13. Tzenios N, Chahine M, Tazanios M. Obesity and endometrial cancer: the role insulin resistance and adipokines. Special Journal of the Medical Academy and other Life Sciences. 2023 Feb 9;1(2). doi: 10.58676/sjmas.v1i2.12.
14. Wise MR, Jordan V, Lagas A, Showell M, Wong N, Lensen S, et al. Obesity and endometrial hyperplasia and cancer in premenopausal women: A systematic review. American journal of obstetrics and gynecology. 2016 Jun 1;214(6):689-e1. doi: 10.1016/j.ajog.2016.01.175.
15. Yen CF, Kim MR, Lee CL. Epidemiologic factors associated with endometriosis in East Asia. Gynecology and minimally invasive therapy. 2019 Jan 1;8(1):4-11. doi: 10.4103/GMIT.GMIT_83_18.

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STUDY OF VASCULAR ACCESS IN HAEMODIALYSIS PATIENTS USING ULTRASONOGRAPHY

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The purpose of this study was to evaluate the efficacy of arteriovenous fistula using ultrasound technique in patients undergoing haemodialysis, taking into account their anamnesis analysis and their psychological state assessment. The study involved 76 patients with chronic kidney disease aged 25 to 70 years. During the ultrasound assessment of arteriovenous fistula in patients, the diameter, lumen, compressibility of the vein and its location relative to the skin were analyzed, as well as the feeding artery was examined. Bloodflow assessment in vascular access was performed using colour Doppler mapping and pulse dopplerometry. In patients without complications in vascular access, the average diameter of the feeding artery was 4.3±1.4 mm. The diameter of the anastomosis ranged from 1.4 mm to 10 mm. The volumetric bloodflow rate in the vascular access was from 500 ml/min to 1600 ml/min which corresponds to the standard values for a functioning arteriovenous fistula. Anatomical and individual tissue characteristics of each patient and concomitant diseases reduce the efficacy of fistula and increase the risk of complications. Ultrasonography allows for the timely detection of anatomical and functional changes affecting the effectiveness of hemodialysis, which makes this method a valuable tool for diagnostics and monitoring. Authors conclude that ultrasound Doppler study is the main method for vascular access monitoring in the complex management of patients receiving renal replacement therapy. Evaluation of the psychological state of patients on hemodialysis showed a decrease in interest in life, a feeling of dissatisfaction, despair, hopelessness and fear for the future, which worsened during the outbreak of military actions in Ukraine.

Key words: chronic kidney disease, hemodialysis, arteriovenous fistula, ultrasonography, efficacy, quality of life.

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ДОСЛІДЖЕННЯ СУДИННОГО ДОСТУПУ У ПАЦІЄНТІВ НА ГЕМОДІАЛІЗІ ІЗ ЗАСТОСУВАННЯМ УЛЬТРАСОНОГРАФІЇ

Метою дослідження було визначення ефективності артеріовенозної фістули за допомогою ультразвукового методу у пацієнтів, які перебувають на гемодіалізі, враховуючи аналіз анамнезу та оцінку їхнього психологічного стану. У дослідженні взяли участь 76 пацієнтів із хронічною хворобою нирок віком від 25 до 70 років. При ультразвуковій оцінці артеріовенозної фістули у пацієнтів проводився аналіз діаметра, просвіту, компресивності вени та її розташування щодо шкіри, а також дослідження артерії живлення. Оцінка кровотоку в судинному доступі здійснювалася з використанням кольорового доплерівського картування та імпульсної доплерометрії. У пацієнтів без ускладнень у судинному доступі середній діаметр живильної артерії становив 4.3±1.4 мм. Діаметр анастомозу складав від 1.4 мм до 10 мм. Об'ємна швидкість кровотоку в судинному доступі дорівнювала від 500 мл/хв до 1600 мл/хв, що відповідає нормативним показникам для артеріовенозної фістули що функціонує. Анатомічні та індивідуальні особливості тканин кожного пацієнта, супутні захворювання знижують ефективність фістули та збільшують ризик ускладнень. Ультрасонографія дозволяє своєчасно виявляти анатомічні та функціональні зміни, що впливають на ефективність гемодіалізу, що робить цей метод цінним інструментом діагностики та моніторингу. Автори висловлюють, що ультразвукове доплерівське дослідження є основним методом моніторингу судинного доступу в комплексному лікуванні пацієнтів, які отримують замісну ниркову терапію. Оцінка психологічного стану пацієнтів, які перебувають на гемодіалізі, показала зниження інтересу до життя, почуття незадоволеності, відчаю, безвихідь та страху за майбутнє, що посилилося в період початку військових дій в Україні.

Ключові слова: хронічна хвороба нирок, гемодіаліз, артеріовенозна фістула, ультрасонографія, ефективність, якість життя.

The study is a fragment of the research project "The latest treatment, diagnostic and preventive approaches for diseases of the female reproductive system and high-risk pregnancy", state registration No. 0122U201370.

Kidney diseases are among the most common diseases worldwide and the number of patients suffering from chronic kidney disease increases annually. Chronic renal failure affects more than 10 % of the world's population. This pathology is one of the leading causes of death worldwide in the 21st century [7, 8]. According to WHO estimates, kidney diseases are the tenth leading cause of death. The mortality rate from these diseases increased from 813 thousand cases in 2000 to 1.3 million in 2019 [7].

Patients with chronic renal failure require constant, systematic monitoring and treatment in a hospital setting. For most patients, artificial blood filtration is the only treatment option and a way to prolong life. In Ukraine, as of 2023, there are 6.017 patients with chronic renal failure on haemodialysis according to the National Registry of Patients with Chronic Kidney Disease and patients with acute kidney injury treated with haemodialysis [13].

According to the recommendations of the National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (KDOQI) Clinical Practice Guideline for Vascular Access [10], haemodialysis requires the creation of permanent access to the patient's vascular bed. The current option of choice is the use of a native arteriovenous fistula (AVF), a synthetic prosthesis, and a central venous catheter. According to a number of authors, AVF is currently the preferred method of vascular access for haemodialysis in long-term therapy. This vascular access has a longer duration of operation and the least number of complications in patients [3, 14]. Effectively functioning vascular access is a key element in providing high-quality medical care to patients undergoing haemodialysis [6].

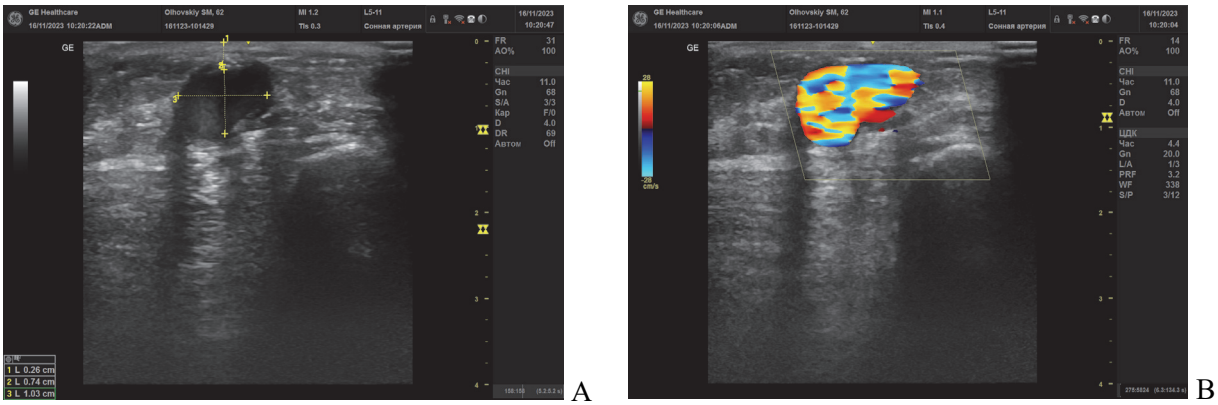
The purpose of the study was to evaluate the efficacy of arteriovenous fistula using ultrasound technique in patients undergoing haemodialysis, taking into account their anamnesis analysis and their psychological state assessment.

Materials and methods. The study was conducted on the basis of the municipal non-profit enterprise "Odesa Regional Centre of Nephrology and Dialysis" during 2021-2024. 76 patients with chronic kidney disease undergoing haemodialysis with a "mature" fistula were under observation. The age of the patients varied from 25 to 70 years and was equal to 46.4±6.2 years. 42 patients (55.3 %) were female and 34 patients (44.7 %) were male among the examined patients. All the patients received haemodialysis three times a week. All patients gave written informed consent before the beginning of clinical observation which allowed to use results of their treatment for scientific purposes.

A vascular access and a variant of anastomosis from the side of the vein to the side of the artery were formed on the forearm in all patients. Ultrasound evaluation of AVF functioning was performed before the dialysis procedure.

Patients were examined in a sitting position facing the operator. At the same time, the patient's arm was placed on the table in an extended position, without applying a tourniquet.

The research was performed using "Versana Essential" (USA) ultrasound device with a linear sensor (frequency range 4.2–13.0 MHz). The anatomical configuration of the vascular access (VAS) was visualized during ultrasound examination in the B-mode (fig 1 A). The diameter, lumen, compressibility and location of the efferent vein relative to the skin were evaluated. The assessment of the bloodflow of the vascular access was conducted using pulse Doppler and colour Doppler mapping (fig 1 B).



A B

Fig. 1. Echogram parameters in AVF. A – B mode of detection; B – Colour Doppler mapping mode.

Volumetric bloodflow (VBF) in the adductor artery was determined 2 cm proximal to the anastomosis (fig 2 A, B). The bloodflow velocity (fig 2 C, D) together with diameter and depth of the vein (fig 2 E, F) were also assessed.

The size and position of the control volume in the spectral Doppler was adjusted according to the size of the vessel (occupying at least ¾ of the investigated vessel) and the Doppler angle was 60 °.

To detect the haemodialysis impact on patients' physical and emotional state the quality of life of these patients was estimated using the SF-36 questionnaire which contains 36 questions grouped into 8 domains characterising physical and psychoemotional health [4].

Statistical processing of the obtained data was carried out using the Statistica 10.0 software package (StatSoft Inc., USA).

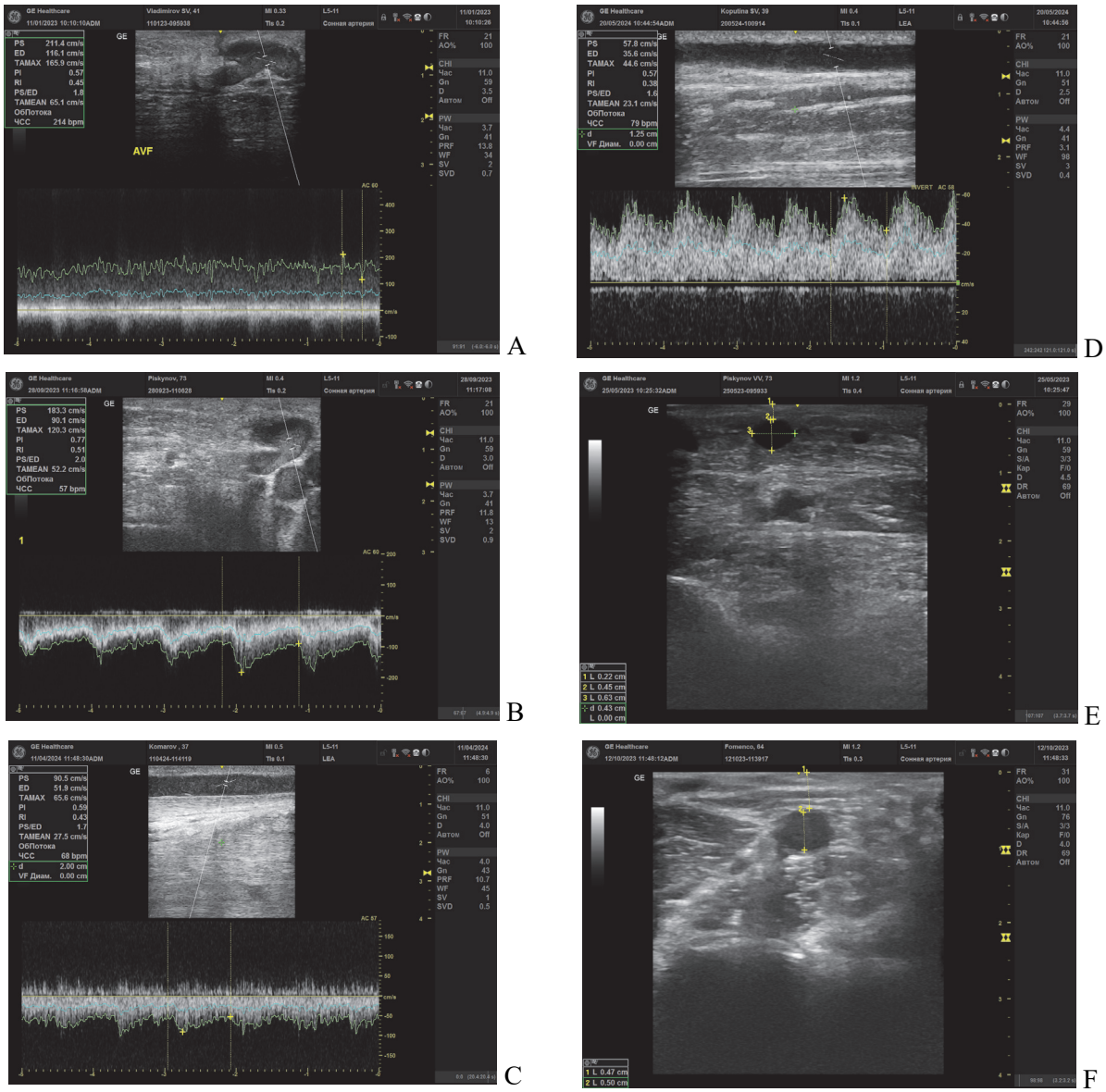


Fig. 2. Quantitative parameters of ultrasound registration. A – Bloodflow velocity evaluation in AVF in patient V.; B – Bloodflow velocity evaluation in AVF in patient P.; C – Echogram of the patient's K. outflow vein with bloodflow velocity determination; D – Echogram of the patient's K. outflow vein with bloodflow velocity determination; E – Evaluation of the diameter and depth of the vein in patient P.; F – Evaluation of the diameter and depth of the vein in patient F.

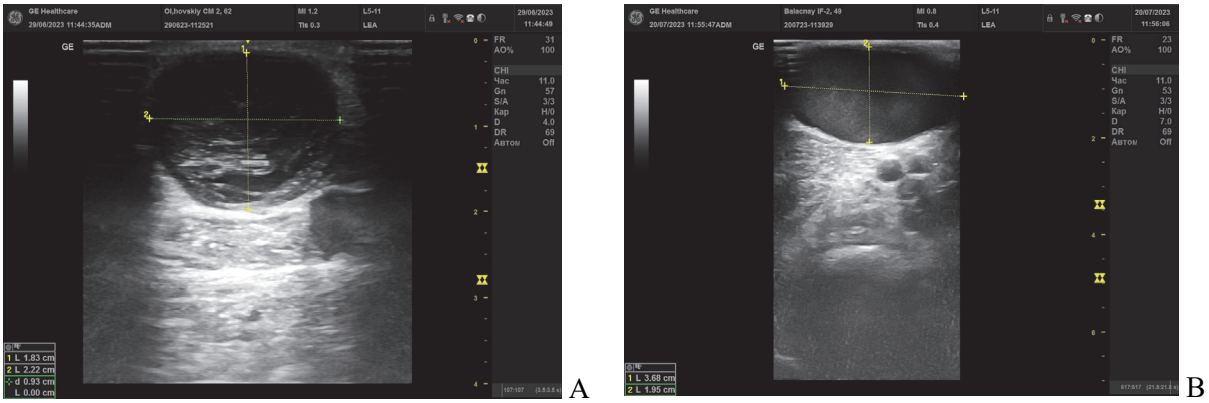
Results of the study and their discussion. According to anamnestic data, all patients who took part in the study had one or more somatic diseases before the start of the hemodialysis program. 57 patients (75.0 %) had frequent infectious diseases in childhood and adolescence. Among the endocrine disorders, 3 patients (3.95 %) had type 2 diabetes and the number of patients with I–II degree obesity was 14 (18.4 %) and 2 patients (2.6 %) with III degree obesity. In the structure of diseases of the gastrointestinal tract, chronic pancreatitis (27.6 %) and chronic cholecystitis (35.5 %) were noted. The main factors in chronic renal failure development were: chronic glomerulonephritis (48.6 %), urolithiasis (9.2 %), polycystic kidney disease (2.6 %). In 14.4 % (11 patients) concomitant pathology was chronic arterial hypertension.

4 patients (5.2 %) had a history of surgical interventions to create a new permanent vascular access for hemodialysis due to complications from existing fistula. 2 male patients (2.6 %) had a history of right kidney transplantation, and in both cases their mothers acted as donors.

Analysis of echographic data showed that the depth of the abductor vein in patients was 0.49±0.5 cm that reveals to be sufficient for multiple punctures. The diameter of the vein was 5.2–6.0 mm with preserved compressibility. In patients without vascular access complications, the mean diameter of the feeding artery was 4.3±1.4 mm. The diameter of the anastomosis ranged from 1.4 mm to 10 mm (on average 4.0±1.3 mm). An important determined indicator was VBF in the vascular access, which absolute data ranged from 500 ml/min to 1600 ml/min (on average 1045.2±405.6 ml/min), which corresponds to normal indexes for a functioning AVF.

The upper limbs palpation revealed hemodynamic disturbances manifested in hand temperature asymmetry (a colder hand with AVF) without limb ischemia. Among the most frequent complications of AVF during hemodialysis were soft tissue hematomas of the forearm (12 patients or 15.7 %) that appeared after the hemodialysis procedure (fig. 3 A). During observation, the hematomas did not increase in size, were not accompanied by vein compression, and were treated conservatively.

In 3 (3.9 %) patients examined during observation of permanent vascular access, the diameter of the outflow vein was less than 5.0 mm and the VBF was less than 500 ml/min, which made it possible to predict AVF dysfunction. VBF less than 300 ml/min with the presence of thrombotic masses partially occluding the lumen was observed in 1 patient (1.3 %), which indicated the development of thrombosis and did not allow the hemodialysis procedure. Stenosis in the venipuncture area was observed in 3 patients (3.9 %), with subsequent loss of vascular access in 1 patient. AVF aneurysm with intact skin, without thrombotic masses, with Doppler "Yin-Yang" symptom was visualized in 1 patient (fig. 3 B).



A B

Fig. 3. Echograms of hemodialysis patients with variants of complications. A – Soft tissue hematoma of the forearm in patient O.; B – Aneurysm of the draining vein in patient B.

As a result of a questionnaire, the psychological state of patients undergoing hemodialysis was assessed. Low physical activity and constant fatigue were recorded in all surveyed patients. It was found that 46 people (60.5 %) experienced a decrease in interest in life, a feeling of dissatisfaction, periods of depressed mood, a feeling of oppression and hopelessness. In 15 patients (19.7 %), such sensations occurred more than half the time, and in 17 (22.3 %) – almost daily.

Against the background of the outbreak of military actions, all surveyed patients spoke about the experienced feeling of hopelessness. Fear from the realization of the lack of access to life-saving treatment and the awareness of the inevitability of severe suffering aggravated anxiety, causing panic attacks, depressive states and a sense of doom. Sleep disorders, such as difficulty falling asleep, superficial sleep or excessive sleepiness, were reported by 40 patients (52.6 %).

With the onset of military actions in Ukraine, 5 patients (6.5 %) stopped undergoing hemodialysis procedures and left for the territories of other countries, where they received emergency medical care. At the same time, 4 patients for one reason or another returned to the country for hemodialysis procedures (5.2 %). In parallel with physical difficulties, the emotional burden remained throughout the entire stay in the territory of another country. Moving and the process of adaptation in a foreign country were accompanied by overexertion, loneliness, a feeling of despair and fear for the future. The need for constant, regular medical care in an unfamiliar environment, combined with language and cultural barriers created additional difficulties. Those surveyed spoke of their doubts about whether they would be able to find the strength and resources to continue treatment or adapt to new living conditions. Patients recalled the attention, help and support from their relatives and friends, as well as new acquaintances and medical staff.

Thus, ultrasonographic assessment of AVF is the leading method at all stages of patient management with renal replacement therapy. This noninvasive method allows for a quick and accurate assessment of vascular access functioning and identification of possible disorders in its functioning. Echographic parameters are key to ensuring effective fistula operation and hemodialysis. Echographic parameters such as vein diameter (at least 5 mm) and volumetric bloodflow (at least 500 ml/min) are key indicators of AVF effectiveness. Regular ultrasound mapping of vessels allows for timely detection of deviations in AVF operation, minimization of the risk of complications and has diagnostic value for further patient management.

It seems to us that a more detailed discussion of the data obtained will be possible by focusing on the following key issues of the topic raised.

The effective programmed hemodialysis implementation is possible only with reliable, stable and functional vascular access. Adequate vascular access both formation and maintenance determines hemodialysis duration and the patient's quality of life. Currently, AVF is supposed to be the optimal first-line vascular access for long-term hemodialysis and its use is actively recommended in clinical guidelines in various countries [9]. This type of vascular access provides the best results in terms of durability, minimizing the number of complications. However, the creation of functional access of this type is a rather complex process that depends on many factors, including the anatomical features of the patient, such as the diameter and location of the vessels, as well as their condition [9, 12].

Above half of the patients in our study (55.2 %) undergoing hemodialysis were women. According to foreign authors, in high-income countries, hemodialysis is initiated in men 1.2–1.4 times more often than in women, despite the higher risks of chronic kidney disease among women [1]. One of the key pathogenetic mechanisms for end-stage renal failure development in women today is preeclampsia which occurs during pregnancy. This serious obstetric complication poses an immediate threat to both the life of the mother and the fetus, and also has a significant impact on the deterioration of the long-term prognosis of renal function in women with already reduced nephron reserve [2].

Individual characteristics of the patient's body and the presence of chronic diseases play a significant role, since they can affect vascular wall both stiffness and elasticity together with vascular patency [15]. In our study, among patients receiving renal replacement therapy, such concomitant diseases as glomerulonephritis, urolithiasis and polycystic kidney disease, as well as metabolic and vascular disorders, including diabetes mellitus and cardiovascular diseases, predominated, which is consistent with the data presented by a number of authors [8].

Finally, vascular access plays an important role in hemodialysis, providing adequate bloodflow for effective blood purification in patients with chronic kidney disease. One of the most effective methods for assessing and monitoring the state of vascular access is ultrasound diagnostics. According to the American College of Radiology, ultrasound, along with fistulography, is recognized as one of the main approved methods for diagnosing possible AVF dysfunction [11]. Ultrasound imaging allows for a comprehensive and dynamic assessment of the arteriovenous fistula. The method allows for determining morphological changes in the vascular wall, lumen diameter, localization and degree of stenosis, identifying signs of thrombosis, as well as complications associated with vascular access puncture, and assessing bloodflow parameters in color and pulsed Doppler modes [11].

It should be noted that echographic parameters, including vein diameter (at least 5 mm) and volumetric bloodflow rate in vascular access (at least 500 ml/min), serve as the main criteria for AVF functioning efficiency which corresponds to literature data. Thus, duplex Doppler ultrasound data with bloodflow volume assessment indicate that an optimally functioning AVF demonstrates a bloodflow rate within the range of 700 to 1300 ml/min. Bloodflow parameters less than 500 ml/min are considered to be a vascular access dysfunction predictors as well as the potential development of thrombosis. Also, a decrease in bloodflow volume by more than 25 % within 1-4 months with initially stable values above 1000 ml/min may serve as a sign vascular access dysfunction approaching [5].

Patient-oriented studies have also shown that fatigue, insomnia, cramps, depression, anxiety, and frustration are key symptoms that negatively affect the treatment outcomes of patients undergoing dialysis [6].

Our results correlate with the existing published results in the scientific literature. Thus, ultrasound can detect both early signs of AVF dysfunction and complications that arise with multiple punctures. Taking into consideration its high information content, availability, and safety, the study is the main method for monitoring vascular access in the complex management of patients receiving renal replacement therapy.

Conclusions

1. Ultrasonographic assessment of AVF is the leading method at all stages of patient management with renal replacement therapy.

2. This noninvasive method allows for a quick and accurate assessment of vascular access functioning and identification of possible disorders in its functioning.

3. Echographic parameters such as vein diameter and volumetric bloodflow are key indicators of AVF effectiveness.

4. Regular ultrasound mapping of vessels allows for timely detection of deviations in AVF operation, minimization of the risk of complications and has diagnostic value for further patient management.

5. Ultrasound Doppler study is the main method for vascular access monitoring in the complex management of patients receiving renal replacement therapy.

Prospects for further research aimed at detailed clinical and laboratory study of the arteriovenous fistula characteristics of bloodflow and its depth during hemodialysis to develop precise clinical recommendations for this manipulation prognostic efficacy identification and possible complications prevention.

References

1. Antlanger M, Noordzij M, van de Luijtgaarden M, Carrero JJ, Palsson R, Finne P. et al. Sex differences in kidney replacement therapy initiation and maintenance. Clin J Am Soc Nephrol. 2019; 14(11): 1616-1625. doi: 10.2215/CJN.04400419.
2. Barrett PM, McCarthy FP, Evans M, Kublickas M, Perry IJ, Stenvinkel P. et al. Hypertensive disorders of pregnancy and the risk of chronic kidney disease: A Swedish registry-based cohort study. PLoS Medicine. 2020; 17(8): 1003255. doi: 10.1371/journal.pmed.1003255.
3. Brown RS, Patibandla BK, Goldfarb-Rumyantzev AS. The survival benefit of "Fistula First, Catheter Last" in hemodialysis is primarily due to patient factors. J Am Soc Nephrol. 2017; 28(3): 645–652. doi: 10.1681/ASN.2016010019.
4. Chuasuwan A, Pooripussarakul S, Thakkinstian A, Ingsathit A, Pattanaprateep O. Comparisons of quality of life between patients underwent peritoneal dialysis and hemodialysis: a systematic review and meta-analysis. Health Qual Life Outcomes. 2020; 18(1): 191. doi: 10.1186/s12955-020-01449-2.
5. Higgins MCSS, Diamond M, Mauro DM, Kapoor BS, Steigner ML, Fidelman N. et al. ACR Appropriateness Criteria® Dialysis Fistula Malfunction. Practice Guideline. J Am Coll Radiol. 2023; 20 (11): 382–412. doi:10.1016/j.jacr.2023.08.016.
6. Himmelfarb J, Vanholder R, Mehrotra R, Tonelli M. The current and future landscape of dialysis. Nat Rev Nephrol. 2020; 16(10): 573–585. doi: 10.1038/s41581-020-0315-4.
7. Jager KJ, Kovesdy C, Langham R, Rosenberg M, Jha V, Zoccali C. A single number for advocacy and communication - worldwide more than 850 million individuals have kidney diseases. Kidney Int. 2019; 96(5): 1048–1050. doi: 10.1016/j.kint.2019.07.012.
8. Kovesdy CP. Epidemiology of chronic kidney disease: an update 2022. Kidney Int Suppl (2011). 2022; 12(1): 7–11. doi: 10.1016/j.kisu.2021.11.003.
9. Lawson JH, Niklason LE, Roy-Chaudhury P. Challenges and novel therapies for vascular access in haemodialysis. Nat Rev Nephrol. 2020; 16(10): 586–602. doi: 10.1038/s41581-020-0333-2.
10. Lok CE, Huber TS, Lee T, Shenoy S, Yevzlin AS, Abreo K. et al. National Kidney Foundation. KDOQI Clinical Practice Guideline for Vascular Access: 2019 Update. Am J Kidney Dis. 2020; 75 (4 Suppl 2): 1–164. doi: 10.1053/j.ajkd.2019.12.001.
11. Meola M, Ibeas J, Lasalle G, Petrucci I. Basics for performing a high-quality color Doppler sonography of the vascular access. J Vasc Access. 2021; 22 (1): 18–31. doi: 10.1177/11297298211018060.
12. Natale P, Ju A, Strippoli GFM, Craig JC, Saglimbene VM, Unruh ML. et al. Interventions for fatigue in people with kidney failure requiring dialysis. Cochrane Database Syst Rev. 2023; 2023(8): CD013074. doi: 10.1002/14651858.CD013074.pub2.
13. Novakivskyy V, Shurduk R, Grin I, Tkachenko T, Pavlenko N, Hrynevych A. et al. War in Ukraine and dialysis treatment: human suffering and organizational challenges. Clin Kidney J. 2023; 16(4): 676-683. doi: 10.1093/ckj/sfad003.
14. Saran R, Robinson B, Abbott KC, Bragg-Gresham J, Chen X, Gipson D. et al. US Renal Data System 2019 annual data report: epidemiology of kidney disease in the United States. Am J Kidney Dis. 2020; 75(1): 6–7. doi: 10.1053/j.ajkd.2019.09.003.
15. Zolotaryova NA, Vastyanov RS. The investigation of vascular stiffness in patients depending on different degrees of arterial hypertension. World of Medicine and Biology. 2024; 1(87): 65-69. doi: 10.26724/2079-8334-2024-1-87-65-69.

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