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Prognosis Impact of Postoperative Dysnatremia in Cardiac Surgery under Extracorporeal Circulation

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Dysnatremias have several particular aspects concerning their etiology and evolution. They are associated with morbidity and mortality in various clinical contexts.
The Primary aim of our study is to evaluate the prognosis impact of postoperative dysnatremia in cardiac surgery under extracorporeal circulation.
Methods: This is a descriptive and analytical retrospective study, concerning patients operated for a period of 18 months between September 2018 and February 2020 in the cardiovascular surgery department at the Mohammed V Military teaching hospital in Rabat, and including 253 adult patients.
The bioassay of plasma sodium was done immediately, at 4, 24 and 48 hours after admission to the intensive care unit.

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Results: The average age of the patients was 56 years with male predominance. Fifty-seven patients (22.5%) presented at least hypernatremia and 30 patients (11.9%) at least hyponatremia. The overall mortality rate was 7.9%. 17.5% when hypernatremia.
Conclusion: The level of plasma sodium after admission to intensive care is an independent predictor of morbidity and mortality during cardiac surgery under extracorporeal circulation. Hypernatremia is an alarm signal that requires rapid and effective management to avoid progression to serious complications.

Keywords: Prognosis; dysnatremia; cardiac surgery; extracorporeal circulation.

1. INTRODUCTION

Natremia is the main determinant of extracellular osmolarity and therefore of hydration and cell volume [1].

It is normally between 136 and 145 mmol/l or mEq/l [2].

During heart surgery, extracorporeal circulation is a support technique that provokes a systemic inflammatory response responsible for several hydro-electrolyte disorders including dysnatremia.

The involvement of dysnatremia in the morbidity and mortality of patients operated for cardiac surgery under extracorporeal circulation, and the specific mechanisms responsible for it remain unclear [3,4].

The aim of our study is to evaluate the prognosis impact of postoperative dysnatremia in cardiac surgery under extracorporeal circulation.

2. METHODS

This is a descriptive and analytical retrospective study, carried out within the cardiovascular surgery department of the Mohamed V Military teaching hospital of Rabat over a period of 18 months between September 2018 and February 2020.

We included 253 patients over 18 years of age in whom plasma sodium levels were assayed before and after scheduled or emergent cardiac surgery under extracorporeal circulation.

We excluded from our study patients aged under 18, those with preoperative dysnatremia or those who died intraoperatively.

We collected clinical, biological and radiological data.

Preoperative medication management was done according to the guidelines [5].

Intraoperative monitoring for all patients consists of Electrocardiogram, Noninvasive blood pressure, Pulse oximetry, arterial line, central venous pressure, capnography, Temperature, Diuresis, Activated clotting time, blood gazes [6,7,8].

Anesthetic induction was made by Fentanyl 3 µg / kg, Propofol 2 to 3 mg / kg or Etomidate 0.3 mg / kg and Cisatracurium 0.15 mg / kg or Rocuronium 0.6 mg / kg.

Anesthesia maintenance was done with TIVA of Propofol, Sevoflurane or Isoflurane.

Cephazolin 2g administered 30 minutes before the incision then at the fourth hour and maintained for 48 hours makes antibiotic prophylaxis.

All patients were operated by a median sternotomy.

Extracorporeal circulation is installed between an aortic cannula and an atrio-caval venous cannula, in the event of aortic valve surgery or coronary surgery, or two superior and inferior vena cava cannulas in other cases.

Before inserting the cannulas, a bolus of heparin at a dose of 300 IU/kg was given with an ACT target of more than 400 seconds.

After aortic clamping, myocardial protection is ensured by crystalloid cardioplegia or anterograde intermittent cold blood administered by the root of the aorta until cardiac arrest and then repeated every 25 to 30 minutes as well as local cooling with a solution ice flowed into the pericardium.

Exit from extracorporeal circulation is done after slowly warming the patient to reach a core temperature of 36°C.

Exit from the extracorporeal circulation can be simple with spontaneous defibrillation, or difficult requiring an internal electric shock, and sometimes the use of inotropic and/or vasoactive drugs, antiarrhythmics or even assistance with intra-aortic balloon pump (IABP).

Heparin was antagonized by an initial dose of protamine sulphate at a dose of 1mg for each 100 IU of heparin administered.

Bleeding is prevented by administering tranexamic acid at a dose of 15 to 30 mg/kg before and after injection of protamine.

The duration of the aortic clamping, the duration of the extracorporeal circulation and the duration of the surgical intervention as well as the postoperative hemodynamics were collected.

Postoperatively, all patients were admitted to intensive care unit.

Plasma natremia was assayed preoperatively and postoperatively at H0, H4, H24 and H48. The normal value for plasma sodium is taken to be a level between 136 and 145 mmol/l.

Patients are divided into three groups according to the value of serum sodium:

G1: Group of patients with normal natremia,
G2: Group of patients with hyponatremia.
G3: Group of patients with hypernatremia.

The variables studied postoperatively are:

- Cardiovascular, respiratory, renal, neurological, infectious and haematological complications (postoperative bleeding > 100ml/h for 3 hours or use of a blood transfusion).
- Overall morbidity: defined by the occurrence of one or more complications.
- Surgical revision.
- Length of stay in intensive care and hospital stay.
- Mortality: Defined by death occurring during the 30 days following surgery.

Data entry and statistical analysis was performed using SPSS 20.0 software.

The quantitative variables are expressed as mean and standard deviation in the case of a Gaussian distribution and as median and quartiles in the case of a non-Gaussian distribution and the qualitative variables in counts and percentages.

The comparison of demographic and perioperative variables was made by parametric or non-parametric tests depending on the distribution of the variable.

A value of P <0.05 was taken as statistically significant.

3. RESULTS

Two hundred fifty three patients were included in our study, the average age is 56 years (18-83) with a sex ratio of 2/1 (M/F), BMI>25 kg/m2 in 80% of patients.

Postoperatively, 30 patients presented at least hyponatremia (11.9%), 57 at least hypernatremia (22.5%) and 166 patients did not present dysnatremia (65.6%).

Table 1 summarizes the demographics of patients in the three groups.

There was no significant difference between the three groups of patients regarding demographics.

Table 1. Patient demographics

Variables	Normonatremia Group N=166	Hyponatremia Group N=30	Hypernatremia Group N=57	*p*
Age	55±13	53±13	58±11	0.239
Sex				
Males	106 (63.9%)	21 (70%)	37(64.9%)	0.810
Femelle	60 (36.1%)	9 (30%)	20(35.1%)	0.379
BMI ≥ 25	26.2 ± 4	26.4 ± 5.4	25.9 ± 3	0.784
HT	48 (28.9%)	7 (23.3%)	16(28.1%)	0.822
Diabetes	44 (26.5%)	7 (23.3%)	17(29.8%)	0.405
Smoking	56 (33.7%)	16 (53.3%)	22(38.6%)	0.120
AF	39 (23.5%)	39 (23.5%)	18(31.6%)	0.377

BMI: Body Mass Index HT: Hypertension AF: Atrial Fibrillation

Table 2 summarizes the paraclinical characteristics of the patients.

There was no significant difference between the three groups of patients regarding paraclinical characteristics.

Cardiogenic shock, myocardial infarction, tamponade and cardiac arrhythmias was the most common postoperative complications.

Renal and respiratory failures (pneumonia, ARDS) came in second place.

25 patients required blood transfusion and five presented lower limb ischemia.

The average stay in intensive care was 48 hours (39-72) and the hospital stay lasted 11 days (10-14) on average.

20 patients died with a mortality rate of 7.9%.

Table 3 summarizes the perioperative patients' data in the three groups:

Table 2. The paraclinical characteristics of the patients

Variables	Normonatremia Group N=166	Hyponatremia Group N=30	Hypernatremia Group N=57	*p*
CTR	0.54±0.07	0.54±0.04	0.55±0.06	0.875
LVEF (<40%)	11(6.6%)	2(6.6%)	7(12.3%)	0.401
Hemoglobin (g/dl)	12 [10.8-13]	13.4 [11.2-14.9]	13 [11.7-14.1]	0.926
WBC (x1000/µl)	17 [12.2-21.3]	8.5 [6.1-10.3]	7.4 [5.7-8.4]	0.09
CRP (mg/l)	4.1 [1.5-1]	3.7 [1.2-6.4]	4 [1.4-7.2]	0.758
Creatinine (mg/ml)	10 [8-115]	9 [8-11]	8.5 [7-10]	0.32
Urea (mmol/l)	0.38 [0.3-0.5]	0.34 [0.3-0.41]	0.37 [0.3-0.4]	0.56
GFR (ml/min/1,73m2)	74 [60-88]	77 [61-91]	75 [66-85.5]	0.729

CTR: Cadio-Thoracic Ratio; LVEF: Left Ventricular Ejection Fraction; WBC: White Blood Cells; CRP: C Reactive Protein; GFR: Glomerular Filtration Rate

Table 3. Perioperative patients' data

Variables	Normonatremia Group N=166	Hyponatremia Group N=30	Hypernatremia Group N=57	*p*
ECC Time (min)	121[98-153]	127[107-162]	170[124-240]	<0,001
Aortic clamping time (min)	83[69-112]	95[72-128]	124[87-149]	<0,001
Vasoactive Drugs	108(65%)	22(23,3%)	43(75,4%)	0,986
Type of surgery				
CABG	85(51,2%)	18(6%)	30(52,6%)	0,674
Valve Replacement	67(40,4%)	6(20%)	15(26,3%)	0,031
Combined	6(3,6%)	1(3,3%)	8(14%)	0,010
Ventilation time (h)	5[4-8]	6[5-12]	15[5-20]	<0,001
ICU Stay (h)	48[36-71]	48[43-68]	68[44-134]	0,010
Bleeding(>1000cc)	14(8,4%)	4(13,3%)	7(12,2%)	0,560
Acute Renal failure	20(12%)	7(23,3%)	10(17,6%)	0,309
Stroke	1(0,6%)	1(3,2%)	3(5,3%)	0,015
Pneumonia	1(0,6%)	2(6,7%)	4(7%)	0,014
Wound infection	13(7,8%)	1(3,3%)	7(12,3%)	0,025
Hospital Stay(d)	11[9-14]	11[9-14]	12[10-15]	0,096
Death	9(5,4%)	1(3,3%)	10(17,5%)	<0,001

ECC: extracorporeal circulation CABG: Coronary Artery Bypass Grafting ICU: Intensive Care Unit (h): hour (d): day (cc): cubic centimetre

The mortality rate was significantly higher in the Hypernatremia group.

4. DISCUSSION

Sodium is an extracellular ion and its plasma concentration determines the movement of water between intracellular and extracellular fluids [9-11].

Dysnatremias are the most common electrolyte disturbance in patients admitted to the Intensive Care Units [12–13].

The use of extracorporeal circulation (ECC) is essential in the majority of cardiac surgery procedures.

A systemic inflammatory response is often produced in patients undergoing cardiac surgery under ECC, leading to an imbalance in osmotic regulation and increased morbidity and mortality [14].

Hyponatremia is a common electrolyte disorder in patients in the intensive care unit after cardiac surgery, it may be due to increased blood volume, neuroendocrine dysfunction or low cardiac output and is associated with serious complications [15-16].

Hypernatremia always leads to plasma hypertonia and therefore intracellular dehydration [17-18] few studies have reported that elevated sodium levels after cardiac surgery under ECC can be explained by the high use of diuretics, and by hypoxia [19].

The ischemia-reperfusion process during ECC, generates an intracellular accumulation of Na+ Caused by acidosis and the exchange of H + / Na +; and the influx of Calcium via the Na+/Ca2+ channels [20,21].

Furthermore, a high plasma sodium level may be due to acute hypoxemia, which would have reducing the concentration of aldosterone and secondarily that of plasma renin. Sudden reactivation of renin and the angiotensin aldosterone system causes sodium retention [22].

Few studies have assessed the incidence and impact of dysnatremia on patients operated for cardiac surgery under ECC, but several have assessed the incidence of postoperative dysnatremia in intensive care units [23,24].

Tables 4 and 5 show the incidence of dysnatremia according to studies in the literature.

Nicolini and al. [25] proved that the duration of mechanical ventilation in the hypernatremia group was longer than in the normal and low sodium groups. Ditto for the stay in intensive care which was 4.37 [2-6] days compared to 3.68 [1-5] days in the hyponatremia group and 2.77 ± 1.9 in the normonatremia group (P <0.001). However, the mortality rate was much higher in the hypernatremia group (29.6%) vs 10.3% in the case of hyponatremia and 5.4% in the normal group. (P<0.001).

Linder and al. [26] found in their study of 2314 patients that patients with hypernatremia had a longer stay in intensive care and a higher mortality rate.

Waite and al. found the same results in their study [27] carried out on a large population of 207,702 patients.

Table 4. Incidence of hypornatremia according to studies in the literature

Study	Study Type	Natremia threshold (mmol/l)	ICU Type	Population (N)	Hyponatremia incidence (%)
Stelfox et al. [28]	Retrospective	<133	Medico-Surgical	8 142	11%
Sakr Y et al. [29]	Retrospective	<135	Surgical	10 923	11,2%
Gucytemez et al [30]	Retrospective	135-130 130-125 <125	Surgical	1244	25% 6,7% 3%
Nicolini et al. [25]	Retrospective	<135	Surgical	1599	9,6%
Our Study	Retrospective	<136	Surgical	253	11,9%

Table 5. Incidence of hypernatremia according to studies in the literature

Study	Study type	Natremia threshold (mmol/l)	ICU Type	Population (N)	Hypernatremia Incidence (%)
Stelfox et al.	Retrospective	>145	Medico-surgical	8 142	26%
Darmon et al. [31]	Retrospective	>145	Surgical	8 140	15,3%
Waite et al. [27]	Retrospective	>149	Surgical	207 702	4,3%
Gucytemez et al	Retrospective	145-150 150-155 >155	Surgical	1244	3, 3% 1,3% 0,6%
Alansari et al [32]	Retrospective	>145	Surgical	864	5,8%
Nicolini et al	Retrospective	>145	Surgical	1599	5%
Our study	Retrospective	>145	Surgical	253	22,5%

Gucytemez and al. [30] studied the correlation between the severity of dysnatremia and the poor postoperative prognosis of patients admitted to the ICU and found that patients with severe hypernatremia >150 mmol/l had a mortality rate of 100% compared to the group moderate hypernatremia (57.1%) and borderline hypernatremia (25.7%).

In parallel with the studies cited, the average duration of mechanical ventilation, the length of stay in intensive care, in the hypernatremia group were longer compared to the other groups in our study.

The mortality rate was much higher in the hypernatremia group with 17.5% vs 5.4% in the normal group and only 3.3% in the hyponatremia group, with a statistically significant difference. (P<0.001).

Thus, the data of our study were able to prove that hypernatremia is a predictive factor of morbidity and mortality in the postoperative period of cardiac surgery under ECC.

Table 6 summarizes the demographic and postoperative parameters in the studies of the literature in case of hypernatremia.

Among the limitations of our study we can cite: The small number of patients, the retrospective and unicentric nature of the study as well as the dosage of natremia which was limited to the first 48 hours postoperatively.

Thus, close monitoring of serum sodium, as well as the conduct of therapeutic strategies aimed at early normalization of serum sodium levels can improve the prognosis of patients after cardiac surgery under ECC.

Table 6. Demographic and postoperative parameters according to studies in cases of hypernatremia

Study	Nicolini and al. (n=81)	Stelfox and al. (n=2157)	Gucytemez and al. (56)			Our study (n=57)
			HyperNa limit	HyperNa Moderate	HyperNa strict	
Age (years)	64,5±15	60	62	62	65	58±11
Male (%)	18	60	68,6	71,4	42,9	64,9
Mechanical Ventilation (hours)	18	16	---	---	---	15[5-20]
Vasoactive Drugs (%)	56,8	38	---	---	---	54,4
ICU Stay (days)	4,37[2-6]	7[4-13]	2	6,5	6	3[1,8-5,5]
Mortality (%)	29,6	23	25,7	57,1	100	17,5

5. CONCLUSION

Extracorporeal circulation in the context of cardiac surgery risks causing severe hydro-electrolyte disorders.

Dysnatremia in the postoperative period of cardiac surgery can have a variable incidence depending on the studies.

In our study, the mortality rate in case of hypernatremia was the highest (17.5%) consistent with data from the literature.

Close monitoring of serum sodium, as well as the conduct of therapeutic strategies aimed at early normalization of serum sodium levels can improve the prognosis of patients after cardiac surgery under extracorporeal circulation.

CONSENT

It is not applicable

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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