The history of bioimpedance spectroscopy nursing essay

Health & Medicine, Nursing

To determine the hydration state, clinical (pedal edema, interdialytic weight gain, ultrafiltration rate or blood pressure) or paraclinical (inferior vena cava diameter and its collapsibility index, relative plasma volume monitoring) surrogate parameters are used. A new method, which uses bioimpedance spectroscopy, defines objectively the individual hydration state on the basis of an individual's normal extracellular volume, taking into account the individual's body composition. The bioimpedance spectroscopy method applied was validated by isotope dilution methods, by accepted reference body composition methods, by techniques that measure relative changes in fluid volumes and by extensive clinical assessment of the hydration state in more than 1000 healthy subjects and patients. Recent studies indicate that the hydration state, evaluated using the bioimpedance spectroscopy method, is an important and independent predictor of mortality in chronic HD patients secondary only to the presence of diabetes, but stronger than blood pressure. Extravascular lung water (ELW) is a relatively small, but fundamental component of body fluids volume and represents the water content of the lung interstitium that is strictly dependent on the filling pressure of the left ventricle, the hemodynamic parameter considered as the golden standard for guiding fluids therapy in critical care. When the air content decreases - as in pulmonary edema, pulmonary fibrosis, etc. - the acoustic mismatch needed to reflect the ultrasound beam is created, and some images appear. In the presence of extravascular lung water, the ultrasound beam finds subpleural interlobular septa thickened by edema. The reflection of the beam creates some comet-tail reverberation artifacts, called B-lines or ultrasound lung comets. In recent years, the use of lung ultrasonography to detect ELW has received growing attention in clinical research in intensive care patients, in patients with heart failure and in patients with chronic kidney disease undergoing hemodialysis. The aim of the present study is to determine the prevalence of pulmonary congestion in hemodialysis patients, to measure the effect of standard ultrafiltration dialysis on ELW, to investigate the relationship between WLW, body fluids volume status, and echocardiographic parameters of cardiac performance and to test the prognostic value of extravascular lung water.

Methods

Patients.

Between May 26, 2011 and July 3, 2012, we invited, to take part into the study, 110 patients undergoing chronic hemodialysis treatment in our unit who fulfilled the inclusion criteria. Ninety-six patients accepted and were enrolled. Details of the patient population are presented in Table 1. HD therapy was performed three times per week for 4–5 h. A majority of patients were treated using 4008 series Fresenius Medical Care dialysis systems. Dialysis membranes were high-flux membranes. Based on a personal evaluation, patients were stratified into four classes of dyspnoea according to New York Heart Association (NYHA) classification. Categories of increasing severity in the NYHA classification show a progressively higher mortality risk in dialysis patients. Biochemical parameters were determined at the beginning of each month, according to the protocol of our dialysis center.

Lung comets

The echocardiographic examinations were performed with patients in the near-to-supine or supine positions. Ultrasound scanning of the anterior and lateral chest was obtained on the right and left hemithorax, from the second to the fourth (on the right side to the fifth) intercostal spaces, and from parasternal to midaxillary line for a total of 28 positions per complete examination, as was previously described. The comet-tail sign was defined as an echogenic, coherent, wedge-shaped signal with a narrow origin in the near field of the image. In each intercostal space, the number of comet-tail signs was recorded at the parasternal, midclavear, anterior axillary, and midaxillary sites. At every scanning site, lung comets may be counted from zero to ten. Zero is defined as a complete absence of lung comets in the investigated area; the full white screen in a single scanning site is considered, when using a cardiac probe, as corresponding to 10 lung comets. The sum of the comet-tail signs yielded a score denoting the extent of extravascular fluid in the lung. On the basis of this score, we grouped patients into 3 categories of increasingly severe pulmonary congestion (none or mild: < 16 comets, moderate: 16 – 30 comets and severe: > 15 comets).

Bioimpedance spectroscopy

The hydration state and the body composition were assessed with a portable whole body bioimpedance spectroscopy device (BCM—Fresenius Medical Care D GmbH). This device measures the impedance spectroscopy at 50 frequencies. Measurements were performed before the start and 30 minutes after the finish of the HD treatment. Electrodes were attached to one hand

and one foot on the same side of the body. All measurements were performed by two trained physicians. The extracellular water (ECW), intracellular (ICW) and total body water (TBW) were determined using the method described previously. To facilitate the comparison between patients, the hydration state was normalized to the ECW (ΔHS = HS/ECW). The patient population was divided into a hyperhydrated, normohydrated and hypohydrated groups using a cutoff of 15% for the relative hydration status (ΔHS > 15%). The definition of hyperhydration for ΔHS > 15% is based on the work described by Wabel et al.

Echocardiography

Echocardiographic measurements were obtained in each patient before dialysis by two standard Siemens echocardiography instruments (Acuson X300 premium edition and Acuson CV70).

Statistical analysis.

Data are expressed as mean ±SD, median, and interquartile range, or as percent frequency, as appropriate. Comparisons among groups were made by p value for linear trend (1-way analysis of variance or chi-square test). Among patients, comparisons were made by paired t test (normally distributed data) or by Wilcoxon signed rank test (non-normally distributed data). Correlations between variables were investigated by Pearson product moment correlation coefficient (r), contingency coefficient, or by Spearman rank correlation coefficient (rho), as appropriate. The prognostic value of lung comets score for predicting mortality was investigated by the Kaplan–Meier analysis and Cox regression analysis. All calculations were made using a standard statistical package (SPSS for Windows, version 19. 0. 1, Chicago, Illinois).

Results

Ninety-six patients (51% males) were enrolled. The demographic and clinical characteristics of the study population are reported in Table 1. The most frequent cause of chronic kidney disease was chronic glomerulonephritis (in 35, 4% of cases). Twenty-three patients (24%) had diabetic nephropathy and six patients (6, 3%) had chronic obstructive pulmonary disease. Patients with lung disease had a higher (median: 30, interquartile range 15, 6 to 101, 5 vs. median: 9, interquartile range 3 to 17) score than those without (p = 0, 003). Thirty-three patients (34, 4%) were not on any antihypertensive drug and thirty-one patients (32, 3%) had a NYHA score of at least 3. The median residual diuresis was 200 ml per day (interquartile range 0 to 575 ml per day)

Pre-dialysis.

The mean pre-dialysis arterial pressure and heart rate were 147. 6±24. 6/74. 9±15. 3 mmHg and 74. 6±16 beats/min, respectively. The median number of pre-dialysis lung comets was 11 (interquartile range 4 to 19). On the basis of preestablished thresholds, lung congestion was classified as absent to mild (≤ 15 lung comets) in 64 patients (66. 7%), moderate (16 to 30 lung comets) in 24 patients (20. 8%), and severe (> 30 lung comets) in the remaining 12 patients (12. 5%). There was no difference between these three groups in regard to sex, diabetes, systolic and diastolic blood pressure and different biochemical parameters, with the exception of serum calcium and lung disease. A significant difference was also observed when we analysed the NYHA functional class between these groups, patients with moderate or severe lung congestion having higher NYHA functional class (Table 1). The pre-dialysis lung comets score correlated significantly with the hydration status, determined using the BCM (rho = 0. 23, p = 0. 024). Table 2 shows the data obtained using the BCM on TBW, ECW and ICW and their relationship with the lung comet score. On the basis of ΔHS, 77 patients (80. 2%) were classified as being normohydrated and 19 patients (19. 8%) as hyperhydrated. There was no hypohydrated patient. We found no difference in NYHA class between the normohydrated and hyperhydrated patients (p= 0. 5), but there was a significant difference in the lung comets score between these two groups (p= 0. 048). Among the hyperhydrated patients, 14 (73. 7%) were asymptomatic (NYHA class I and II). The lung comet score before dialysis was not related to any of the anatomical and functional echocardiographic parameters evaluated in the study, with the exception of the mitral and aortic regurgitation (r= 0. 39, p= 0. 006 and r= 0. 42, p= 0. 002 , respectively). We found a significant difference (p= 0. 047) in the left atrial diameter between the three groups of lung congestion (Table 3). We also found no difference comparing the ecocardiographic parameters between the normohydrated and hyperhydrated patients (as defined by ΔHS).

Post-dialysis.

The mean post-dialysis arterial pressure and heart rate were 134±20. 2/70±11. 7 mmHg and 77±11. 7 beats/min, respectively. The median number of post-dialysis lung comets was 4. 5 (interquartile range 2 to 9). After dialysis there were 87 patients (90. 6%) with absent or mild lung congestion, 4 patients (4. 2%) with moderate, and 5 patients (5. 2%) with severe lung congestion. Post-dialysis there was no difference between these groups in regard to sex, diabetes, lung disease, systolic and diastolic blood pressure and different biochemical parameters, with the exception of pre-dialyisis serum albumin (p= 0. 004). The post-dialysis lung congestion class maintained its correlation with the NYHA functional class (r= 0. 548, p <0. 001), and also with some of the parameters determined using the BCM (hydration status, TBW and ICW). Using the post-dialysis ΔHS, 11 patients (11. 5%) were hypohydrated, 84 patients (87. 5%) were normohydrated, and only one (1%) remained hyperhydrated. The lung comets score after dialysis correlated weakly with the left atrial diameter and the left ventricular ejection fraction (rho= 0. 28, p= 0. 013 and rho=-0. 28, p= 0. 013, respectively), and with the mitral regurgitation (r= 0. 34, p= 0. 037).

Pre-post-dialysis.

The body weight reduced from 70. 2±17. 3 kg pre-dialysis to 68. 4±17. 1 kg post-dialysis (p <0. 001). The mean arterial pressure and the lung comets score were also significantly lower than at the start of dialysis (p <0. 001 for the systolic, p= 0. 001 for the diastolic pressure, and p <0. 001 for the lung comets score). The proportion of patients who were hyperhydrated fell significantly after dialysis (p <0. 001). The reduction in the lung comet score was correlated with the pre-dialysis comet score (rho= 0. 83, p <0. 001), but not with any of the BCM or ecochardiographic parameters.

Survival.

The median time of observation was 405. 5 days (interquartile range 234. 75 to 518). At that time 13 patients (13. 5) were deceased: six patients (9. 4%) in the group with absent or mild lung congestion, two patients (10%) and five patients (41. 7%) in the group with moderate and severe lung congestion, respectively (Figure 1, p= 0. 008 by log-rank test). Cox regression...