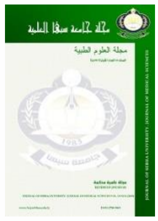
SEBHA UNIVERSITY JOURNAL OF JOURNAL OF MEDICAL SCIENCES VOL.17 NO. 1 2022
DOI: 10.51984/JOMS.V17I1.2269

مجلة جامعة سبها للعلوم الطبية
Journal of Medical Sciences

Journal homepage: www.sebhau.edu.ly/journal/index.php/joms



# Evaluation of Dialysis Efficiency for Renal Failure Patients in Libya's Southern, Ubari Region

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**Keywords:**
Blood Parameters
Dialysis Efficiency
Hemodialysis
Low Urea Rate
Renal Failure

**ABSTRACT**

Kidney disease is one of the most common causes of kidney failure in the world. Dysfunctional kidneys cannot effectively eliminate harmful toxins and maintain normal body functions. To eliminate accumulated toxins, individuals suffering from this condition undergo hemodialysis or peritoneal dialysis. This study aimed to evaluation of the effectiveness of dialysis in removing toxins, as well as the effects of hemodialysis on electrolytes and biochemical substances. Method: 24 haemodialysis patients were recruited from the Ubari region in the south of Libya. Blood samples were collected before and after dialysis and analysis of blood biochemical, haemotoligical and electrolytes parameters. In each patient, the average concentrations of these parameters and the rate of urea decline were calculated. Results: It showed in Al-Tanahma Dialysis Unit, WBC and MCHC, urea, creatinine, uric acid, and potassium concentrations were significantly different ($P<0.05$) before and after hemodialysis. Hb, RBC, Hct, MCV, MCH, PLT, CL-, and Na+ before and after hemodialysis showed no significant differences. In the Ubari Dialysis Unit, there are significant differences ($P<0.05$) before and after hemodialysis in Hb, RBC, Hct, Na+, K-, urea, creatinine, and uric acid. No significant differences in MCV, MCH, MCHC, WBC, PLT, and CL- before and after hemodialysis. Most patients (71.4%) in the Al-Tanahma Unit had urea decline rates under 65%, and 28.6% had urea decline rates over 65%. In the Ubari Unit, half of the patients (50%) had a rate under 65% and (50%) were rated higher than 65%. Conclusion, both units, as well as each patient, was found to be ineffective with hemodialysis. A comparison of similar studies with several dialysis units in this area will allow us to determine factors that contribute to the ineffectiveness of dialysis in kidney disease patients.

# تقييم كفاءة الغسيل الدموي لمرضى الفشل الكلوي في وحدتي الغسيل أوباري و التناحمة بمنطقة أوباري- الجنوب الليبي

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**الكلمات المفتاحية:**
تحليل الدم
كفاءة غسيل الكلى
غسيل الكلى
معدل انخفاض اليوريا
الفشل الكلوي

**الملخص**

**المقدمة:** مرض الكلى هو أحد أكثر أسباب الفشل الكلوي شيوعًا في العالم. حيث لا تستطيع كلى مرضى الفشل الكلوى أداء وظيفتها والتخلص من السموم الضارة بشكل فعال والحفاظ على وظائف الجسم الطبيعية. وللتخلص من السموم المتراكمة يخضع الأفراد الذين يعانون من الفشل الكلوى إلى غسيل الكلى البريتوني. **الهدف:** هدفت هذه الدراسة إلى تقييم فعالية غسيل الكلى في إزالة السموم ، وكذلك تأثير غسيل الكلى على الإلكتروليتات والمواد البيوكيميائي. **الطريقة:** أجريت الدراسة على 24 مريضا لغسيل الكلى من منطقة أوباري جنوب ليبيا، حيث تم جمع عينات الدم قبل وبعد غسيل الكلى وتحليل العوامل البيوكيميائية ومؤشرات خلايا الدم والشوارد الالكترونية في الدم. لكل مريض، وتم حساب متوسط مستوى تركيزات هذه المكونات الدموية ومعدل انخفاض اليوريا. **النتائج:** أظهرت الدراسة وجود فروق معنوية بين تراكيز اليوريا والكرياتينين وحمض

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*Article History : Received 30 October 2022 - Received in revised form 20 December 2022 - Accepted 30 December 2022*

البوليك والبوتاسيوم وكريات الدم البيضاء ومتوسط تركيز الهيموجلوبين في وحدة التناحمة للغسيل الكلوي قبل وبعد غسيل الكلى. ولم توجد فروقا معنوية في كل من الهيموجلوبين و الهيماتوكريت وكريات الدم الحمراء ومتوسط حجم الهيموجلوبين ومتوسط تركيز الهيموجلوبين والصفائح الدموية والبوتاسيوم والكلور، بينما بوحدة غسيل الكلى في أوباري وجدت فروقا معنوية قبل وبعد غسيل الكلى في خضاب الدم و وكريات الدم الحمراء و الهيماتوكريت والصوديوم واليوريا والكرياتينين وحمض البوليك. كما أظهرت الدراسة عدم وجود فروقا معنوية في ومتوسط حجم الهيموجلوبين ومتوسط تركيز الهيموجلوبين والصفائح الدموية وكريات الدم البيضاء والكلور قبل وبعد غسيل الكلى. و كان لدى معظم المرضى (71.4٪) في وحدة التناحمة معدلات انخفاض في اليوريا أقل من 65٪ ، و 28.6٪ لديهم معدلات انخفاض في اليوريا تزيد عن 65٪. وبينما في وحدة أوباري ، معدل نصف المرضى (50٪) أقل من 65٪ و (50٪) تم تصنيفهم أعلى من 65٪. **الخلاصة:** انخفاض كفاءة الغسيل الدموى لدى هؤلاء المرضى في كلا المركزين بمنطقة أوبارى جنوب ليبيا. ونقترح إجراء دراسة مقارنة مماثلة مع عدة وحدات غسيل كلى في المنطقة والتي ستسمح لنا بتحديد العوامل التي تسهم في عدم فعالية غسيل الكلى لدى مرضى الكلى.

## Introduction

Kidney failure refers to the kidneys' inability to filter and excrete waste from the body due to a deficiency in their functions. In the body, the kidney regulates water and salt levels and maintains blood pressure, which leads to metabolic waste accumulation [1]. Kidney failure is one of the most common diseases in the world, which affects people of all ages and sexes, and affects elderly males more than females [2]. The disease is a major public health problem that has a significant economic impact on the healthcare system. A number of chronic diseases cause kidney failure or insufficiency, including high blood pressure, diabetes, vasculitis, and recurring chronic bacterial and viral infections [3]. In addition, it is caused by severe or sudden dehydration of the kidneys, obstructions of the urinary tract, or immune disorders such as lupus erythematosus [4], [5]. In the advanced stages of kidney disease, swelling in the legs and difficulty breathing are caused by the accumulation of fluids in the body due to the lack of urine volume and the weak kidneys [6]. Reduced glomerular filtration rate (GFR) of less than 60 ml/min is a sign of kidney damage and reduced functioning, which is much higher in people with diabetes [7], [8]. The kidneys gradually deteriorate until dialysis is necessary when the patient reaches the final stage of renal failure. Resulting in high levels of urea, creatinine, reduce filtration and metabolic wastes [9], [10]. There is always a relation between serum urea concentration and clinical indices for estimating renal function. As a result of kidney disease, blood urea nitrogen (BUN) levels increase, with levels exceeding 100 mg/dL indicating severe kidney damage, while levels decrease with fluid excess [11]. Creatinine is often measured as a measure of kidney function, creatinine clearance valves (110-150ml/min) are used in males and females (100-130 ml/min) [12].

The process of hemodialysis involves pumping blood from the artificial kidney into the purification fluid, which removes toxins and excess salts from the body [13]. In chronic kidney disease, red blood cells exhibit abnormal morphological changes. There is an increase in blood viscosity in kidney disease patients, which may be related to changes in red blood cell shapes and reduced functional abilities [14], [15]. A study reported that 99.5% of patients with renal failure had a decreased platelet count and hemodialysis affects haemoglobin and anaemia of normochromic normocytic type [16]. Anaemic diseases are often common among patients with chronic renal disease. This causes a reduction in the amount of oxygen reaching the heart and makes it harder for it to pump enough red blood cells to the organs and tissues [17]. A recent study reported, kidney failure adversely affects blood electrolytes, resulting in negative health effects throughout the body [18]. Therefore, effective hemodialysis can improve a patient's quality of life and reduce kidney failure complications [19]. A study suggested that subcutaneous (Eprex) injections and morning dialysis can improve dialysis adequacy, but the type of device dialysis used has no significant effect [20]. There are also a number of factors that can contribute to the inefficient dialysis method, such as inappropriate filters, and short dialysis period of time [21], [22]. However, dialysis is an effective treatment method for patients with end-stage renal disease [23].

In this study, we aimed to assess hemodialysis' efficiency, its ability to eliminate metabolic toxins from the body, and the effect of the dialysis process on blood values. This study was conducted on patients with chronic kidney disease in the symmetrical dialysis Ubari Region.

## Materials and Methods

Patients with renal failure from Ubari region that undergo a regular Dialysis in both Ubari Dialysis Unit (UDU) and Al-Tanahma Dialysis Unit (ADU) were selected as subjects in this study, The group of participants ranged in age from 20 to 70 years old (average age of 45 years). After a fast of at least eight hours, Venous blood samples were collected before and after dialysis and were divided into two parts. In the first part anticoagulant EDTA was added to be used for hematological tests, complete blood count (CBC) by using Mindray- BC300 plus. While the second part of the blood sample was collected in a plain tube (without adding any anticoagulant) and left to clot and serum was separated by centrifugation for the determination of biochemical tests, like, Urea, Creatinine and electrolytes were done by photometry 4040 and Medica- Easylyte plus. For dialysis a Freseius medical care 4008s and 5008s were used in both units.

## Statistical Analysis

The obtained results were statistically analyzed using the Minitab program. The mean and standard deviation of the values of haematological and biochemical tests were calculated, as well as the statistical measures of the relationship between the values of the variables for groups. Significant differences at the level of $P < 0.05$ were used. To assess the efficiency of hemodialysis, the low urea rate for patients was calculated using the following equation.

Urea Reduction Ratio; (ratio is higher than 65% evidence of dialysis efficiency [24]).

$$URR = -\frac{pre - dialysis\ urea - post - dialysis\ urea}{pre - dialysis\ urea} \times 100$$

## Results

### The results of the hematological and biochemical values of the cases in the hemodialysis, ADU.

As shown in Tables 1 and 2, Results showed that mean values before and after hemodialysis were different. A significant difference in the mean values of white blood cells (WBC), as well as the mean value of corpuscular haemoglobin concentration (MCHC) before and after hemodialysis, was found at $P<0.05$. The mean value concentrations of urea, creatinine, uric acid and potassium before and after hemodialysis were significant ($P<0.05$). While no significant differences were recorded with the haematological parameters haemoglobin (Hb), red blood cells (RBC), hematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and platelet (PLT) and biochemical parameters, chloride (CL-) and potassium (K+) between before and after hemodialysis.

**Table (1): Comparison between the mean values of hematological tests before and after hemodialysis, Al-Tanahma Dialysis Units.**

| Parameters in ADU | Mean ± standard deviation | | P- value (P<0.05) |
|---|---|---|---|
| | Before dialysis | After dialysis | |
| Hb(gm /dl ) | 9.2 ± 1.6 | 10.0 ± 2.1 | 0.1 |
| RBC(×1012 /L ) | 3.02 ± 0.6 | 2.8 ± 1.1 | 0.5 |
| Hct (%) | 28.36 ± 6.8 | 26.65 ± 6.5 | 0.4 |
| MCV (fl) | 89.2 ± 8.1 | 88.1 ± 8.9 | 0.17 |
| MCH (pg) | 30.5 ± 2.7 | 31.2 ± 2.6 | 0.3 |
| MCHC (L/ L) | 35.07 ± 1.4 | 34.1 ± 1.6 | 0.002 |
| WBC(×109 /L ) | 6.8 ± 1.7 | 4.2 ± 1.8 | 0.000 |
| PLT(×109 /L ) | 226.5 ± 101.8 | 166.3 ± 45.3 | 0.07 |

**Table 2: Comparison between the mean values of biochemical tests before and after hemodialysis, Al-Tanahma Dialysis Units.**

| Parameters In ADU | Mean ± standard deviation | | P- value (P<0.05) |
|---|---|---|---|
| | Before dialysis | After dialysis | |
| Urea (mg/dL) | 194.9± 61.8 | 92.4± 46.8 | 0.1 |
| Creatinine (mg/dL) | 11.57 ±4.4 | 5.4 ± 2.6 | 0.5 |
| Uric Acid (mg/dL) | 7.1± 1.3 | 2.7± 0.8 | 0.4 |
| Na+ (mmol/L) | 134.7 ± 5.08 | 135.6 ± 3.2 | 0.17 |
| CL- (mmol/L) | 93.2± 9.2 | 94.9± 3.8 | 0.3 |
| K+ (mmol/L) | 4.8± 0.8 | 3.8± 0.4 | 0.002 |

**The results of the hematological values of the cases in the hemodialysis, UDU**

The results of the mean of haematological and biochemical values obtained before and after hemodialysis were as in Tables (3 and 4)). Significant differences were found when at ($P<0.05$) between the mean values of each Hb, RBC and Hct parameters of $P < 0.05$ and mean value concentrations of urea, creatinine, uric acid, Na+and K- were also a significant different $P < 0.05$ between before and after hemodialysis. While no significant differences were found with the haematological MCV, MCH, MCHC, WBC and PLT and biochemical parameters CL- between before and after hemodialysis.

**Table (3): Comparison between the mean values of hematological tests before and after hemodialysis, Ubari Dialysis Unit.**

| Parameters In UDU | Mean ± standard deviation | | P- value (P<0.05) |
|---|---|---|---|
| | Before dialysis | After dialysis | |
| Hb(gm /dl ) | 8.55±1.33 | 1.44 10.12± | 0.001 |
| RBC(×1012 /L ) | 2.9 ± 0.48 | 3.5 ± 0.44 | 0.000 |
| Hct (%) | 25.37 ± 3.88 | 30.39 ± 4 | 0.000 |
| MCV (fl) | 85.76 ± 4 | 86.75 ± 4.41 | 0.31 |
| MCH (pg) | 28.9 ± 1.47 | 28 ± 2.27 | 0.3 |
| MCHC (L/ L) | 33.68 ± 1.03 | 32.33 ± 3.28 | 0.225 |
| WBC (×109 /L ) | 5.49 ± 1.80 | 5.81 ± 1.85 | 0.6 |
| PLT (×109 /L ) | 177.1 ± 66.7 | 187.1 ± 67 | 0.69 |

**Table (4): Comparison between the mean values of biochemical tests before and after hemodialysis, Ubari Dialysis Unit.**

| Parameters In UDU | Mean ± standard deviation | | P- value (P<0.05) |
|---|---|---|---|
| | Before dialysis | After dialysis | |
| Urea (mg/dL) | 163.2 ± 13.51 | 54 ± 16.9 | 0.000 |
| Creatinine (mg/dL) | 9.33 ± 1.90 | 5.8 ± 2.29 | 0.001 |
| Uric Acid (mg/dL) | 7.8 ± 1.55 | 3.43 ± 1.23 | 0.000 |
| Na+ (mmol/L) | 134 ± 3.73 | 132 ± 3.86 | 0.000 |
| CL- (mmol/L) | 93.2 ± 3.2 | 94.9 ± 3.8 | 0.47 |
| K+ (mmol/L) | 4.8 ± 0.8 | 3.8 ±0.4 | 0.001 |

**Measuring the efficiency of hemodialysis.**

According to the results obtained in this study, the urea reduction rate (URR) was calculated for each patient. There were 10 patients (71.4%) with a rate less than 65% in ADU, and 4 patients (28.6%) with a rate higher than 65%. The difference between the two groups was significant ($P<0.001$). UDU results showed that 5 patients (50%) were rated less than 65% and 5 patients (50%) were rated higher than 65%. There was a significant difference between the two groups ($P<0.003$).

**Discussion**

Several patients with hemodialysis renal failure from ADU and UDU in southern Libya participated in this study. A haematological and biochemical analysis was performed on all samples twice: before and after dialysis. A decrease in haematological indices was observed after dialysis tratment in this study. Results in this study agreed with previous studies showing changes in blood values are associated with kidney disease [25]. Significant differences were found in the value of WBC and MCHC cells, but not in all other parameters before and after dialysis in the ADU. While no significant differences were found in the value of WBC and MCHC cells, but only significant differences in Hb, RBC and Hct parameters in the UDU. These differences may be caused by the difference in the number of samples of patients in the two dialysis units and the severity of their anaemia. Based on the current results, the low haemoglobin values indicate that the kidneys are producing less erythropoietin, which is necessary to produce red blood cells [26], [27]. In adults and post-menopausal women, haemoglobin concentrations below 13.0 g/dL indicate anaemia, and in pre-menopausal women, concentrations below 12.0 g/dL indicate anaemia [28]. Renal anemia exists when the hemoglobin level in pre-dialysis and dialysis patients is less than 11 g/dl [29]. Kidney failure is associated with anaemia, which is expected at all stages but becomes more severe as the disease progresses [30].

In this study, platelet counts in both dialysis units did not differ significantly before and after washing. In a previous study, several chronic kidney failure patients had a marked reduction in platelet count during dialysis of 50% or more [31]. In the process of washing, platelets may adhere to the washing membrane, aggregate, and become activated, which results in a decrease in their number [16]. Results from the ADU showed significant differences in urea, creatinine and uric acid levels before and after washing. By measuring these nitrogen compounds in their formation, renal function is examined, and ammonia and other metabolic compounds are removed from the body [32]. Blood toxicity can occur when these compounds accumulate in the blood at high concentrations [33]. In this study, a rise in potassium and urea with low sodium is a sign of kidney loss while serum creatinine depends on several factors, including muscle mass [34]. Results have shown that no significant differences were found in sodium or chloride concentration, but a significant difference was found in potassium concentration. While, a significant difference was observed in the results of UDU, urea, and creatinine nitrogen compounds in the body, as well as uric acid, sodium, and potassium levels, but not chlorine. Similarly, the study suggested that low potassium after dialysis reduces hyperkalaemia risk in patients at the end stages [35]. Based on these results, urea clearance can be used to estimate the efficiency of dialysis and the success of dialysis [36]. Most patients(71.4%) in the ADU had urea decline rates under 65%, and 28.6% had urea decline rates over 65%, with significant differences ($P< 0.001$) between the two groups. In the UDU, half of the patients (50%) had a rate under 65% and (50%) were rated higher than 65% with a significant difference ($P< 0.003$) between the two groups. These results illustrate the inefficiency of haemodialysis in both dialysis units in the Ubari region**.**

**Conclusion**

In the Ubari region, a study concluded that both dialysis units are inefficient. According to this study results, performing more similar studies and comparing them with several dialysis units in this area will allow us to determine factors that contribute to inadequacy of dialysis in chronic kidney disease patients.

**Abbreviations and Acronyms**

GFR: Glomerular filtration rate, BUN: Blood urea nitrogen, ADU: Al-Tanahma Dialysis Units, UDU: Ubari Dialysis Unit, EDTA: Ethylenediaminetetraacetic acid, WBC: White blood cells, MCHC: Corpuscular haemoglobin concentration, Hb: Haematological parameters haemoglobin, RBC: Red blood cells, Hct: Hematocrit, MCV: Mean corpuscular volume, MCH: Mean corpuscular haemoglobin, PLT: Platelet, CL-: Chloride, K+: Potassium and URR: Urea reduction rate.

**Acknowledgment**

The authors thank staffs at both Ubari Dialysis Unit (UDU) and Al-Tanahma Dialysis Units (ADU) for help in this study and all Patients with renal failure from Ubari region.

**References**

[1]- Yang, T., Richards, E. M., Pepine, C. J., & Raizada, M. K. (2018). The gut microbiota and the brain–gut–kidney axis in hypertension and chronic kidney disease. *Nature Reviews Nephrology*, *14*(7), 442-456.

[2]- Eriksen, B. O., & Ingebretsen, O. C. (2006). The progression of chronic kidney disease: a 10-year population-based study of the effects of gender and age. *Kidney international*, *69*(2), 375-382.

[3]- Romagnani, P., Remuzzi, G., Glassock, R., Levin, A., Jager, K. J., Tonelli, M., ... & Anders, H. J. (2017). Chronic kidney disease. *Nature reviews Disease primers*, *3*(1), 1-24.

[4]- Amend Jr, W. J., & Vincenti, F. G. (2008). Prerenal renal failure. *General Urology*, 531.

[5]- Centers for Disease Control and Prevention. (2019). Chronic kidney disease in the United States, 2019. *Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention*, *3*.

[6]- Sanyaolu, A., Okorie, C., Annan, R., Turkey, H., Akhtar, N., Gray, F., & Nwaduwa, I. (2018). Epidemiology and management of chronic renal failure: a global public health problem. *Biostatistics Epidemiol Int J*, *1*(1), 11-16.

[7]- Pun, P. H., Smarz, T. R., Honeycutt, E. F., Shaw, L. K., Al-Khatib, S. M., & Middleton, J. P. (2009). Chronic kidney disease is associated with increased risk of sudden cardiac death among patients with coronary artery disease. *Kidney international*, *76*(6), 652-658.

[8]- Razavian, M., Heeley, E. L., Perkovic, V., Zoungas, S., Weekes, A., Patel, A. A., ... & Cass, A. (2012). Cardiovascular risk management in chronic kidney disease in general practice (the AusHEART study). *Nephrology Dialysis Transplantation*, *27*(4), 1396-1402.

[9]- Jaar, B. G., Coresh, J., Plantinga, L. C., Fink, N. E., Klag, M. J., Levey, A. S., ... & Powe, N. R. (2005). Comparing the risk for death with peritoneal dialysis and hemodialysis in a national cohort of patients with chronic kidney disease. *Annals of internal medicine*, *143*(3), 174-183.

[10]- Miller, W. G., & Inker, L. A. (2020). Laboratory evaluation of kidney function. *Contemporary Practice in Clinical Chemistry*, 611-628.

[11]- Pagana , Kathleen D. Mosby's Manual of Diagnostic and Laboratory Tests. St. Louis Mosby, Inc., 1998 and Rebecca J.F Gale Encyclopedia of Medicine. 2002

[12]- Corbett JV. 7th Ed. 2008. Laboratory tests and diagnostic procedures with nursing diagnoses; pp. 90–107.

[13]- Reddy, N. P. (2009). Design of artificial kidneys. *ABOUT THE EDITOR*, 143.

[14]- Brodsky, S. V., Satoskar, A., Chen, J., Nadasdy, G., Eagen, J. W., Hamirani, M., ... & Nadasdy, T. (2009). Acute kidney injury during warfarin therapy associated with obstructive tubular red blood cell casts: a report of 9 cases. *American Journal of Kidney Diseases*, *54*(6), 1121-1126.

[15]- Reggiori, G., Occhipinti, G., De Gasperi, A., Vincent, J. L., & Piagnerelli, M. (2009). Early alterations of red blood cell rheology in critically ill patients. *Critical care medicine*, *37*(12), 3041-3046.

[16]- Hakim, Y. A., Abbas, A. A., Khalil, A., & Mustafa, T. H. I. A. (2016). The effect of hemodialysis on hemoglobin concentration, platelets count and white blood cells count in end stage renal failure. *International Journal of Medical Research & Health Sciences*, *5*(5), 22-35.

[17]- González-Alonso, J., & Calbet, J. A. (2003). Reductions in systemic and skeletal muscle blood flow and oxygen delivery limit maximal aerobic capacity in humans. *Circulation*, *107*(6), 824-830.

[18]- Dhondup, T., & Qian, Q. (2017). Electrolyte and acid-base disorders in chronic kidney disease and end-stage kidney failure. *Blood purification*, *43*(1-3), 179-188.

[19]- Barzegar, H., Moosazadeh, M., Jafari, H., & Esmaeili, R. (2016). Evaluation of dialysis adequacy in hemodialysis patients: A systematic review. *Urology journal*, *13*(4), 2744-2749.

[20]- Shahdadi, H., Balouchi, A., Sepehri, Z., Rafiemanesh, H., Magbri, A., Keikhaie, F., ... & Sarjou, A. A. (2016). Factors affecting hemodialysis adequacy in cohort of Iranian patient with end stage renal disease. *Global journal of health science*, *8*(8), 50.

[21]- Kjellstrand, C. M., Buoncristiani, U., Ting, G., Traeger, J., Piccoli, G. B., Sibai-Galland, R., ... & Blagg, C. R. (2008). Short daily haemodialysis: survival in 415 patients treated for 1006 patient-years. *Nephrology Dialysis Transplantation*, *23*(10), 3283-3289.

[22]- Tonelli, M., Muntner, P., Lloyd, A., Manns, B. J., James, M. T., Klarenbach, S., ... & Alberta Kidney Disease Network. (2011). Using proteinuria and estimated glomerular filtration rate to classify risk in patients with chronic kidney disease: a cohort study. *Annals of internal medicine*, *154*(1), 12-21.

[23]- Mowatt, G., Vale, L., & MacLeod, A. (2004). Systematic review of the effectiveness of home versus hospital or satellite unit hemodialysis for people with end-stage renal failure. *International journal of technology assessment in health care*, *20*(3), 258-268.

[24]- Davenport, A., Perisanidou, L. I., & Steenkamp, R. (2017). UK Renal Registry 19th Annual Report: Chapter 6 Adequacy of Haemodialysis in UK Adult Patients in 2015: National and Centre-specific Analyses. *Nephron*, *137*(Suppl. 1), 151-164.

[25]- Seki, M., Nakayama, M., Sakoh, T., Yoshitomi, R., Fukui, A., Katafuchi, E., ... & Kitazono, T. (2019). Blood urea nitrogen is independently associated with renal outcomes in Japanese patients with stage 3–5 chronic kidney disease: a prospective observational study. *BMC nephrology*, *20*(1), 1-10.

[26]- Hayat, A., Haria, D., & Salifu, M. O. (2008). Erythropoietin stimulating agents in the management of anemia of chronic kidney disease. *Patient preference and adherence*, *2*, 195.

[27]- Naeem, M., Ashraf, A., Safdar, H. M. Z., Khan, M. Q., Rehman, S. U., Iqbal, R., & Ahmad, G. (2020). Biochemical changes in patients with chronic kidney failure in relation to complete blood count and anemia. *IJB*, *16*(1), 267-271.

[28]- Stevens, P. (2005). Optimizing renal anaemia management—benefits of early referral and treatment. *Nephrology Dialysis Transplantation*, *20*(suppl_8), viii22-viii26.

[29]- Mimura, I., Tanaka, T., & Nangaku, M. (2015). How the target hemoglobin of renal anemia should be?. *Nephron*, *131*(3), 202-209.

[30]- McClellan W, Aronoff SL, Bolton WK, et al. 2004. The prevalence of anemia in patients with chronic kidney disease. *Curr Med Res Opin*, 20:1501–10.

[31]- Daugirdas, J. T., & Bernardo, A. A. (2012). Hemodialysis effect on platelet count and function and hemodialysis-associated thrombocytopenia. *Kidney international*, *82*(2), 147-157.

[32]- Hibbard, T., & Killard, A. J. (2011). Breath ammonia analysis: Clinical application and measurement. *Critical Reviews in Analytical Chemistry*, *41*(1), 21-35.

[33]- Weiner, I. D., Mitch, W. E., & Sands, J. M. (2015). Urea and ammonia metabolism and the control of renal nitrogen

excretion. *Clinical Journal of the American Society of Nephrology*, *10*(8), 1444-1458.

[34]- Gowda, S., Desai, P. B., Kulkarni, S. S., Hull, V. V., Math, A. A., & Vernekar, S. N. (2010). Markers of renal function tests. *North American journal of medical sciences*, *2*(4), 170.

[35]- Bushinsky, D. A., Williams, G. H., Pitt, B., Weir, M. R., Freeman, M. W., Garza, D., ... & Bakris, G. L. (2015). Patiromer induces rapid and sustained potassium lowering in patients with chronic kidney disease and hyperkalemia. *Kidney international*, *88*(6), 1427-1433.

[36]- Torreggiani, M., Fois, A., Njandjo, L., Longhitano, E., Chatrenet, A., Esposito, C., ... & Piccoli, G. B. (2021). Toward an individualized determination of dialysis adequacy: A narrative review with special emphasis on incremental hemodialysis. *Expert Review of Molecular Diagnostics*, *21*(11), 1119-1137.