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Artificial Intelligence-Assisted Electrocardiography for Early Diagnosis of Thyrotoxic Periodic Paralysis
Shih-Hua P. Lin,1 Chih-Chien Sung,1 Min-hua Tseng,2 1Tri-Service General Hospital, Taipei, Taiwan; 2Chang Gung Memorial Hospital, Tao-yang, Taiwan.

Background: Thyrotoxic periodic paralysis (TPP) characterized by acute weakness, hypokalemia and hyperthyroidism is a medical emergency with a great challenge in early diagnosis since most TPP patients do not have overt symptoms. Since both hypokalemia and hyperthyroidism in TPP significantly affect the cardiovascular system, electrocardiography (ECG) as a prompt and non-invasive bedside tool universally used in the ED may detect these electrical changes. To assess artificial intelligence (AI)-assisted electrocardiography (ECC) combined with routine laboratory data in the early diagnosis of TPP.

Methods: A deep learning model (DLM) based on ECG12Net, an 8-layer convolutional neural network, was constructed to detect hypokalemia and hyperthyroidism. The development cohort consisted of 39 ECCs from patients with TPP and 502 ECCs of hypokalemic control; the validation cohort consisted of 11 ECCs of TPP and 36 ECCs of non-TPP with weakness. The AI-ECC based TPP diagnostic process was then consecutively evaluated in 22 male patients with TPP-like features. Results: In the validation cohort, the DLM-based ECC system detected all cases of hypokalemia in TPP patients with a mean absolute error of 0.26 meq/L and diagnosed TPP with an area under curve (AUC) of ~80%, surpassing the best standard ECG parameter (AUC=0.725 for the QR interval). Combining the AI predictions with the estimated glomerular filtration rate (eGFR) and serum chloride (CT) boosted the diagnostic accuracy of the algorithm to AUC 0.986. In the prospective study, our AI ECG system achieved perfect performance (F-measure 100%) on the task of hypokalemia detection in them and the integrated AI with routine laboratory had a PPV of 100% and F-measure 87.5% for TPP diagnosis.

Conclusions: AI-ECC system reliably identifies hypokalemia in patients with paralysis and its integration with routine blood chemistries provides valuable decision support for the early diagnosis of TPP to avoid life-threatening complication.

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Will the Real Sodium Stand Up!
Nia Fleming, Michael Basir, Ro-Kaye A. Simmonds, Latoya N. Gayle, Zachary Banbury, Deborah A. Fein. Englewood Health, Englewood, NJ.

Introduction: Hyponatremia is a common finding as it could be precipitated by multiple factors ranging from medications to simple dehydration. Accuracy approach to management depends on assessing serum osmolality in an effort to distinguish cases of true, factitious or pseudohyponatremia. We present a case of hyponatremia secondary to hyperlipidemia.

Case Description: 36 year old Asian woman with HTN, Type 2 DM, HLD presented with 1 day of epigastric pain. On exam S1, S2 were heard with vesicular breath sounds throughout, epigastric tenderness and no focal neurological deficits. Initial labs: sodium 114 potassium 3.5 chloride 85 glucose 254, BHB 3.7. Sodium corrected for glucose 116 CO2, BUN, Cr and AG were incalculable. Urinalysis: pH 6.0, ketones +160, glucose >1000, protein >1000. Total cholesterol 1020, HDL 25, Triglycerides >5600, LDL incalculable, serum osmolality 314, lipase 57. Venous blood gas: 7.37/30.1/94.8/17.8, sodium 82. VBG 132 Abdominal ultrasound revealed a normal pancreas with hepatic steatosis. She was treated in ICU with normal saline, insulin infusion, isosapent ethyl and gemfibrozil. Abdominal pain resolved and insulin was changed to Glargine. Over three days triglycerides trended down to 1744 and sodium to 132. She was discharged on isosapent ethyl, gemfibrozil, atorvastatin, glargine, metformin and lisinopril, with a sodium of 132.

Discussion: Sodium is most commonly measured by indirect potentiometric (ISE) measurement. By this method serum specimens are diluted based on estimated typical balance of serum to solid blood components. By this method factitious low sodium results are known to occur in patients with significantly elevated lipids and protein. As in this case, direct sodium measured by VBG/AGB are most accurate. Typically markedly elevated serum triglyceride with concentrations>1500 mg/dl are thought to be responsible for factitious hyponatremia. In our patient the value of serum sodium on admission was unexpectedly low at 114 and severe hypercholesterolemia may have contributed. Applying the following formula to correct for triglycerides = Measured Na+ Plasma triglycerides (g/L) x 0.002; measured serum sodium would have been expected to be 125 meq. In cases of extremely high lipids, one must consider lab techniques for measuring serum sodium, as well as full lipid panel in the evaluation and treatment of factitious hyponatremia.

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Admission Sodium and Related Features to Predict Falls in Machine Learning Models
Alexander S. Leidner,1 Biruth Workeneh,2 Bing Ho.1 1Northwestern University Feinberg School of Medicine, Chicago, IL; 2The University of Texas MD Anderson Cancer Center, Houston, TX.

Background: Hyponatremia has been associated with an increased risk for falls, but evidence is primarily limited to outpatient events. Hyponatremia is a potential surrogate of conditions that may lead to falling including volume depletion, malignancy, pain, polypharmacy, and weakness. We hypothesized that a model could be developed to predict falls based upon accessible variables present on all hospital admissions. An accurate model could allow for measures to lower in-hospital falls.

Methods: Medical records from a single institution were collected over a period of 2011 to 2019. Subjects included admitted patients who suffered a recorded in-hospital fall and were admitted, and controls matched for admission on the same date. Variables collected include sodium, glucose, age and gender. There were 17,103 patients total of which 1,203 had unique falls. Data was split into an 80% training, 20% validation and 20% testing split. We computed an unadjusted odds ratio of falls for those with very low sodium (<126). We trained logistic regression, random forest, XGBoosted forest, and neural net classifiers. Classifier cutoff was calculated using Youden values.

Results: We did not see an increased incidence of falls in the population with a low sodium (N=377) with an unadjusted odds ratio of 0.62 (CI 0.38-1.01). Similarly, the model performances did not result in clinically useful predictions with a unanimously high false positive and false negative rates (Figure 1).

Conclusions: Despite reports of hyponatremia as an indicator of fall risk we did not observe this. The fall-prediction models did have the capacity for high performance on the training data, but this does not translate to validated performance. This discrepancy is termed ‘overfitting’ and is important to evaluate as machine learning models have a large cancer capacity than traditional models to incorporate previously seen examples. If a model cannot make predictions on new data it cannot be clinically useful. These models may be enhanced using other basic admission features and is the subject of future work.

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Association of Serum Sodium Levels with Bone Mineral Density, Fracture, and Mortality in Patients Undergoing Maintenance Hemodialysis
Kensuke Sode,1 Hirotaka Komaba,1 Yosuke Nakagawa,1 Takehiro Wada,2 Takatoshi Kakita,2 Masafumi Fukagawa.1 1Tokai Daigaku, Hiraizuka, Japan; 2Tokai Daigaku Igakubu Fuzoku Hachioji Byoin, Hachioji, Japan.

Background: Hyponatremia is implicated in pathological bone resorption and has been identified as a risk factor for bone fracture in the general population, but limited data exist in patients undergoing dialysis.

Methods: We analyzed a historical cohort of 2,292 patients undergoing maintenance hemodialysis in Japan. We first examined the association of baseline serum sodium levels with metacarpal bone mineral density (BMD) in a subgroup of 456 patients with available data. Next, we examined the association of baseline serum sodium levels with incident fracture and mortality in the overall cohort, using Cox regression models adjusted for potential confounders (age, sex, dialysis vintage, diabetes, prior cardiovascular disease, history of fracture, body mass index, hemoglobin, albumin, and creatinine) and competing risks regression models accounting for death as a competing endpoint.

Results: Baseline mean ± SD serum sodium level in the overall cohort was 139.7 ± 2.9 mg/dL, and among patients with available data, median metacarpal BMD T-score was -2.05 (IQR, -3.35 to -0.99). Serum sodium levels were not associated with metacarpal BMD T-score in unadjusted or adjusted models. During a median follow-up of 5.4 years (IQR, 2.5-7.0 years), 712 patients died; 113 experienced clinical fractures; and 64 experienced asymptomatic vertebral fractures as estimated by height loss. In addition, Cox proportional hazards regression models were associated with metacarpal BMD T-score (HR, 0.95 per 1 mg/dL higher; 95% CI, 0.92-0.98) but not incident clinical fracture (HR, 0.97 per 1 mg/dL higher; 95% CI, 0.90-1.04) or any fracture (a composite of clinical fracture and vertebral fracture). Similar results were obtained in competing risks regression models.

Conclusions: Serum sodium levels were associated with mortality but not BMD or incident fracture in maintenance hemodialysis patients.