AIM OF THE WORK

The aim of this study was to explore the effects of chronic lead exposure on the thyroid function of occupationally exposed workers in Alexandria.

SUBJECTS AND METHODS

The present study included one hundred subjects occupationally exposed to lead in a factory for bullets and shots in Alexandria. Because few female workers were assigned to lead-exposed production areas, only male workers were recruited. Age of the study subjects was in the range of 16-49 years old. The study subjects were classified according to the blood level of lead into 3 groups:

Group I (n= 38): 10-25 micrograms/dl

Group II (n= 36): 26 -40 micrograms/dl.

Group III (n= 26): 41-60 micrograms/dl.

Exclusion criteria:

1. Past history of thyroid disorders.
2. Family history of thyroid disorders.
3. Diabetes mellitus as it affects thyroid function tests to variable extents.
4. Patients receiving drugs that affect thyroid function like: lithium, iodine and amiodarone.
5. Smoking.

Ethical considerations:

All the participants were requested to sign a written informed consent regarding the procedure according to the study protocol that no harm to the subjects would be allowed and the name of the factory will not be mentioned in the study.

All individuals in this study were subjected to the following:

1. Thorough history taking.
2. Questioner about the fulfillment of instructions to decrease lead exposure in the work place, including the use of protective equipments and taking any nutritional supplements. [96,97]
3. Complete clinical examination including:
   a. Vital signs. [83]
   b. Body weight and height to asses BMI [98]
   c. Head and neck examination.
4. Routine laboratory investigations as:
   a. Complete blood count (CBC): CBC was measured from EDTA-blood samples using automated cell counters. [99]
   b. Kidney function tests "urea and creatinine" and liver function tests "AST and ALT". [100,101]
   c. Fasting Blood Sugar level (FBS) [102]
   d. Blood lipids (cholesterol &TG). [103]
5. Specific laboratory investigation:

     a.   Blood lead level. [104]
     b.   FT3, FT4 and TSH. [105]
     c.   Anti TPO. [106]
6.   Thyroid ultra sound. [107]

Body Mass Index

A standardized method used to evaluate weight and body fat. BMI is calculated by dividing weight in Kg by height in meters squared.

BMI values were interpreted as follow:
- 18.4 or less=under wt.
- 18.5-24.9= normal wt.
- 25-29.9=over wt.
- 30 or more =obese.

Head and neck examination

Examination of the thyroid gland was done to exclude enlarged thyroid gland.

Blood lead level

For the measurement of lead levels in blood (Pb-B), 5 ml of blood was obtained from the antecubital vein and was collected in heparinized lead-free tubes. Collection of samples was done in a lab near the target factory and transported in an ice box to the central lab.

Lead was measurd by AA 6650 Shimad ZU atomic absorption spectrophotometer using this procedure:-

I- Nitric acid and perchloric decomposition and precipitation of proteins:

1- Wight 1 ml of sample (whole blood)in a clean and dry conical flask.
2-Add 5ml of concentrated nitric acid and mix.
3- Gently heat on a hot plate to start sample reaction.
4- After the brown fumes of nitric acid start to disappear let the sample to cool then add 1ml of concentrated perchloric acid and gently heat to concentrate, if the contained material darkens add 0.5-1ml of concentrated nitric acid and continue heating.
5- When the contained material becomes yellowish or colorless, precipitation is complete.
6- After cooling add 0.5 ml of concentrated hydrochloric acid.
7- Wash down the flask walls with distilled water and filter to a 10 ml volumetric flask, add water to the mark and mix thoroughly to prepare measurement solution.

II-Analysis of samples by atomic absorption:

1- After choosing the proper hollow cathode lamp for the analysis ,the lamp should be allowed to warm up for a minimum of 15 minutes unless operated in double beam mode.

2- During this period, align the instrument, position the monochromatic at the correct wave length, select the proper monochromatic slit width and adjust the hollow cathode current according to the manufactuerer, recommendation

3- Light the flam and regulate the flow of fuel and oxidant, adjust the burner and nebulizer flow rate for maximum percent absorption and stability and balance the photometer.

4- Run a series of standards of the element and construct a calibration curve by plotting the concentration of the standard against the absorbance.

5- Aspirate the samples and determine the concentrations from calibration curve.

6- Standards must be run each time a sample or a set samples are run.

III- Calculation:

Read the metal value in mg/l by this equation:

Mg/l metal in sample =A x (C+B/B)

A=mg/l of metal undiluted from calibration curve

B=ml of demonized distilled water used for dilution

C=ml of sample.

Then results should be divided by 10 to give results in μg/dl.

Thyroid function tests:

1- Measurement of FT3:

Sample collection and handling:

Venous blood samples were collected aseptically without additives, stored at 18-25C for 15-45minutes then centrifuged to obtain the serum specimens which were stored at 2-8C to be analyzed at the second day.

Principle of the test

The STALA-PACKFT3 is a competitive enzyme immunoassay which is performed entirely in the STAIA-PACK FT4 test cups. Free tri-iodothyronine (FT3) present in the test sample competes with enzyme –labeled tri-iodothyronine (T3) for a limited number of binding sites on a T3-specific antibody immobilized on magnetic beads**.** the beads are washed to remove the unbound enzyme-labeled free tri-iodothyronine and are then incubated with fluorogenic substrate ,4methylumbelliferyl phosphate (4MUP).The amount of enzyme-labeled freetriiodothyronine that binds to the beads is inversely proportional to the free triiodothyronine concentrations in the test sample. A standard curve using a rrange of known standard concentrations is constructed and unknown free triiodothyronine concentrations are calculated using this curve.

Reagents:

- 5traysx20test cups
- Plastic test cups containing lyophilized 12 magnetic beads with anti T3 monoclonal antibody and 50 μl of T3 conjugated to bovine alkaline phosphatase with sodium azide as apreservative.

2- Measurement of FT4:

Sample collection and handling:

Venous blood samples were collected aseptically without additives, stored at 18-25C for 15-45minutes then centrifuged to obtain the serum specimens which were stored at 2-8C to be analyzed at the second day.

Principle of the test

The STALA-PACK FT4 is a competitive enzyme immunoassay which is performed entirely in the STAIA-PACK FT4 test cups. Free thyroxine(FT4) present in the test sample competes with enzyme –labeled thyroxine (T4)for a limited number of binding sites on a T4-specific antibody immobilized on magnetic beads**.** the beads are washed to remove the unbound enzyme-labeled free triiodothyronine and are then incubated with fluorogenic substrate ,4methylumbelliferyl phosphate (4MUP).The amount of enzyme-labeled free thyroxine that binds to the beads is inversely proportional to the free thyroxine concentrations in the test sample. A standard curve using a range of known standard concentrations is constructed and unknown free thyroxine concentrations are calculated using this curve.

Reagents

Plastic test cups containing lyophilized 12 magnetic beads with anti T4 monoclonal antibody and 140 μl of T4 conjugated to bovine alkaline phosphatase with sodium azide as apreservative.

3-Measurment of TSH:

Sample collection and handling:

Venous blood samples were collected aseptically without additives, stored at 18-25C for 15-45minutes then centrifuged to obtain the serum specimens which were stored at 2-8C to be analyzed at the second day.

Principle of the Procedure

The STALA-PACK TSH is a tow- site immunoenzymometric assay which is performed entirely in the STAIA-PACK test cups. TSH present in the test sample is bound with monocolonal antibody immobilized on magnetic beads and monoclonal antibody conjugated with bovine alkaline phosphatase in the STAIA-PACK test cups.The beads are washed to remove the unbound enzyme-labeled free triiodothyronine and are then incubated with fluorogenic substrate ,4methylumbelliferyl phosphate (4MUP).The amount of enzyme-conjugated with monoclonal antibody that binds to the beads is directly proportional to the TSH concentrations in the test sample. A standard curve using a range of known standard concentrations is constructed and unknown TSH concentrations are calculated using this curve.

Reagents:

Plastic test cups containing lyophilized 12 magnetic beads coated with anti TSH mouse monoclonal antibody and 50 μl of anti TSH mouse monoclonal antibody conjugated to bovine alkaline phosphates with sodium azide as a preservative

4- Measurement of anti-TPO:

Sample collection and handling:

Venous blood samples were collected aseptically without additives, stored at 18-25C for 15-45minutes then centrifuged to obtain the serum specimens which were stored at 2-8C to be analyzed at the second day.

Volume required:

- 50 ul of the pre diluted blood sample(1-in-101 dilution).(sample cup must contain at least 100 ul more than the total volume required).

Principle of the test:

IMMULITE/IMMULITE 1000 Anti-TPO Ab is a solid- phase, enzyme –labeled, chemiluminescent sequential immunometric assay.

Reagents:

1. Anti-TPO AB test units(LTO1)
2. Anti-TPO AB reagent wedges(LTOA,LTOB)
3. Anti- TPO AB adjustors(LTOL,LTOH)
4. Thyroid autoantibody sample diluent(LAAZ4).
5. Chemilumiescent Substrate.

Thyroid ultra sound:

High resolution ultra sonography of the thyroid gland was done by an expert radiologist using 5-10HZ probe device, TOSHIBA xaria high end device, using xaria for both gray scale and duplex assessment of the thyroid gland.

Statistical analysis of the data

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0.

Qualitative data were described using number and percent. Quantitative data were described using minimum and maximum, mean and 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 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 the three studied groups were analyzed using F-test (ANOVA) and Post Hoc test (Scheffe) for pair-wise comparisons, while for abnormally distributed data Kruskal Wallis test was used to compare between different groups and Mann-Whitney Test was assessed for pair-wise comparisons. Correlations between two variables were assessed using spearman coefficients.

Significance of the obtained results was judged at the 5% level.

RESULTS

This prospective study included 100 male subjects working in a factory for bullets and shots. Blood lead level and thyroid function tests were measured and thyroid U/S was done for all subjects. Demographic, laboratory and radiological data were subjected to statistical analysis.

The groups were investigated for significant differences with the use of the Mann-Whitney and Kruskal-Wallis tests. In all comparisons, differences were considered significant with $p < 0.05$.

Table (I):   **Blood lead levels of the study subjects:**

case	BLL µg/ dl	Case	BLL µg/ dl	Case	BLL µg/ dl	Case	BLL µg/ dl	Case	BLL µg/ dl
1	27	21	35	41	40	61	11	81	44
2	44	22	12.4	42	45	62	28	82	48
3	26	23	37	43	19	63	12	83	13
4	14	24	13.7	44	22	64	42	84	29
5	39	25	5	45	25	65	12	85	57
6	39	26	20	46	43	66	37	86	39
7	28.5	27	58.5	47	55	67	5	87	12
8	55	28	40	48	29	68	43	88	37
9	30	29	29	49	8	69	13	89	59
10	26.5	30	37	50	60	70	33	90	25
11	11	31	12	51	13.9	71	35	91	40
12	28	32	48	52	44	72	12.4	92	45
13	12	33	13	53	26	73	55	93	39
14	42	34	29	54	14	74	13.7	94	22
15	27	35	7	55	39	75	60	95	25
16	37	36	39	56	19	76	20	96	13
17	60	37	12	57	20	77	18.5	97	55
18	43	38	37	58	55	78	40	98	29
19	13	39	59	59	30	79	29	99	8
20	33	40	25	60	20	80	37	100	60

1- Demographic data:

A. Age:

The mean age for group I was 34.11± 9.22 years, the mean age for group II was 33± 7.77 years and the mean age for group III was 31.54± 9.67 years. It seems that there was no significant difference between the 3 groups regarding age. (Table 2, Figure 4)

B: Duration of exposure:

The mean duration of exposure of group I was7.74± 4.93 years, the mean duration of exposure of group II was 7.44± 4.37 years and the mean duration of exposure of group III was7.92±5.80 years. There was no significant difference between the three groups regarding duration of exposure. (Table II, Figure 5)

Table (II): Comparison between the studied groups according to demographic data.

	Group I (n = 38)	Group II (n = 36)	Group III (n = 26)	Total (n=100)
Age				
Min. – Max.	19.0 – 49.0	16.0 – 45.0	18.0 – 49.0	16.0 – 49.0
Mean ± SD	34.11 ± 9.22	33.0 ± 7.77	31.54 ± 9.67	33.04 ± 8.82
Median	35.0	35.0	30.0	35.0
$^{KW}\chi^2$ (p)	1.411 (0.494)			
Duration of exposure/year Min – Max Mean ± SD Median	1.0 – 20.0 7.74 ± 4.93 7.0	1.0 – 20.0 7.44 ± 4.37 7.0	2.0 – 21.0 7.92 ± 5.80 6.0	1.0 – 21.0 7.68 ± 4.94 7.0
$^{KW}\chi^2$ (p)	0.050 (0.975)			

Group I:BLL: 10-25 micrograms/dl,   Group II: 26 -40 micrograms/dl   and Group III: 41-60 micrograms/dl
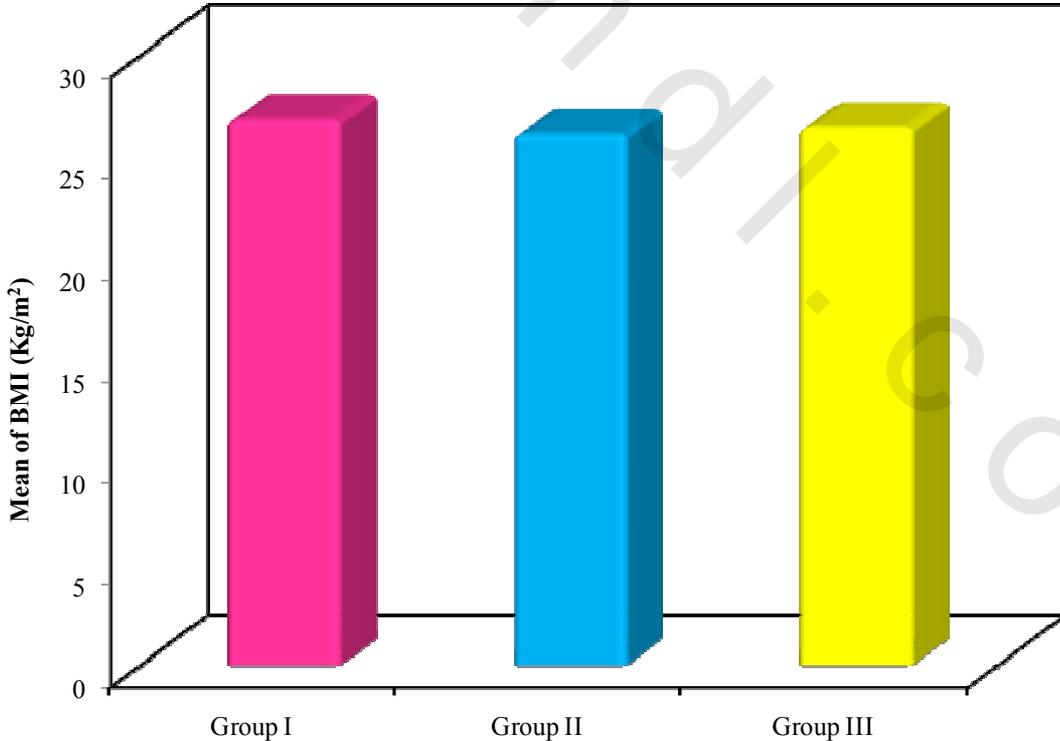$^{KW}\chi^2$: Chi square for Kruskal Wallis test
F: F test (ANOVA)
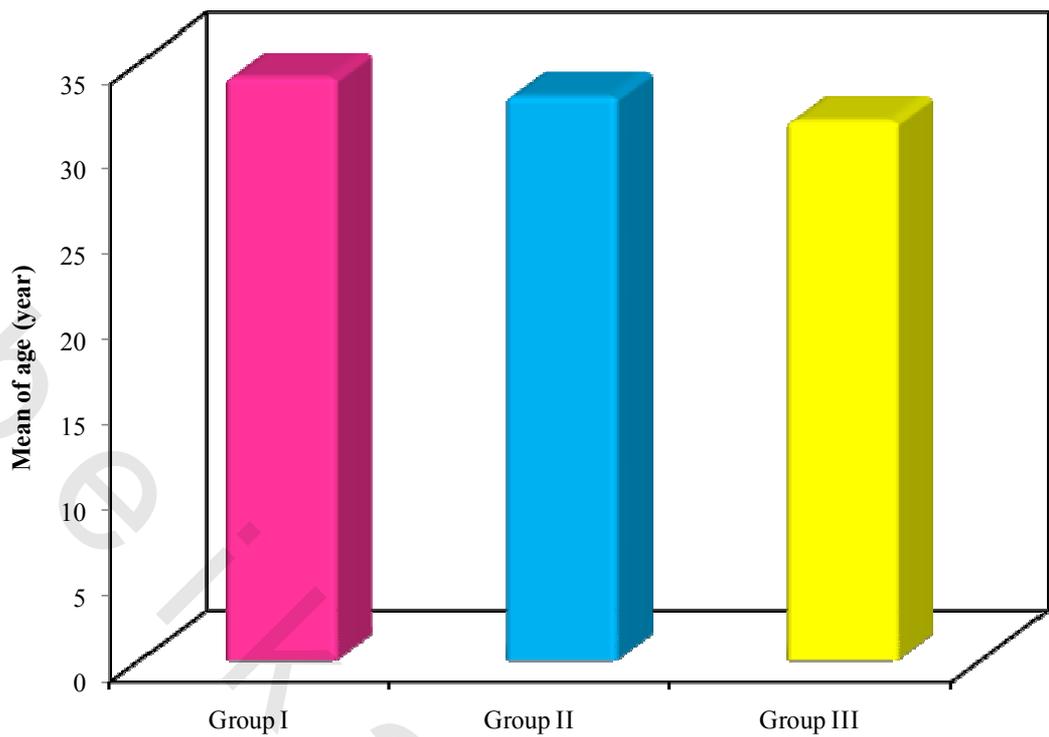
Figure (4): Comparison between the studied groups according to age
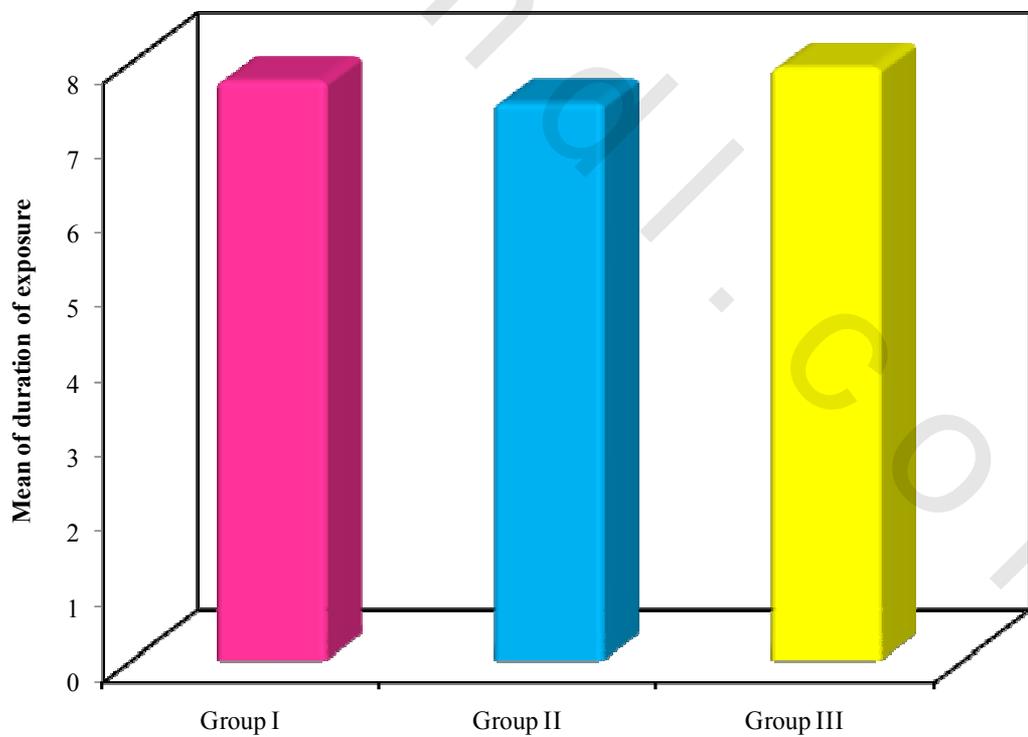
Figure (5): Comparison between the studied groups according to duration of exposure.

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2- Fulfillment of instructions to decrease lead exposure in the work place:

The percent of workers in group I that wear protective equipments was 57.8 and that of group II was 52.7, while that of group III was42.3. There was no significant difference between the three groups regarding wearing protective equipments. (Table III, Figure6)

The percent of workers in group I that take nutritional supplement was 13.1 and that of group II was 13.8, while that of group III was11.5. There was no significant difference between the three groups regarding taking nutritional supplement. (Table III, Figure6)

Table (III): **Comparison between the studied groups according to fulfillment of instructions to decrease lead exposure in the work place.**

	Group I (n = 38)		Group II (n = 36)		Group III (n = 26)		Total (n=100)	
	No.	%	No.	%	No.	%	No.	%
Wearing protective equipments	22	57.8	19	52.7	11	42.3	52	52.0
χ^2 (p)	1.516 (0.469)							
Taking any nutrient supplements	5	13.1	5	13.8	3	11.5	13	13.0
χ^2 (^{MC}p)	0.151 (1.000)							

Group I:BLL: 10-25 micrograms/dl, Group II: 26 -40 micrograms/dl and Group III: 41-60 micrograms/dl.
χ^2: Chi square test
MC: Monte Carlo test
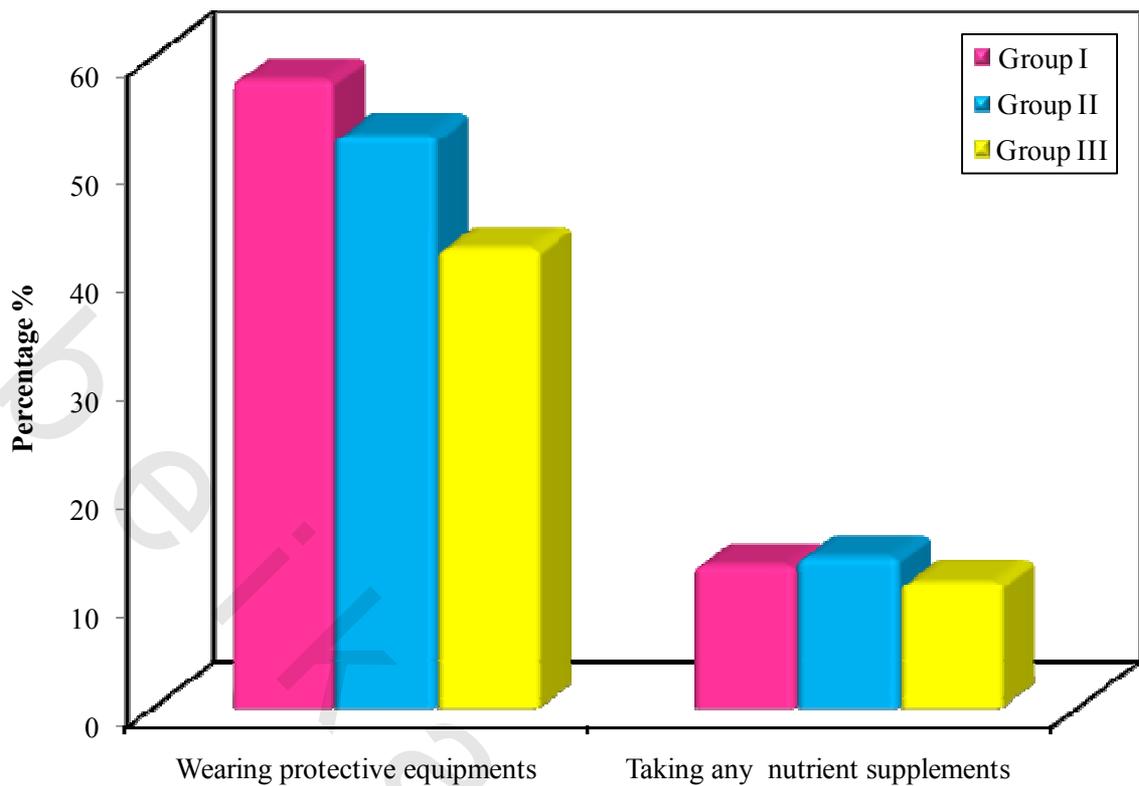
Fulfillment of instructions to decrease lead exposure in the work place.

Figure (6): Comparison between the studied groups according to fulfillment of instructions to decrease lead exposure in the work place.

3- Physical examination:

A-   BMI:

The mean BMI of group I was 26.83 ± 3.74 kg/m^2, and that of group II was 26.10 ± 4.62 kg/m^2 while that of group III was26.42 ± 3.10 kg/m^2. There was no significant difference between the three groups regarding BMI. (Table IV, Figure7)

Table (IV):   Comparison between the studied groups according to BMI

	Group I (n = 38)	Group II (n = 36)	Group III (n = 26)	Total (n=100)
BMI(kg/ m^2)				
Min. – Max.	18.87 – 31.70	19.20 – 38.10	18.87 – 30.90	18.87 – 38.10
Mean ± SD	26.83 ± 3.74	26.10 ± 4.62	26.42 ± 3.10	26.46 ± 3.91
Median	27.87	26.88	26.14	27.66
F (p)	0.315 (0.730)			

Group I:BLL: 10-25 micrograms/dl, Group II: 26 -40 micrograms/dl and Group III: 41-60 micrograms/dl.
$^{KW}\chi^2$: Chi square for Kruskal Wallis test
F: F test (ANOVA)

Figure (7):   Comparison between the studied groups according to BMI

B- Blood pressure measurement:

The mean systolic blood pressure of group I was 115.26± 9.25, and that of group II was 129.19± 18.39 while that of group III was 153.58± 8.47. There was significant difference between group I and group II, between group I and group III and between group II and group III regarding systolic Bp. (Table V, Figure8)

The mean diastolic blood pressure of group I was 81.42± 6.20, and that of group II was 83.36± 8.85 while that of group III was 95.58± 2.98. There was significant difference between group I and group III and between group II and group III regarding diastolic Bp. (Table V , Figure8)

Table (V): **Comparison between the studied groups according to blood pressure measurement.**

	Group I (n = 38)	Group II (n = 36)	Group III (n = 26)	Total (n=100)
Systolic/mmHG				
Min – Max	100.0 – 130.0	100.0 – 160.0	140.0 – 170.0	100.0 – 170.0
Mean ± SD	115.26 ± 9.25	129.19 ± 18.39	153.58 ± 8.47	130.24 ± 19.98
Median	114.0	130.50	156.50	128.50
F (p)	65.617^* $(<0.001^*)$			
Sig. bet. grps	I-II[***], I-III[***], II-III[***]			
Diastolic/mmHG				
Min – Max	70.0 – 90.0	70.0 – 100.0	90.0 – 100.0	70.0 – 100.0
Mean ± SD	81.42 ± 6.20	83.36 ± 8.85	95.58 ± 2.98	85.80 ± 8.89
Median	81.0	81.0	95.50	86.0
F (p)	37.891^* $(<0.001^*)$			
Sig. bet. grps	I-III[***], II-III[***]			

Group I:BLL: 10-25 micrograms/dl, Group II: 26 -40 micrograms/dl and Group III: 41-60 micrograms/dl.
F: F test (ANOVA)
Sig. bet. grps was done using Post Hoc Test (Scheffe)
*: Statistically significant at $p \leq 0.05$
**: Statistically significant at $p \leq 0.01$
***: Statistically significant at $p \leq 0.001$
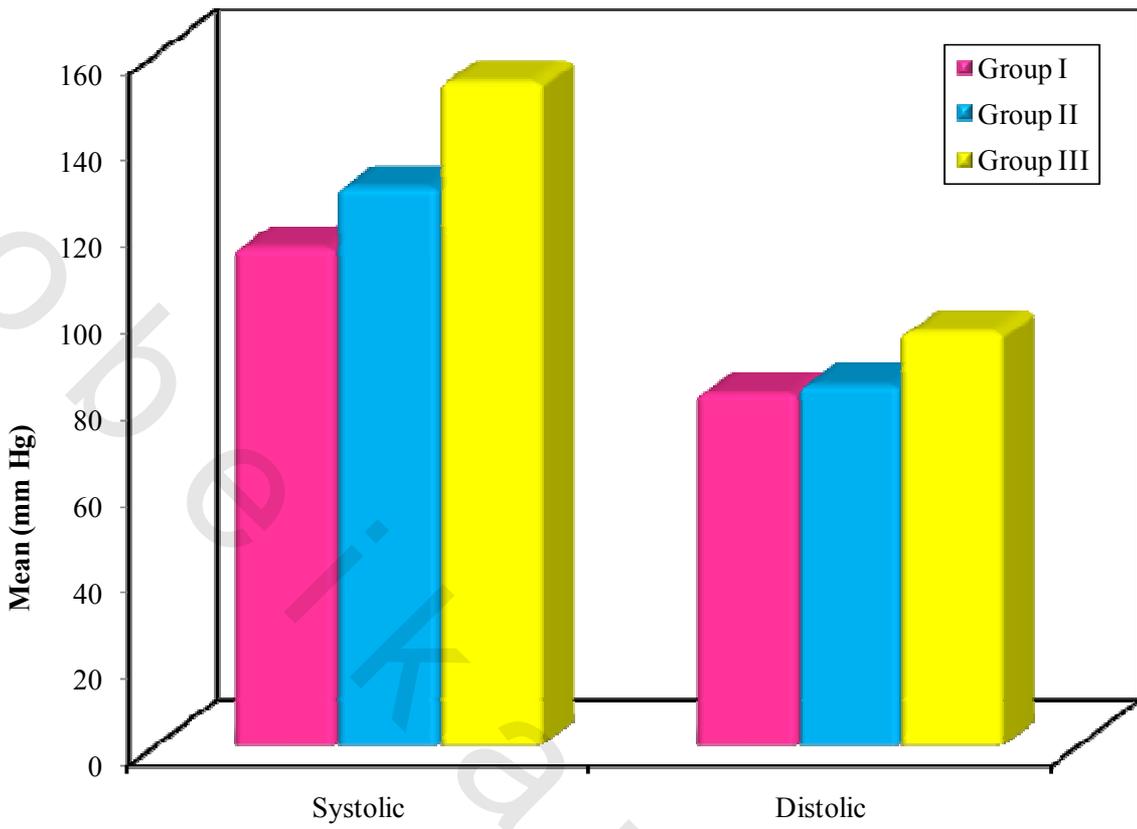
Figure (8): Comparison between the studied groups according to blood pressure measurement.

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3. Comparison between the 3 studied groups according to routine laboratory investigations:

Routine laboratory investigations were done, CBC, FBS, AST, ALT, urea and creatinine.

CBC:

The mean Hb of group I was11.99± 1.75g/dl and of group II was11.19± 1.82g/dl while that of group III was11.14± 1.33g/dl. There was no significant difference between the 3 groups regarding Hb. (Table VI, Figure 9)

The mean MCV of group I was78.11±7.37 and of group II was77± 9.0 while that of group III was 75.31± 6.38. There was no significant difference between the 3 groups regarding MCV. (Table VI, Figure 10)

The mean MCH of group I was 26.47± 3.68 and of group II was25.11± 4.65while that of group III was24.23± 2.44. There was no significant difference between the 3 groups regarding MCH. (Table VI, Figure11)

The mean WBCs of group I was 7.39± 1.21 ($10^3/\mu$l) and of group II was7.50± 1.78 ($10^3/\mu$l) while that of group III was 7.85± 1.94 ($10^3/\mu$l). There was no significant difference between the 3 groups regarding WBCs. (Table VI, Figure12)

The mean Platelets of group I was 288.42± 42.30 ($10^3/\mu$l) and of group II was 276.58± 68.20 ($10^3/\mu$l) while that of group III was 308.31± 48.97 ($10^3/\mu$l). There was no significant difference between the 3 groups regarding Platelets. (Table VI, Figure13)

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Table (VI):   Comparison between the studied groups according to CBC

	Group I (n = 38)	Group II (n = 36)	Group III (n = 26)	Total (n=100)
Hb (g/dl)				
Min – Max	8.30 – 14.70	8.90 – 15.10	9.80 – 14.70	8.30 – 15.10
Mean ± SD	11.99 ± 1.75	11.19 ± 1.82	11.14 ± 1.33	11.48 ± 1.71
Median	11.80	10.70	11.0	11.0
F (p)	2.839 (0.063)			
MCV				
Min – Max	67.0 – 89.0	65.0 – 94.0	65.0 – 94.0	65.0 – 94.0
Mean ± SD	78.11 ± 7.37	77.0 ± 9.0	75.31 ± 6.38	76.98 ± 7.77
Median	78.0	76.0	75.0	76.0
F (p)	1.000 (0.372)			
MCH				
Min – Max	20.0 – 33.0	19.0 – 34.0	19.0 – 29.0	19.0 – 34.0
Mean ± SD	26.47 ± 3.68	25.11 ± 4.65	24.23 ± 2.44	25.40 ± 3.88
Median	26.0	24.0	25.0	25.0
F (p)	2.842 (0.063)			
WBC (10^3/µl)				
Min. – Max.	5.40 – 9.70	4.90 – 10.20	4.70 – 11.0	7.40 – 11.0
Mean ± SD	7.39 ± 1.21	7.50 ± 1.78	7.85 ± 1.94	7.55 ± 1.63
Median	7.00	7.50	8.0	7.0
F (p)	0.631 (0.534)			
Platelets (10^3/µl)				
Min. – Max.	200.0 – 360.0	150.0 – 400.0	200.0 – 400.0	150.0 – 400.0
Mean ± SD	288.42 ± 42.30	276.58 ± 68.20	308.31 ± 48.97	289.33±55.43
Median	282.0	270.50	307.50	290.0
F (p)	2.559 (0.083)			

Group I:BLL: 10-25 micrograms/dl, Group II: 26 -40 micrograms/dl and Group III: 41-60 micrograms/dl.
F: F test (ANOVA)
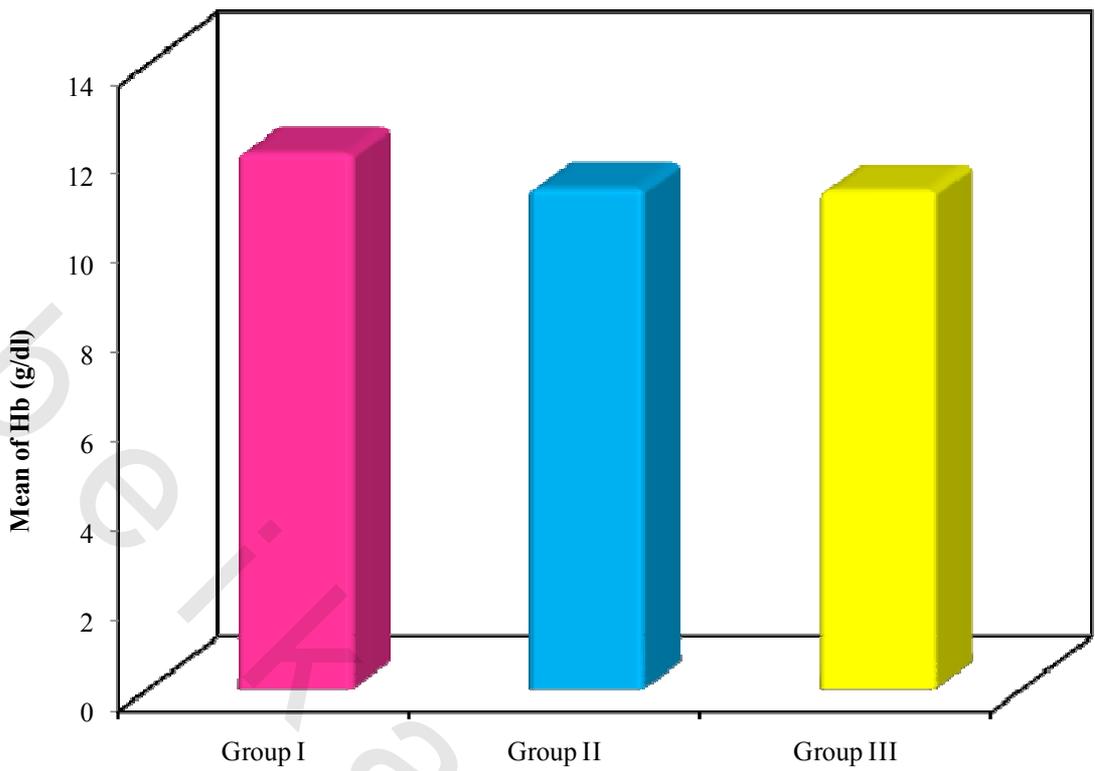
Figure (9): Comparison between the studied groups according to HB
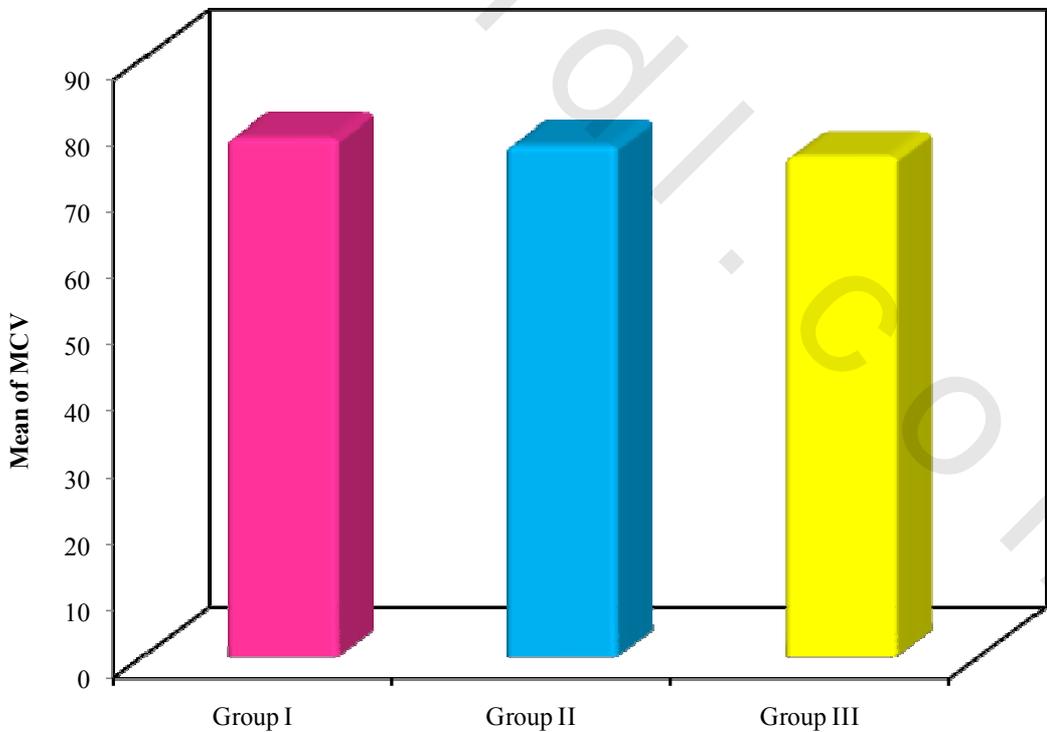
Figure (10): Comparison between the studied groups according to MCV

36
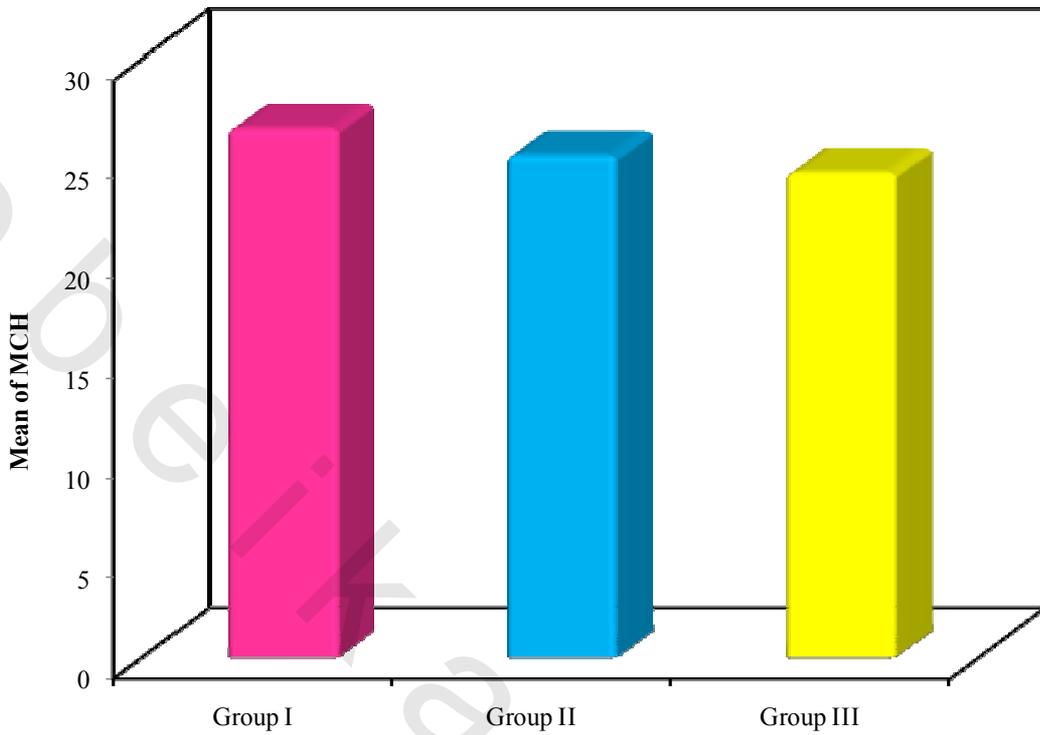
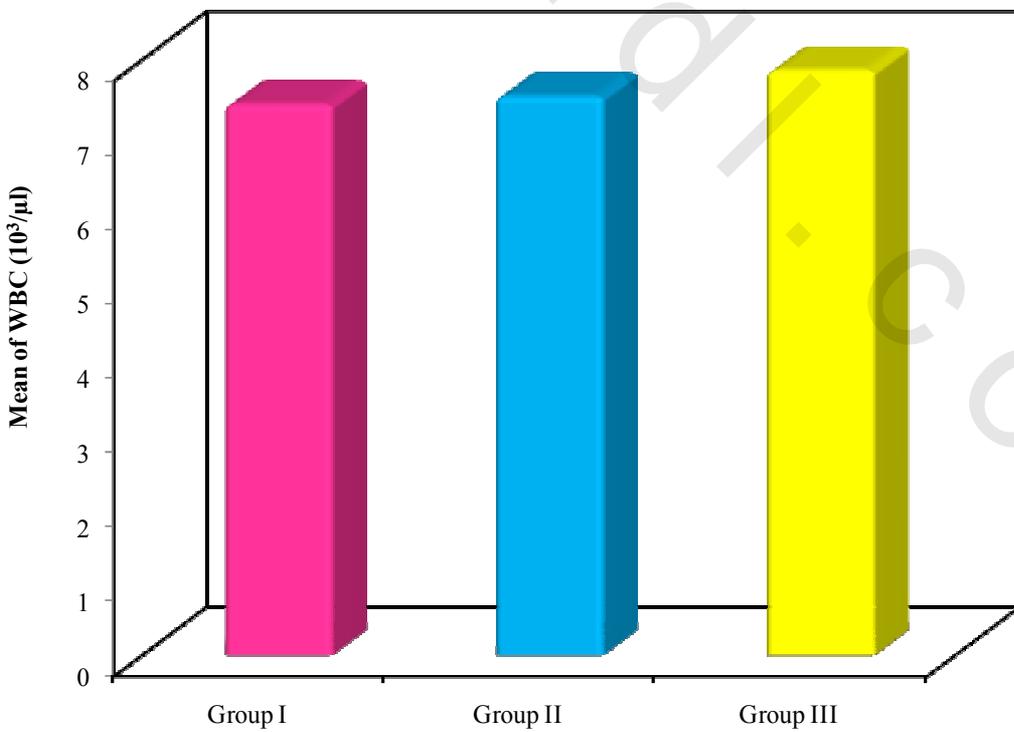**Figure (11):**   Comparison between the studied groups according to MCH

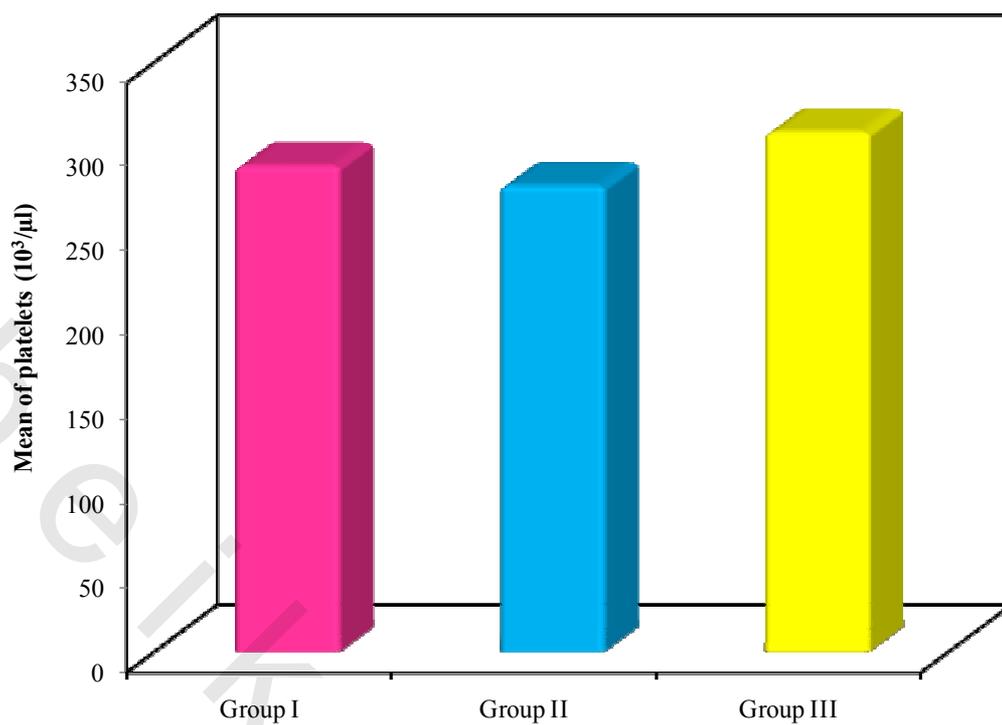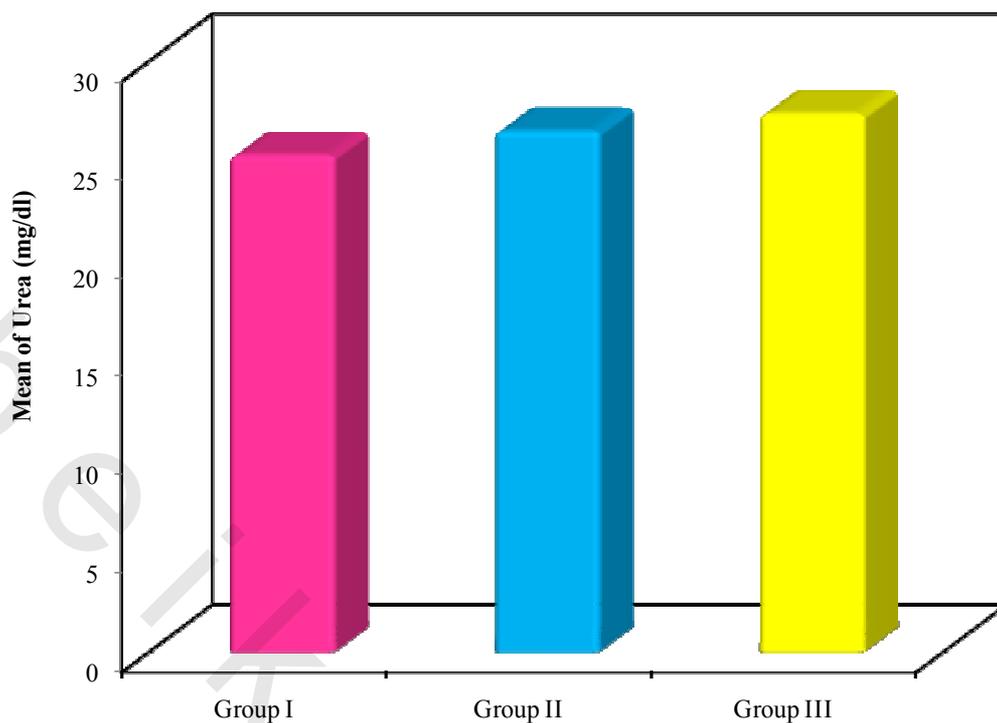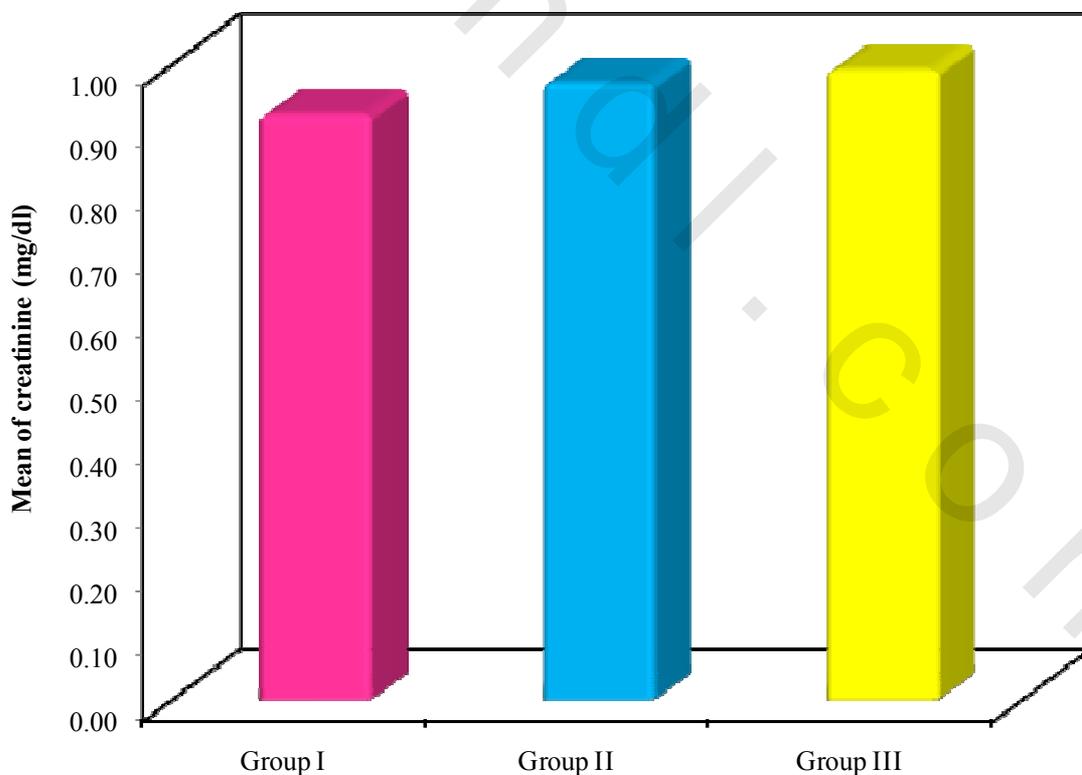**Figure (12):**   Comparison between the studied groups according to WBCs.

Figure (13): Comparison between the studied groups according to platelets

Urea and creatinine:

The mean urea of group I was 25.21± 3.24 mg/dl and of group II was 26.44± 4.38 mg/dl while that of group III was 27.31± 4.36 mg/dl. There was no significant difference between the 3 groups regarding to blood urea. (Table VII, Figure14)

The mean creatinine of group I was 0.92± 0.21 mg/dl and of group II was 0.97± 0.06 mg/dl while that of group III was 0.99± 0.08 mg/dl. There was no significant difference between the 3 groups regarding to serum creatinine. (Table VII, Figure15)

Table (VII):   Comparison between the studied groups according to urea and creatinine

	Group I (n = 38)	Group II (n = 36)	Group III (n = 26)	Total (n=100)
Urea (mg/dl)				
Min. – Max.	19.0 – 31.0	19.0 – 33.0	20.0 – 33.0	19.0 – 33.0
Mean ± SD	25.21 ± 3.24	26.44 ± 4.38	27.31 ± 4.36	26.20 ± 4.03
Median	25.0	26.0	27.0	26.0
F (p)	2.525 (0.111)			
Creatinine (mg/dl)				
Min. – Max.	0.62 – 1.22	0.90 – 1.10	0.80 – 1.10	0.62 – 1.22
Mean ± SD	0.92 ± 0.21	0.97 ± 0.06	0.99 ± 0.08	0.95 ± 0.14
Median	0.92	1.00	1.00	1.00
F (p)	2.367 (0.099)			

Group I:BLL: 10-25 micrograms/dl, Group II: 26 -40 micrograms/dl and Group III: 41-60 micrograms/dl.
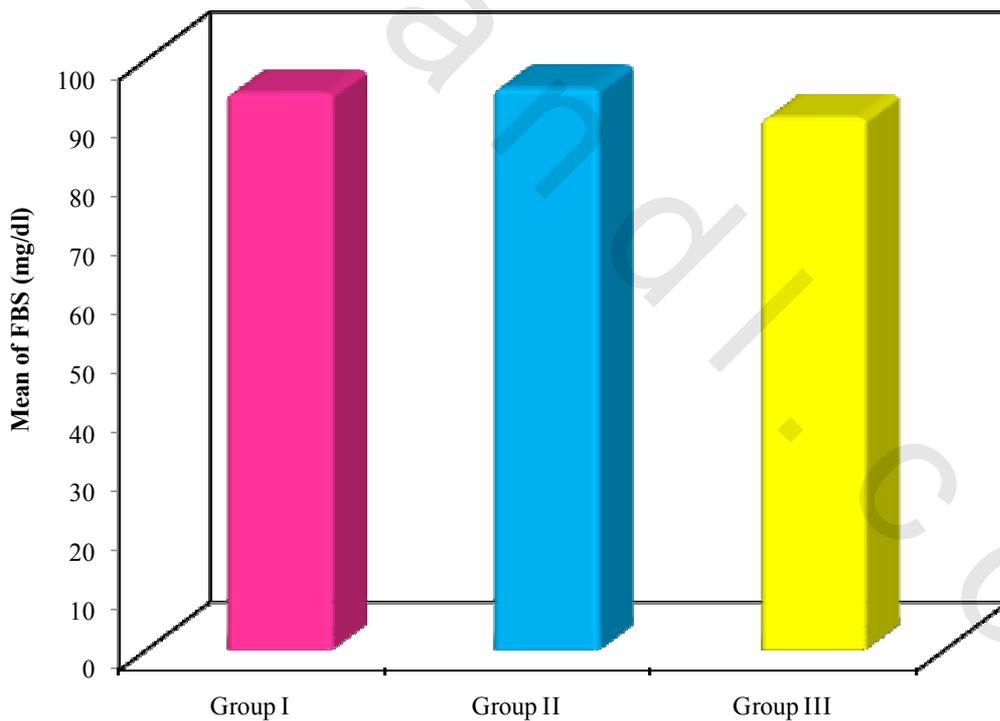F: F test (ANOVA)

Figure (14): Comparison between the studied groups according to urea

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

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FBS:

The mean FBS of group I was 94.21± 11.05 mg/dl and of group II was 95.06± 11.84 mg/dl while that of group III was 90.0± 11.86 mg/dl. There was no significant difference between the 3 groups regarding to blood FBS. (Table VIII, Figure16)

Table (VIII): Comparison between the studied groups according to FBS

	Group I (n = 38)	Group II (n = 36)	Group III (n = 26)	Total (n=100)
FBS (mg/dl)				
Min. – Max.	75.0 – 114.0	80.0 – 115.0	70.0 – 112.0	70.0 – 115.0
Mean ± SD	94.21 ± 11.05	95.06 ± 11.84	90.0 ± 11.86	93.42 ± 11.62
Median	96.50	92.0	91.0	92.0
F (p)	1.589 (0.209)			

Group I:BLL: 10-25 micrograms/dl, Group II: 26 -40 micrograms/dl and Group III: 41-60 micrograms/dl.
F: F test (ANOVA)

Figure (16): Comparison between the studied groups according to FBS

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ALT&AST:

The mean AST of group I was 21.82± 3.94 (IU/L) and of group II was 23.03± 6.20 (IU/L) while that of group III was 21.35± 4.52 (IU/L). There was no significant difference between the 3 groups regarding to blood AST. (Table XI, Figure17)

The mean ALT of group I was 23.61± 4.86 (IU/L) and of group II was 26.08± 6.63 (IU/L) while that of group III was 26.15± 4.12 (IU/L). There was no significant difference between the 3 groups regarding to blood ALT. (Table XI, Figure17)

Table (IX):   Comparison between the studied groups according to AST and ALT

	Group I (n = 38)	Group II (n = 36)	Group III (n = 26)	Total (n=100)
AST (IU/L)				
Min. – Max.	16.0 – 29.0	13.0 – 35.0	13.0 – 28.0	13.0 – 35.0
Mean ± SD	21.82 ± 3.94	23.03 ± 6.20	21.35 ± 4.52	22.13 ± 5.0
Median	21.0	22.0	22.50	22.0
F (p)	0.973 (0.381)			
ALT (IU/L)				
Min. – Max.	15.0 – 31.0	13.0 – 38.0	19.0 – 33.0	13.0 – 38.0
Mean ± SD	23.61 ± 4.86	26.08 ± 6.63	26.15 ± 4.12	25.16 ± 5.49
Median	24.0	26.0	26.0	25.0
F (p)	2.537 (0.084)			

Group I:BLL: 10-25 micrograms/dl, Group II: 26 -40 micrograms/dl and Group III: 41-60 micrograms/dl.
F: F test (ANOVA)
Sig. bet. grps was done using Post Hoc Test (Scheffe)
*: Statistically significant at $p \leq 0.05$
**: Statistically significant at $p \leq 0.01$
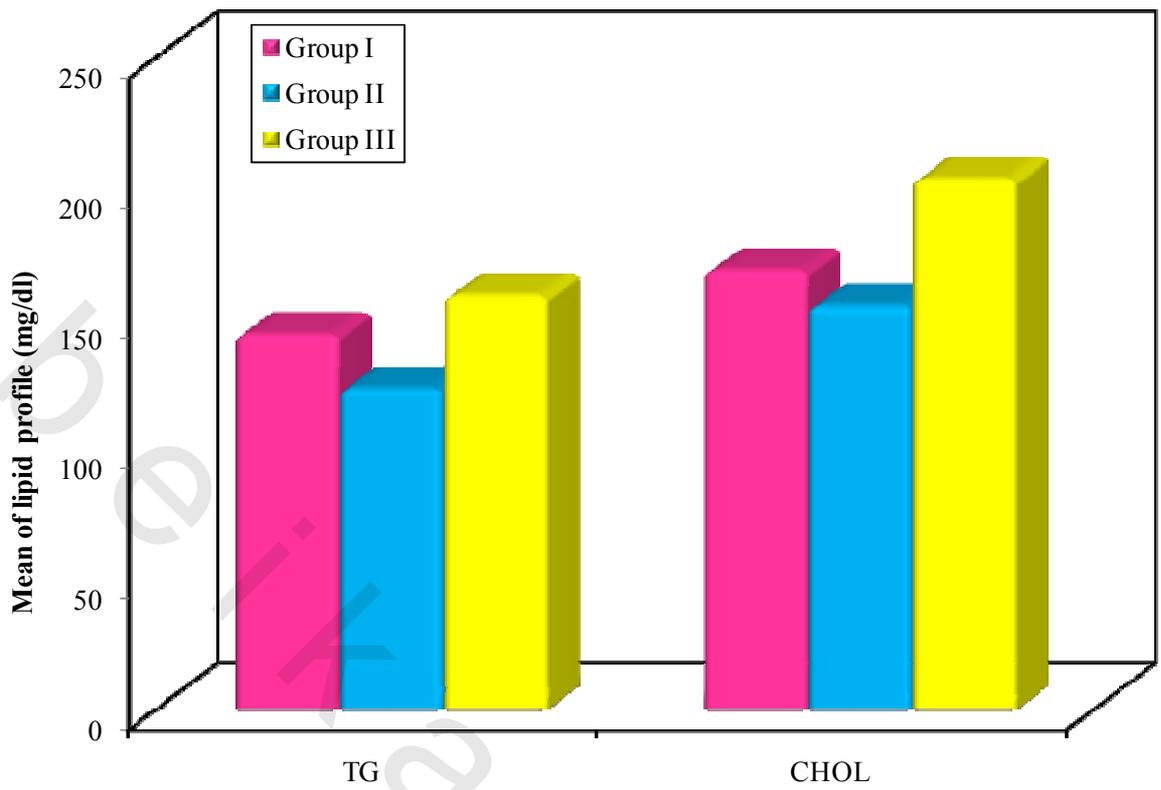***: Statistically significant at $p \leq 0.001$
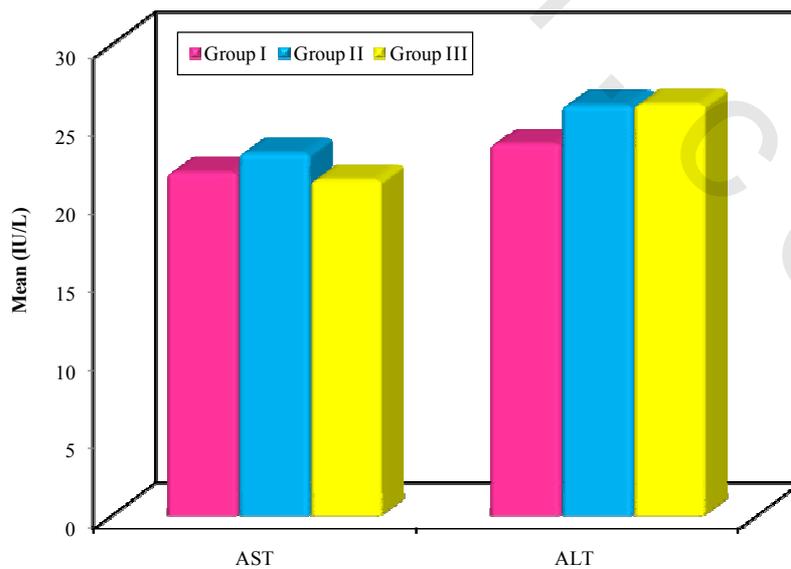
Figure (17):   Comparison between the studied groups according to AST and ALT

3. Comparison between the 3 studied groups according to lipid profile:

The mean value of serum Cholesterol in group I was 168.16± 36.54mg/dl and in group II was 154.72± 40.29 mg/dl while that of group III was 203.31± 49.30. There was significant difference between group I and group III and between group II and group III regarding serum cholesterol level. (Table X, Figure18)

The mean value of serum triglyceride in group I was 143.68± 22.29 mg/dl and in group II was 123.06± 29.28 mg/dl while that of group III was158.46± 21.48. There was significant difference between group I and group II and between group II and group III regarding serum TG level. (Table X, Figure18)

Table (X):   Comparison between the studied groups according to serum cholesterol and T.G

	Group I (n = 38)	Group II (n = 36)	Group III (n = 26)	Total (n=100)
Serum Cholestrol(mg/dl)				
Min – Max	78.0 – 230.0	40.0 – 211.0	110.0 – 270.0	40.0 – 270.0
Mean ± SD	168.16 ± 36.54	154.72 ± 40.29	203.31 ± 49.30	172.46 ± 45.37
Median	180.0	170.0	220.0	172.50
$^{KW}\chi^2$ (p)	15.445[*] (<0.001)			
Sig. bet. grps[@]	I-III[**],II-III[***]			
serumTG(mg/dl)				
Min – Max	90.0 – 180.0	90.0 – 175.0	110.0 – 180.0	90.0 – 180.0
Mean ± SD	143.68 ± 22.29	123.06 ± 29.28	158.46 ± 21.48	140.10 ± 28.36
Median	150.0	120.0	160.0	150.0
F (p)	15.951[*] (<0.001)			
Sig. bet. grps[#]	I-II[**],II-III[***]			

Group I:BLL: 10-25 micrograms/dl, Group II: 26 -40 micrograms/dl and Group III: 41-60 micrograms/dl.
F: F test (ANOVA)
$^{KW}\chi^2$: Chi square for Kruskal Wallis test
#:Sig. bet. grps was done using Post Hoc Test (Scheffe)
@:Sig. bet. grps was done using Mann Whitney test
*: Statistically significant at $p \le 0.05$ **: Statistically significant at $p \le 0.01$
***: Statistically significant at $p \le 0.001$

Figure (18): Comparison between the studied groups according to serum cholesterol and T.G

3- Thyroid function tests:

The mean value of FT3 in group I was 2.91± 0.36 Pg/ml, in group II was3.08 ± 0.39 Pg/ml and in group III was 3.14 ± 0.49 Pg/ml. there was no significant difference between the 3 groups according to FT3. (Table XI, Figure19)

The mean value of FT4 in group I was 1.19 ± 0.30 ng/dl, in group II was 1.25 ± 0.36 ng/dl and in group III was 1.33 ± 0.30 ng/dl. There was no significant difference between the 3 groups according to FT4. (Table XI, Figure19)

The mean value of TSH in group I was 1.84 ± 0.82 uIU /ml, in group II was1.81 ± 1.04 uIU /ml and in group III was 5.83 ± 2.72 uIU/ml. There was significant difference between group I and III and between group II and III regarding TSH. (Table XI, Figure19)

The mean value of ATPO in group I was 17.29 ± 11.26IU/ml and in group II was 15.43 ± 10.21 IU/ml while in group III was17.31 ± 9.84 IU/ml. There was no significant difference between the 3 groups according to ATPO. (Table XI, Figure20)

Table (XI):   Comparison between the studied groups according to serum fT3, fT4, TSH and ATPO

	Group I (n = 38)	Group II (n = 36)	Group III (n = 26)	Total (n=100)
FT3 Pg/ml				
Min – Max	2.25 – 3.40	2.25 – 3.80	2.25 – 3.90	2.25 – 3.90
Mean ± SD	2.91 ± 0.36	3.08 ± 0.39	3.14 ± 0.49	3.03 ± 0.42
Median	3.0	3.10	3.10	3.10
F (p)	3.042 (0.052)			
FT4 ng/dl				
Min – Max	0.82 – 1.82	0.87 – 2.0	0.92 – 1.82	0.82 – 2.0
Mean ± SD	1.19 ± 0.30	1.25 ± 0.36	1.33 ± 0.30	1.25 ± 0.33
Median	1.11	1.13	1.30	1.13
$^{KW}\chi^2$ **(p)**	4.151 (0.125)			
TSH mIU/ml				
Min – Max	0.03 – 3.0	0.91 – 5.0	0.81 – 9.30	0.03 – 9.30
Mean ± SD	1.84 ± 0.82	1.81 ± 1.04	5.83 ± 2.72	2.87 ± 2.37
Median	2.0	1.36	6.50	2.11
$^{KW}\chi^2$ **(p)**	28.579[*] (<0.001)			
Sig. bet. groups[@]	I-III[***],II-III[***]			
ATPO IU/ml				
Min – Max	2.60 – 49.30	1.20 – 33.0	6.0 – 34.0	1.20 – 49.30
Mean ± SD	17.29 ± 11.26	15.43 ± 10.21	17.31 ± 9.84	16.63 ± 10.46
Median	11.30	10.75	13.0	12.50
$^{KW}\chi^2$ **(p)**	2.502 (0.286)			

Group I:BLL: 10-25 micrograms/dl, Group II: 26 -40 micrograms/dl and Group III: 41-60 micrograms/dl.
F: F test (ANOVA) $^{KW}\chi^2$: Chi square for Kruskal Wallis test
#:Sig. bet. grps was done using Post Hoc Test (Scheffe)
@:Sig. bet. grps was done using Mann Whitney test
*: Statistically significant at p ≤ 0.05   **: Statistically significant at p ≤ 0.01
***: Statistically significant at p ≤ 0.001
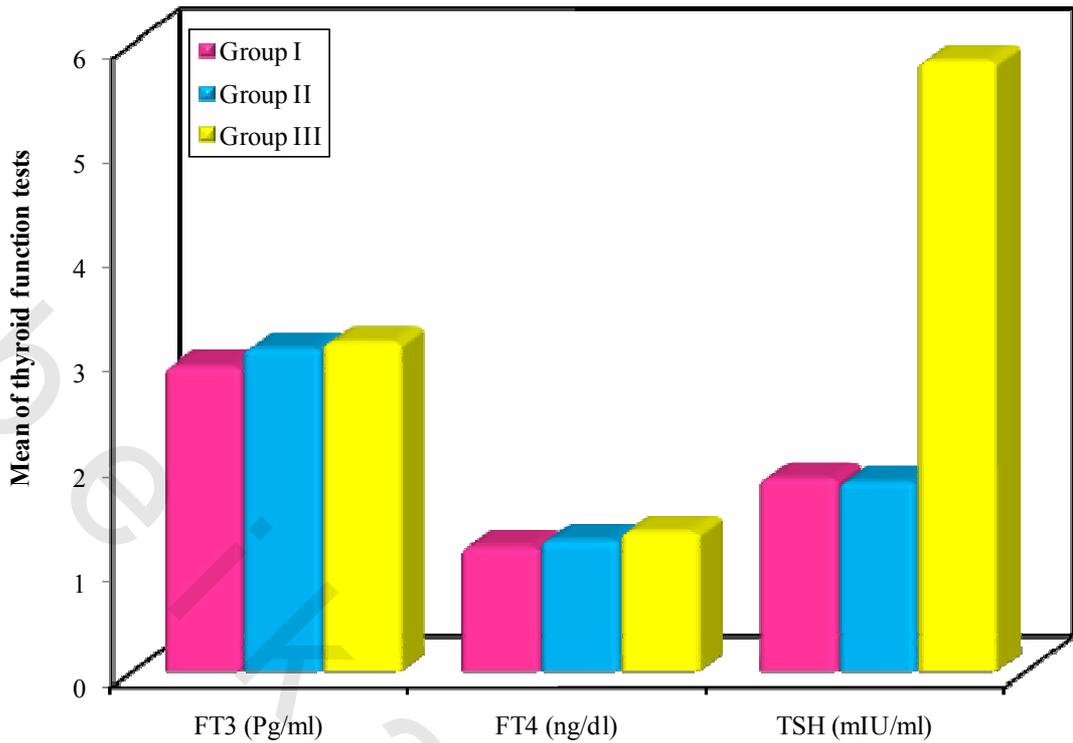
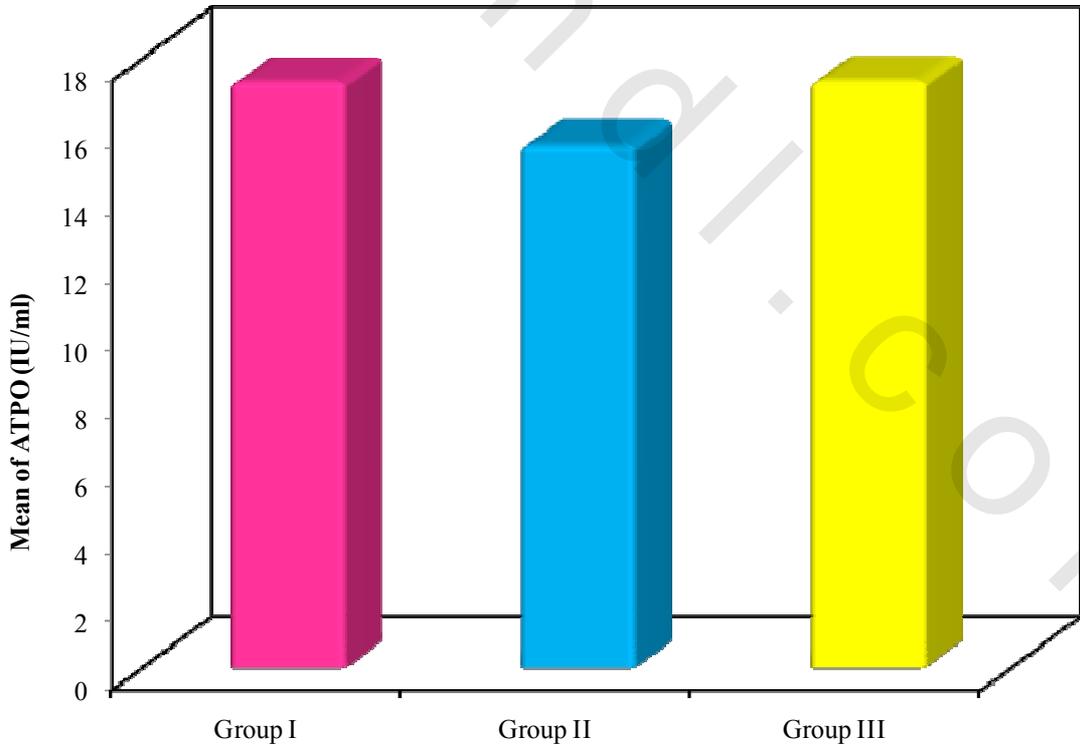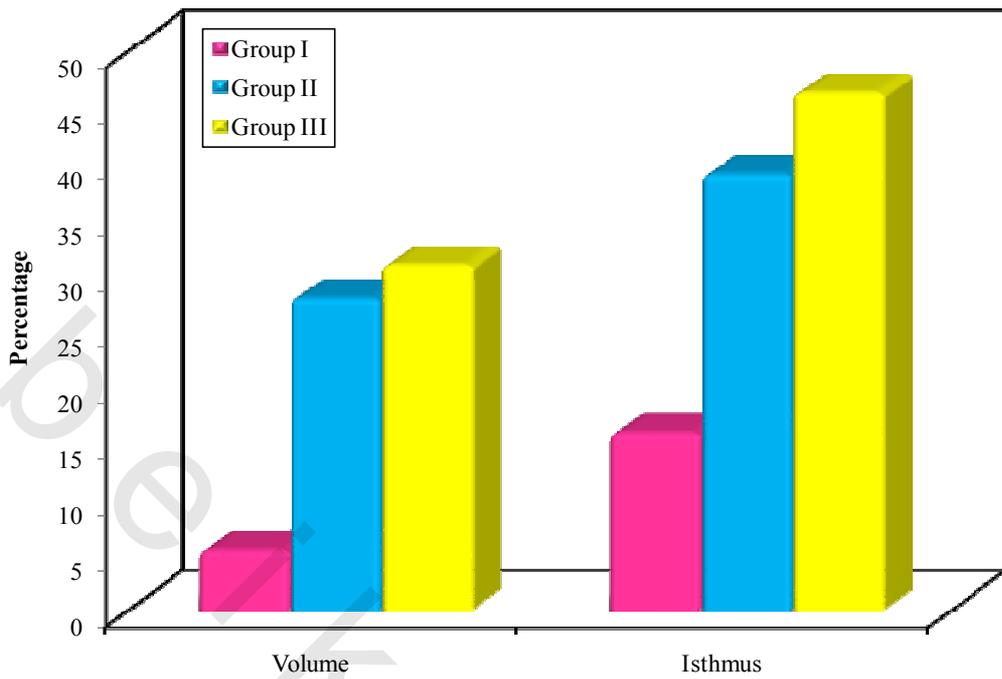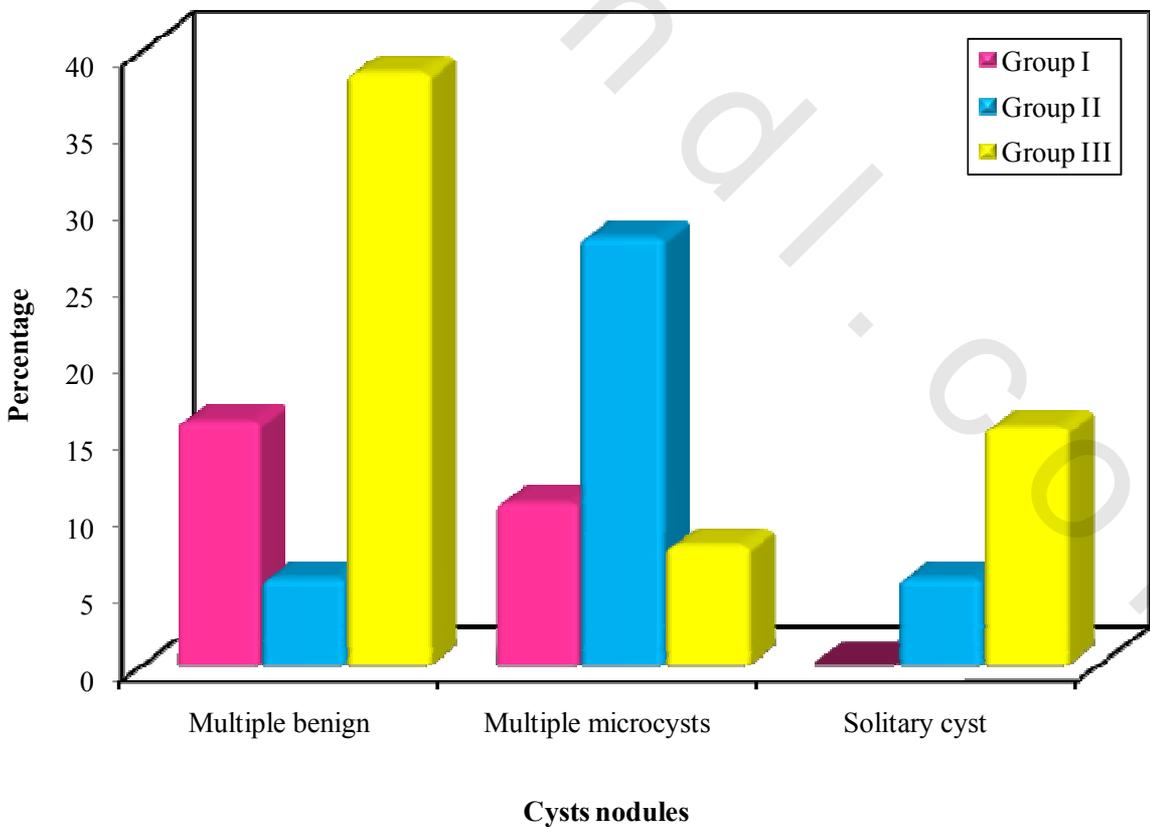**Figure (19):** Comparison between the studied groups according to fT3, fT4, TSH

Figure (20): Comparison between the studied groups according to ATPO

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4- Thyroid ultra sound

Comparison of U/S finding of the three studied groups revealed many abnormalities regarding size and texture.

Enlarged lobes volume was found in 5.3% of group I, 27.8% of group II and 30.8% of group III with Significant difference between group I and II and between group I and III. (Table XII, Figure21)

Enlarged isthmus was found in 15.8% of group I, 38.9% of group II and 46.2% of group III with Significant difference between group I and II and between group I and III. (Table XII, Figure21)

Cysts and nodules were found in26.3% of group I, 39% of group II and 61.6% of group III with Significant difference between group I and II, between group I and III and between group II and III. (Table XII, Figure22)

Coarse echo texture was found in10.5% of group I, 38.9% of group II and 46.5% of group III with Significant difference between group I and II and between group I and III. (Table XII, Figure23)

No calcification or Doppler changes were found in all the study subjects. (Table XII)

Table (XII): Comparison between the studied groups according to thyroid gland ultrasound finding.

	Group I (n = 38)		Group II (n = 36)		Group III (n = 26)		Total (n=100)	
	No	%	No	%	No	%	No	%
Lobes volume								
Enlarged	2	5.3	10	27.8	8	30.8	20	20.0
χ^2 **(p)**	8.404* (0.015)							
Sig. bet. groups	I-II**, I-III*							
Isthmus volume								
Enlarged	6	15.8	14	38.9	12	46.2	32	32.0
χ^2 **(p)**	7.768* (0.021)							
Sig. bet. groups	I-II*,I-III**							
Cysts nodules								
Multiple benign	6	15.8	2	5.6	10	38.5	18	18.0
Multiple microcysts	4	10.5	10	27.8	2	7.7	16	16.0
Solitary cyst	0	0.0	2	5.6	4	15.4	6	6.0
χ^2 (^MCp)	23.514* (0.001)							
Sig. bet. groups	I-II*,I-III**,II-III**							
Calcification								
No	38	100.0	36	100.0	26	100.0	100	100.0
Yes	0	0.0	0	0.0	0	0.0	0	0.0
Doppler								
Normal	38	100.0	36	100.0	26	100.0	100	100.0
Abnormal	0	0.0	0	0.0	0	0.0	0	0.0
Echo texture								
Coarse "Abnormal"	4	10.5	14	38.9	12	46.2	30	30.0
χ^2 **(p)**	11.447* (0.003)							
Sig. bet. grps	I-II**,I-III**							

Group I:BLL: 10-25 micrograms/dl, Group II: 26 -40 micrograms/dl and Group III: 41-60 micrograms/dl.

χ^2: Chi square test

*: Statistically significant at $p \leq 0.05$

Sig. bet. grps was done using Chi square test

*: Statistically significant at $p \leq 0.05$

**: Statistically significant at $p \leq 0.01$

***: Statistically significant at $p \leq 0.001$

Figure (21): Comparison between the studied groups according to lobes volume and isthmus volume.

Cysts nodules

Figure (22): Comparison between the studied groups according to cysts and nodules
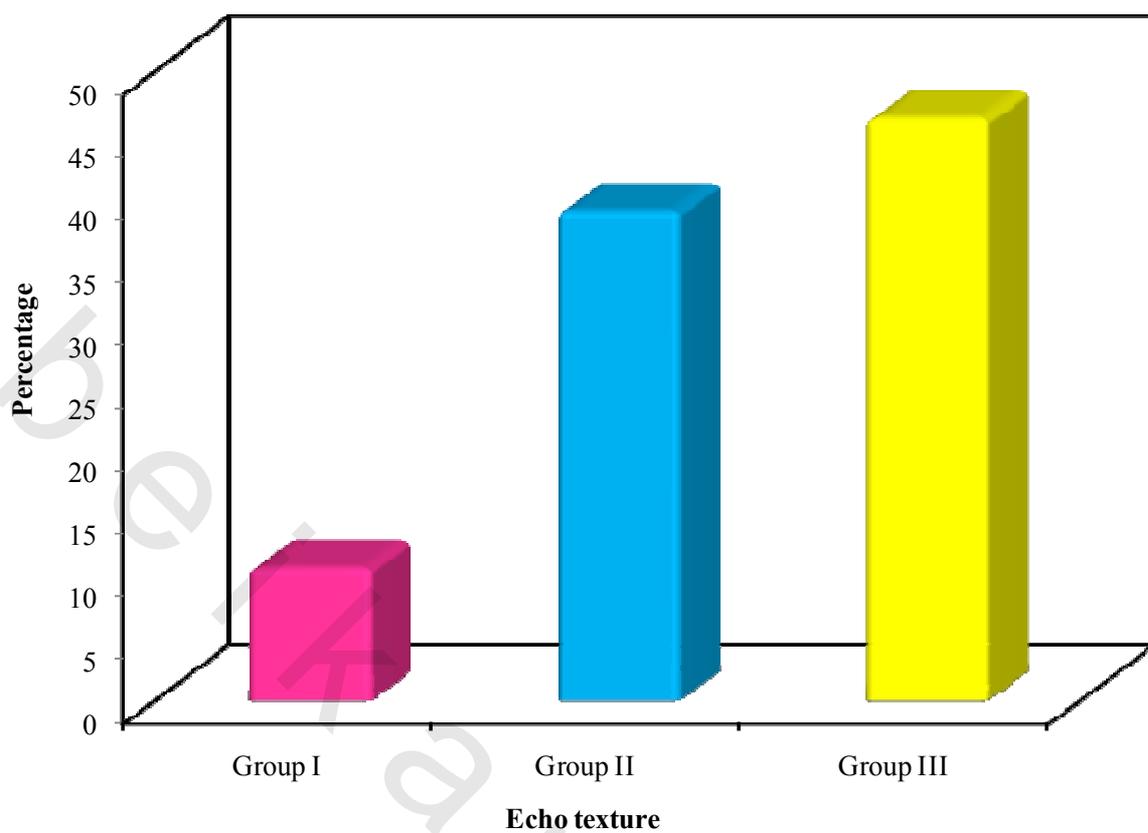
49

Figure (23): Comparison between the studied groups according to coarse echo texture of thyroid U/S.
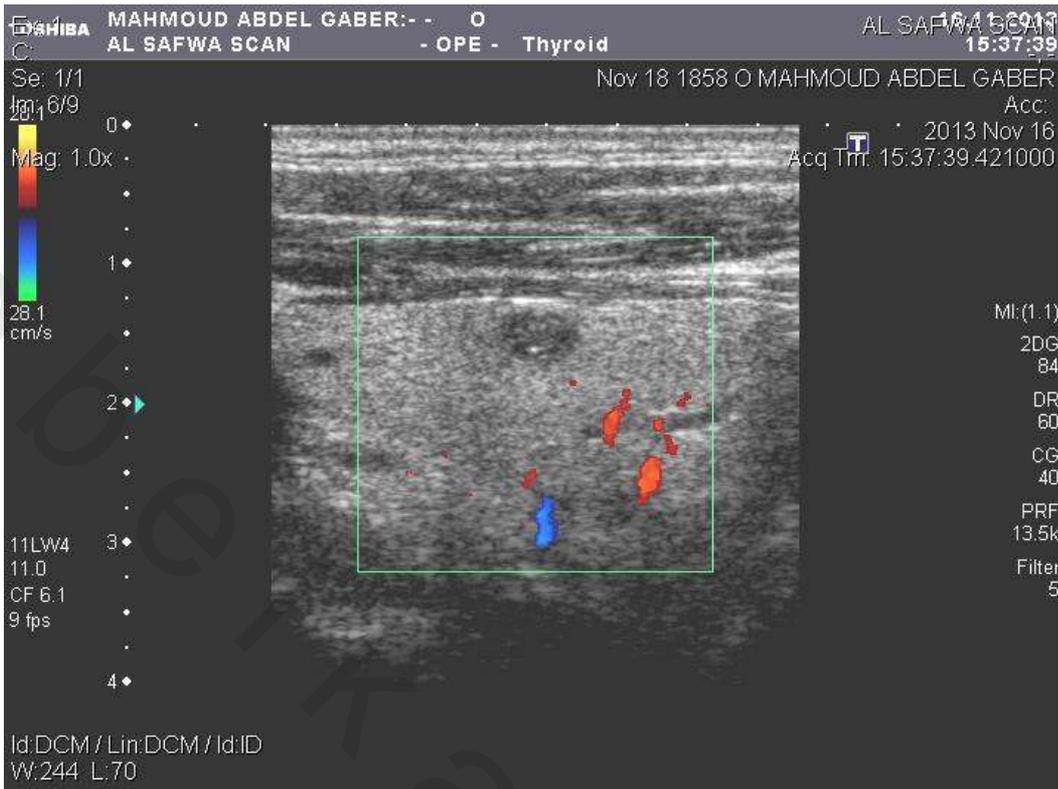
50

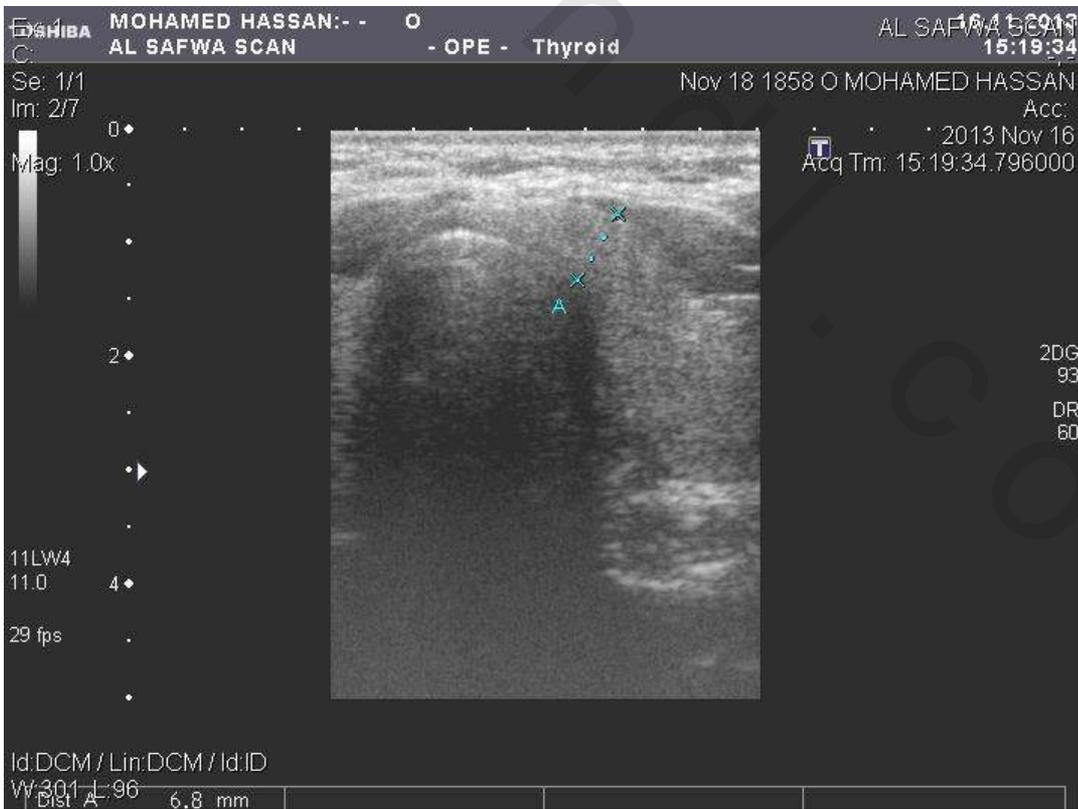**Figure (24): U/S picture of the thyroid gland showing normal Doppler.**

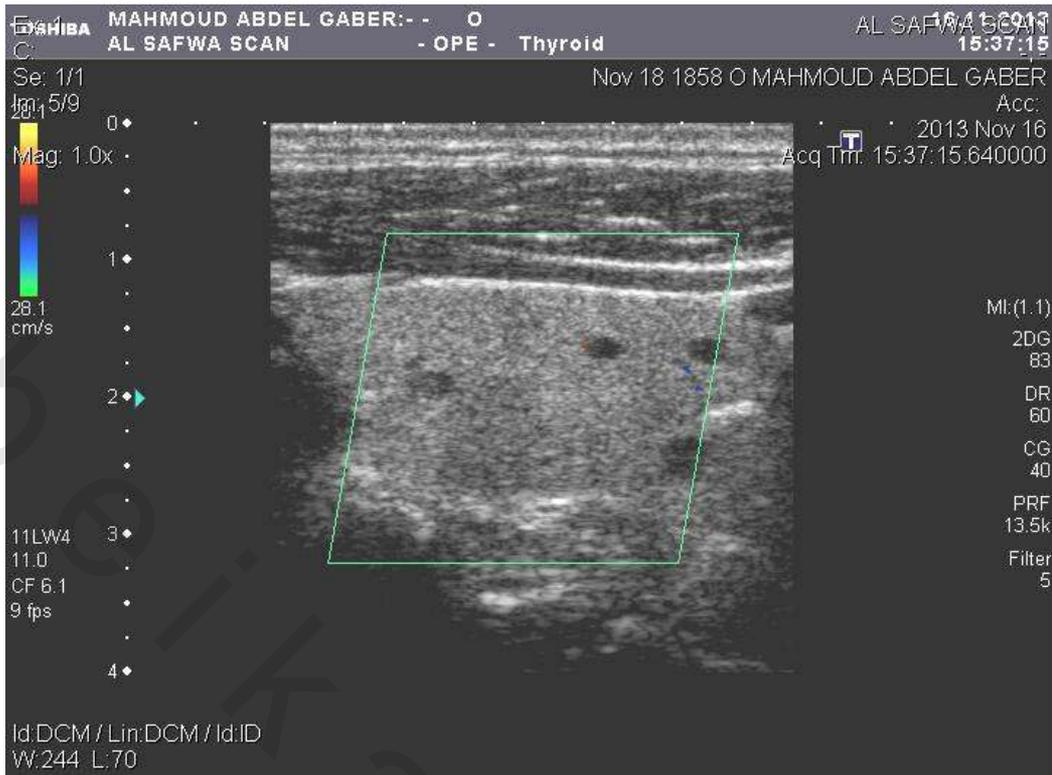**Figure (25):U/S picture of the thyroid gland showing enlarged isthmus volume.**

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Figure (26): U/S picture of the thyroid gland showing multiple nodules.
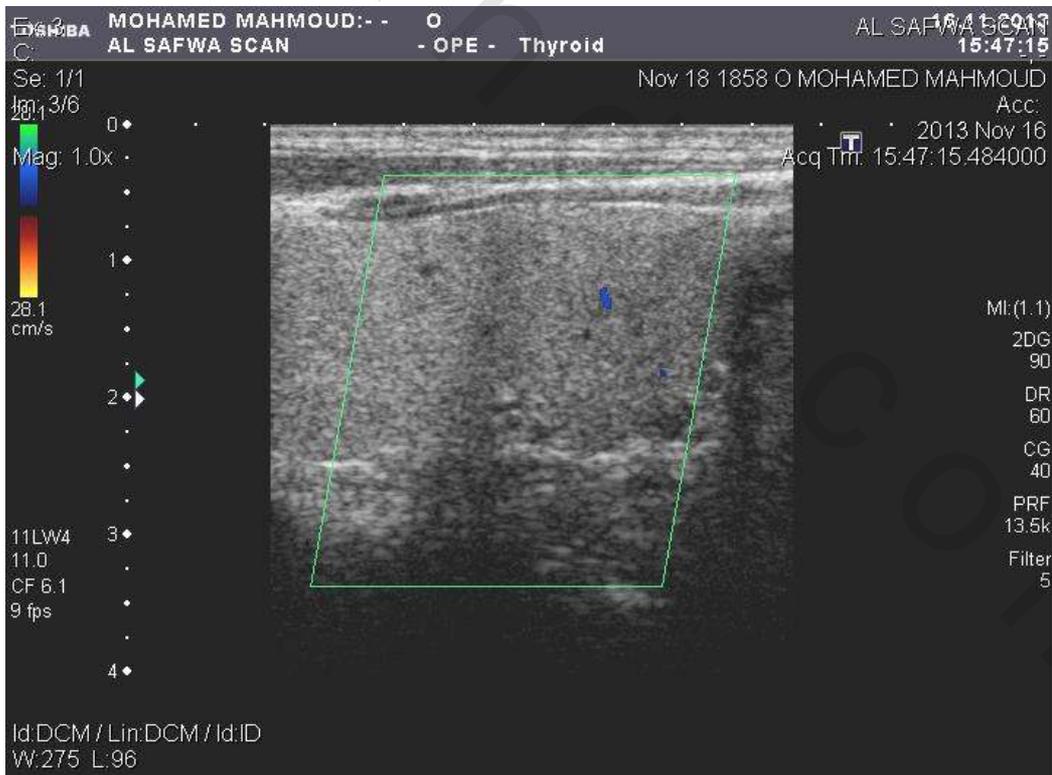
Figure (27): U/S picture of the thyroid gland showing coarse echo texture of the gland.

Figure (28): U/S picture of the thyroid gland showing coarse echo texture of the gland, with multiple micro cystic nodules dispersed allover the gland.

Correlation between BLL with FT3, FT4, TSH and ATPO

Table (XIII): Correlation between BLL with FT3, FT4, TSH, ATPO, duration of exposure, blood pressure measurement serum cholesterol and TG.

	BLL	
	r_s	p
FT3	0.115	0.253
FT4	0.123	0.222
TSH	0.383[*]	<0.001
ATPO	0.131	0.195
Duration of exposure	0.061	0.550
Systolic	0.444[*]	<0.001[*]
Diastolic	0.347[*]	<0.001[*]
Cholesterol	0.088	0.385
TG	0.086	0.394

r_s: Spearman coefficient

*: Statistically significant at $p \leq 0.05$

No significant correlation was found between blood lead level and serum FT3.
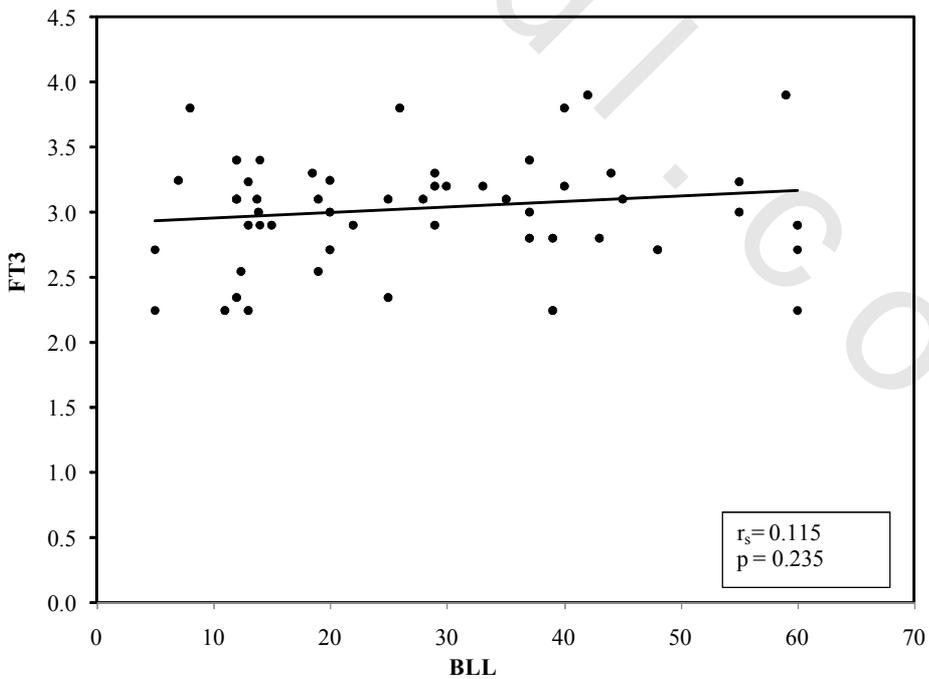
Figure (29): Correlation between BLL with serum FT3.

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No significant correlation was found between blood lead level and serum FT4.
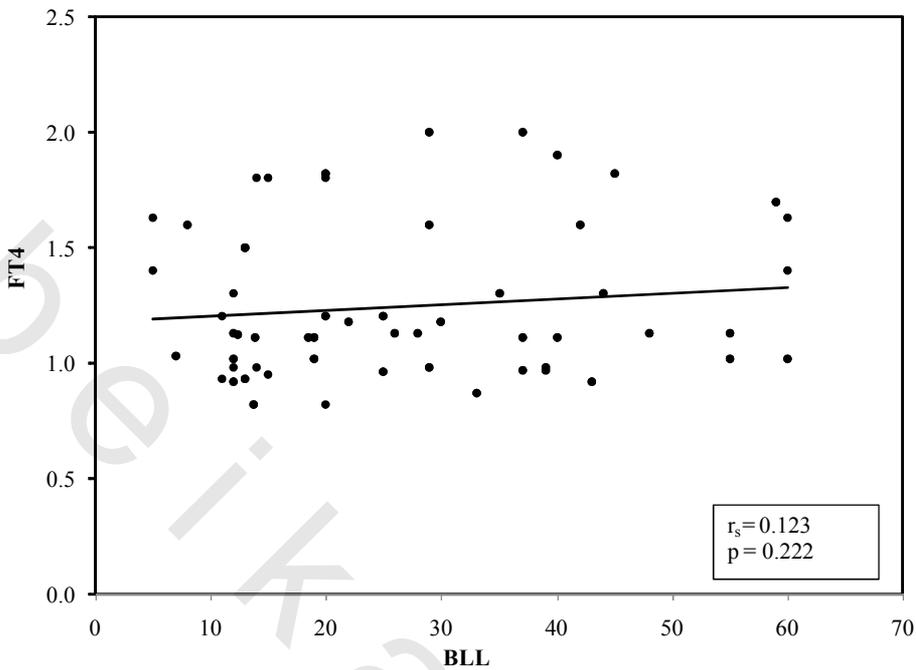
Figure (30): Correlation between BLL with serum FT4.

Significant positive correlation was found between blood lead level and serum TSH.
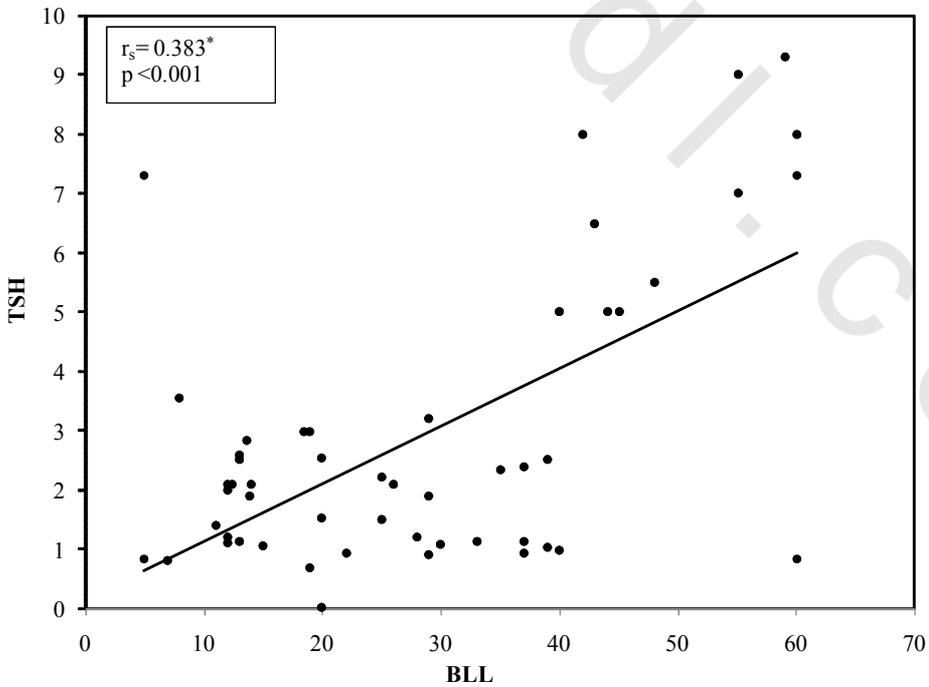
Figure (31): Correlation between BLL with serum TSH

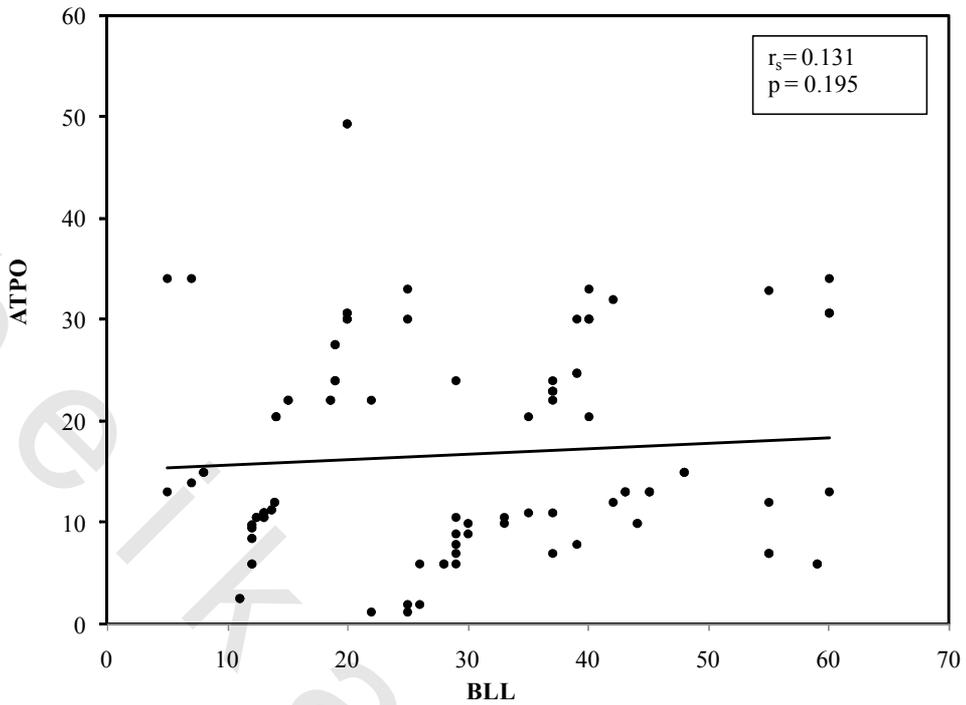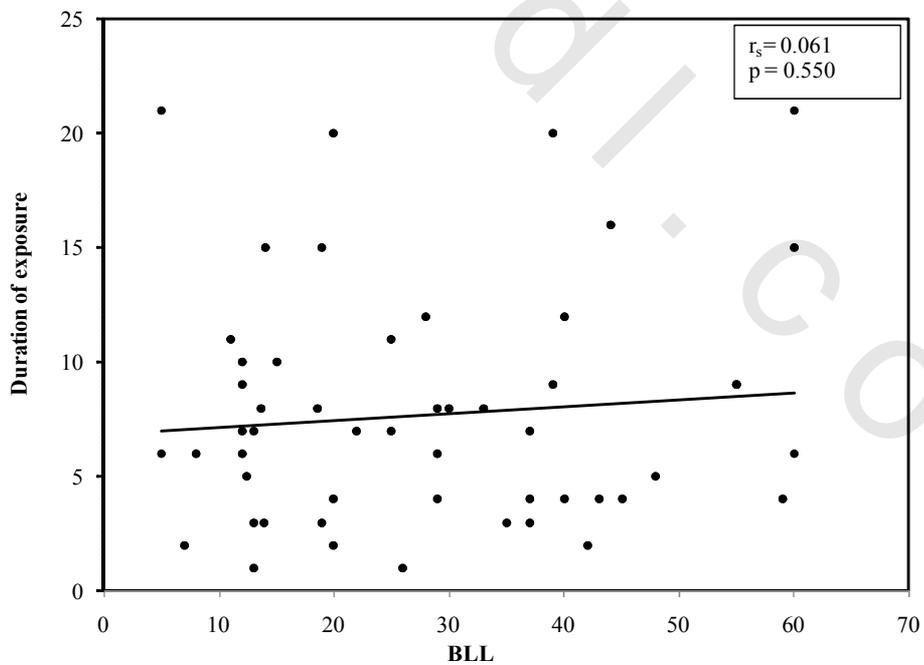No significant correlation was found between blood lead level and ATPO.

Figure (32): Correlation between BLL with ATPO

No significant correlation was found between blood lead level and duration of exposure.

Figure (33): Correlation between BLL with duration of exposure.

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Significant positive correlation was found between blood lead level and systolic Bp.
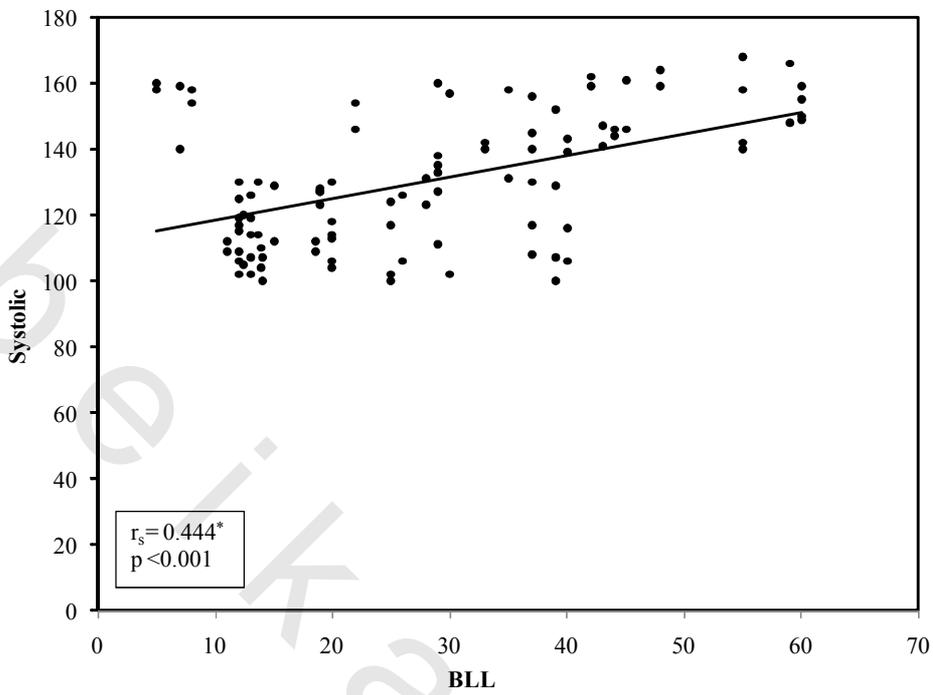

Figure (34): Correlation between BLL with systolic BP.

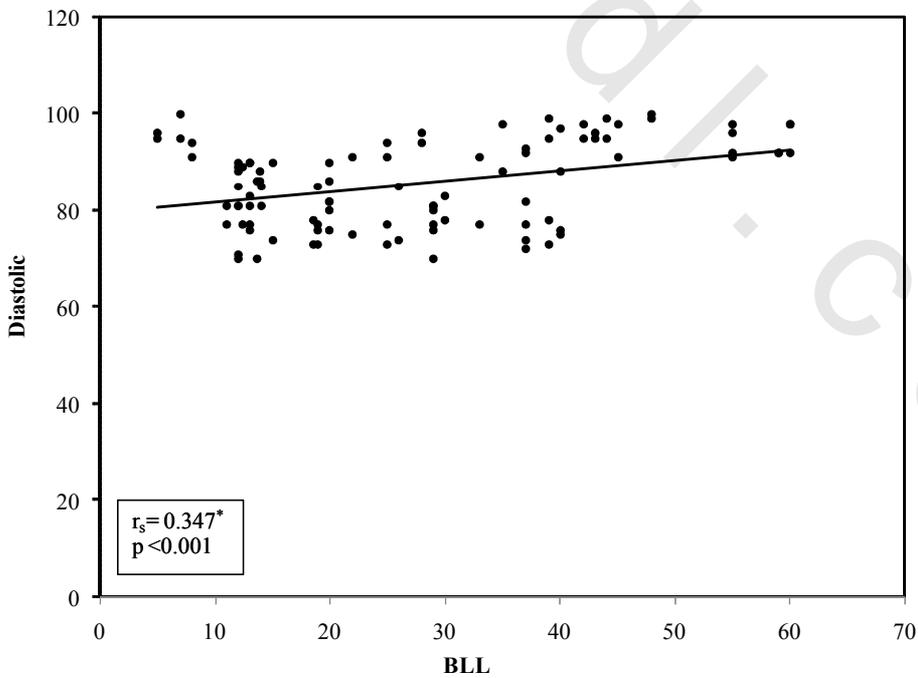Significant positive correlation was found between blood lead level and diastolic Bp.

Figure (35): Correlation between BLL with diastolic BP.

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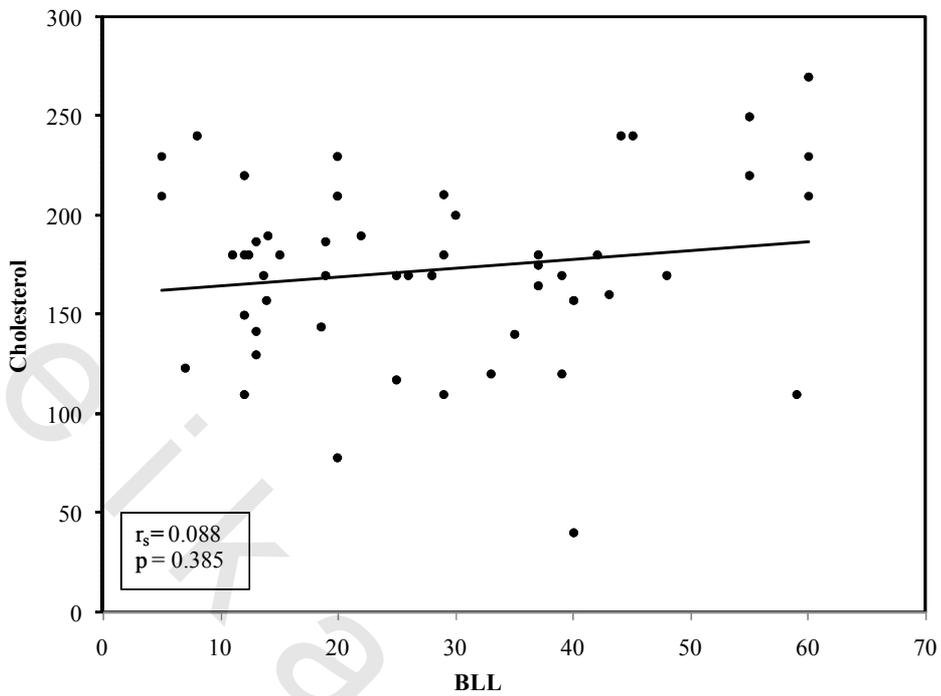No significant correlation was found between blood lead level and serum cholesterol level.

Figure (36): Correlation between BLL with Cholesterol

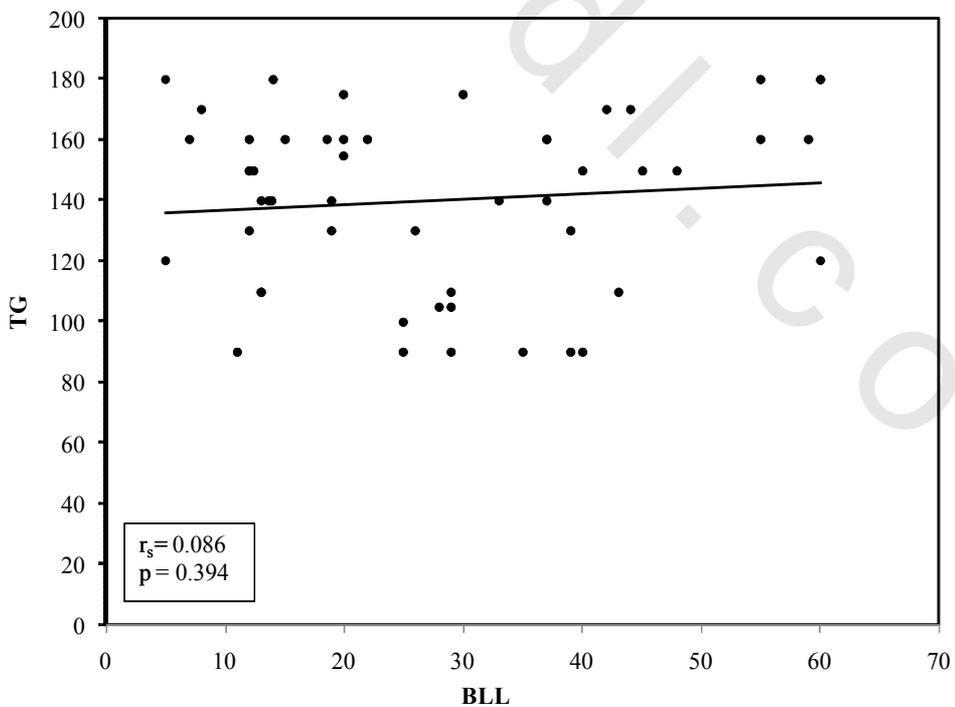No significant correlation was found between blood lead level and serum triglyceride level.

Figure (37): Correlation between BLL with TG