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The effects of preoperative hyponatremia on left ventricular ejection fraction and relation with clinical outcomes

Preoperatif hiponatreminin sol ventrikül ejeksiyon fraksiyonu üzerine etkileri ve klinik sonuçlarla ilişkisi

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Abstract

Aim: In this study, we aim to investigate the relation between preoperative serum sodium levels and postoperative clinical follow-up; moreover, to compare the left ventricular ejection fraction increment in hyponatremic and normonatremic cases. Herein, we present one-year results of our clinic in open cardiac surgery performed patients.

Materials and Methods: This is a retrospective study of cases who underwent open cardiac surgery between February 2014-2015 in our clinic. Transplantation assist device implanted cases and hemodialysis receiving patients by reason of chronic renal failure were excluded.

Patients were divided into two groups according to blood serum sodium levels on admission day as normonatremic (135–145 mEq/L) or hyponatremic <135 mEq/L. The demographic characteristics of the patients, duration of intubation and length of intensive care unit (ICU) stay, need for inotropic support, mediastinal drainage amount, alteration in left ventricular ejection fraction (LVEF), intraaortic balloon pump (IABP) usage ratio, occurrence of acute renal failure, cardiopulmonary bypass time, cross clamping time and differences in clinical outcomes were examined.

Results: Hyponatremia was observed in 31,3% of patients and those had higher NYHA classification score. There was no statistical difference between groups in LVEF alteration was determined (p=0.756). Postoperative duration of intubation (p=0.003), need of blood products transfusion(p=0.033), vasoactive inotropic support (p=0.021) and postoperative amount of drainage was statistically higher in hyponatremic cases surplus(p=0.018). Peroperatively, both aortic cross clamping time (p=0.018) and cardiopulmonary bypass durations (p=0.026) were higher in hyponatremic group. Furthermore, postoperative mortality was also significantly higher (p=0.001).

Conclusion: We suggest that being hyponatremic has a prognostic importance in patients who undergo open cardiac surgery.

Keywords: Hyponatremia, ejection fraction, open heart surgery.

Öz

Amaç: *Bu çalışmamızda preoperatif serum sodyum değeri ile postoperatif klinik durum arasındaki ilişkiyi saptamayı ve hiponatremik hastaların operasyon sonrasında sol ventrikül ejeksiyon fraksiyonundaki artışın normonatremik olgularla karşılaştırmayı amaçladık.*

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Gereç ve Yöntem: *Şubat 2014 – 2015 tarihleri arasında kliniğimize başvuran ve açık kalp cerrahisi operasyonu olan, transplantasyon, yapay kalp implantasyonu yapılan olgular ve hemodiyaliz gerektiren kronik böbrek yetmezlik olguları dışındaki tüm hastalar çalışmamıza dahil edildi. Hastalar kan serum sodyum değerlerine göre operasyon öncesi iki gruba ayrıldı. Demografik veriler, entübasyon süreleri, yoğun bakım süreleri, inotrop kullanımı, oluşan komplikasyonlar, sol ventrikül ejeksiyon fraksiyonu değişimi, intraaortik balon pompası kullanımı, kardiyopulmoner baypas süreleri, kross klemp süreleri ve klinik sonuçlar arasındaki fark değerlendirildi.*

Bulgular: *Hiponatreminin postoperatif EF değişimi üzerine etkisi saptanmamıştır. Olguların serum sodyum değerine göre NYHA sınıflaması karşılaştırıldığında olguların hiponatremik hastalarda yüksek NYHA sınıfında olma arasında anlamlı fark saptanmıştır. Hiponatremik grupta postoperatif dönemde entübasyon süreleri, kullanılan kan ürünü ve postop drenaj miktarı anlamlı derecede fazladır. Hiponatremik hastalarda postoperatif akut böbrek yetmezliği görülme sıkılığı artmıştır. Hiponatremik hastalarda postoperatif mortalite oranları anlamlı derecede yüksektir.*

Sonuç: *Çalışmamızda preoperatif hiponatreminin, kalp cerrahisi hastalarında prognostik önemi olduğunu düşünmekteyiz.*

Anahtar Sözcükler: *Hiponatremi, ejeksiyon fraksiyonu, açık kalp cerrahisi.*

Introduction

Hyponatremia is a frequently detected electrolyte disorder and is associated with increased mortality in general population (1). Especially it's one of the most common finding in heart failure and related to severity of ventricular dysfunction. Previous studies have shown that hyponatremia worsen outcomes in patients with heart failure, myocardial infarction, pulmonary arterial hypertension, and pulmonary embolism (2, 3). Preoperative hyponatremia is prevalent in candidates' patients for cardiac surgery and known as an independent risk factor for postoperative complications, long term hospitality and mortality (3).]Also left ventricular dysfunction is accepted as an independent risk factor (4, 5).

Therefore, in this study, we aim to assess the relation between preoperative sodium (Na) value and postoperative clinical follow-up; moreover, to compare the postoperative left ventricular ejection fraction increment between hyponatremic and normonatremic cases.

Materials and Methods

The study was compiled in accordance with the principles of Declaration of Helsinki and conducted with an ethical committee approval of Dokuz Eylül University Medical Faculty (Date: 13/02/2014 Protocol Nr: 1350-GOA and Judgment No:2014/06-05)

Herein, we retrospectively evaluated a total of 128 patients (77 males, 51 females; median age 62.5 range 23 to 85) between February 2014-2015 in our clinic who underwent open cardiac surgery for various indications. Pediatric cases and the patients receiving hemodialysis for of chronic renal failure and heart transplanted or assist device implanted patients were excepted. Six cases were operated off-pump and one case was operated on-pump without aortic cross clamping. Sternal approach or cannulation methods were not calculated separately. The protocols were performed by six different surgeons.

Patients were divided into two groups according to level of serum sodium (sNa). Hyponatremia was defined on admission as sNa concentration below 135 mEq/L. Normonatremic values were in range between 135-145 mEq/L. There was no measurement above 145 mEq/L among patients, thus hypernatremia could not be examined. Postoperatively no measurement was above 145 mEq/L among patients. Control echocardiography were examined after discharge in first three months.

All required data were obtained from the hospital records. As a routine in preoperative preparation all prespecified data including preoperative sNa values, creatinine, LVEF measurements, BNP levels and postoperative inotrope or blood product need, amount of drainage, IABP requirement, etc. were previously recorded. Types of surgery (valve replacement, coronary grafting, tubular graft interpositioning, etc) and cross clamping, surgical procedure time additively cardiopulmonary bypass time were also noted.

Primary objectives of this study were to investigate the impact of how being hyponatremic, preoperatively effects on hospital mortality, morbidity and clinical outcomes in intensive care unit compared to normonatremic cases. Secondary objectives include to assess postoperative LVEF alteration, amount of drainage, need of blood product and vasoactive inotrope score, IABP necessity ratio and changes in prespecified surgical timings.

Statistical analysis

Statistical software SPSS 16.0 was used for acquired data. Data were described as mean ± standard deviation (SD). For analysis of quantitative data between the groups, normally distributed data were analyzed using the Student t-test, while abnormally distributed data were analyzed using the Mann-Whitney U test. Intergroup comparison of normally distributed variables was done using the paired-samples t-test. The Pearson and Spearman correlation analyses were used to evaluate the intervariable relationship. Less than 0.05 p values were considered statistically significant.

Results

A total of 128 patients were evaluated. median age was 62.5±13.2 years with 71 males (%60.2). Patients were divided into two groups according to serum sodium levels. When compared there was no significant difference in distribution except for chronic renal failure incidence. Hyponatremia was noted in 40 (30.2%) patients with median sodium 128 mEq/L (IQR 118-134) versus 138 mmol/L (IQR 135–143) in normonatremic patients (p<0.001) As expected, patients with hyponatremia were more likely to have more severe symptoms (New York Heart Association (NYHA) Functional Class IV; %0.8 vs. %0.8 p<0.001) All demographic and clinical characteristics of the cohorts are detailed in Table-1**.**

Table-1. Presentation of demographics in two groups

	Total n=128	**Hyponatremia (<135mEq/L) n=40 (%30.2)**	**Normonatremia (<135mEq/L) n=88 (%69.8)**	P
Age	62.5±13.2	62.58±13.58	61.55±12.07	0.389
Gender	51F, 77M	12F, 28M	39F, 51M	0.494
BMI, kg/m^2	28.6±4.5	28.1±4.0	28.8±4.7	0.421
Diabetes	14 (%10.9)	5 (%3.9)	9 (%7)	0.103
Arterial Hypertension	10 (%7.8)	4 (%3.1)	6 (%4.7)	0.356
Chronic Renal Failure	5 (%3.8)	2 (%1.5)	3 (%2.3)	0.003
NYHA Class				
I	6 (%4.7)	1 (%0.8)	5 (%3.9)	0.013
II	87 (%70.2)	24 (%18.8)	53 (%51.4)	0.005
III	33 (%25.7)	14 (%10.9)	19 (%14.8)	0.108
IV	2 (%1.6)	1 (%0.8)	1 (%0.8)	<0.001
Preop. EF%	50.52±10.96	50.38±11.79	50.65±10.41	0.855
SBP, mmHg	129 (105-180)	132 (110-180)	127 (105-165)	0.073
DBP, mmHg	76(45-110)	74(45-110)	80 (50-105)	0.052
Sodium	134 (118-143)	129 (118-134)	138 (135-143)	<0.001
Potassium	4.5±0.5	4.5±0.9	4.4±0.7	0.227
Creatinine	1.07±1.05	1.24±1.03	1.00±1.06	0.458
GFR	78 (6-133)	72 (8-133)	81 (6-220)	0.197
BNP	814±685	1.890±1.281	705±533	0.849

Table-2. Variety of surgical procedures

	Total	Hyponatremia	Normonatremia
AVR	14 (%10.9)	5 (%3.9)	9 (%7)
AVR+CABG	1 (%0.8)	-	1 (%0.8)
AVR +MVR	5 (%3.9)	1 (%0.8)	4 (%3.1)
BENTHALL	3 (%2.3)	1 (%0.8)	2 (%1.5)
CABG*	76 (%59.4)	24 (%18.8)	52 (%50.6)
CABG+ MR	1 (%0.8)	-	1 (%0.8)
MVR	17 (%13.3)	6 (%4.7)	9 (%8.9)
MVR +CABG	2 (%1.6)	1 (%0.8)	1 (%0.8)
MVR +TP	4 (%3.1)	1 (%0.8)	3 (%2.3)
MVR+ TVR	2 (%1.6)	-	2 (%1.5)
TUBULAR GRAFT	2 (%1.6)	-	2 (%1.5)
TVR**	1 (%0.8)	-	1 (%0.8)
	128(%100)	40 (%31.3)	88 (%68.7)

* In six cases off-pump cabg procedure was performed

** Surgical technique is performed without cross clamping

Table-3. Comparison of postoperative alteration in clinical parameters

	Total n=109	Hyponatremia n=27 (40)	Normonatremia n=82 (88)	P
ICU duration (day)	6.68 (1-80)	11.4 (2-80)	5.8 (1-26)	0.038
Drainage (ml)	594.4 (100-2300)	626.3 (200-2300)	570.2 (100-1600)	0.018
Inotrope support	108 (%87.4)	36 (%90)	76 (%59.4)	0.021
Cross clamp (min.)	68.2 (20-169)	71.9* (28-156)	66.4 (20-169)	0.026
CPB time (min.)	114.3 (46-212)	121.6 (53-212)	110.7 (46-219)	0.018
EF%	50.52±10.96	50.52±10.96	50.52±10.96	0.914
EF alteration	-0.92 (-25/30)	-1.85 (-25/15)	-0.68 (-20/30)	0.756
Blood product (unit)	5.32 (3-25)	6.31 (4-25)	4.94 (3-21)	0.033
Intubation time (hour)	3.18 (1-60)	5.55 (1-60)	2.12 (1-15)	0.003
IABP	7+1 Ecmo	5+1 Ecmo	2	0.002
Acute renal failure occurance	10 (%8)	7 (%5.6)	3 (%2.4)	0.004
Mortality	19 (%14.2)	13 (%11.4)	6 (%4.8)	<0.001

Various types of open cardiac procedures have been performed: More than half of the patients were CABG cases, where 6 of them were off-pump procedures. One case received tricuspid valve replacement without aortic cross clamping. Median sternotomy was general route of access, but different incisions were also performed for redo or minimally invasive surgery. Distribution of surgical protocols are shown below (Table-2)**.**

When peroperative measures compared between groups both cross clamping (p=0.018) and cardiopulmonary bypass timing (p=0.026) were higher in hyponatremic group. All evaluated clinical outcomes are listed and compared in Table-3**.**

In addition to ICU, cardiovascular support necessity in hyponatremic group was distinctly higher. Only two IABP were placed in normonatremic group on contrary to five IABP and one ECMO in hyponatremic group (p=0.002). Moreover, need for blood products transfusion was statistically higher in hyponatremic group (p=0.033). Vasoactive inotropic support need difference was significantly higher in study group (p=0.021). Duration of intubation was statistically higher in hyponatremic group (p=0.003). Amount of drainage was also higher in hyponatremic group (p=0.003). Occurrence of acute renal failure was statistically significant in study group (p=0.004)

All investigated parameters in the ICU were higher; as expected, Length of stay in the ICU was also longer in hyponatremic group (p=0.038). Mortality rate was higher in hyponatremic group and it was statistically significant (p=0.001)

Despite all, after discharge from ICU, the differences between the results of measured EF values in three months were statically no significant (p=0.914). Therefore, alteration in EF values was also similar (p=756).

Discussion

In most patients, hyponatremia was mild to moderate and asymptomatic. Nausea, vomiting, headache, loss of appetite, lethargy, fatigue, apathy, disorientation, fainting, agitation, muscle cramps and convulsions are the main symptoms. Hyponatremia is associated with heart failure and left ventricular dysfunction. In our study, we aimed to evaluate the relationship between postoperative morbidity and mortality in preoperative hyponatremic patients and the effect of hyponatremia on postoperative left ventricular EF.

Since hyponatremia causes an increase in morbidity and mortality rates in cardiac operations, it is necessary to follow closely and carefully the serum sodium values before and after surgical intervention. Routine blood values and ejection fraction determined with TTE are assessed together before surgery and necessary interventions are made. Morbidity and mortality rates are tried to be reduced.

In a study on 500 patients who are admitted to intensive care unit after cardiac surgery, Polderman et al. (6)[1] found hyponatremia at six percent of the patients. They found that electrolyte imbalances cause increased urinary excretion, intraoperative hypothermia and intracellular shift due to extracorporeal circulation (6, 7). But they didn't evaluate the relationship between hyponatremia and patient characteristics.

Henry Thomas Stelfox et al. (8) evaluated the frequency of both hyponatremia and hypernatremia in intensive care unit patients undergoing cardiac surgery, related factors and outcomes. It has been found that the frequent occurrence of hyponatremia and hypernatremia in intensive care unit is significantly related to the demographic and clinical characteristics of the patients and is associated with increased mortality.

In a study by Crestenello et al. (9), preoperative hyponatremia was found to be twice as frequent in patients with low EF as in patients with normal EF. There was no significant relation between serum sodium levels and EF (10). They found that preoperative hyponatremia increased the rates of postoperative complications and mortality and long-term survival rates were found to be lower in patients with normal and low EF. It has been observed that preoperative hyponatremia increases mortality in patients with normal EF (4). In our study, there was no relationship between preoperative serum sodium value and changes in EF.

İn the same study Crestenello et al. (4) evaluated the severity of heart failure due to NYHA classification. Compared to normonatremic patients, hyponatremic patients had higher rates of NYHA Class 3 and 4 symptoms independent of EF. Therefore, preoperative hyponatremia was more correlated with cardiac insufficiency than EF.

OPTIMIZED-Hfregistery study evaluated 47000 patients admitted to hospital due to heart failure. This study showed that coexistence of

hyponatremia and left ventricular disfunction increased the hospital mortality rates, hospitalization time, recurrent hospital admission due to heart failure and long term mortality compared to hyponatremia only (3). In our study we only evaluated the relation between hyponatremia and mortality which we found significant.

Conclusion

In this study the effect of hyponatremia on postoperative morbidity, complications and mortality is evaluated. Preoperative hyponatremia in patients undergoing open heart surgery is an important parameter that should be taken into consideration in preoperative evaluation because of increasing postoperative morbidity and mortality. In our study, postoperative intubation times, postoperative blood product use, postoperative drainage, postoperative acute renal failure and postoperative mortality were found to be closely related to preoperative hyponatremia.

Limitations

The present study inherits all the limitations of retrospective studies. The utilized data depends on accuracy of hospital records. Moreover, normonatremic group included more than twofold patients compared to study group. On the other hand, distribution of various surgical protocols was not similar between groups; besides performed by different surgical teams. Further randomized, prospective studies should be done on this subject to determine advanced results.

Declaration of conflicting interests

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