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# Nutritional assessment of patients in haemodialysis by bioimpedance spectroscopy and BMI

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## ABSTRACT

**INTRODUCTION.** Dialysis patients carry an increased risk of malnutrition, which is often defined by BMI. In this study, we aimed to evaluate the quality of BMI as a marker of nutritional status in haemodialysis (HD) patients by comparing BMI to body composition measurements from bioimpedance spectroscopy (BIS).

**METHODS.** This observational study included 85 patients receiving chronic HD in 2021 at the Dialysis Clinic, Gødstrup Hospital, Denmark. Nutritional status was assessed with BMI and BIS, which determined values of fat tissue index (FTI), lean tissue index (LTI) and overhydration. Furthermore, albumin blood levels were also assessed.

**RESULTS.** Patients with diabetes had a significantly lower LT and a higher FTI and BMI than their diabetes-free counterparts. LTI was inversely correlated to age, and BMI was correlated with FTI but not with LTI.

**CONCLUSIONS.** Our study illustrates that calculation of BMI in HD patients should be used with caution as it does not correlate with LTI, which is an important prognostic factor. We propose body composition assessment, e.g., by BIS, as a supplement to BMI in nutritional assessments.

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**TRIAL REGISTRATION.** Not relevant, as the project was performed as a quality assurance study.

A considerable number of dialysis patients are malnourished, which is associated with poor quality of life and an increased risk of premature death [1, 2]. Dialysis patients lose body protein mass and energy stores due to, e.g., uremic toxicity, hypercatabolic status and inflammation [1]. Contrary to the general population, a high BMI has overall been shown to be protective in dialysis patients [3], and the proportions of both lean and fatty tissue are gaining interest as prognostic markers [2, 3].

In clinical practice, screening for malnutrition is often done by measuring BMI, although more nuanced and updated malnutrition definitions exist. Several of these definitions include parameters such as weight loss and muscle mass in addition to BMI [4]. However, both BMI and weight loss can be unreliable measures in patient groups characterised by excess fluid and patients who experience variations in body weight before and after a dialysis session. In comparison, lean tissue is unaffected by fluid status and is therefore a more applicable marker of malnutrition in this patient group [5].

Bioimpedance spectroscopy (BIS) is an easy and non-invasive method to evaluate lean tissue in clinical settings. Although other methods of assessing body composition exist, this study focuses on BIS, as it is often available in dialysis clinics where it is used for dry-weight estimation [6]. No data are currently available on the nutritional status of Danish haemodialysis (HD) patients assessed by BIS.

In this hypothesis-generating, retrospective, longitudinal, observational study, all patients in a Danish, middle-sized dialysis department were examined with BMI measurements, BIS and plasma albumin.

We aimed to evaluate the quality and reliability of BMI as a marker of nutritional status in HD patients by comparing it to BIS measurements. Furthermore, we intended to provide nutritional characteristics of Danish HD patients by BIS, as this may be used to evaluate the need for further nutritional interventions.

## Methods

### Design

The project was conducted as an observational study in the Dialysis Clinic, Gødstrup Hospital, Denmark, from 1 February 2021 to 17 June 2021. In this period, 102 patients were receiving chronic centre HD at the Dialysis Clinic. All patients receiving chronic HD at the Dialysis Clinic at this time were eligible to join the study, except for patients with limp amputation or a biventricular pacemaker. Chronic HD was defined as HD for more than three months. Blood samples were identified by accessing the patient's medical records and selecting those closest in time to the assessment. The project was conducted as a quality assurance study and approved by the hospital management.

### Body composition monitor

Body composition was measured non-invasively with BIS using a body composition monitor (BCM), Fresenius Medical Care. Measurements were made with the patients in the supine position before dialysis was initiated and with only one preceding dialysis-free day.

BIS measurements at 50 frequencies between 5 and 1,000 kHz make it possible to differentiate extra- and intracellular fluid as low currents cannot pass the cell membrane and consequently cannot enter the intracellular fluid [7, 8]. The measured parameters are corrected for BMI as differences in body composition may introduce systematic errors to the volumes [7]. The body volume model is used to calculate extracellular water, intracellular water and total body water, and the body composition model differentiates normally hydrated fat mass, normally hydrated lean mass and the remaining proportion of water and makes it possible to calculate parameters of adipose tissue, lean tissue and overhydration [9]. Lean tissue index (LTI) is defined as lean tissue mass over height squared, and fat tissue index (FTI) as fat tissue mass over height squared.

### Blood samples

Plasma levels of albumin were measured using routine methods at the Department of Clinical Biochemistry, Goedstrup Hospital, Denmark, and identified in the patients' electronic medical records. The blood samples used were the closest available to the BCM measurements, taken within 28 days of BCM measurement.

### Statistics

The authors conducted all statistical analyses using IBM SPSS statistics version 22.0 (IBM Corp.; Armonk, NY, United States). Normality and variance equality tests were made for all data, and the statistical significance level was set to $p < 0.05$ for all analyses.

Continuous variables were reported as means (± standard deviation, SD) or as medians (25-75%) depending on whether the data were normally distributed or not. Categorical variables were reported as percentages with numbers in parentheses. Unpaired normally distributed continuous variables were tested for difference using an unpaired t-test. Unpaired non-normally distributed continuous data were analysed using the Mann-Whitney test. Pearson's or Spearman's test was used for correlation analyses depending on whether data were normally distributed or not, respectively.

*Trial registration:* not relevant, as this was a quality assurance study.

## Results

**Patients**

The study included 85 patients, 52 males and 33 females. BIS measurements were unavailable in four patients due to measurement failure. Demographic data are displayed in **Table 1**. Among patients, 37% had diabetes, and diabetic kidney disease was the most common origin of kidney disease.

**TABLE 1** Demographic and nutritional data.

| | |
|---|---|
| Patients, N | 85 |
| Age, median (25-75%), yrs | 69 (55-76) |
| *Gender of patients, % (n)* | |
| Male | 61 (52) |
| Dialysis vintage, median (25-75%), yrs | 2.25 (0.75-5.00) |
| *Presumed origin of renal disease, % (n)* | |
| Diabetic kidney disease | 27 (23) |
| Hypertensive or vascular disease | 14 (12) |
| Glomerulonephritis | 13 (11) |
| Reflux or congenital defects | 9 (8) |
| Polycystic kidney disease | 7 (6) |
| Pyelonephritis or interstitial nephritis | 5 (4) |
| Circulatory disease | 5 (4) |
| Lithium | 2 (2) |
| Chemotherapy | 2 (2) |
| Unknown causes | 15 (13) |
| *Diabetes, % (n)* | |
| Type 1 | 6 (5) |
| Type 2 | 31 (26) |
| Subtotal | 36[a] (31) |
| BMI, median (25-75%), kg/m² | 27.7 (22.6-30.8) |
| *Bioimpedance spectroscopy measurements* | |
| Overhydration, mean (± SD), l | 2.0 (± 2.2) |
| Relative overhydration, mean (± SD), % | 9.8 (± 10.4) |
| LTI, mean (± SD), kg/m² | 12.8 (± 2.7) |
| FTI (25-75%), kg/m² | 12.6 (9.5-18.5) |
| *Blood samples* | |
| Plasma albumin, median (25-75%), g/l | 34 (33-36) |

FTI = fat tissue index; LTI = lean tissue index; SD = standard deviation.
a) Round-off discrepancy.

**Nutritional data**

Nutritional data from BIS and blood samples are shown in Table 1 and **Table 2.** The mean BMI was 27.7 kg/m$^2$, and no significant gender difference was found ($p = 0.402$). Diabetic patients had a significantly higher FTI ($p = 0.015$), higher BMI ($p = 0.033$) and lower LTI ($p = 0.030$) than nondiabetic patients. No significant BMI difference was found between diabetic and non-diabetic women ($p = 0.157$) or between diabetic and non-diabetic men ($p = 0.187$).

**TABLE 2** Data from bioimpedance spectroscopy, grouped by gender and diabetes status.

| | Males | | Females | |
|---|---|---|---|---|
| | diabetic (n = 13) | nondiabetic (n = 36) | diabetic (n = 17) | nondiabetic (n = 15) |
| LTI, mean (± SD), kg/m² | 12.8 (± 2.0) | 13.9 (± 2.9) | 11.1 (± 1.4) | 12.1 (± 2.5) |
| FTI, median (25-75%), kg/m² | 13.8 (10.0-15.7) | 10.8 (7.8-14.8) | 18.6 (13.6-23.0) | 13.3 (10.4-19.5) |
| BMI, median (25-75%), kg/m² | 29.5 (24.7-31.8) | 25.9 (22.3-29.3) | 29.6 (26.7-35.3) | 26.2 (21.8-29.9) |

FTI = fat tissue index; LTI = lean tissue index; SD = standard deviation.

**Figure 1** displays LTI by patient age. LTI values ranged from 8.5 to 23.6 kg/m$^2$. The plot shows that LTI decreased with age.

**FIGURE 1** Plot of lean tissue index (LTI) and age distribution.

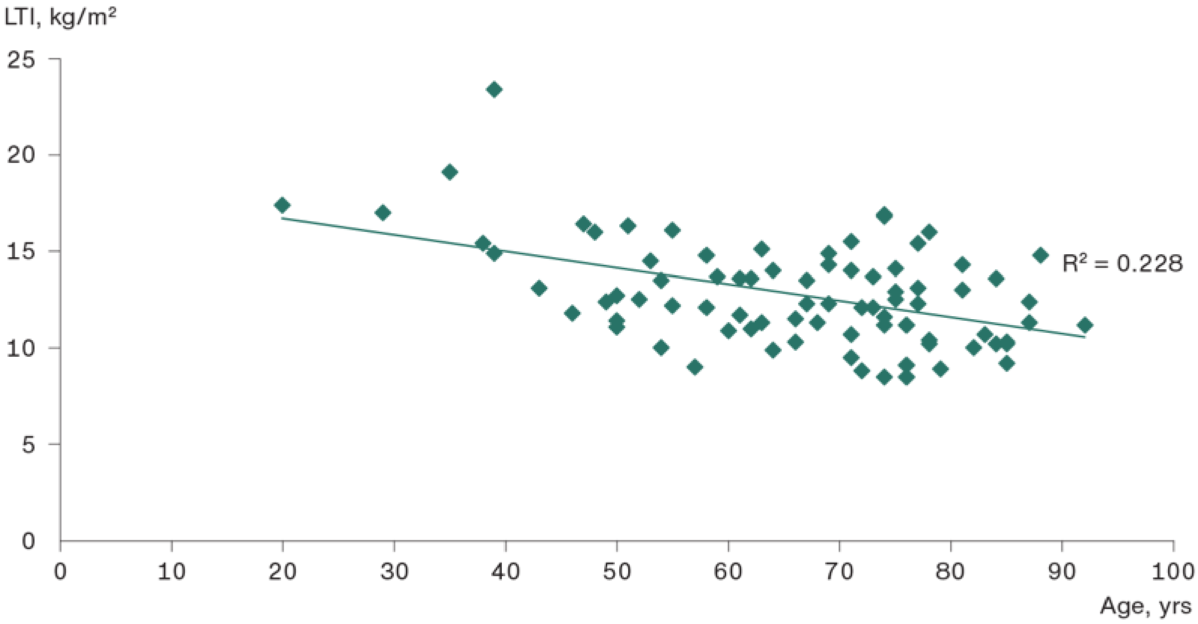
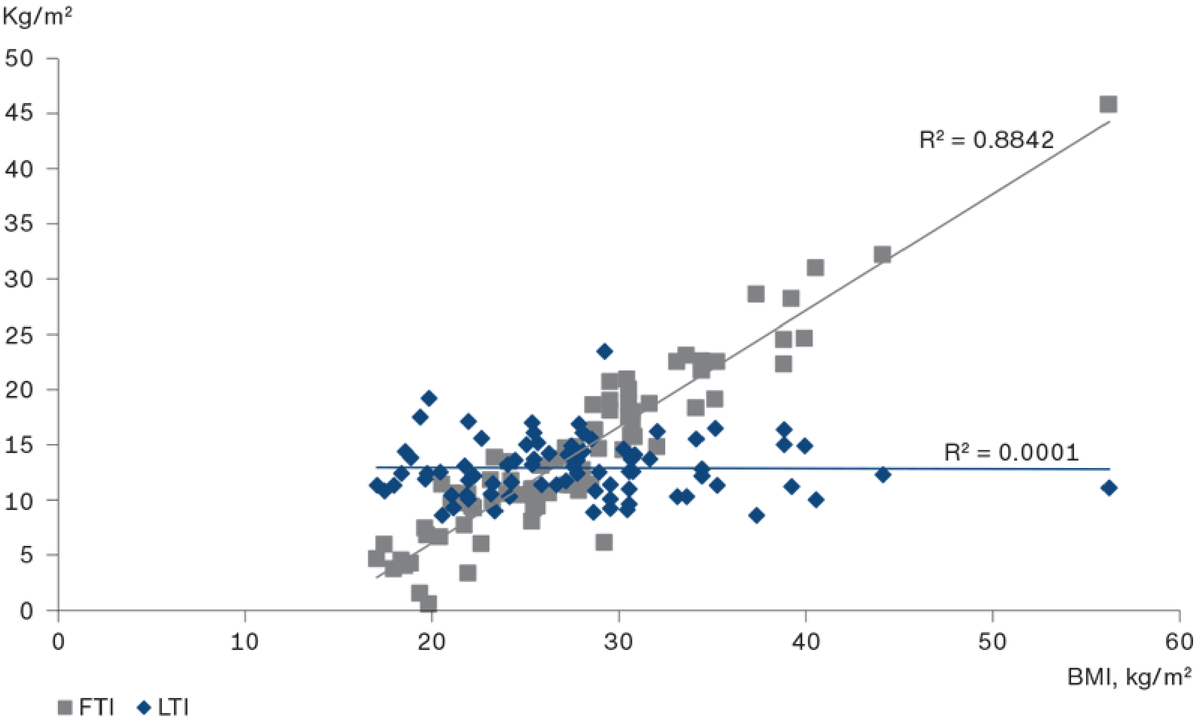



**Figure 2** shows a plot of LTI and FTI values presented by BMI values. Patients with LTI values in the lowest tenth percentile (< 9.9 kg/m$^2$) had BMI values ranging from 20.6 to 40.6 kg/m$^2$.

**FIGURE 2** Plot of lean tissue index (LTI) and fat tissue index (FTI) by BMI.




**Correlation analysis**

BMI correlated significantly with FTI ($r = 0.916$, $p < 0.0001$) but not with LTI. LTI was significantly inversely correlated with age ($r = -0.477$, $p < 0.0001$), whereas age did not correlate with BMI or FTI. Albumin showed no correlation with either BMI, LTI, FTI or age.

## Discussion

In the present study, we analysed nutritional data from the BIS and BMI measurements of 85 HD patients in one dialysis centre.

**The use of BMI versus LTI for nutritional screening**

Patients with LTI values in the lowest tenth percentile had BMIs ranging from 20.6 to 40.6 kg/m$^2$. According to the WHO classification, these patients fall within the normal to obese range. Therefore, using BMI alone would fail to identify these patients as being at risk of malnutrition. Another Danish study previously measured body composition in dialysis patients but was based on skinfold measurements, which makes direct comparison with our results difficult [10]. However, the former study found that 10% of their patients had a combination of low muscle mass and obesity. Together with our findings, this demonstrates the considerable number of dialysis patients with a high BMI in conjunction with a low muscle mass.

In our study, BMI correlated with FTI but not with LTI. This was also the case when patients were divided into subgroups based on gender and diabetes status (data not shown). The lack of correlation between LTI and BMI was also seen in a similar study with 934 HD patients [11]. This finding strongly underlines the challenges associated with assessing nutritional status in dialysis patients merely by BMI, especially as a low LTI is associated with poorer survival in HD patients [2, 12]. BMI has also been shown to be an inadequate screening tool with which to detect obesity in chronic kidney disease (CKD) [13]. Although the use of BMI can be problematic, studies on dialysis patients have consistently found a high BMI to be a strong predictor of improved survival [3]. A large study suggested that a higher FTI is protective in HD patients with a low LTI [2], highlighting the need to consider both lean and fat tissue compartments when evaluating nutritional status.

**Methods for assessing body composition**

Dual-energy X-ray absorption (DEXA) scans are considered a gold standard method for assessing body composition. However, DEXA cannot be used bedside. It involves radiation and is not ideal in patients with notable overhydration [14]. Skinfold measurement is another easily accessible method. However, unlike BIS, it is operator-dependent and does not consider overhydration [14]. Good accordance was reported between BIS and gold standard methods in the assessment of fluid compartments in HD patients [15]. Even so, a study in CDK patients showed that BIS overestimated the fat-free tissue index compared to values obtained by DEXA [5], while another study in HD patients suggested 7.4% overestimation of fat tissue with BIS compared to DEXA [14]. Despite the limitations of BIS, it is superior to BMI alone in nutritional assessment of HD patients, as shown in this study. Compared to other methods, BIS is a more feasible and practical approach because it is already present in many dialysis clinics [6].

**Mortality**

Low LTI is associated with poorer survival in HD patients [2, 12], and high BMI is associated with improved survival [3]. A large international study found the best survival rates in HD patients with an LTI between 15 and 20 kg/m$^2$ and an FTI between 4 and 15 kg/m$^2$. Only a minor part of our patients (16%) had LTI values in that range, whereas most (68%) had FTI values in the ideal range. Randomised clinical trials have shown that certain nutritional interventions have the potential to improve both quality of life and nutritional parameters [16, 17]. Even so, randomised studies showing that these results translate into improvement in mortality, specifically in HD patients, are currently lacking. However, a randomised clinical trial including 5,015 medical inpatients at nutritional risk showed improved survival after individualised nutritional support [18], and a longitudinal prospective study with nutritional intervention in non-dialysis end-stage CKD showed effect on survival and morbidity [19].

**Influence of different factors on nutritional parameters**

Due to age-related muscle loss, older patients generally have less lean tissue than younger patients [12]. This was also the case in our study, where LTI correlated inversely with age. Other studies in HD populations have found a correlation between dialysis vintage and low LTI [11]. This was not the case in our study, likely because of the short time in dialysis for most of our patients. Additionally, body composition is influenced by gender and comorbidities, e.g., diabetes [12]. We found that diabetic patients had a significantly lower LTI, a higher FTI and a higher BMI than non-diabetic patients. Similar findings were seen in other studies [12], and mounting evidence suggests that DM is a risk factor for malnutrition in HD patients. With higher BMI values but lower amounts of lean tissue than their counterparts, the diabetic subgroup of patients is particularly at risk of having malnutrition underdiagnosed if malnutrition screenings are based exclusively on BMI rather than, e.g., a combination of BIS and BMI.

**The study population compared to other populations**

Nutritional status was similarly assessed by BIS in a multicentric, international cohort of 37,345 European HD patients [2]. Compared to this cohort, our HD population had a higher BMI, a higher LTI and a higher FTI. The international cohort had fewer men, lower age and fewer diabetics than our study population. However, our results indicate that this Danish population may be in a more favourable nutritional status than the international cohort.

**Strengths and limitations**

Sample size calculation was not performed. Due to the retrospective nature of our study, there is a risk of bias and lack of data. The study population was small and recruited from a single dialysis centre. Data were obtained on 85 out of the 102 patients in the cohort, but we have no data on the remaining 17 patients. The screening was performed systematically. Moreover, although the patient number is limited, the population appears to be representative of the entire Danish dialysis population in terms of age, gender distribution and origin of kidney disease [20]. The most common cause of renal failure was diabetic kidney disease, which was also seen in other HD cohorts worldwide [12]. It would have been beneficial to include more BIS measurements to analyse variance.

## Conclusions

We compared BMI and BIS measurement to evaluate the nutritional status of a population of patients in centre HD. This study showed that calculation of BMI should be used with caution in HD patients as it does not correlate with LTI, which is a well-known and important prognostic factor. We therefore propose body composition assessment, e.g., by BIS, as a supplement to BMI, as it is an easy, accessible way to identify patients at risk of malnutrition while evaluating their hydration status.

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## REFERENCES

1. Carrero JJ, Thomas F, Nagy K et al. Global prevalence of protein-energy wasting in kidney disease: a meta-analysis of contemporary observational studies from the International Society of Renal Nutrition and Metabolism. J Ren Nutr. 2018;28(6):380-92. https://doi.org/10.1053/j.jrn.2018.08.006
2. Marcelli D, Usvyat LA, Kotanko P et al. Body composition and survival in dialysis patients: Results from an international cohort study. Clin J Am Soc Nephrol. 2015;10(7):1192-200. https://doi.org/10.2215/CJN.08550814
3. Caetano C, Valente A, Oliveira T, Garagarza C. Body composition and mortality predictors in hemodialysis patients. J Ren Nutr. 2016;26(2):81-6. https://doi.org/10.1053/j.jrn.2015.10.005
4. Cederholm T, Jensen GL, Correia MITD et al. GLIM criteria for the diagnosis of malnutrition – a consensus report from the global clinical nutrition community. Clin Nutr. 2019;38(1):1-9. https://doi.org/10.1016/j.clnu.2018.08.002
5. Eyre S, Bosaeus I, Jensen G, Saeed A. Using bioimpedance spectroscopy for diagnosis of malnutrition in chronic kidney disease stage 5 - is it useful? J Ren Nutr. 2022;32(2):170-7. https://doi.org/10.1053/j.jrn.2021.03.007
6. Stenberg J, Lindberg M, Furuland H. Clinical praxis for assessment of dry weight in Sweden and Denmark: a mixed-methods study. Hemodial Int. 2016;20(1):111-9. https://doi.org/10.1111/hdi.12336

7. Moissl UM, Wabel P, Chamney PW et al. Body fluid volume determination via body composition spectroscopy in health and disease. Physiol Meas. 2006;27(9):921-33. https://doi.org/10.1088/0967-3334/27/9/012
8. Dou Y, Zhu F, Kotanko P. Assessment of extracellular fluid volume and fluid status in hemodialysis patients: current status and technical advances. Semin Dial. 2012;25(4):377-87. https://doi.org/10.1111/j.1525-139X.2012.01095.x
9. Chamney PW, Wabel P, Moissl UM et al. A whole-body model to distinguish excess fluid from the hydration of major body tissues. Am J Clin Nutr. 2007;85(1):80-9. https://doi.org/10.1093/ajcn/85.1.80
10. Koefoed M, Kromann CB, Juliussen SR et al. Nutritional status of maintenance dialysis patients: low lean body mass index and obesity are common, protein-energy wasting is uncommon. PLoS One. 2016;11(2):e0150012. https://doi.org/10.1371/journal.pone.0150012
11. Valtuille R, Casos ME, Fernandez EA et al. Nutritional markers and body composition in hemodialysis patients. Int Sch Res Notices. 2015:695263. https://doi.org/10.1155/2015/695263
12. Castellano S, Palomares I, Moissl U et al. Appropriate assessment of body composition to identify haemodialysis patients at risk. Nefrologia. 2016;36(3):268-74. https://doi.org/10.1016/j.nefro.2016.01.007
13. Agarwal R, Bills JE, Light RP. Diagnosing obesity by body mass index in chronic kidney disease: an explanation for the "obesity paradox?". Hypertension. 2010;56(5):893-900. https://doi.org/10.1161/HYPERTENSIONAHA.110.160747
14. Rymarz A, Szamotulska K, Niemczyk S. Comparison of skinfold thicknesses and bioimpedance spectroscopy to dual-energy X-ray absorptiometry for the body fat measurement in patients with chronic kidney disease. Nutr Clin Pract. 2017;32(4):533-8. https://doi.org/10.1177/0884533617692528
15. Wabel P, Chamney P, Moissl U, Jirka T. Importance of whole-body bioimpedance spectroscopy for the management of fluid balance. Blood Purif. 2009;27(1):75-80. https://doi.org/10.1159/000167013
16. Calegari A, Barros EG, Veronese FV, Thomé FS. Malnourished patients on hemodialysis improve after receiving a nutritional intervention. J Bras Nefrol. 2011;33(4):394-401
17. Liu PJ, Guo J, Zhang Y et al. Effects of oral nutritional supplements on the nutritional status and inflammatory markers in patients on maintenance dialysis: a systematic review and meta-analysis of randomized clinical trials. Clin Kidney J. 2023;16(11):2271-88. https://doi.org/10.1093/ckj/sfad130
18. Schuetz P, Fehr R, Baechli V et al. Individualised nutritional support in medical inpatients at nutritional risk: a randomised clinical trial. Lancet. 2019;393(10188):2312-2321. https://doi.org/10.1016/S0140-6736(18)32776-4
19. Pérez-Torres A, García MEG, Ossorio-González M et al. The effect of nutritional interventions on long-term patient survival in advanced chronic kidney disease. Nutrients. 2021;13(2):621. https://doi.org/10.3390/nu13020621
20. Dansk Nefrologisk Selskabs Landsregister (DSNL). Danish Nephrology Registry (DNR). Årsrapport 2020. Annual report 2020. Dansk Nefrologisk Selskab, 2021. https://nephrology.dk/wp-content/uploads/2022/05/Aarsrapport-2020_SSS_kh300920.pdf (Jan 2025)


 