leq 0.01$, ***: Statistically significant at $p \leq 0.001$

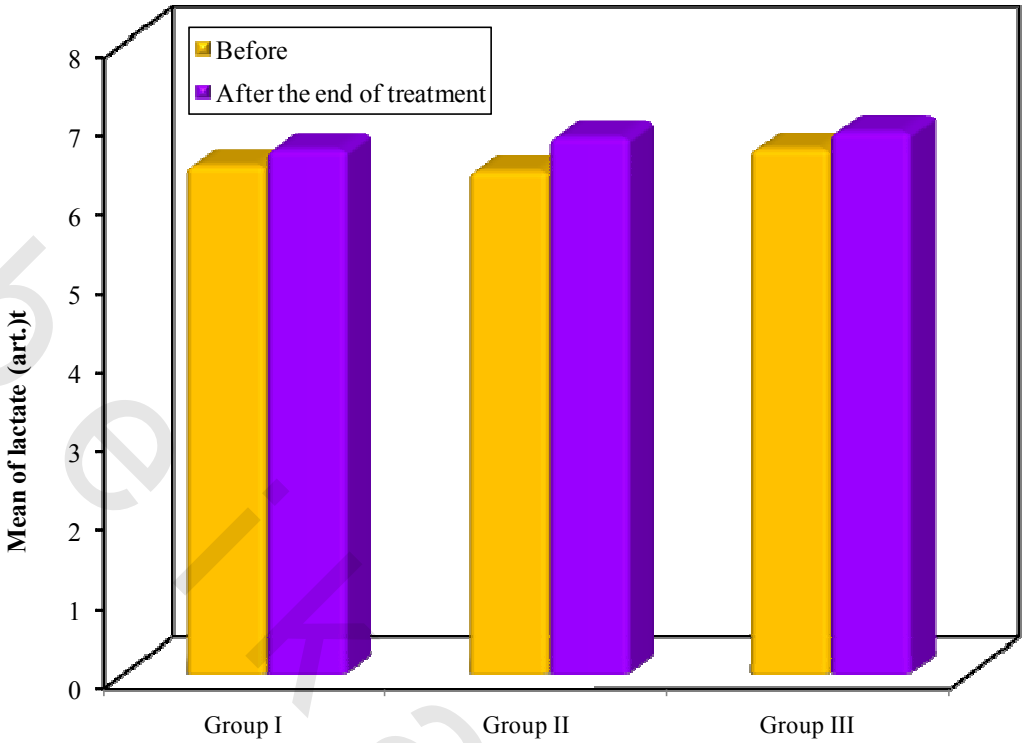


**Figure (19): Comparison between the three studied groups regarding arterial lactate level.**

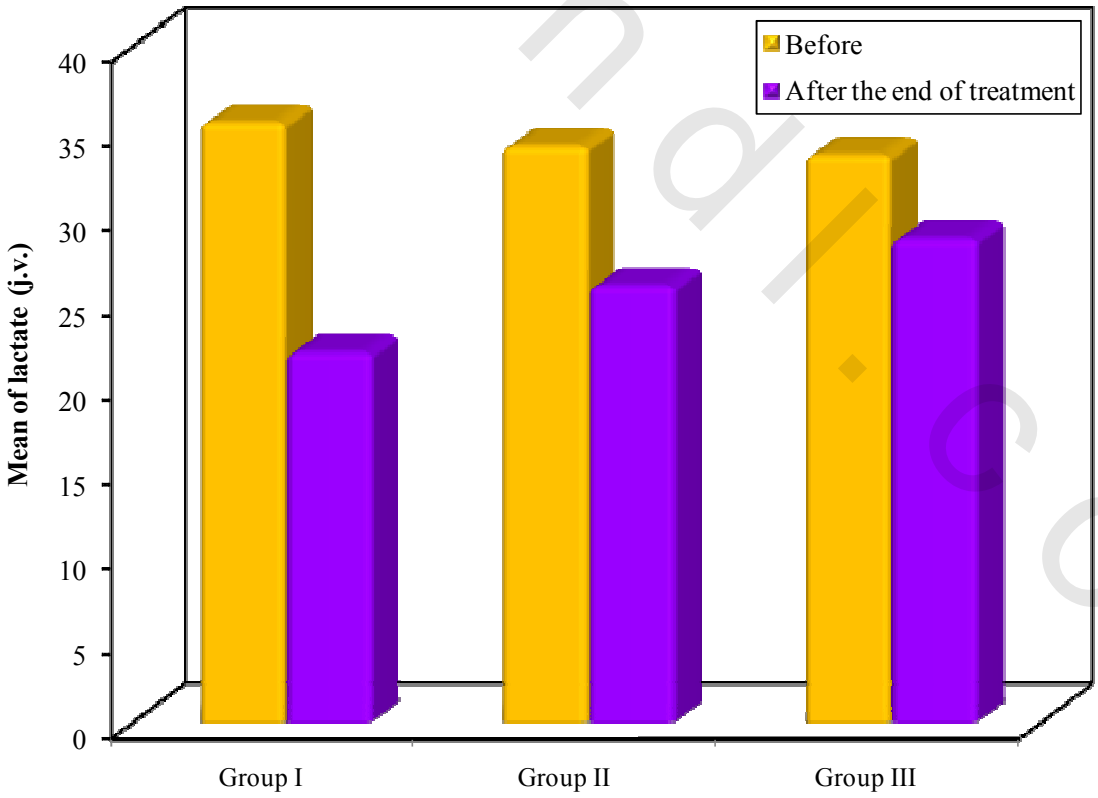


**Figure (20): Comparison between the three studied groups regarding jugular venous Lactate level .**

## Comparison between the studied groups according to lactate oxygen index (L.O.I.)

Before the onset of treatment, L.O.I in group I ranged from 0.038 - 0.082 with a mean L.O.I of 0.059±0.013, in group II it ranged from 0.032-0.090 with a mean L.O.I of 0.058±0.017, while in group III it ranged from 0.037-0.083 with a mean L.O.I of 0.057±0.014. There was no statistically significant difference between the three groups regarding L.O.I before the onset of treatment (P=0.957).

At the end of the study, L.O.I in group I ranged from 0.020-0.043 with a mean L.O.I of 0.029±0.006, in group II it ranged from 0.026-0.059 with a mean L.O.I of 0.040±0.009, while in group III it ranged from 0.028-0.062 with a mean L.O.I of 0.043±0.008. There was a statistically significant decrease regarding L.O.I in group I as compared to both groups II and III, and also in group II as compared to group III (P< 0.05).

**Table (19): Comparison between the three studied groups regarding lactate oxygen index (L.O.I.)**

| L.O.I. | Group I | Group II | Group III | F | p |
|---|---|---|---|---|---|
| **Before** | | | | | |
| Min – Max. | 0.038 - 0.082 | 0.032-0.090 | 0.037-0.083 | | |
| Mean ± SD. | 0.059±0.013 | 0.058±0.017 | 0.057±0.014 | 0.044 | 0.957 |
| Median | 0.054 | 0.057 | 0.058 | | |
| **After the end of treatment** | | | | | |
| Min – Max. | 0.020-0.043 | 0.026-0.059 | 0.028-0.062 | | |
| Mean ± SD. | 0.029±0.006 | 0.040±0.009 | 0.043±0.008 | 21.297* | <0.001* |
| Median | 0.029 | 0.042 | 0.043 | | |
| **Significance between groups** | I-II***,I-III***, II- III* | | | | |
| **$p_1$** | <0.001* | <0.001* | <0.001* | | |

F: F test (ANOVA), Significance between groups was done using Post Hoc Test (Scheffe)
$p_1$: p value for Paired t-test for comparing between before and after the end of treatment
*: Statistically significant at $p \leq 0.05$, ***: Statistically significant at $p \leq 0.001$

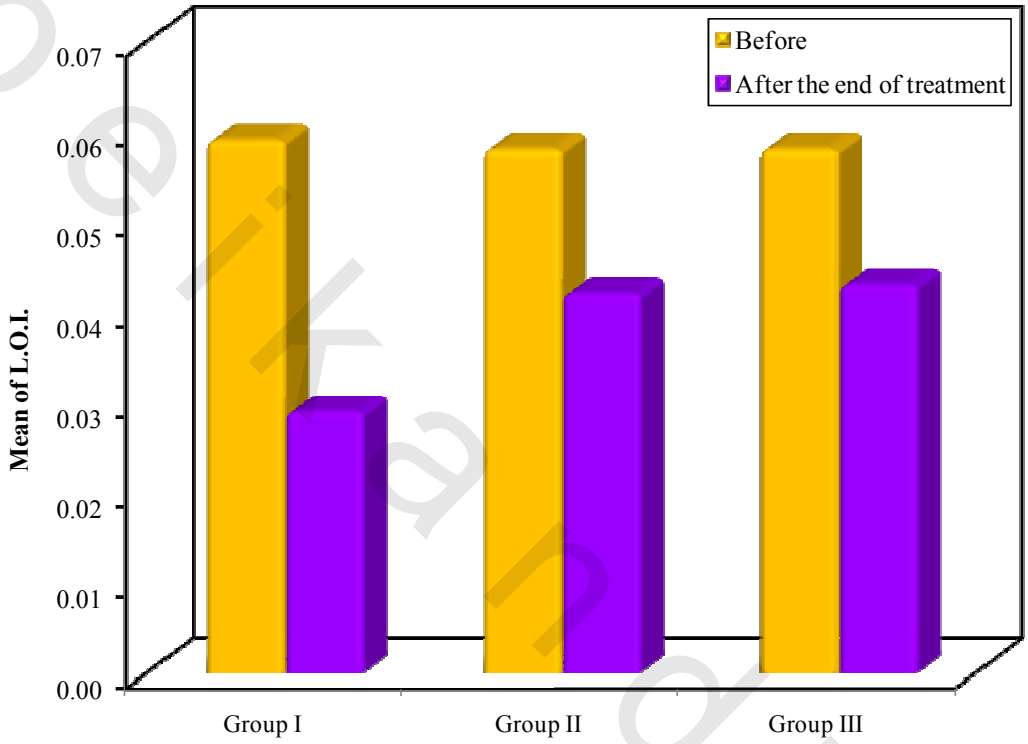


**Figure (21): Comparison between the studied groups according to L.O.I.**

## Comparison between studied groups according to Glasgow outcome score

In group I, GOS (4) was the commonest GOS representing 10 patients (40%), while it represents only 7 patients (28%) in groups II and 5 patients in group III.

Glasgow outcome scale (5) was the second common GCS in group I representing 7 patients (28%), 4 patients (16%) in group II, and 1 patient (4%) in group III.

Glasgow outcome scale (3) represents 5 patients (20%) in group I, 8 patients (32%) in group II, and 8 patients (32%) in group III.

Glasgow outcome scale (2) was the commonest GOS in group III representing 11 patients (44%), 6 patients (24%) in group II, and 3 patients (12%) in group III.

Glasgow outcome scale (0) was the least GOS represented by no patients in all the three groups.

There was a statistically significant difference between group I and group II, between group I and group III, and between group II and group III regarding Glasgow outcome scale ($P < 0.05$).

**Table (20): Comparison between studied groups according to Glasgow outcome score**

| | Group I | | Group II | | Group III | | Test of Significance | p |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | | |
| **GOS (1)** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | - | - |
| **GOS (2)** | 3 | 12.0 | 6 | 24.0 | 11 | 44.0 | 6.304* | 0.043* |
| **GOS (3)** | 5 | 20.0 | 8 | 32.0 | 8 | 32.0 | 0.987 | 0.611 |
| **GOS (4)** | 10 | 40.0 | 7 | 28.0 | 5 | 20.0 | 2.383 | 0.342 |
| **GOS (5)** | 7 | 28.0 | 4 | 16.0 | 1 | 4.0 | 5.357 | MCp=0.075 |
| **$\chi^2$** | 11.419 | | | | | | | |
| **MCp** | 0.068 | | | | | | | |
| **Significane between groups** | I-II*,I-III*, II-III*, | | | | | | | |

p: p value for comparing between the studied groups , $\chi^2$: value for Chi square, MC: Monte Carlo test, Sig. bet. grps was done using Monte Carlo test, *: Statistically significant at $p \leq 0.05$, GOS: Glasgow outcome score

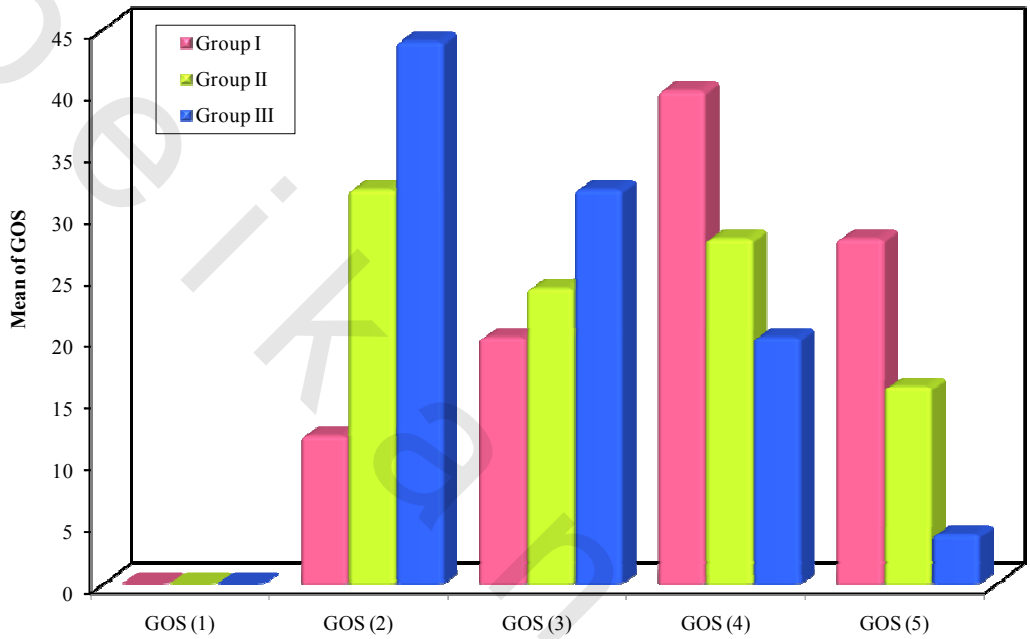


**Figure (22): Comparison between studied groups according to Glasgow outcome score.**