

Effects of Pneumoperitoneum on Renal Concentrating Ability

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Abstract

Background: Electrolytes concentration and body fluid volume were regulated mainly under the control of renal system. Defect in renal perfusion may lead to alteration in renal function which will lead to imbalance in body fluid and electrolyte. The pneumoperitoneum induced by abdominal laparoscopic procedure may caused defects in renal perfusion and this will lead to impairment of renal concentrating ability.

Objective: This work is aimed to assess the renal concentration ability among patients undergoing abdominal laparoscopic surgical operations.

Patients and Methods: This study was conducted on 70 patients who were undergoing abdominal laparoscopic surgical operations at Al-Hilla Teaching Hospital and 70 healthy subjects as volunteers, the period of study were from November 2015 to August 2016. Full history and physical examination was performed on all the study subjects. The history involved any past history of ischemic heart diseases, renal disease or those who presented with impaired renal function and diabetes mellitus in pre-operative examination were excluded from the study. The following parameters were done for all patients and controls: plasma creatinine (P_{cr}), plasma sodium (P_{Na}), plasma osmolarity (P_{osm}), urine creatinine (U_{cr}), urine sodium (U_{Na}) and urine osmolarity (U_{osm}). The values of urine and plasma of different parameters were used for calculation of the osmolar clearance (C_{osm}), fractional excretion of sodium (FE_{Na}), free water clearance (C_{H_2O}) and creatinine clearance (C_{cr}).

Results: The mean values of P_{cr} for patients enrolled in this study were significantly higher after operation than that before operations ($P < 0.001$). While there was a significant decrease in the means of U_{Na} , U_{osm} , C_{osm} , C_{cr} and P_{Na} after operation in comparison with the preoperative values (for all $P < 0.001$). On the other hand, there were no significant changes in the mean of P_{osm} and FE_{Na} after operation in comparison with the preoperative values. Also, this study revealed significant changes in C_{H_2O} ; there were 62:70 (88.6 %) of patients had negative C_{H_2O} , and 8:70 (11.4 %) who had positive C_{H_2O} in pre-operative collected samples. However, after operation 52:70 (74.3 %) of patients who had positive C_{H_2O} , and only 18:70 (25.7%) had negative C_{H_2O} , ($P < 0.05$).

Conclusions: In this study, we found that the abdominal laparoscopic operations had an effect on concentrating ability of the kidneys. The osmolar clearance and free water clearance were simple and inexpensive tests for measurement of renal concentrating ability.

Keywords: Pneumoperitoneum, Renal concentration ability, laparoscopic surgical operations.

الخلاصة

الخلفية: إن تركيز الأملاح وحجم السوائل في الجسم ينظم بشكل أساسي بواسطة الجهاز البولي و إي خلل في وصول الدم إلى الكيتين قد يؤدي إلى تغيير في وظائف الكليتين والذي بدوره سوف يؤدي إلى اختلال التوازن في

سوائل وأملاح الجسم. إن عملية استرواح الجوف البطنى الناجم عن إجراء العمليات الناضورية للبطن قد تسبب خلل في وصول الدم إلى الكيتين وهذا سيؤدي إلى ضعف قدرة الكيتين على التركيز البولي.

الهدف: يهدف هذا العمل إلى تقييم قدرة الكيتين على تركيز البول لدى المرضى الذين يخضعون لعمليات جراحية بالمنظار في البطن.

المرضى وطرق العمل: أجريت هذه الدراسة على 70 مريضاً من الذين خضعوا لعمليات جراحية بالمنظار في البطن في مستشفى الحلة التعليمي و 70 شخصاً سليماً كمتطوعين، كانت فترة الدراسة من تشرين الثاني 2015 إلى آب 2016. أخذت معلومات كاملة مع الفحص السريري لجميع الأشخاص الخاضعين للدراسة. المعلومات تشمل إي تاريخ مرضي في القلب والأوعية الدموية، إي مرض كلوي أو أولئك الذين يعانون من خلل في وظائف الكلى والسكري في فحص ما قبل الجراحة ليتم استبعادهم من الدراسة. وقد أجريت الفحوصات المختبرية التالية لجميع المرضى والأصحاء: الكرياتينين في البلازما (P_{cr})، والصوديوم في البلازما (P_{Na})، أوزمولية البلازما (P_{osm})، الكرياتينين في البول (U_{cr})، الصوديوم في البول (U_{Na})، وأوزمولية البول (U_{osm}) واستخدمت قيم البول والبلازما لحساب إزالة الأوزمولية (C_{osm})، والطرح الجزئي للصوديوم (FE_{Na})، وإزالة المياه الحرة (C_{H_2O}) وتصفية الكرياتينين (C_{cr}).

النتائج: كان متوسط قيم الكرياتينين في البلازما للمرضى في هذه الدراسة بعد إجراء العمليات الجراحية أعلى بكثير منها قبل العمليات ($P < 0.001$). في حين كان هناك انخفاض كبير في متوسط قيم الصوديوم في البول وأوزمولية البول وإزالة الأوزمولية وتصفية الكرياتينين والصوديوم في البلازما بعد العمليات الجراحية مقارنة مع القيم قبل الجراحة ($P < 0.001$). من ناحية أخرى، لم تكن هناك تغييرات كبيرة في متوسط أوزمولية البلازما والطرح الجزئي للصوديوم بعد العمليات الجراحية مقارنة مع القيم قبل الجراحة. كما كشفت هذه الدراسة تغييرات كبيرة في إزالة المياه الحرة كان هناك 70:62 (88.6%) من المرضى كانت لديهم تحليل إزالة المياه الحرة سلبية، و 70:8 (11.4%) كان إيجابياً في العينات التي تم جمعها قبل العملية، بينما بعد عملية 70:52 (74.3%) من المرضى كانت لديهم تحليل إزالة المياه الحرة إيجابياً، و 70:18 (25.7%) كان سلبياً، ($P < 0.05$).

الاستنتاجات: في هذه الدراسة، وجدنا أن عمليات المنظار البطنى كان لها تأثير على قدرة الكلى على تركيز البول وإن إزالة الأوزمولية وإزالة المياه الحرة هما اختبارين بسيطين وغير مكلفين لقياس قدرة التركيز الكلوي.

الكلمات المفتاحية: استرواح البطن، قدرة التركيز الكلوي، العمليات الجراحية بالمنظار.

Introduction

The renal system has a major role in homeostasis of many body systems, most of those systems will be affected by major surgical operations, one of these operation are laparoscopic interventions. during abdominal laparoscopic procedures, insufflation of CO_2 in peritoneal cavity (Pneumoperitoneum) will lead to increase of intra-abdominal pressure. The renal system can be affected during this procedure, Allen *et al.* (2009) and Sophie *et al.* (2011). In the past 15 years, there was increased incidence of acute kidney injury (AKI) in many surgical operations in spite of technical advances in therapeutics. In spite of using plasma creatinine level in recognizing of AKI, it does not differentiate among all causes of this condition, Coca and Parikh (2008). Use of tests rather than P_{cr} for early diagnosis of AKI may result in shortening the duration of kidney injury, decreasing the need for hemodialysis and improving survival, Lameire *et al.* (2006). Concentrating ability of kidney by definition is ability of the kidney to excrete in the urine high concentrations of solutes from the blood plasma. The test of concentrating ability of kidneys includes the

measurement of the following tests: Fractional excretion of sodium (FE_{Na}), Free water clearance (C_{H_2O}), osmolar clearance (C_{osm}) and creatinine clearance (C_{cr}). C_{H_2O} used to determine the ability of urine concentration or dilution by recognizing the solute clearance from that of free water, Won and Joseph (2004) and Robert (2008). The tubular damage in renal ischemia, caused the tubular cells to become less responsive to ADH and this lead to impairs renal concentrating ability, the C_{H_2O} determination represented the most clinical method that used to measure directly the concentrating ability of the kidneys, Aziz *et al.* (2012); and Nader and Mohsen (2016). This study aimed to assess the effect of pneumoperitoneum on renal concentrating ability.

Materials and Methods

The present study was performed on 70 patients (24 males and 46 females) who were admitted to Al-Hilla Teaching Hospital for laparoscopic abdominal surgical operations apart from renal surgery, the duration of this work lasted from November 2015 to August 2016, the results of patients were matched with 70 healthy subjects as control group. Full history and complete physical examination were performed in all the subjects. The exclusion criteria included: diabetes mellitus, ischemic heart diseases, pregnancy, any chronic illness, patients who were intake nephrotoxic drugs and previous kidney diseases. The blood samples were taken one day before and after operation and the following parameters were analyzed: plasma and urine sodium (a flame photometer was used in this test), plasma and urine osmolarity (osmometer 800c1 was used), plasma creatinine (spectrophotometer was used), urine sodium, urine osmolarity and urine creatinine (spectrophotometer was used after dilution of urine sample 10 times and the results multiplied by 10). The calculation of FE_{Na} , C_{osm} , C_{H_2O} and C_{cr} by using different parameters values of plasma and urine according to the following equations: $[FE_{Na} = (U_{Na} * P_{cr}) / (P_{Na} * U_{cr}) * 100]$, $[C_{osm} (ml / hr) = U_{osm} \times V / P_{osm}]$, $[C_{H_2O} = V - C_{osm}]$ and $[C_{cr} = [(140 - \text{age in years}) \times (\text{body weight in kg})] / P_{cr} \text{ multiply result} \times 1.22 \text{ for male patients or } 1.04 \text{ for female}]$, Carstens (1993) and Guder (1995).

Statistical analysis

The data were statistically analyzed by using of SPSS program (version 18). Chi-square test was used for the analysis of C_{H_2O} . The differences between pre- and post-operative parameters were analyzed by using a paired t-test. The comparison among all post-operative parameters were performed by using correlation test and a descriptive statistical analysis was taken to know the frequencies and percentages of abnormalities in renal function tests after operations. P value <0.05 regarded the lowest limit of significance.

Results

1. The mean difference between the study parameters before and after laparoscopic surgical operations: table (1) shows that there was a significant decrease in the means of U_{osm} , C_{cr} , C_{osm} , P_{Na} , and U_{Na} after operation in comparison with the preoperative values ($P < 0.001$). The mean values of P_{cr} were significantly higher after operation than that before operations ($P < 0.001$). On the other hand, there were no significant changes in the P_{osm} and FE_{Na} after operation in comparison with the preoperative values.

Table (1): The mean values $\pm$ SD and P-Values for plasma and urine parameters (before and after operations)

Parameters	Mean $\pm$ SD (n=140)			
	Controls (n=70)	Patients (n=70)		P Values
		Before operation	After operation	
Plasma creatinine ($\mu\text{mol/L}$)	56.4 $\pm$ 17.3	64.4 $\pm$ 19.2	89.95 $\pm$ 27.1*	0.001
Plasma osmolarity (mosm/L)	282 $\pm$ 28.3	264.3 $\pm$ 36.1	270.8 $\pm$ 36.3	0.65
Urine osmolarity (mosm/L)	365 $\pm$ 68.7	519.8 $\pm$ 170.9	287.3 $\pm$ 97.5*	0.001
Creatinine clearance (ml/min/1.73m ²)	125 $\pm$ 23.9	143.2 $\pm$ 52.6	98.2 $\pm$ 29.3*	0.001
Fractional excretion of sodium%	0.9 $\pm$ 0.1	0.85 $\pm$ 0.21	0.79 $\pm$ 0.3	0.5
Osmolar clearance (ml/hr)	119 $\pm$ 20.2	91.3 $\pm$ 33.9	56.6 $\pm$ 20.1*	0.001
Plasma sodium (mmol/L)	144 $\pm$ 11.9	146.9 $\pm$ 17.6	137.8 $\pm$ 18.5*	0.001
Urine sodium (mmol/L)	150.9 $\pm$ 28.7	118.7 $\pm$ 30.3	59.9 $\pm$ 29.2*	0.001

*significant (p < 0.001)

2. Distribution of abnormal renal functions tests in patients after operations

Table (2) illustrated the frequencies of abnormal renal function tests after operations in patients involved in this study.

Table (2): Distribution of abnormal renal function tests in patients after operations

Parameters	Frequencies of abnormal renal function tests (n=70)
Plasma creatinine ($\mu\text{mol/L}$)	8 (11.4%)
Plasma osmolarity (mosm/L) hyper-osmolar	7 (10%)
Plasma osmolarity (mosm/L) hypo-osmolar	11 (15.7%)
Urine osmolarity (mosm/L) hyper-osmolar	14 (20%)
Urine osmolarity (mosm/L) hypo-osmolar	49 (70%)
Creatinine clearance (ml/min)	12 (17.1%)
Fractional excretion of sodium %	58 (82.8%)
Osmolar clearance (ml/hr)	48 (68.6%)

2. **Free water clearance (C_{H_2O}):** Figure (1) revealed that there was a significant statistical difference in the levels of C_{H_2O} in patients before and after operations 62:70 (88.6 %) of patients had negative C_{H_2O} , and 8:70 (11.4 %) who had positive C_{H_2O} in pre-operative collected samples, while after operation 52:70 (74.3 %) of patients who had positive C_{H_2O} and only 18:70 (25.7%) had negative C_{H_2O} , ($P < 0.05$).

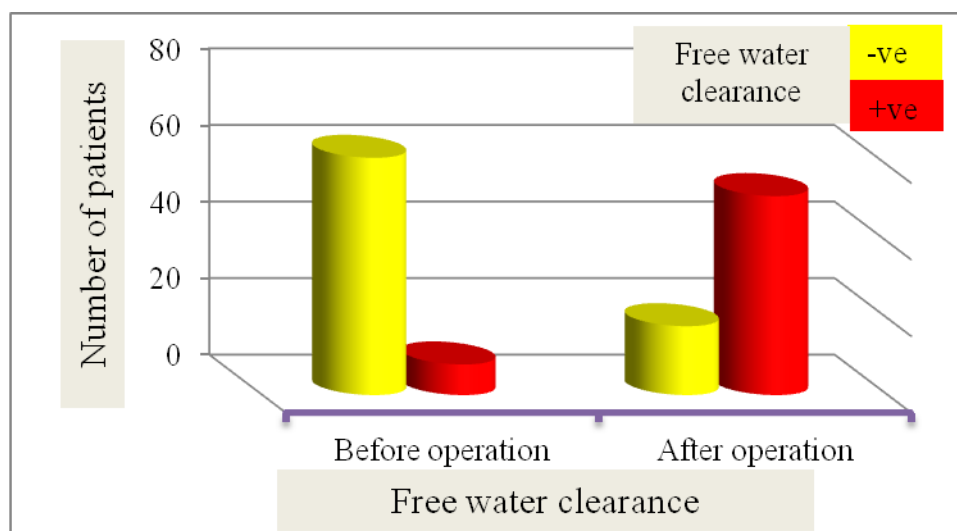


Figure (1): Free water clearance before and after operations

3. Relation between parameters of renal function tests after operations:

- 3.1. Figure (2) shows the relation between P_{cr} and FE_{Na} after operation, there was a significant positive correlation between them ($r = 0.3$, $p < 0.001$).

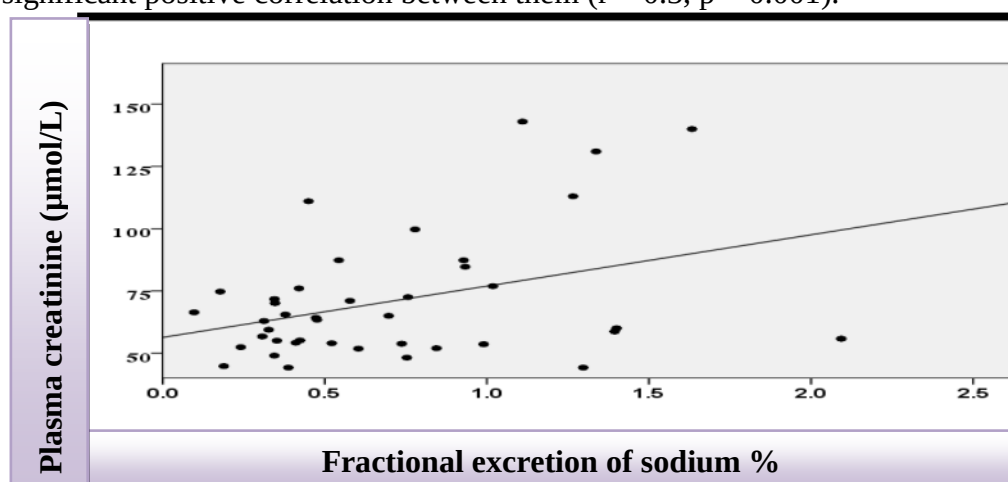


Figure (2): Relation between P_{cr} and FE_{Na} .

- 3.2. In figure (3), there was a positive correlation between P_{osm} and C_{cr} ($r = 0.2$, $p < 0.05$).

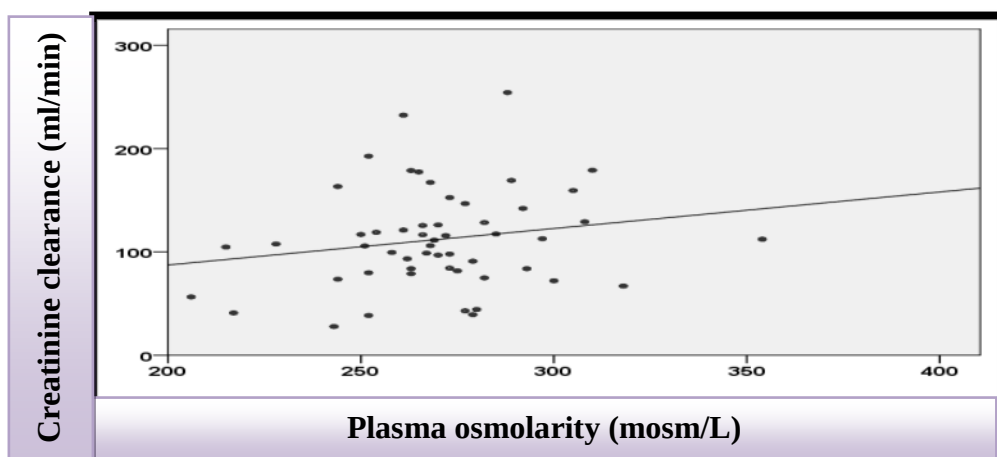


Figure (3): Relation between C_{cr} and P_{osm} .

3.3. Figure (4) revealed a significant positive correlation between C_{cr} and U_{osm} ($r = 0.3$, $p < 0.05$).

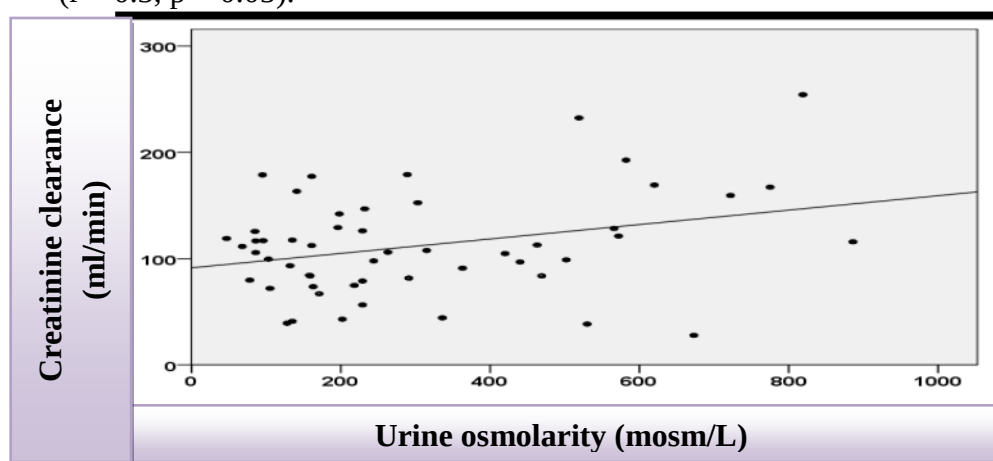


Figure (4): Relation between C_{cr} and U_{osm}

3.4. Figure (5) revealed a significant positive relation between C_{osm} and U_{osm} ($r = 0.8$, $p < 0.001$).

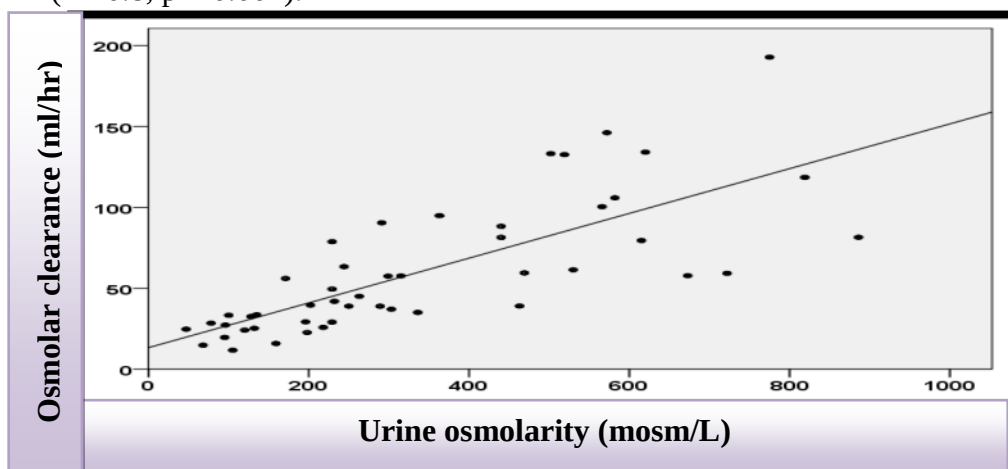


Figure (5): Relation between C_{osm} and U_{osm}

3.5. Figure (6) showed a significant positive relation between C_{osm} and C_{cr} ($r = 0.5$, $p < 0.001$).

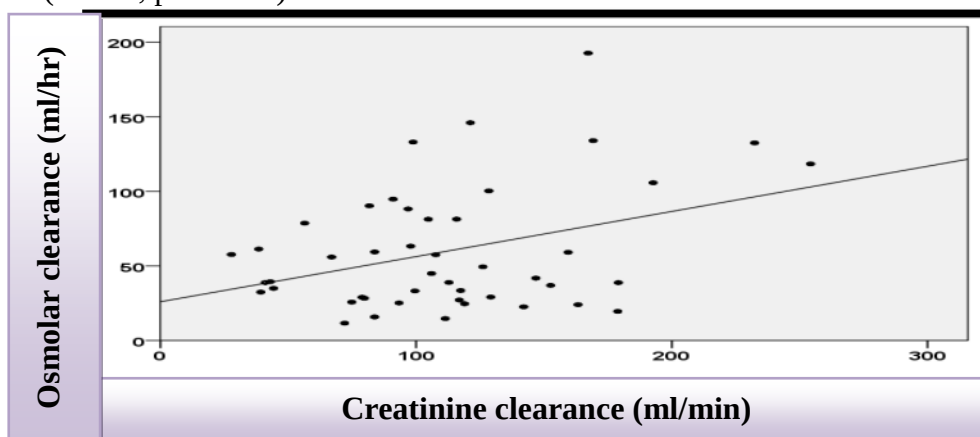


Figure (6): Relation between C_{osm} and C_{cr}

3.6. Figure (7) showed a significant positive relation between U_{Na} and C_{cr} ($r = 0.2$, $P < 0.05$).

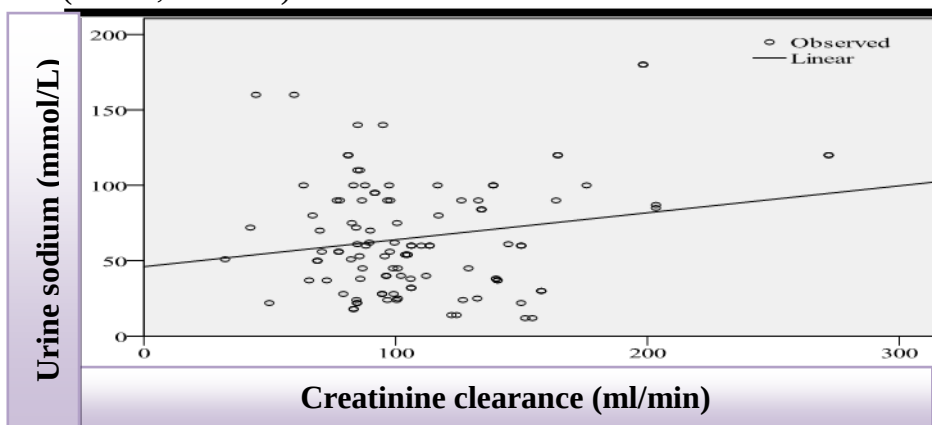


Figure (7): Relation between U_{Na} and C_{cr}

3.7. Figure (8) showed a significant positive relation between U_{Na} and FE_{Na} ($r = 0.4$, $P < 0.001$).



Figure (8): Relation between U_{Na} and FE_{Na}

3.8. Figure (9) revealed a significant positive relation between C_{osm} and U_{Na} ($r = 0.6$, $p < 0.001$).

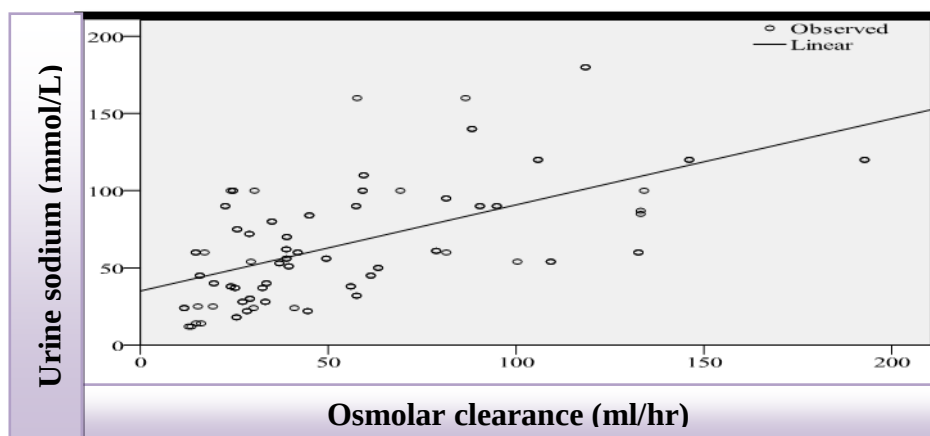


Figure (9): Correlation between C_{osm} and U_{Na}

Discussion

This study showed that the mean values of P_{cr} for patients were increased significantly after operations than that before operations, and this was consistent with the studies performed by Loef *et al.* (2005), Allen *et al.* (2009) and Nader and Mohsen (2016). The mean values of C_{cr} revealed a significant decrease after operations when compared with the pre-operative values, this study was in agreement with other studies like Hunter (2008); Kashyap *et al.* (2009) and Sebastião *et al.* (2011). In our study, we found that there was a significant statistical difference in C_{H_2O} before and after operations. The explanation of the results in this work is probably due to impairment in ability of kidney to concentrate the urine after operations and this agreed with other authors who found that the laparoscopic surgical operations altered the renal function, and one of the renal function is the kidney's ability to concentrate the urine Markus and Lukas (2001); and Thakar *et al.* (2005). There are three factors responsible for renal hemodynamic changes in pneumoperitoneum: impaired cardiac output, direct pressure effect of the pneumoperitoneum and decrease the venous return, the local compressing effect of pneumoperitoneum is the most important factor London *et al.* (2000); and Edelstein and Schrier (2007).

Conclusions and recommendations

From this study, we conclude that the pneumoperitoneum that induced in laparoscopy are associated with changes in some renal functions tests mainly the creatinine clearance and concentrating ability of the kidneys. Osmolar clearance and free water clearance are a good, easy and inexpensive investigations for identifying the concentrating ability of kidney. We recommend for another study to perform follow up for similar patients after doing laparoscopy to determine the patients who get recovery from who get permanent renal disease.

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