A STUDY ON ETIOLOGY AND CLINICAL OUTCOME OF HYPONATREMIA PATIENTS ADMITTED IN ICU IN TIRUNELVELI MEDICAL COLLEGE HOSPITAL

DISSERTATION SUBMITTED TO THE TAMILNADU

DR.M.G.R. MEDICAL UNIVERSITY, CHENNAI

In partial fulfilment of the requirements for the degree of

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DEPARTMENT OF GENERAL MEDICINE

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MAY-2023

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I hereby certify that this dissertation entitled **"A STUDY ON ETIOLOGY AND CLINICAL OUTCOME OF HYPONATREMIA PATIENTS ADMITTED IN ICU IN TIRUNELVELI MEDICAL COLLEGE HOSPITAL"** is a record of work done by **Dr. M.RAMESH ARAVINDH**, in the Department of General Medicine, Tirunelveli Medical College, Tirunelveli, during her postgraduate degree course period from 2020-2023. This work has not formed the basis for previous award of any degree.

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I solemnly declare that the dissertation entitled **"A STUDY ON ETIOLOGY AND CLINICAL OUTCOME OF HYPONATREMIA PATIENTS ADMITTED IN ICU IN TIRUNELVELI MEDICAL COLLEGE HOSPITAL"** is done by me at Tirunelveli Medical College Hospital, Tirunelveli under the guidance and supervision of **Prof. Dr. ALAGESAN, M.D.D.M** The dissertation is submitted to The Tamilnadu Dr. M.G.R. Medical University towards the partial fulfilment of requirements for the award of M.D. Degree (Branch I) in General Medicine.

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THE FOLLOWING DOCUMENTS WERE REVIEWED AND APPROVED

1.	TIREC Application Form	☐
2.	Study Protocol	☐
3.	Department Research Committee Approval	☐
4.	Patient Information Document and Consent Form in English and Vernacular Language	☐
5.	Investigator's Brochure	☐
6.	Proposed Methods for Patient Accrual Proposed	☐
7.	Curriculum Vitae of The Principal Investigator	☐
8.	Insurance /Compensation Policy	☐
9.	Investigator's Agreement with Sponsor	☐
10.	Investigator's Undertaking	☐
11.	DCGI/DGFT approval	☐
12.	Clinical Trial Agreement (CTA)	☐
13.	Memorandum of Understanding (MOU)/Material Transfer Agreement (MTA)	☐
14.	Clinical Trials Registry-India (CTRI) Registration	☐

THE PROTOCOL IS APPROVED IN ITS PRESENTED FORM ON THE FOLLOWING CONDITIONS

1. The approval is valid for a period of 2 year/s or duration of project whichever is later
2. The date of commencement of study should be informed
3. A written request should be submitted 3weeks before for renewal / extension of The validity
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Member Secretary, TIREC
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CERTIFICATE – II

This is to certify that this dissertation work entitled **"A STUDY ON ETIOLOGY AND CLINICAL OUTCOME OF HYPONATREMIA PATIENTS ADMITTED IN ICU IN TIRUNELVELI MEDICAL COLLEGE HOSPITAL"**of the candidate **Dr. M.RAMESH ARAVINDH** with registration Number **200120104014** for the award of **M.D.** Degree in the branch of **GENERAL MEDICINE (I).** I personally verified the urkund.com website for the purpose of plagiarism check. I found that the uploaded thesis file contains from introduction to conclusion page and result shows **8 percentage** of plagiarism in the dissertation.

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1 INTRODUCTION

The main cation in extracellular fluid is sodium. One of the most prevalent abnormalities of electrolyte metabolism among patients admitted to hospitals at any given moment is hyponatremia. A blood sodium content of less than 135 meq/l is referred to as hyponatremia. Severe hyponatraemia is a plasma sodium content that is less than 125 (sometimes 115) mmol/liter. (1,2)

Only pathologic conditions, such as severe adrenal insufficiency, sodium-losing kidney disease, extensive burns, chronic diarrhoea, uncontrollable vomiting, excessive and protracted sweating, diabetic ketoacidosis, excessive diuretic use, or continuous gastric suction, can cause a disorder of true sodium and water depletion. (3,4)

The clinical presentation covers a broad spectrum, with individuals ranging from being asymptomatic at one end to experiencing seizures and being in a coma at the other. The majority of the symptoms are neurological.(5) In up to 22% of hospitalised patients, hyponatraemia occurs as an electrolyte anomaly, with daily frequency and prevalence rates of 0.97% and 2.48%, respectively.(1,6)

There are three levels of hyponatremia: mild, moderate, and severe. (Mild - Na values meq/L 130–135; Moderate - Na values meq/L 125–129; Severe - Na values meq/L 125.) The percentages of hospitalised patients with mild to moderate hyponatremia and severe hyponatremia were 15–30% and 1–4%, respectively..(5)

Hyponatraemia is classified diagnostically into three categories based on the clinical history and volume status.

i. Hypo-volumic hyponatraemia.

ii. Euvolemic hyponatraemia.

iii. Hyper-voluemic hyponatraemia.(7)

On Pathophysiological basis, hyponatremias are classified into two groups: hyponatremia due to non-osmotic causes leading to increased secretion of vasopressin (can be hypovolemic, hypovolemic, euvolemic) and hyponatremia without the increase in vasopressin origin (pseudo hyponatremia, intoxication of water, cerebral salt wasting syndrome). (5)

Hyponatremia may negatively impact a variety of physiologic processes and organ systems. (8) Severe hyponatremia (Na 125 mmol/L) on ICU admission was suggested to be an independent predictor predicting hospital mortality. (2) Hyponatraemia is clinically significant despite the fact that the majority of cases are mild and largely symptom-free. This is because:

i. acute severe hyponatraemia can cause significant illness and death;

ii. mortality is higher in patients with hyponatraemia who have a wide range of underlying diseases; and

iii. overly rapid correction of chronic hyponatraemia can result in severe neurological deficit and mortality.(9)

Need for the study / Justification of the study:

This common disorder remains poorly understood in many basic aspects, because of its connection with a plethora of underlying disease conditions, and its numerous aetiologies with differing pathophysiological conditions. Heart failure, hepatic cirrhosis, and nephritic

syndrome are among the potential diagnoses for hyponatremia with an increased ECF volume and decreased effective circulatory volume.(10) Without addressing this problem carefully and methodically, the prognostic implications of the problem are lethal and far-reaching.(11)

Early recognition of hyponatremia and appropriate intervention would improve the outcome. Therefore this study aims to study the aetiology, clinical presentation and associated factors of hyponatremia in patients admitted in Intensive Care Medical Unit. The understanding of the clinical presentation will help in prevention, early identification and appropriate management of the hyponatremia.

2 AIM AND OBJECTIVES

2.1 **AIM:**

To study the aetiology, clinical presentation, outcomes and associated factors of hyponatremia in patients admitted in Intensive Care Medical Unit. The understanding of the clinical presentation will help in prevention, early identification and appropriate management of the hyponatremia.

2.2 **OBJECTIVES:**

I. Primary Objectives:

To determine the aetiology of True hyponatremia in patients admitted in Intensive Care Medical Unit.

To determine clinical presentation of hyponatremia in patients admitted in Intensive Care Medical Unit.

II. Secondary Objectives:

To assess the morbidity and mortality associated with hyponatremia.

To study various diseases and comorbidities associated with hyponatremia.

3 REVIEW OF LITERATURE

Review of Literature of this study on aetiology, clinical presentation and associated factors of hyponatremia in patients, is discussed under the following heads:

a. Sodium-Metabolism
    i. Functions of sodium
    ii. Aldosterone Feedback Loop
    iii. Renin Angiotensin Aldosterone (RAA Axis) system
    iv. Renal handling of Sodium
    v. Na/K-ATPase Pump
    vi. Recommended Dietary Intake
b. Hyponatremia
    i. Metabolism of Sodium
    ii. Renin Angiotensin Aldosterone system and Regulation of Sodium
    iii. Hyponatremia
    iv. Drugs causing Hyponatremia
    v. Pathophysiology of Hyponatremia
    vi. Symptoms of Hyponatremia
    vii. Management of hyponatremia
c. Similar studies in the same topic

a. Metabolism of Sodium:

All living things require sodium, which is provided through food through salt, which is chemically Sodium-Chloride. (3) Sodium is essential for maintaining blood volume, fluid volume, osmotic equilibrium, blood pressure, pH level, and appropriate nerve and muscle contraction in addition to playing a critical part in fluid and electrolyte balance management. (12–14)

Functions of Sodium:

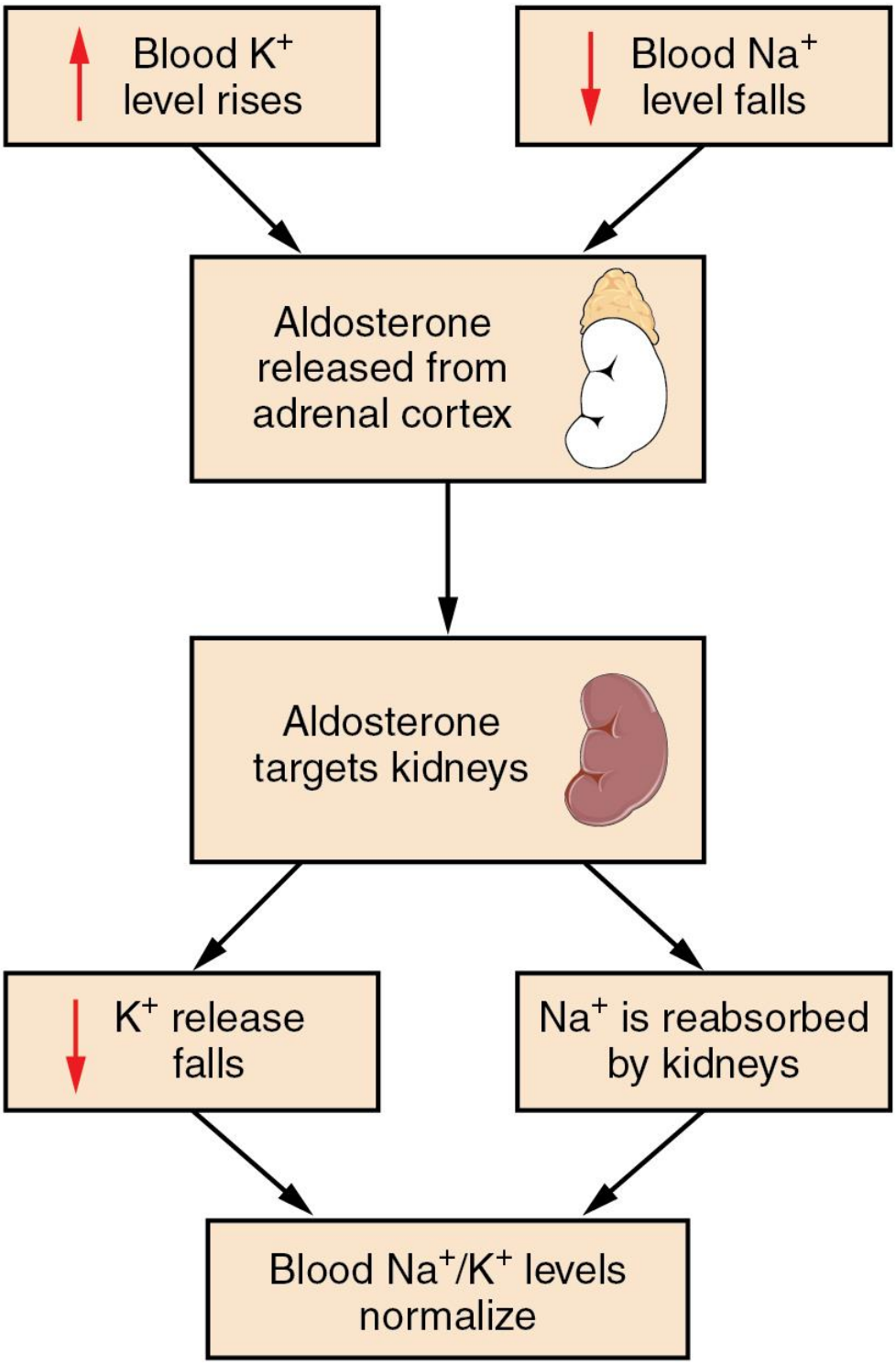
The important functions of Sodium include the following:

i. Nutrition absorption and transport (absorption of chloride, amino acids, glucose, and water)
ii. Maintenance of membrane potential.
iii. Blood volume and blood pressure maintenance I.e., sodium plays a significant role as component of extracellular fluid. Through the renin-angiotensin-aldosterone system, anti-diuretic hormone, and dopaminergic system, this is accomplished. (12–14)

Aldosterone Feedback Loop:

The following figure illustrates the Aldosterone Feedback Loop. (Aldosterone, hormone which is released by the adrenal gland, facilitates reabsorption of Sodium ion (Na+) and thus the reabsorption of water.)(15)

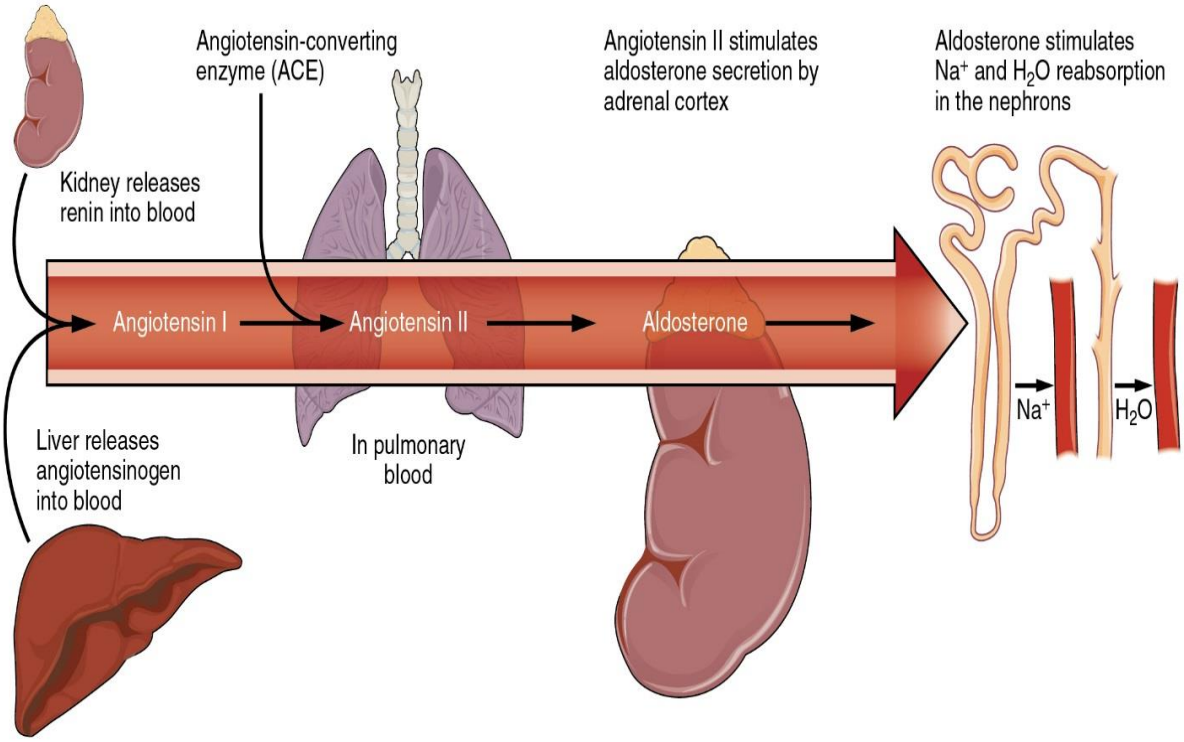
Figure 1.Aldosterone Feedback Loop:



Renin Angiotensin Aldosterone system:

Aldosterone, a hormone secreted by the adrenal gland, aids in the reabsorption of Na+ and subsequently the reabsorption of water, which is crucial for controlling the amount of sodium in the blood. (15) The Renin-Angiotensin System is depicted in the following figure, (Angiotensin II promotes the adrenal cortex's release of aldosterone.)(15)

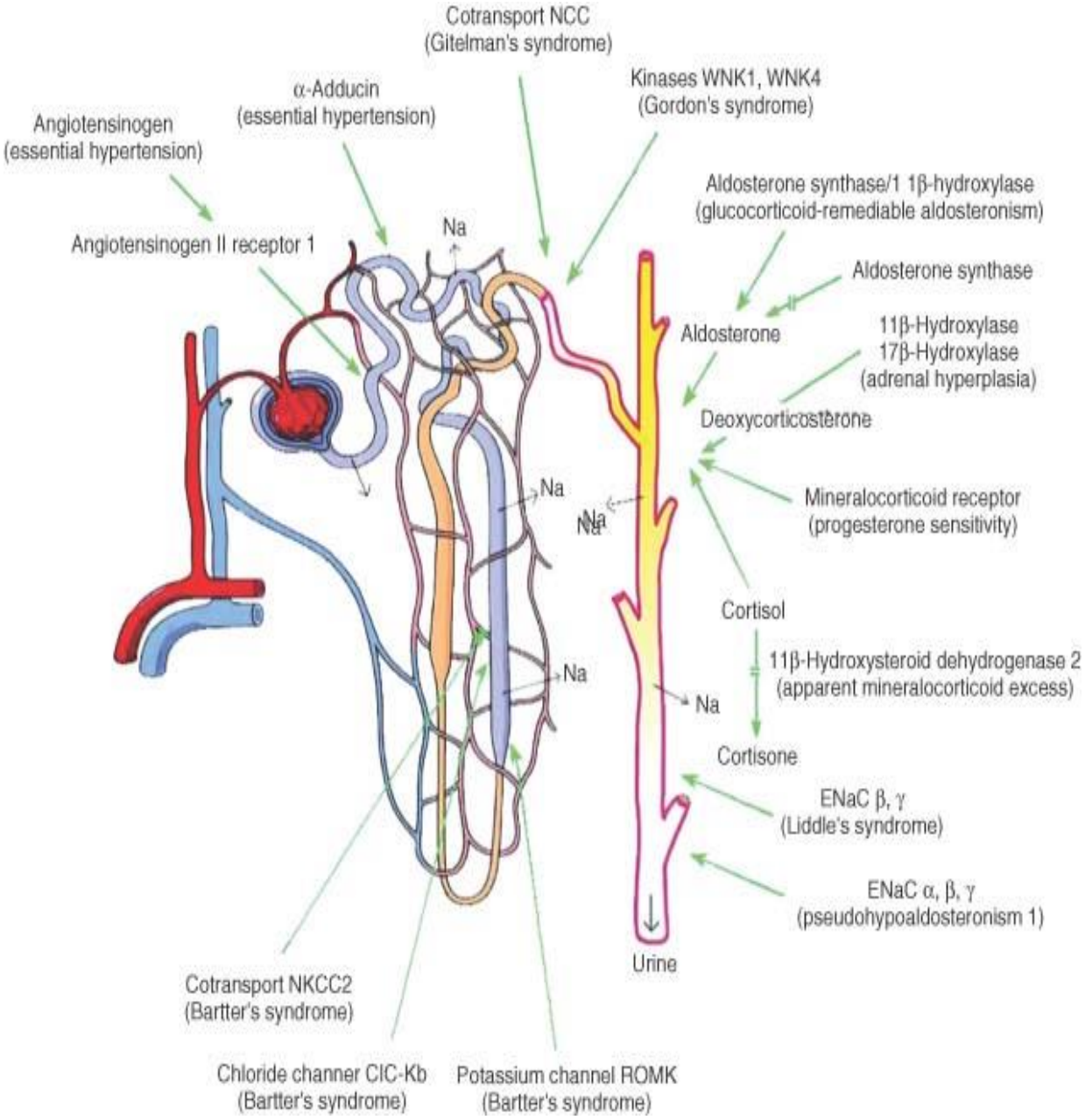
Figure 2.Renin-Angiotensin System:



Renal handling of Sodium:

The following illustration shows how sodium is handled by the kidneys. The two main mechanisms for sodium reabsorption are sodium/proton exchange (HNE1) thyroid hormone driven and sodium/phosphate uptake ("SLC34 (type II)"). caused by glucocorticoid hormones. (3)

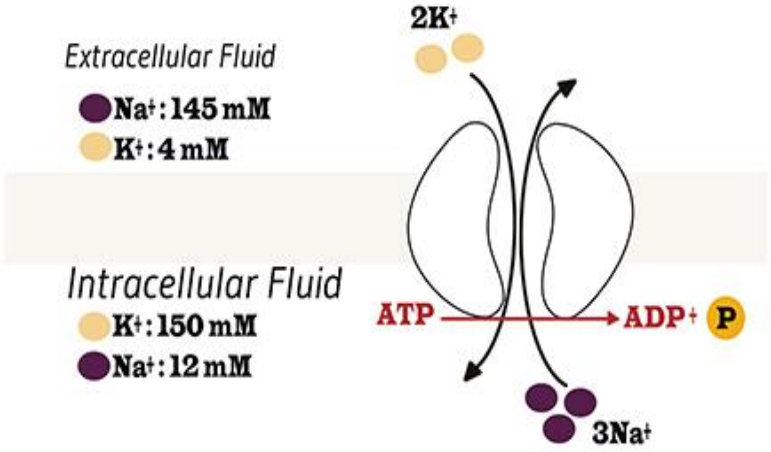
Figure 3.*Renal* ***handling*** *of Sodium*

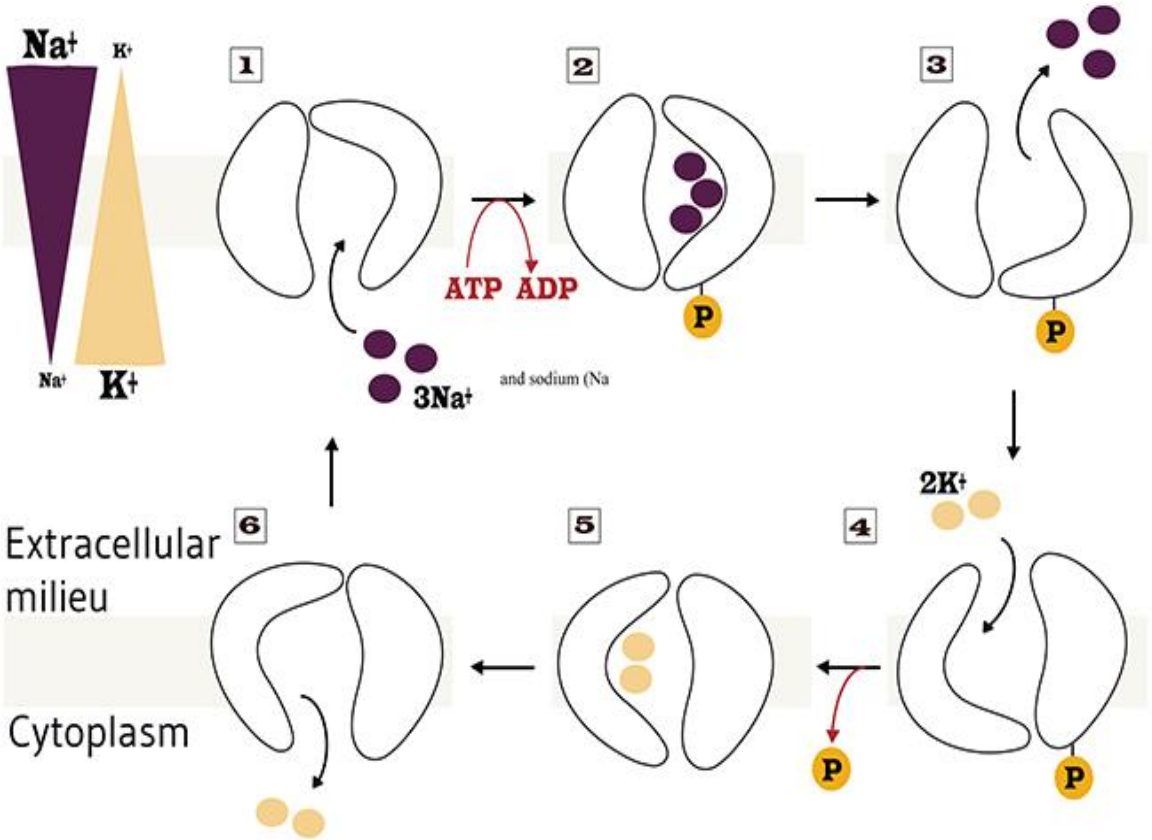


Na/K ATPase Pump:

The Simplified Na/K ATPase Pump Model is shown in the graphic below. (The ATPase enzyme is a solute pump that pumps sodium outside of cells while pumping potassium within, both of which go against the gradients of their concentrations) This pumping is active (i.e. the process requires energy through ATP), (16)

Figure 4.Simplified model of Na/K ATPase Pump:





Recommended Dietary Intake:

The National Academy of Medicine in the United States advised individuals to consume 1.5 grammes (g) of sodium per day, or 3.8 grammes of sodium chloride (common salt), in 2019. An key cause of hypertension, which in turn creates a preventable risk factor for cardiovascular disease, is an excessive intake of dietary sodium. Additional negative health effects, such as osteoporosis, kidney stones, and stomach cancer, have also been linked to excessive dietary sodium intake.(17) An average 70-kg person has a total sodium level of about 4,200 mmol (100 g), of which almost 40% is found in bone and the remaining 60% in the fluid both inside and outside of cells. (18)

b. Hyponatremia:

Increased fluid retention (dilution-hyponatremia) or increased sodium loss from the body may be the causes of hyponatremia, which is defined as a serum-sodium concentration (Na+) more than 135mmol/litre. The following are some examples of mild gradual hyponatremia's clinical symptoms,

i. Nausea,
ii. Vomiting,
iii. Headache,
iv. Easy fatigability,
v. Cramps in muscle.(19,20)

Complications of severe and rapidly emerging hyponatremia may include the following,

i. Cerebral oedema,
ii. Coma,
iii. Seizures,

iv. Unconsciousness

v. Permanent brain damage. (21–23)

Acute or severe hyponatremia may result in death of the individual without prompt identification and appropriate medical management of the condition.(24)

Chronic and mild hyponatremia has been linked to gait and attention problems, a higher risk of falling, a loss of bone density, and a higher risk of fractures, mostly in women and the elderly. (19,20) The following list represents the adverse effects associated with the chronic excessive intake of Sodium:

I. Hypertension. (25–31)

II. Kidney stones. (32)

III. Gastric Cancer. (33)

IV. Endothelial dysfunction. (34–38)

V. Cardiovascular mortality and morbidity. (39,40)

VI. Osteoporosis. (41)

Drugs resulting in Hyponatremia:

The following table illustrates the list of drugs that are involved in causing the increased risk of hyponatremia among the patients.(14,42)

Table 1.Medications that induces the Risk of Hyponatremia:

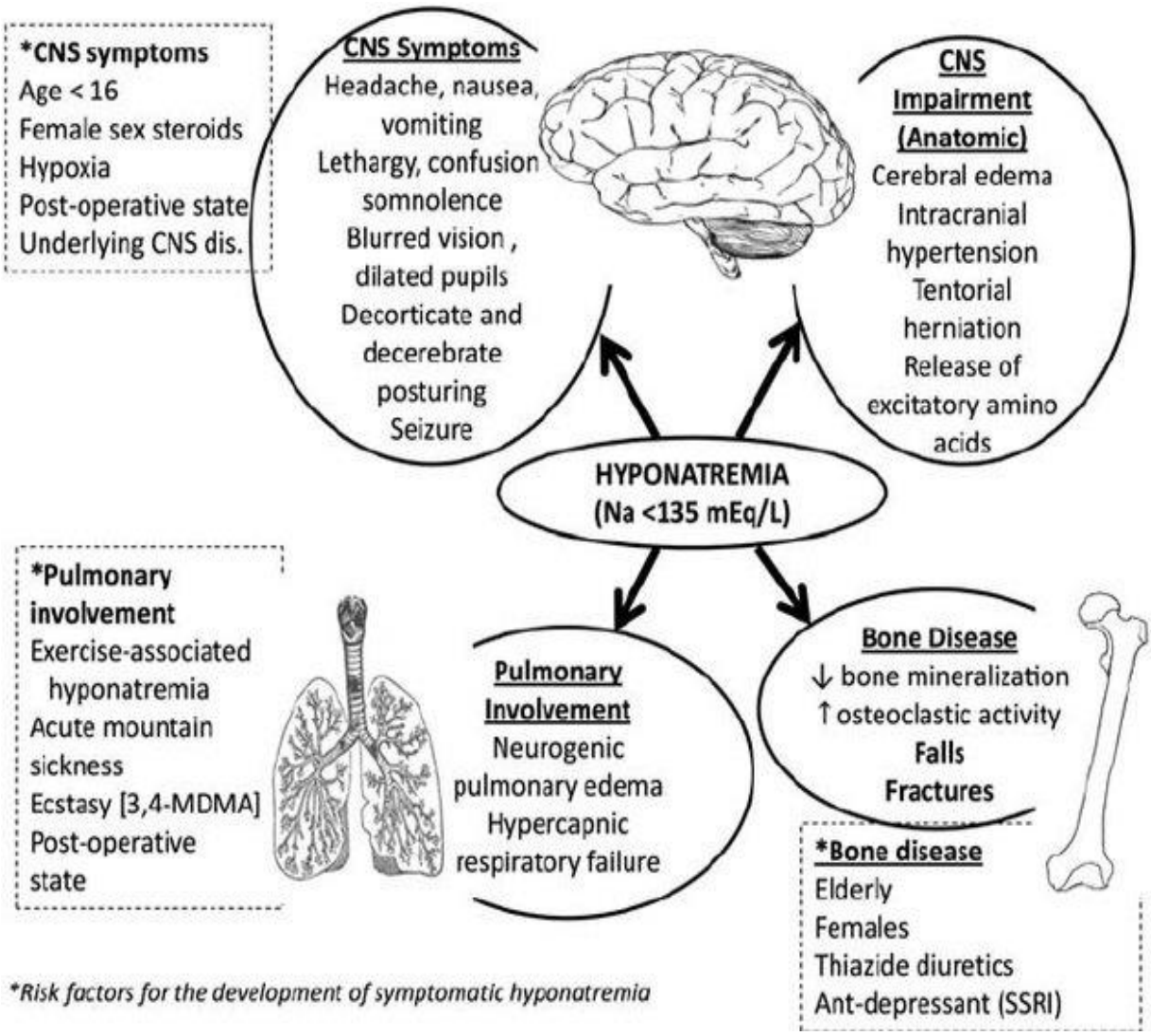
Medication Family	Examples
Diuretics	Hydrochlorothiazide, Furosemide (Lasix)
Non-steroidal anti-inflammatory drugs (NSAIDs)	Ibuprofen (Advil, Motrin), Naproxen sodium (Aleve)
Opiate derivatives	Codeine, Morphine
Phenothiazines	Prochlorperazine (Compazine), Promethazine (Phenergan)
Serotonin-reuptake inhibitors (SSRIs)	Fluoxetine (Prozac), Paroxetine (Paxil)
Tricyclic antidepressants	Amitriptyline (Elavil), Imipramine (Tofranil)

Individual Medications Associated with Hyponatremia
Carbamazepine (Tegretol)
Chlorpropamide (Diabinese)
Clofibrate (Atromid-S)
Cyclophosphamide (Cytoxan)
Desmopressin (DDAVP; nasal or oral)
Lamotrigine (Lamictal)
Oxytocin (Pitocin)
Vincristine (Oncovin)

Pathophysiology of hyponatremia:

The next picture shows an overview of the pathophysiology of hyponatremia, including risk factors, symptoms, and indicators in various organs.(43)

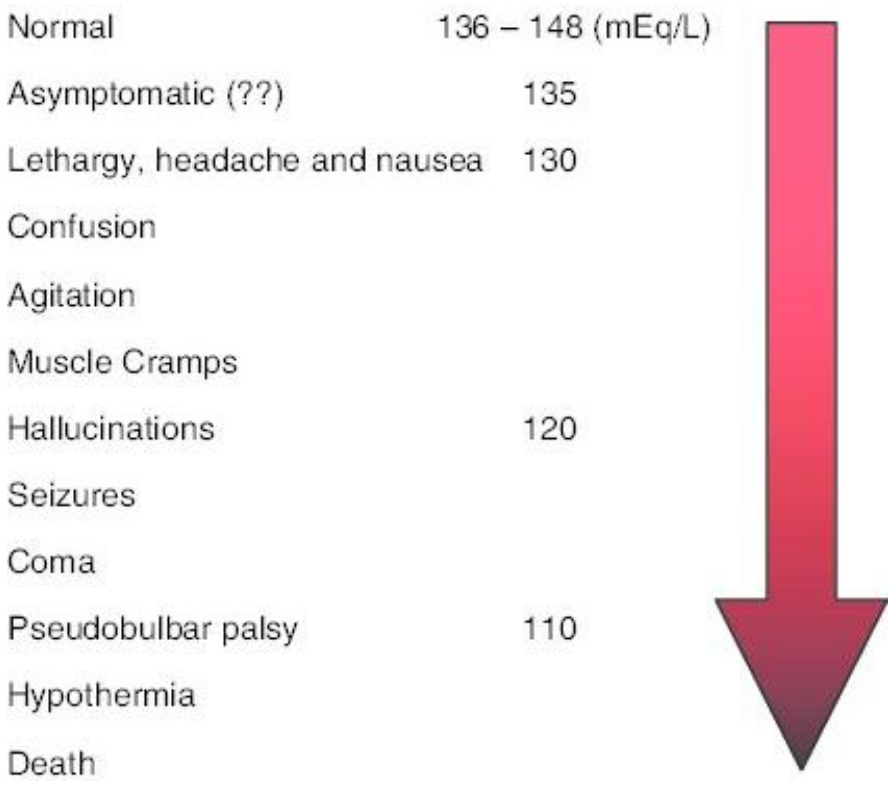
Figure 5.Pathophysiology of hyponatremia:



Symptoms of hyponatremia:

The following image represents the symptoms of hyponatremia approximated with the reducing levels of serum sodium,(44)

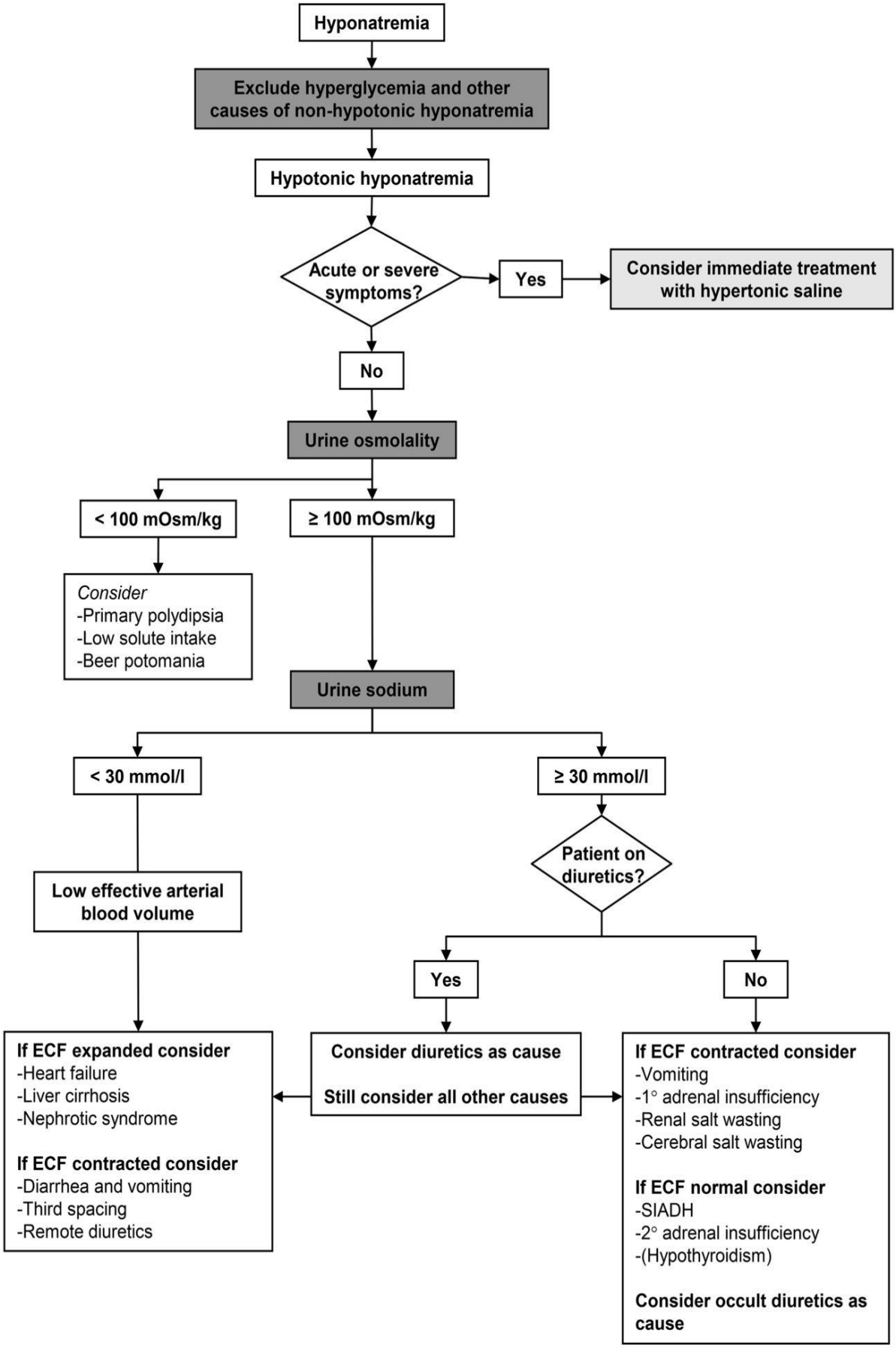
Figure 6.Symptoms of Hyponatremia:



Algorithm for approaching hyponatremia:

The algorithm for treating patients who come with hyponatremia is shown in the accompanying graphic. (The initial stage in assessing hyponatremia is taking a patient's history. The clinician's primary responsibility comes after determining the plasma osmolality: determining the bodily fluid state. The FENa computation aids in the final diagnosis assessment. (45)

Figure 7.Algorithm for approaching the patients with hyponatremia


Hyponatremia
Exclude hyperglycemia and other causes of non-hypotonic hyponatremia
Hypotonic hyponatremia
Acute or severe symptoms?
Yes
Consider immediate treatment with hypertonic saline
No
Urine osmolality
< 100 mOsm/kg
≥ 100 mOsm/kg
Consider
-Primary polydipsia
-Low solute intake
-Beer potomania
Urine sodium
< 30 mmol/l
≥ 30 mmol/l
Low effective arterial blood volume
Patient on diuretics?
Yes
No
If ECF expanded consider
-Heart failure
-Liver cirrhosis
-Nephrotic syndrome
If ECF contracted consider
-Diarrhea and vomiting
-Third spacing
-Remote diuretics
Consider diuretics as cause
Still consider all other causes
If ECF contracted consider
-Vomiting
-1° adrenal insufficiency
-Renal salt wasting
-Cerebral salt wasting
If ECF normal consider
-SIADH
-2° adrenal insufficiency
-(Hypothyroidism)
Consider occult diuretics as cause

Formula for infusion of Sodium:

The following table illustrates the Formulas required to calculate the effect of infusions and fluid losses on [Na+]:(8)

Table 2.Formula for Sodium infusion

Infusate Formula	Fluid-Loss Formula
$\Delta[Na^+]_s = \frac{[Na^+ + K^+]_{inf} - [Na^+]_s}{TBW + 1}$	$\Delta[Na^+]_s = \frac{[Na^+]_s - [Na^+ + K^+]_{fl}}{TBW - 1}$
Projects the effect of gaining 1 L of any infusate (inf) on the patient's $[Na^+]_s$	Projects the effect of losing 1 L of any fluid (fl) on the patient's $[Na^+]_s$

Treatment Guidelines:

The following table illustrates the management of hyponatremia with the specific conditions and therapy.(46)

Table 3.Management of Hyponatremia Summary:

Condition	Therapy
Acute or symptomatic hyponatremia	• Severe symptoms: Bolus 3% saline 100 mL x 3 as needed • Moderate symptoms: Continuous infusion 3% saline 0.5-2 mL/kg/hour
Chronic hyponatremia Syndrome of inappropriate antidiuretic hormone secretion	• Fluid restriction (first-line) • Loops, diuretics, urea, vaptans, salt tablets, demeclocycline (second-line)
Hypovolemic hyponatremia	• Isotronic saline or balanced crystalloids solutions
Hypervolemic hyponatremia	• Fluid restrictions, loop diuretics
Sodium correction rates	• Minimum: 4-8 mmol/L/day, 4-6 mmol/L/day if high risk for osmotic demyelination syndrome (ODS) • Limits: 10-12 mmol/L/day, 8 mmol/L/day if high risk for ODS
Management of overcorrection	• Baseline SNA > 120 mmol/L: Start once limit of Na correction is exceeded • Baseline SNA < 120 mmol/L: Start relowering with electrolyte-free water (10 mL/kg) with or without desmopressin 2µg IV after correction exceeds 6-8

c. Similar studies in the same topic:

Chike M. Nzerue et al, from Georgia, did a Retrospective study, and studied the Predictors of outcomes among the 168 hospitalized patients suffering from severe hyponatremia (defined as Na< 115mmol/L). They observed that more than half of the patients (52.9%) were symptomatic. Mortality rate was high, with nearly one-fifth of the

patients expired. (20.2%). They further observed that Sepsis, respiratory failure/hypoxia and the presence of symptoms predicted poor outcomes among the hospitalized patients with severe hyponatremia.(47)

Marya D. Zilberberg et al, from USA, did a retrospective cohort study, and studied the Epidemiology, clinical and economic outcomes among the 198,281 hospitalized patients from 39 hospitals. They observed that the prevalence of hyponatremia was 5.5% (defined as Na< 135mmol/L). They observed that hyponatremia was independently associated with a 55 % increase in the risk of mortality and significantly increased hospital resource utilization and costs.(48)

Rahil A I et al, observed 53 adult patients with hyponatremia who were admitted to Hamad General Hospital in Qatar had their clinical profiles examined. They discovered that the most frequent cause of hyponatraemia in their investigation was extra-renal loss. Elderly people were more likely than younger people to have hyponatremia. There were no significant gender-related differences or similarities detected..(49)

Baran D et al, studied the Predictors of outcomes among the 78 hospitalized patients suffering from hyponatremia. They observed that more than half of the patients (54%) were asymptomatic. Mortality rate was high, with nearly one-fourth of the patients expired. (27%). They observed that hyponatremia was independently associated with a increased in the risk of mortality. (50)

Prakash Babaliche et al, from Belgaum, Karnataka, did a 1-year prospective cross-sectional observational study, and studied the Predictors of outcomes among the 100 hospitalized patients suffering from hyponatremia (defined as Na< 115mmol/L) in intensive medical care unit. They observed that Vomiting (28%) and disorientation (26%) were the two most typical presenting complaints with hyponatremia. The most frequent cause of

hyponatremia was syndrome of inappropriate antidiuretic hormone secretion (SIADH) (46%) and the most typical form of hyponatremia was euvolemic hypo osmolar hyponatremia (50%).(51)

Kanchana S Pillai et al, from Mumbai, did a cross-sectional observational study, and studied the Predictors of outcomes among the hospitalized patients suffering from hyponatremia. They observed that the prevalence of hyponatremia was 5.2% (defined as Na< 135mmol/L). Mortality rate was high, with more than one-third of the patients expired. (34.6%). The most common cause of hyponatremia was syndrome of inappropriate antidiuretic hormone secretion (SIADH). (52)

Funk GC et al, in Austria looked assessed the prevalence and outcome of hyponatremias among 151,486 persons hospitalised over a ten-year period (1998-2007). 24.6% of the patients in the ICU had hyponatremia. The frequencies of borderline hyponatremia (130 or = Na 135 mmol/L), mild hyponatremia (125 or = Na 130 mmol/L), and severe hyponatremia (Na 125 mmol/L), respectively, were 13.8%, 2.7%, and 1.2%.(2)

Waikar SS et al, examined the Mortality pattern of 98,411 adult patients with mild, moderate, and severe hyponatremia who were hospitalised from 2000 to 2003 at two teaching hospitals in Boston, Massachusetts. Approximately 14.5 percent of patients had hyponatremia (serum sodium concentration lesser than 135 mEq/L) at the time of the initial test. They discovered that individuals with hyponatremia had a greater risk of mortality while receiving medical care (odds ratio 1.47, with a 95% confidence interval of 1.33-1.62).. (11)

Mohan S et al, investigated the prevalence of hyponatremia and its relationship to mortality in 14,697 persons who were at least 18 years old. They discovered a frequency of hyponatremia was 1.72%. They came to the conclusion that, regardless of age, sex, or other

concomitant illnesses, hyponatremia is a prognostic predictor of death in the general population.(14)

Nandini Chatterjee et al, from March 2010 to April 2011, a descriptive study of hyponatremia levels was conducted in tertiary care hospital from Eastern India. 16.4% of the 201 individuals under study had serum Na levels lower than 135 meq/l. Patients with Euvolemic hyponatremia made up the majority of the study group (102; 50.74%), followed by individuals with hypervolemic (54; 26.86%) and hypovolemic (45; 22.4%) type of hyponatremias.(53)

4 RESEARCH QUESTION OR HYPOTHESIS

4.1 **RESEARCH QUESTION:**

What is the clinical profile of hyponatremia in patients admitted in ICU?

4.2 **NULL HYPOTHESIS:**

There is no relationship between the clinical profile and outcomes of hyponatremia in patients admitted in ICU.

4.3 **ALTERNATE HYPOTHESIS:**

There is a relationship between the clinical profile and outcomes of hyponatremia in patients admitted in ICU.

5 METHODOLOGY

5.1 **STUDY SUBJECTS:**

100 patients admitted in IMCU admitted under the Department of General Medicine, Tirunelveli Medical College, with serum sodium less than 135 mmol/L, during the 1 year study period who consent to participate in the study.

5.2 **STUDY DESIGN:**

Hospital based cross sectional study.

5.3 STUDY PERIOD:

Data collection – 1 year (January 2021 to December 2021).

5.4 **STUDY SETTING:**

Department of General Medicine, Tirunelveli Medical College.

5.5 **SAMPLING PROCEDURE:**

Universal Sampling.

5.6 **INCLUSION CRITERIA:**

- ✓ Both Gender
- ✓ >12 yrs of age
- ✓ Serum sodium level less than 135 mmol/L

5.7 **EXCLUSION CRITERIA:**

- ☒ Age less than 12 yrs,
- ☒ Pseudohyponatremia
- ☒ Refusal to participate.

5.8 **SAMPLE SIZE:**

According to **Chike M. Nzerue et al** study, (47)considering the prevalence of Mortality rate of hyponatremia as 20.2% with a precision of 7.88% and 95% confidence interval, the sample size is calculated as

$N = Z21\text{-}\alpha/2 * p * (1 - p) / d2$

Z1-α/2 - two tailed proabability for 95% confidence interval = 1.96

p (%) - prevalence of Mortality rate of hyponatremia = 0.202

d (%) - precision or allowable error for Mortality rate of hyponatremia = 0.0788

N = 1.96^2 * 0.202 * (1 - 0.202) / 0.0788^2

N = 99.72

Thus the total sample size required for the study is 100

5.9 **ETHICAL CONSIDERATION:**

Institutional Ethical Committee approval, from Tirunelveli Medical College, Tirunelveli, was obtained before the start of the study. Informed written consent was obtained.

Source of Funding: None declared

Conflict of Interest: None declared

5.10 **STUDY PROCEDURE:**

100 patients admitted in IMCU admitted under the Department of General Medicine, Tirunelveli Medical College, with serum sodium less than 135 mmol/L were screened with inclusion and exclusion criteria. After explaining the study procedure and purpose, Informed written consent was obtained from each of the participants. After the detailed history, thorough clinical examination, the following biochemical parameters are collected using a pre-structured proforma,

i. Serum sodium

ii. Serum potassium

iii. RBS

iv. LFT, TFT

v. Urea

vi. Creatinine

vii. Urine sodium, urine potassium

viii. Lipid profile.

5.11 BUDGET:

Self. (No additional investigation or intervention)

5.12 STATISTICAL METHODS:

I. Descriptive Statistics:

1. Numerical variables like Age, Serum and urine sodium, Serum and urine osmolaity, RBS, Urea, Creatinine etc., are represented in mean, SD, median, and mode. Histograms are used wherever necessary.
2. Categorical variables like gender, volume status, comorbidities, symptoms, causes of hyponatremia, outcomes etc., are represented in frequencies and percentages. Pie-charts and bar diagrams are used as appropriate.
3. Data was entered in MS excel sheet and analysed using SPSS software version 16.

II. Inferential Statistics:

1. When a Numerical variable is compared with the outcomes, Independent t test is used.
2. When a Categorical Variable is compared with the outcomes, the variables are represented in both by tables and bar diagrams. For test of significance, chi-square test is used.
3. P-values less than 0.05 were considered statistically significant.

6 RESULTS

Results of the study, on aetiology, clinical presentation and associated factors of hyponatremia in ICU patients is discussed under the following headings:

I. Age group

II. Gender

III. Volume Status

IV. Diabetes Mellitus

V. Hypertension

VI. Coronary Artery Disease

VII. Chronic Kidney Disease

VIII. Hypothyroidism

IX. Chronic Liver Disease

X. Headache

XI. Vomiting

XII. Diarrhoea

XIII. Muscle Cramps

XIV. Altered Sensorium

XV. Seizures

XVI. Diuretics

XVII. TFT

XVIII. Co-Syntropin Test

XIX. Cause of Hyponatremia

XX. Serum & Urine Sodium (Meq/L)

XXI. Serum & Urine Osmolality (Mosm/Kg)

XXII. Renal function tests

XXIII. Outcome

XXIV. Comparision of Age group with the Outcome

XXV. Comparision of Gender with the Outcome

XXVI. Comparision of Volume Status with the Outcome

XXVII. Comparision of Cause of Hyponatremia with the Outcome

XXVIII. Comparision of Comorbidities with the Outcome

XXIX. Comparision of Clinical profile with the Outcome

XXX. Comparision of TFT with the Outcome

XXXI. Comparision of Co-Syntropin Test with the Outcome

XXXII. Serum & Urinary Sodium (Meq/L) with Outcome

XXXIII. Serum & Urine Osmolality (Mosm/Kg) with Outcome

XXXIV. Renal function tests with Outcome

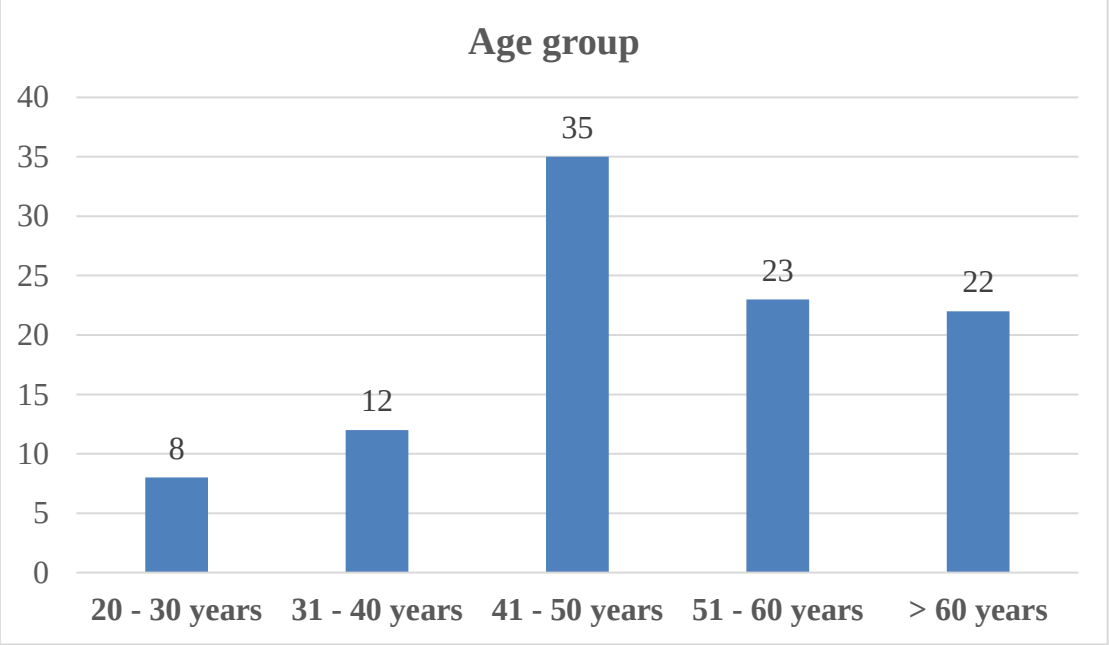
I. Age group

Among the subjects, 35 (35%) were in 41 - 50 years followed by 23 (23%) were in 51 - 60 years and least 8 (8%) were in 20 - 30 years.

Table 4. Age group

Age group	Frequency	Percent
20 - 30 years	8	8.00
31 - 40 years	12	12.00
41 - 50 years	35	35.00
51 - 60 years	23	23.00
> 60 years	22	22.00
Total	100	100.00

Figure 8. Age group



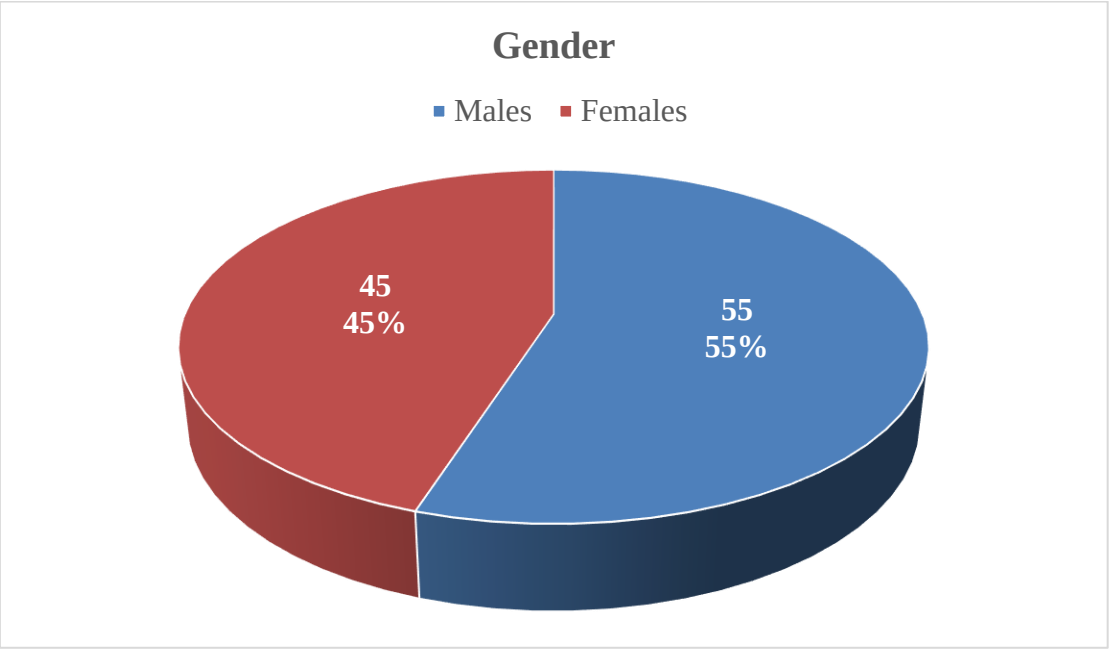
II. Gender

Among the subjects, 55 (55%) were Males and 45 (45%) were Females

Table 5. Gender

Gender	Frequency	Percent
Males	55	55.00
Females	45	45.00
Total	100	100.00

Figure 9. Gender



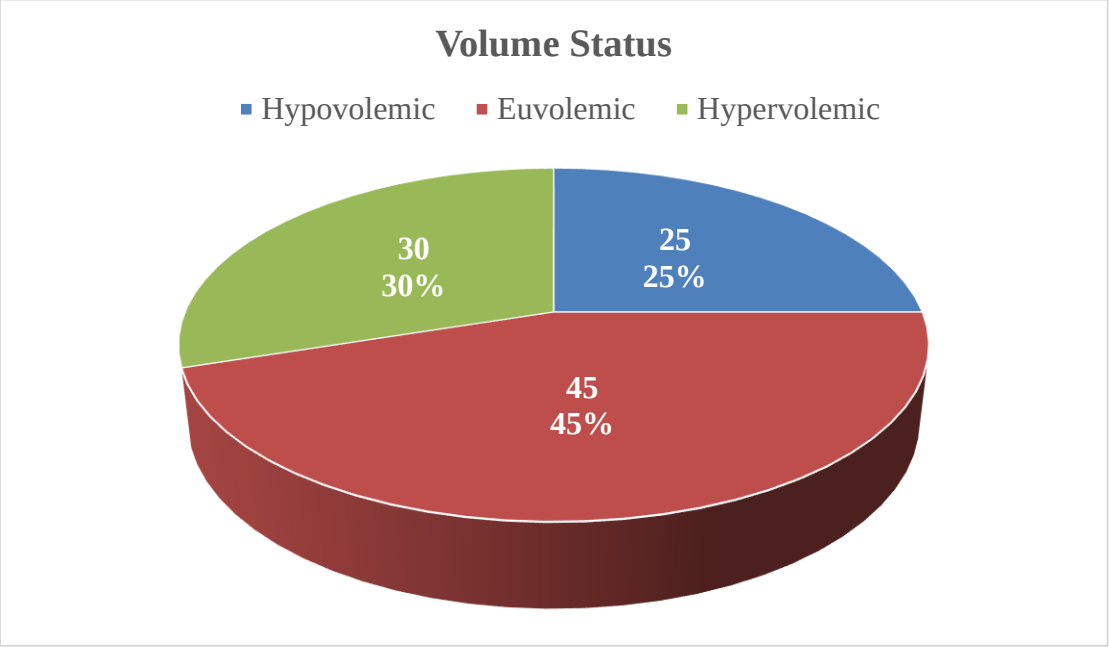
III. Volume Status

Among the subjects, 45 (45%) were Euvolemic followed by 30 (30%) were Hypervolemic and least 25 (25%) were Hypovolemic

Table 6. Volume Status

Volume Status	Frequency	Percent
Hypovolemic	25	25.00
Euvolemic	45	45.00
Hypervolemic	30	30.00
Total	100	100.00

Figure 10. Volume Status



IV. Diabetes Mellitus

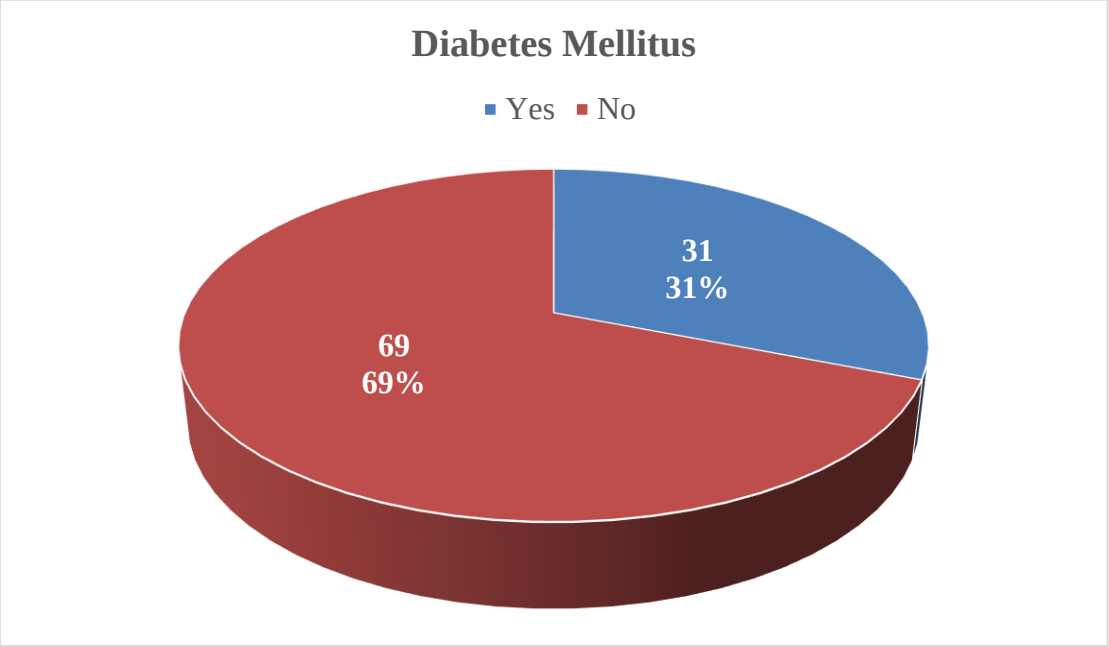
Among the subjects, 31 (31%) had Diabetes Mellitus

Table 7. Diabetes Mellitus

Diabetes Mellitus	Frequency	Percent

Yes	31	31.00
No	69	69.00
Total	100	100.00

Figure 11. Diabetes Mellitus



V. Hypertension

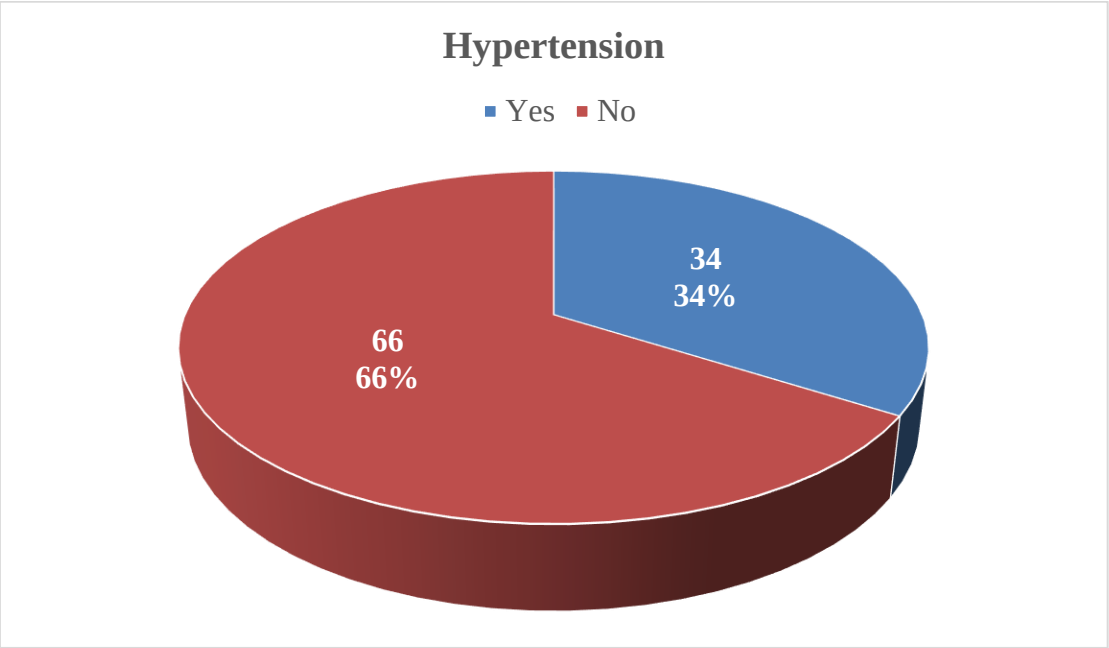
Among the subjects, 34 (34%) had Hypertension

Table 8. Hypertension

Hypertension	Frequency	Percent
Yes	34	34.00

No	66	66.00
Total	100	100.00

Figure 12. Hypertension



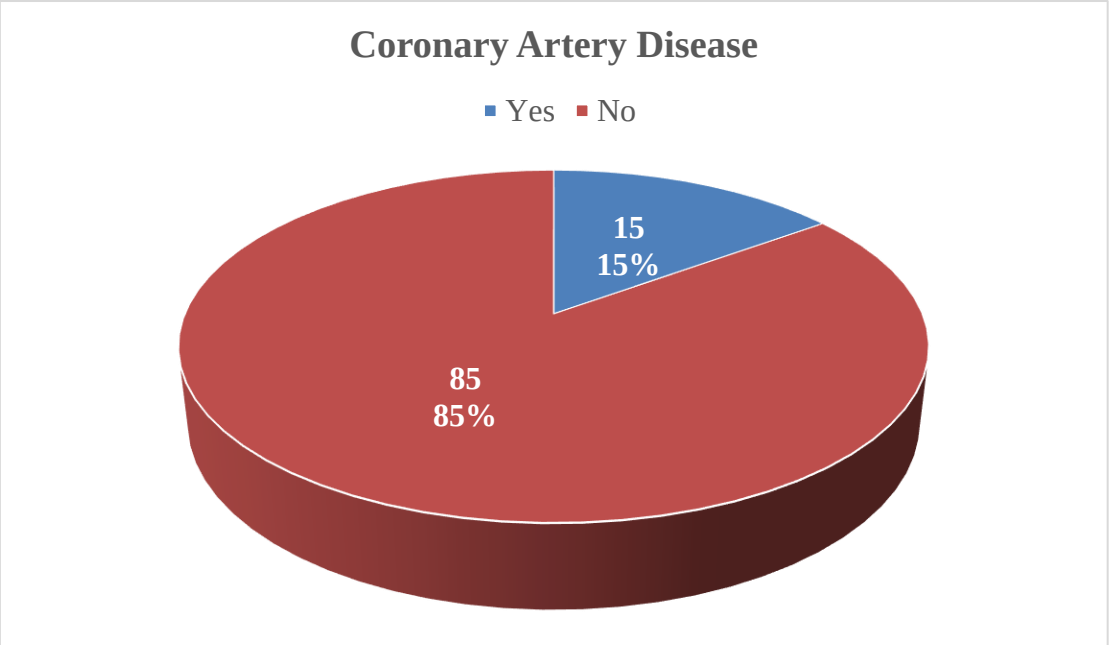
VI. Coronary Artery Disease

Among the subjects, 15 (15%) had Coronary Artery Disease

Table 9. Coronary Artery Disease

Coronary Artery Disease	Frequency	Percent
Yes	15	15.00
No	85	85.00
Total	100	100.00

Figure 13. Coronary Artery Disease



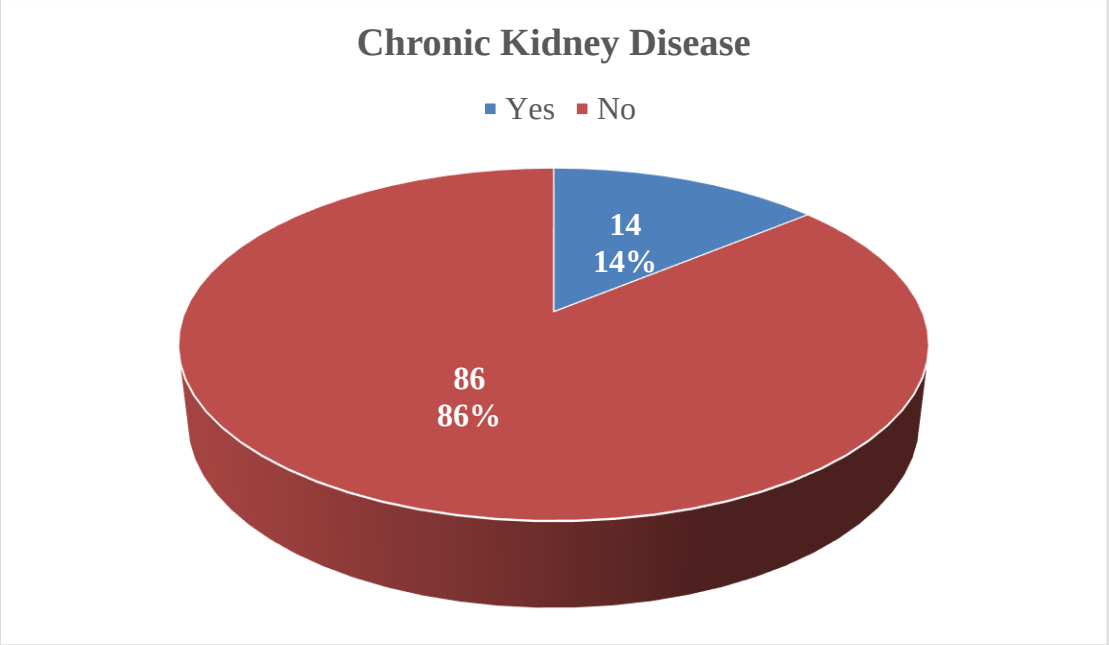
VII. Chronic Kidney Disease

Among the subjects, 14 (14%) had Chronic Kidney Disease

Table 10. Chronic Kidney Disease

Chronic Kidney Disease	Frequency	Percent
Yes	14	14.00
No	86	86.00
Total	100	100.00

Figure 14. Chronic Kidney Disease



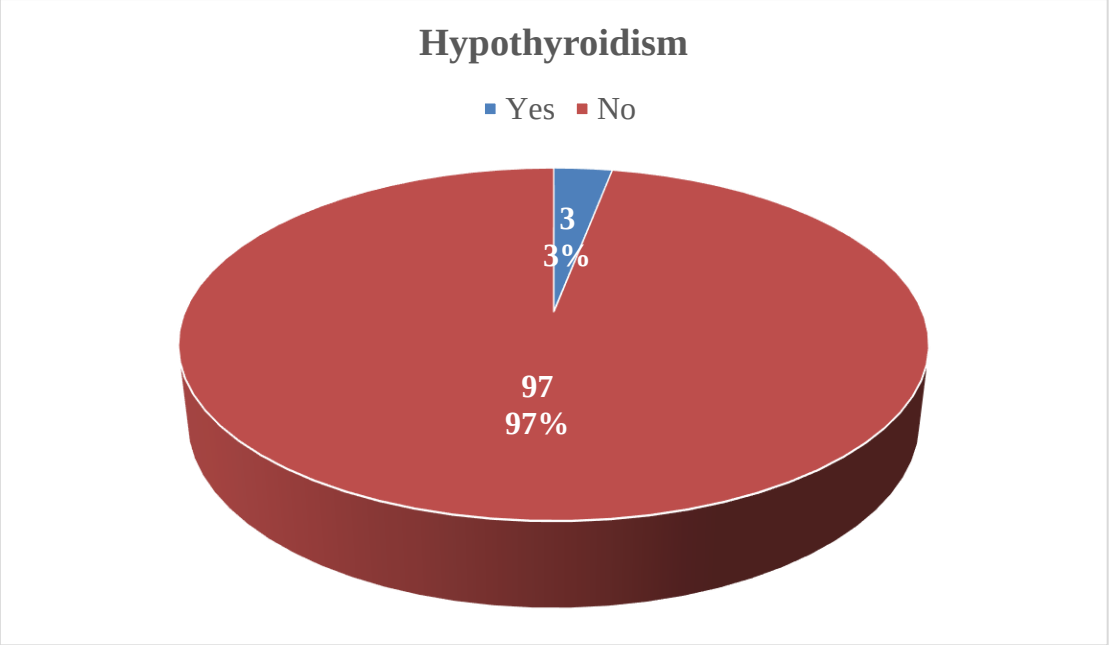
VIII. Hypothyroidism

Among the subjects, 3 (3%) had Hypothyroidism

Table 11. Hypothyroidism

Hypothyroidism	Frequency	Percent
Yes	3	3.00
No	97	97.00
Total	100	100.00

Figure 15. Hypothyroidism



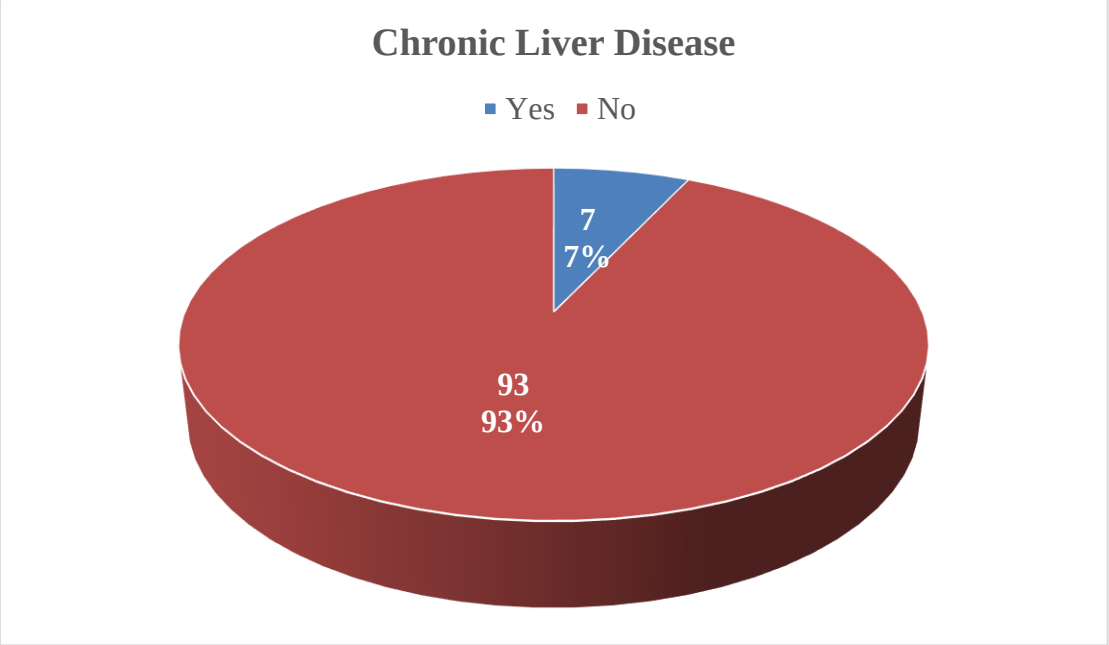
IX. Chronic Liver Disease

Among the subjects, 7 (7%) had Chronic Liver Disease

Table 12. Chronic Liver Disease

Chronic Liver Disease	Frequency	Percent
Yes	7	7.00
No	93	93.00
Total	100	100.00

Figure 16. Chronic Liver Disease



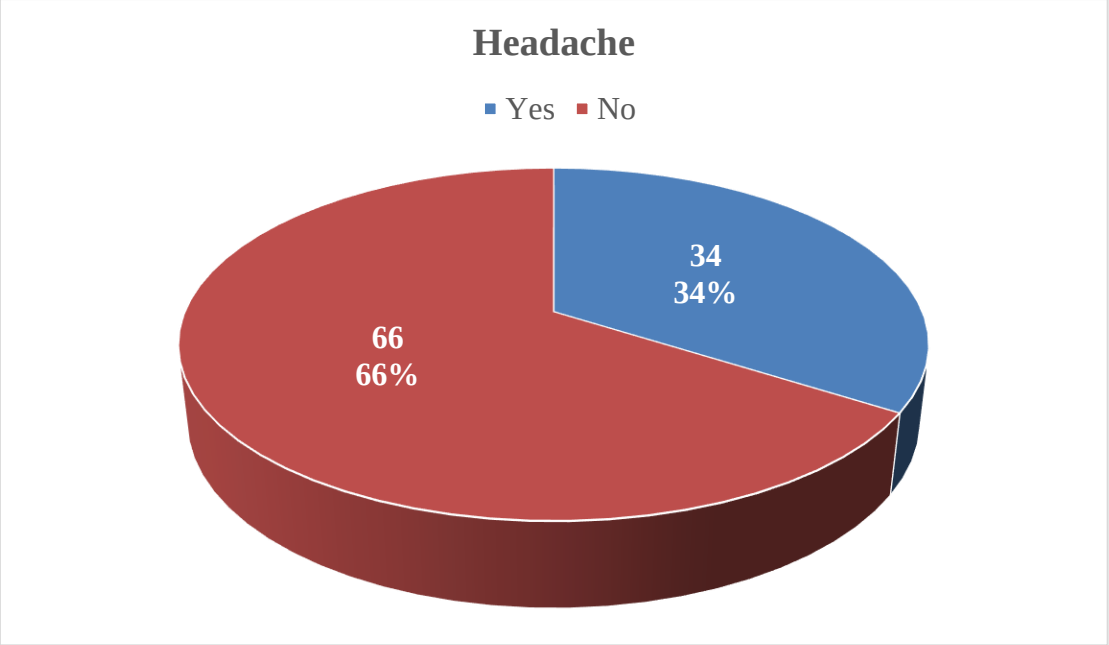
X. Headache

Among the subjects, 34 (34%) had Headache

Table 13. Headache

Headache	Frequency	Percent
Yes	34	34.00
No	66	66.00
Total	100	100.00

Figure 17. Headache



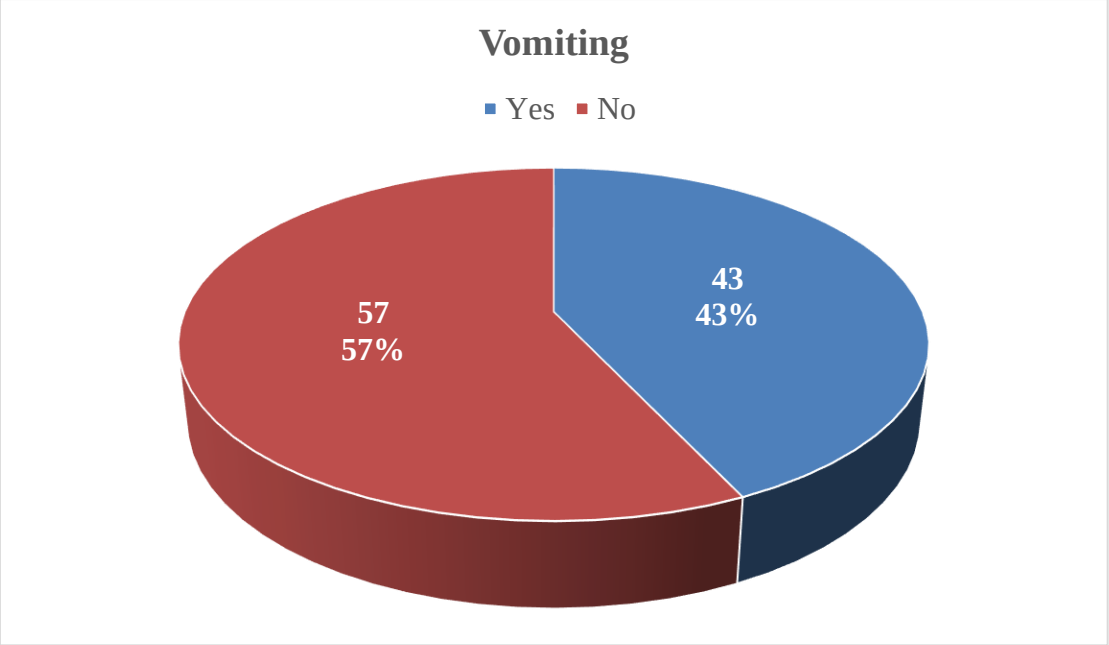
XI. Vomiting

Among the subjects, 43 (43%) had Vomiting

Table 14. Vomiting

Vomiting	Frequency	Percent
Yes	43	43.00
No	57	57.00
Total	100	100.00

Figure 18. Vomiting



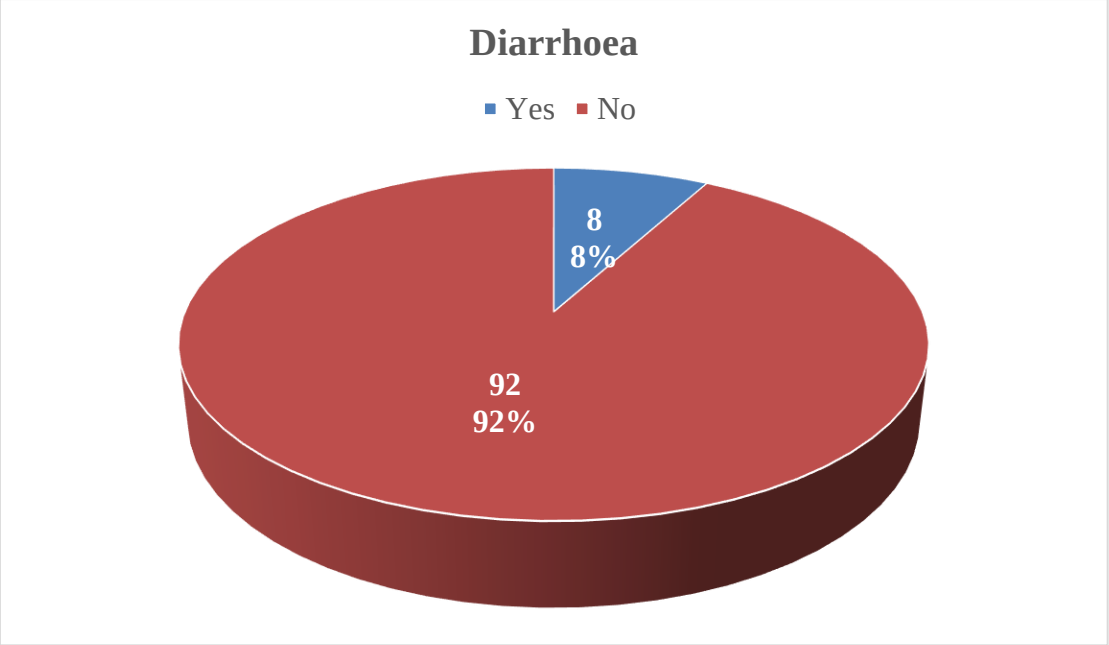
XII. Diarrhoea

Among the subjects, 8 (8%) had Diarrhoea

Table 15. Diarrhoea

Diarrhoea	Frequency	Percent
Yes	8	8.00
No	92	92.00
Total	100	100.00

Figure 19. Diarrhoea



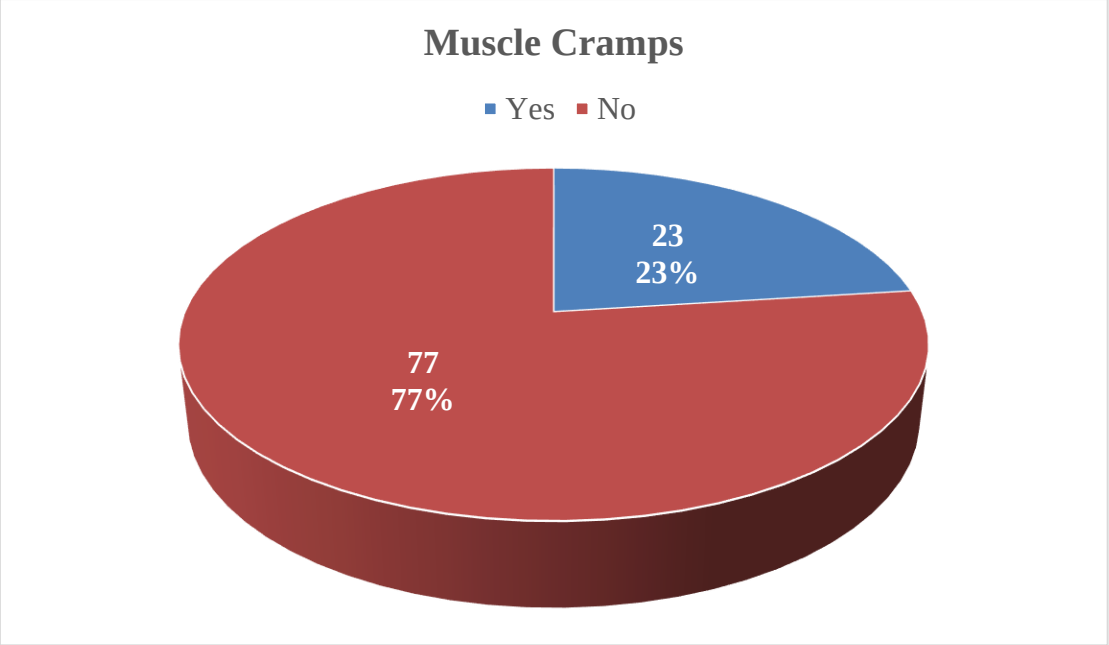
XIII. Muscle Cramps

Among the subjects, 23 (23%) had Muscle Cramps

Table 16. Muscle Cramps

Muscle Cramps	Frequency	Percent
Yes	23	23.00
No	77	77.00
Total	100	100.00

Figure 20. Muscle Cramps



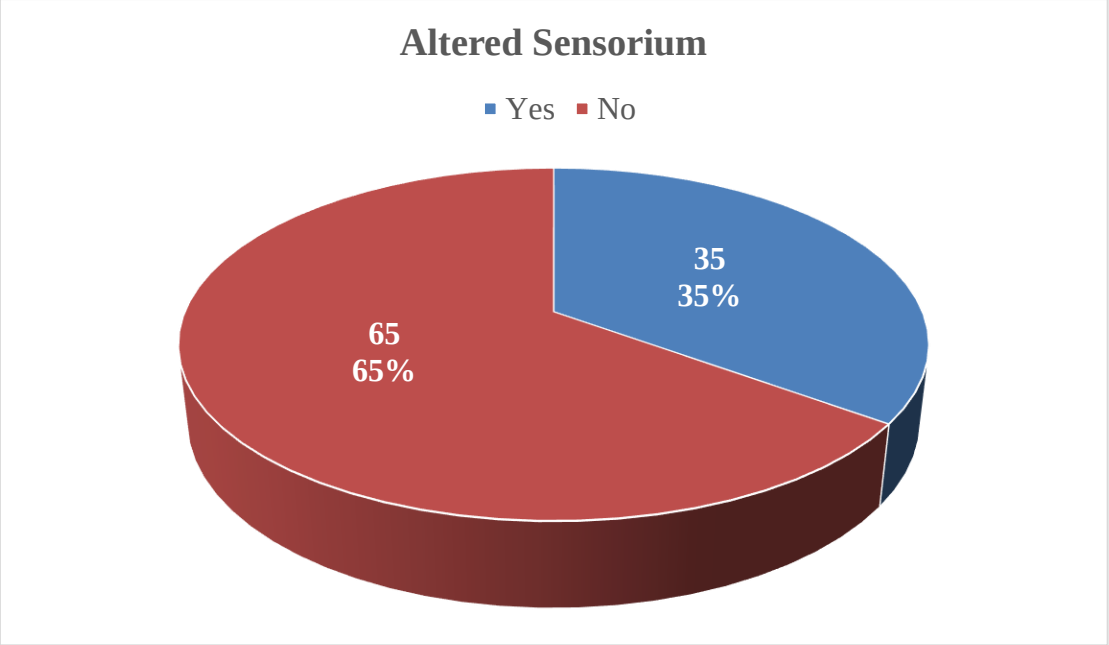
XIV. Altered Sensorium

Among the subjects, 35 (35%) had Altered Sensorium

Table 17. Altered Sensorium

Altered Sensorium	Frequency	Percent
Yes	35	35.00
No	65	65.00
Total	100	100.00

Figure 21. Altered Sensorium



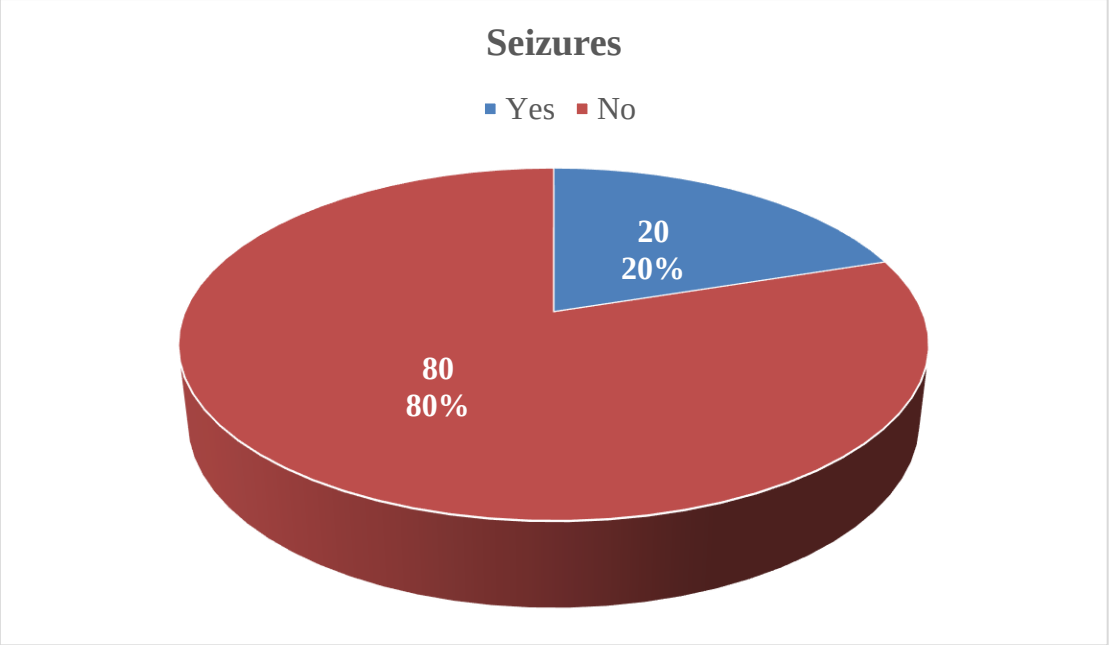
XV. Seizures

Among the subjects, 20 (20%) had Seizures

Table 18. Seizures

Seizures	Frequency	Percent
Yes	20	20.00
No	80	80.00
Total	100	100.00

Figure 22. Seizures



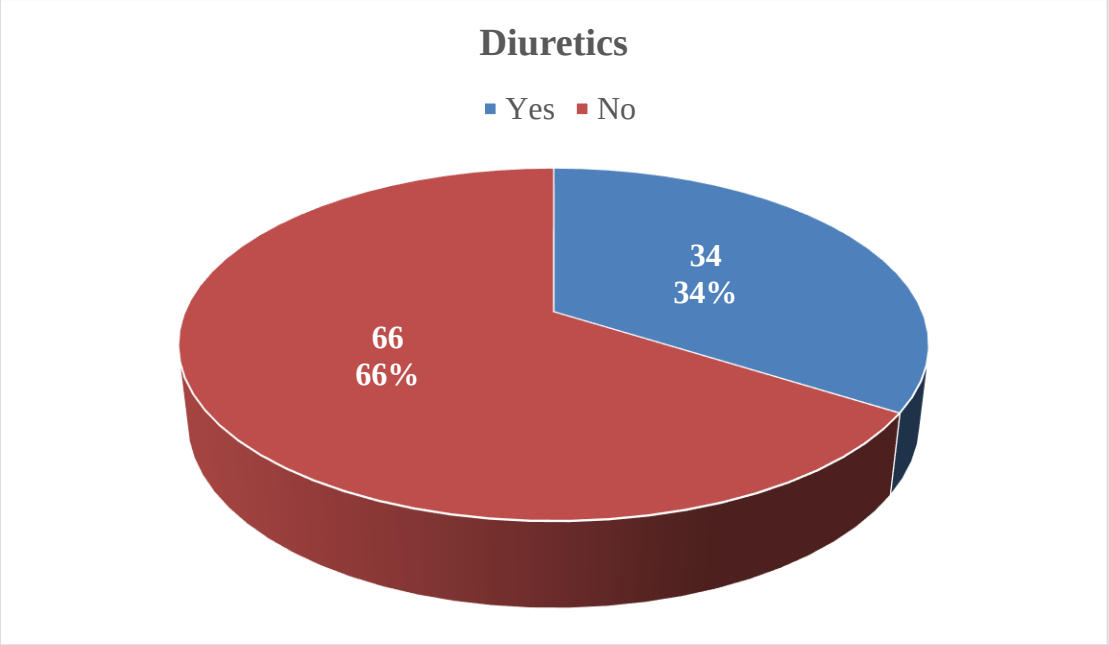
XVI. Diuretics

Among the subjects, 34 (34%) had Diuretics

Table 19. Diuretics

Diuretics	Frequency	Percent
Yes	34	34.00
No	66	66.00
Total	100	100.00

Figure 23. Diuretics



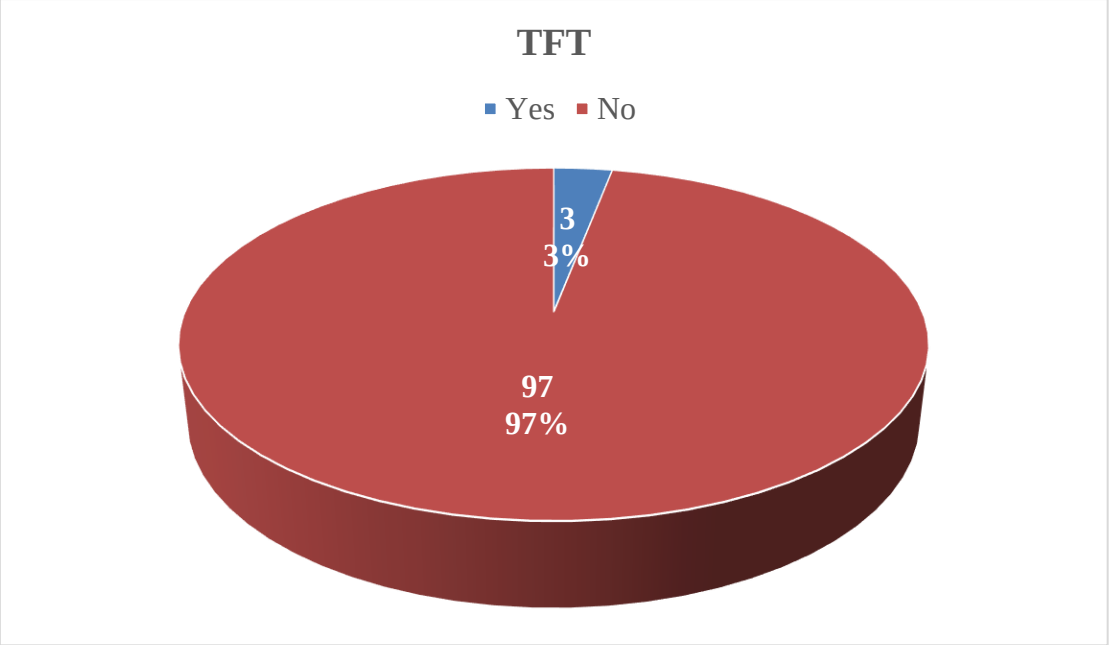
XVII. TFT

Among the subjects, 3 (3%) had TFT

Table 20. TFT

TFT	Frequency	Percent
Yes	3	3.00
No	97	97.00
Total	100	100.00

Figure 24. TFT



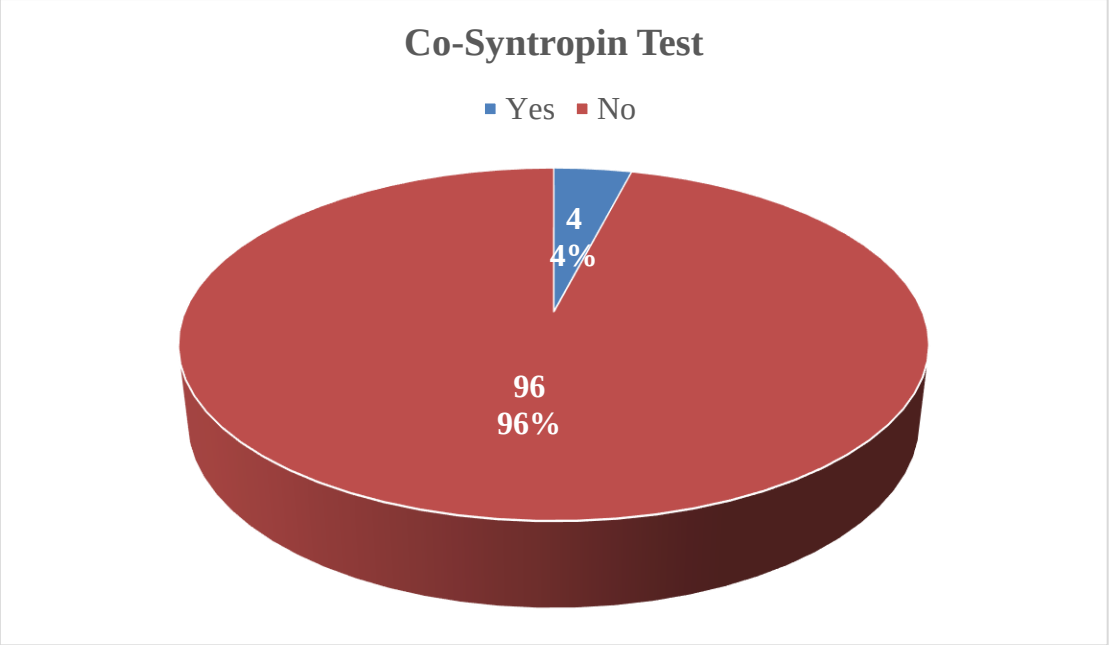
XVIII. Co-Syntropin Test

Among the subjects, 4 (4%) had Co-Syntropin Test

Table 21. Co-Syntropin Test

Co-Syntropin Test	Frequency	Percent
Yes	4	4.00
No	96	96.00
Total	100	100.00

Figure 25. Co-Syntropin Test



XIX. Cause of Hyponatremia

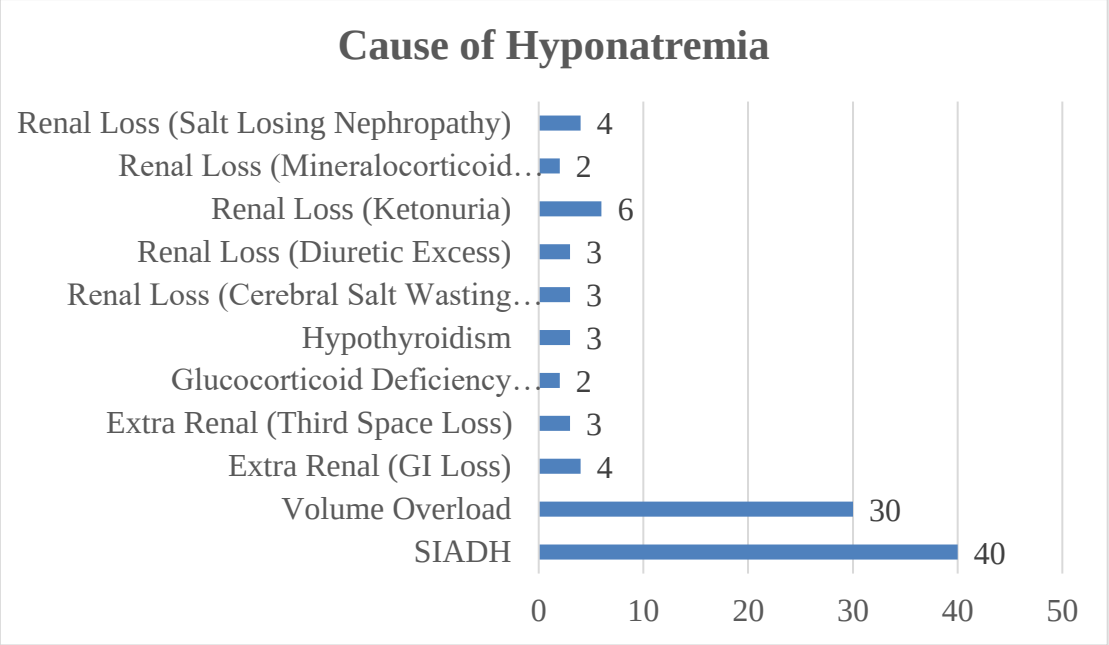
Among the subjects, 40 (40%) were due to SIADH followed by 30 (30%) were due to Volume Overload and least 2 (2%) were due to Glucocorticoid Deficiency (Secondary Adrenal Insufficiency

Table 22. Cause of Hyponatremia

Cause of Hyponatremia	Frequency	Percent
SIADH	40	40.00
Volume Overload	30	30.00
Extra Renal (GI Loss)	4	4.00
Extra Renal (Third Space Loss)	3	3.00
Glucocorticoid Deficiency (Secondary Adrenal Insufficiency	2	2.00
Hypothyroidism	3	3.00
Renal Loss (Cerebral Salt Wasting Syndrome)	3	3.00
Renal Loss (Diuretic Excess)	3	3.00

Renal Loss (Ketonuria)	6	6.00
Renal Loss (Mineralocorticoid Deficiency)	2	2.00
Renal Loss (Salt Losing Nephropathy)	4	4.00
Total	100	100.00

Figure 26. Cause of Hyponatremia



XX. Serum & Urine Sodium (Meq/L)

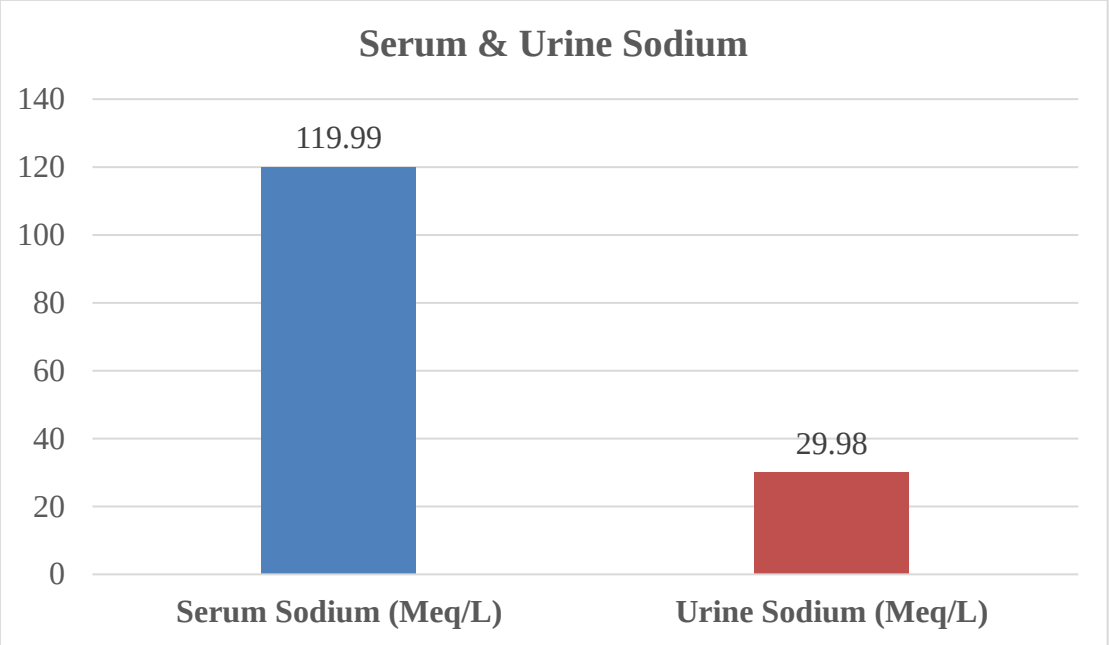
The mean Serum Sodium (Meq/L) among the subjects was 119.99 (± 7.79) ranging from 104 to 132. The mean Urine Sodium (Meq/L) among the subjects was 29.98 (± 13.92) ranging from 6 to 68.

Table 23. Serum & Urine Sodium (Meq/L)

	N	**Mean**	**Std. Deviation**	**Minimum**	**Maximum**

Serum Sodium (Meq/L)	100	119.99	7.79	104.0	132.0
Urine Sodium (Meq/L)	100	29.98	13.92	6.0	68.0

Figure 27. Serum & Urine Sodium (Meq/L)



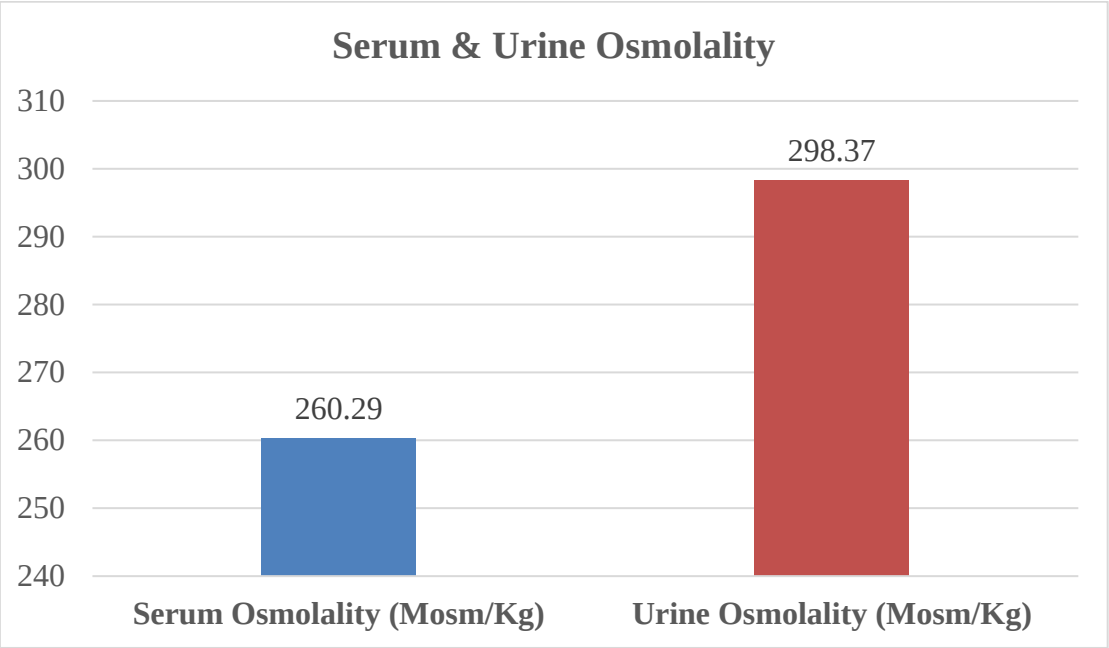
XXI. Serum & Urine Osmolality (Mosm/Kg)

The mean Serum Osmolality (Mosm/Kg) among the subjects was 260.29 (± 10.62) ranging from 234 to 286. The mean Urine Osmolality (Mosm/Kg) among the subjects was 298.37 (± 107.32) ranging from 118 to 651.

Table 24. Serum & Urine Osmolality (Mosm/Kg)

	N	**Mean**	**Std. Deviation**	**Minimum**	**Maximum**
Serum Osmolality (Mosm/Kg)	100	260.29	10.62	234.0	286.0
Urine Osmolality (Mosm/Kg)	100	298.37	107.32	118.0	651.0

Figure 28. Serum & Urine Osmolality (Mosm/Kg)



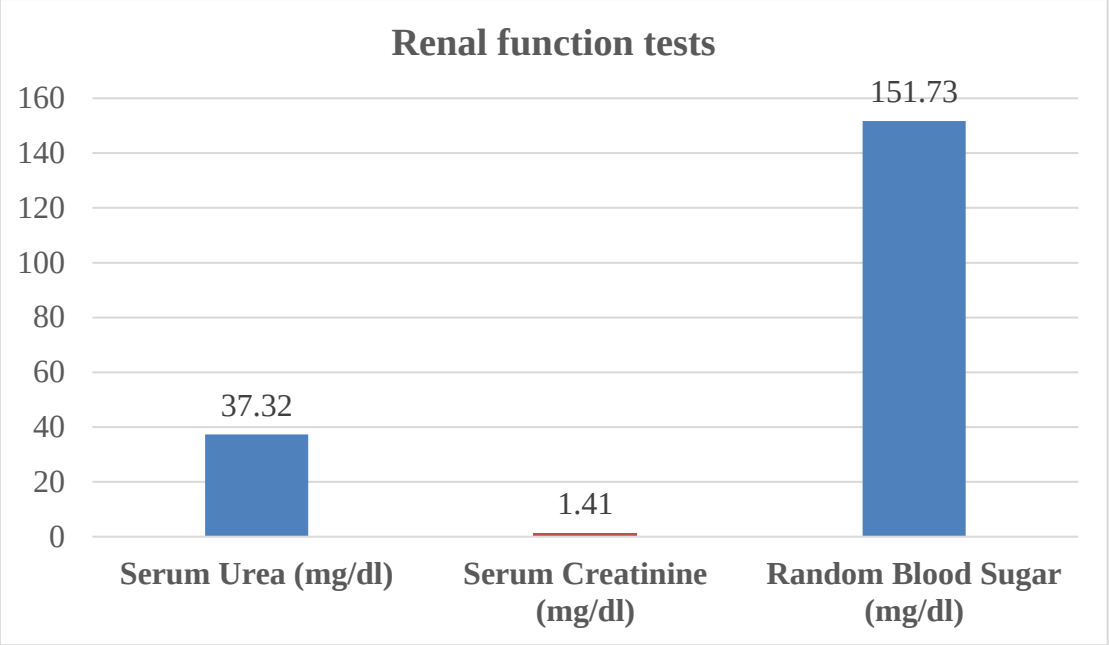
XXII. Renal function tests

The mean Serum Urea (mg/Dl) among the subjects was 37.32 (± 17.08) ranging from 16 to 114. The mean Serum Creatinine (mg/Dl) among the subjects was 1.41 (± 1.22) ranging from 0.6 to 6.5. The mean Random Blood Sugar (mg/Dl) among the subjects was 151.73 (± 66.88) ranging from 87 to 450.

Table 25. Renal function tests

	N	Mean	Std. Deviation	Minimum	Maximum
Serum Urea (mg/dl)	100	37.32	17.08	16.0	114.0
Serum Creatinine (mg/dl)	100	1.41	1.22	0.6	6.5
Random Blood Sugar (mg/dl)	100	151.73	66.88	87.0	450.0

Figure 29. Renal function tests



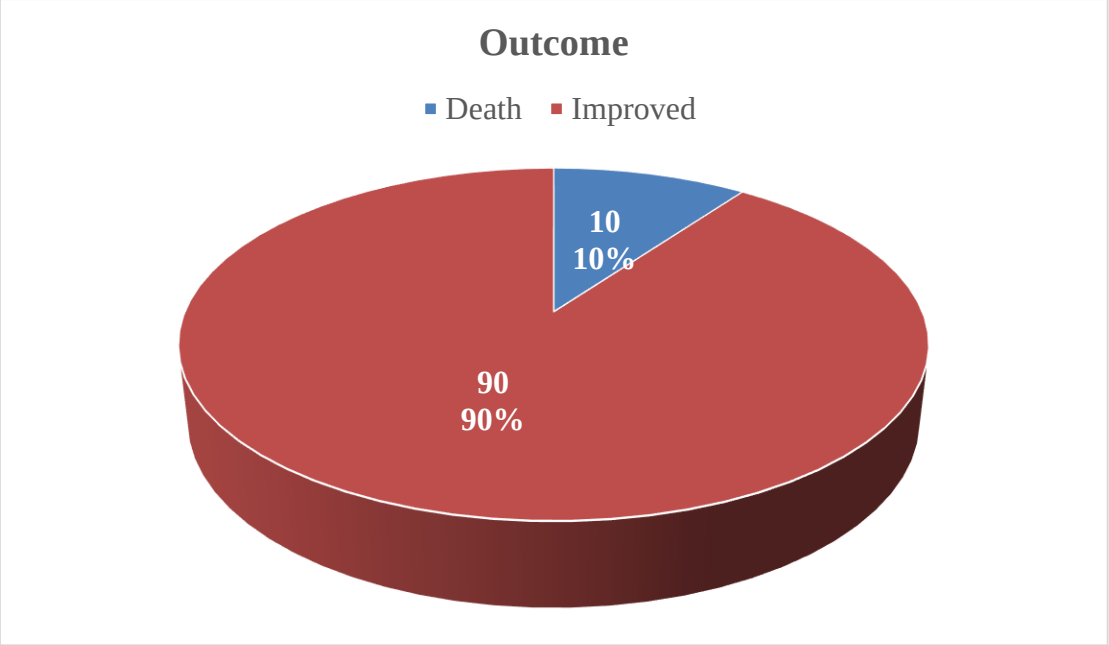
XXIII. Outcome

Among the subjects, 90 (90%) were Improved followed by 10 (10%) had Death.

Table 26. Outcome

Outcome	Frequency	Percent
Death	10	10.00
Improved	90	90.00
Total	100	100.00

Figure 30. Outcome



XXIV. Comparision of Age group with the Outcome

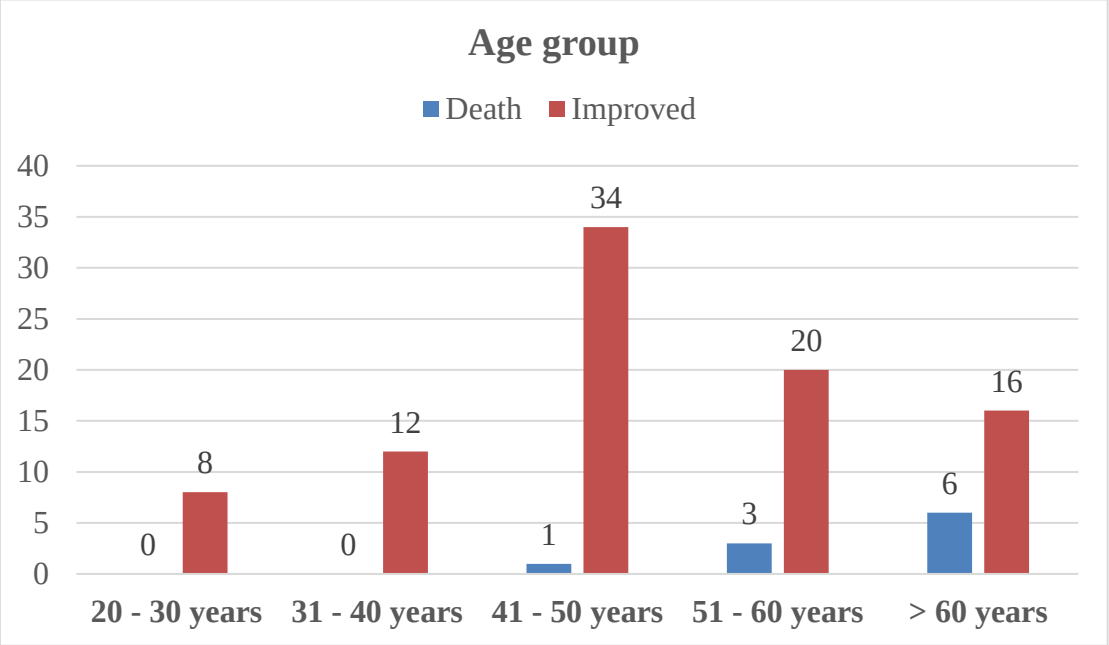
Comparing the Age group with Outcome distribution, > 60 years had higher proportion of death with 27.27% followed by 51 - 60 years with 13.04% and least in 20 - 30 years with 0%. The difference in Outcome between different Age group was statistically significant ($p < 0.05$).

Table 27. Comparision of Age group with the Outcome

Age group	Outcome		Total	Fisher exact p value
	Death	Improved		
20 - 30 years	0 (0%)	8 (100%)	8 (100%)	0.001
31 - 40 years	0 (0%)	12 (100%)	12 (100%)	
41 - 50 years	1 (2.85%)	34 (97.14%)	35 (100%)	

51 - 60 years	3 (13.04%)	20 (86.95%)	23 (100%)	
> 60 years	6 (27.27%)	16 (72.72%)	22 (100%)	
Total	10 (10%)	90 (90%)	100 (100%)	

Figure 31. Comparision of Age group with the Outcome



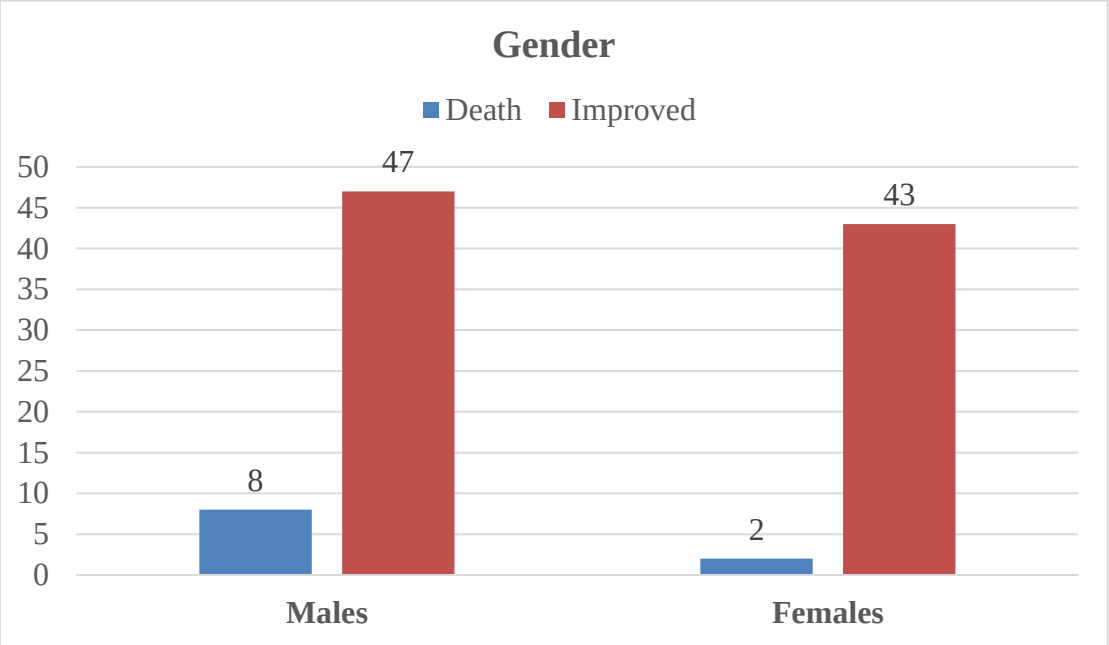
XXV. Comparision of Gender with the Outcome

Comparing the Gender with Outcome distribution, 14.54% of the Males had death which is higher compared to Females of whom 4.44% had death and the difference was not statistically significant ($p > 0.05$)

Table 28. Comparision of Gender with the Outcome

Gender	Outcome		Total	Fisher exact p value
	Death	Improved		
Males	8 (14.54%)	47 (85.45%)	55 (100%)	0.07
Females	2 (4.44%)	43 (95.55%)	45 (100%)	
Total	10 (10%)	90 (90%)	100 (100%)	

Figure 32. Comparision of Gender with the Outcome



XXVI. Comparision of Volume Status with the Outcome

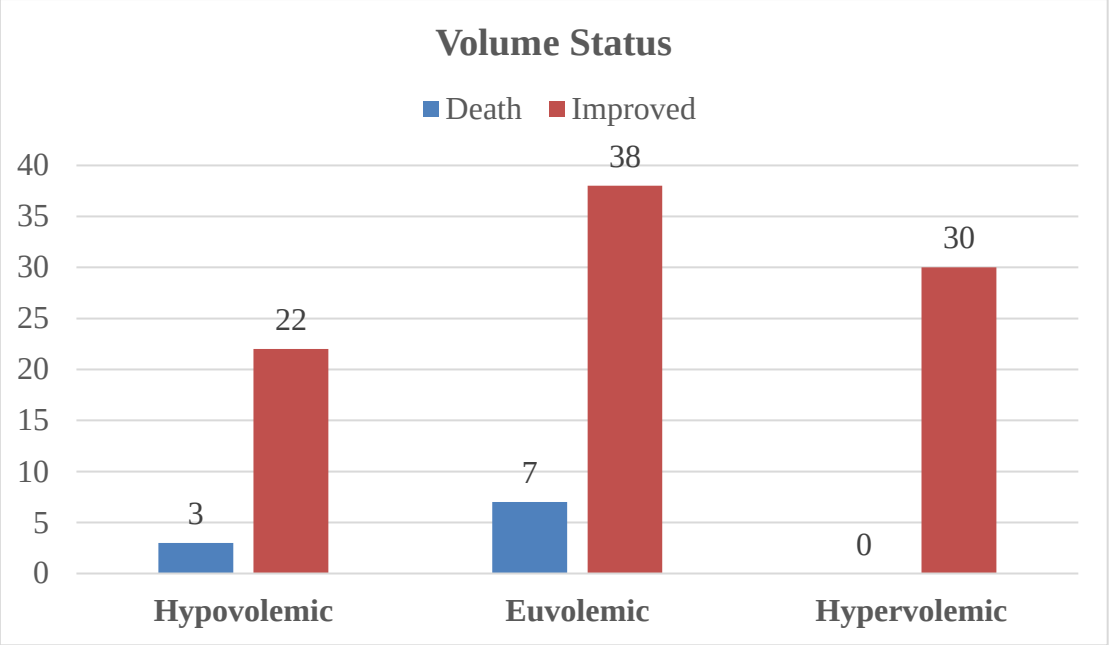
Comparing the Volume Status with Outcome distribution, Euvolemic had higher proportion of death with 15.55% followed by Hypovolemic with 12% and least in Hypervolemic with

0%. The difference in Outcome distribution between different Volume Status was statistically significant ($p < 0.05$).

Table 29. Comparision of Volume Status with the Outcome

Volume Status	Outcome		Total	Fisher exact p value
	Death	Improved		
Hypovolemic	3 (12%)	22 (88%)	25 (100%)	0.049
Euvolemic	7 (15.55%)	38 (84.44%)	45 (100%)	
Hypervolemic	0 (0%)	30 (100%)	30 (100%)	
Total	10 (10%)	90 (90%)	100 (100%)	

Figure 33. Comparision of Volume Status with the Outcome



XXVII. Comparision of Cause of Hyponatremia with the Outcome

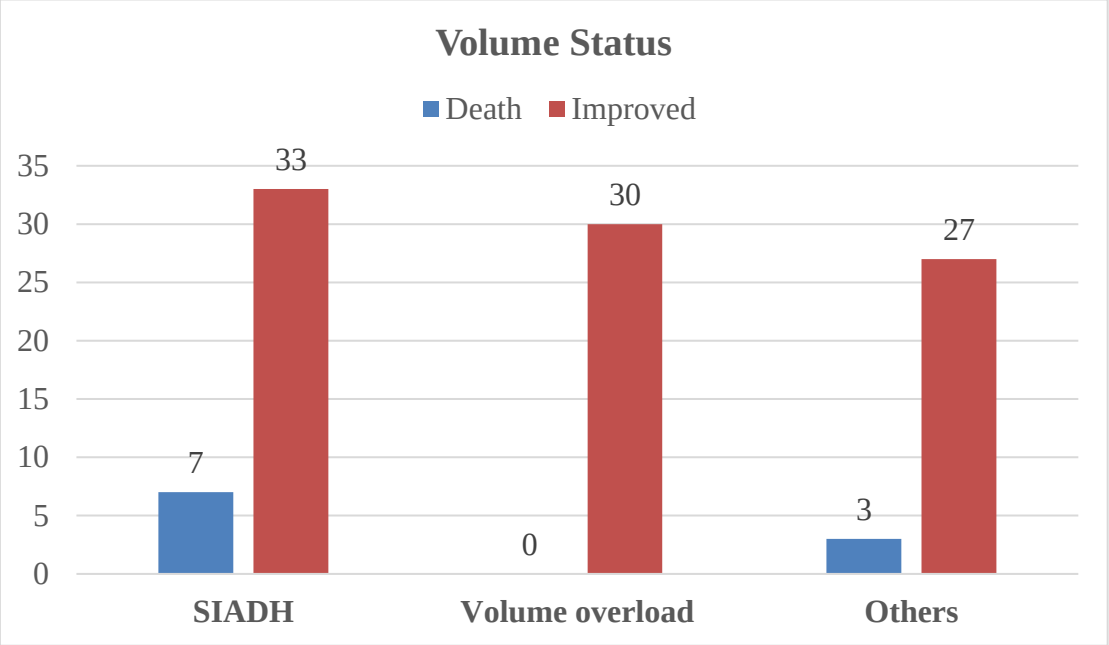
Comparing the Cause of Hyponatremia with Outcome distribution, SIADH had higher proportion of death with 17.5% followed by Others with 10% and least in Volume overload with 0%. The difference in Outcome distribution between different Cause of Hyponatremia was not statistically significant ($p > 0.05$).

Table 30.Comparision of Cause of Hyponatremia with the Outcome

Cause of Hyponatremia	Outcome		Total	Fisher exact p value
	Death	Improved		
SIADH	7 (17.5%)	33 (82.5%)	40 (100%)	0.081
Volume overload	0 (0%)	30 (100%)	30 (100%)	

Others	3 (10%)	27 (90%)	30 (100%)	
Total	10 (10%)	90 (90%)	100 (100%)	

Figure 34.Comparision of Cause of Hyponatremia with the Outcome



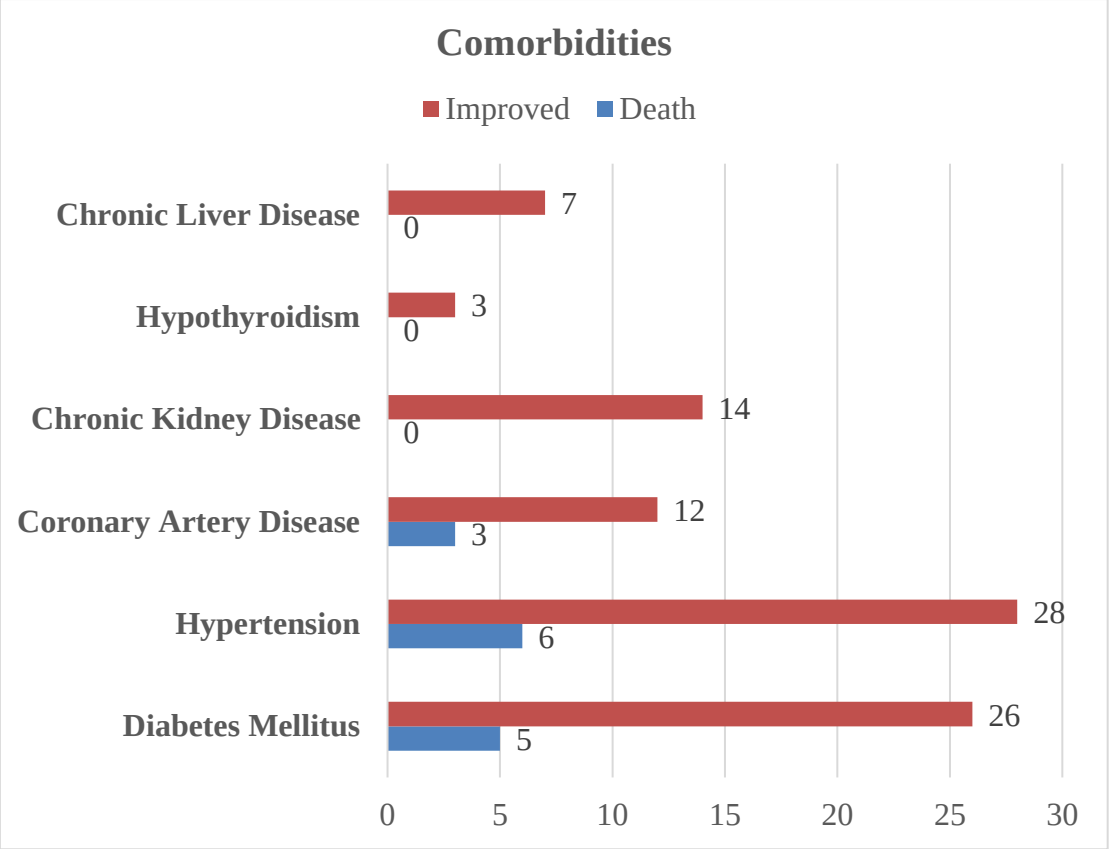
XXVIII. Comparision of Comorbidities with the Outcome

16.1% of the subjects with Diabetes Mellitus, 17.6% of the subjects with Hypertension, 20% of the subjects with Coronary Artery Disease had death. None of the subjects with Chronic Kidney Disease, Hypothyroidism and Chronic Liver Disease had death. The differences were not statistically significant.

Table 31. Comparision of Comorbidities with the Outcome

Comorbidities	Outcome		Chi sq. p value
	Death	Improved	
Diabetes Mellitus	5 (16.1%)	26 (83.9%)	0.110
Hypertension	6 (17.6%)	28 (82.4%)	0.056
Coronary Artery Disease	3 (20%)	12 (80%)	0.130
Chronic Kidney Disease	0 (0%)	14 (100%)	0.205
Hypothyroidism	0 (0%)	3 (100%)	0.727
Chronic Liver Disease	0 (0%)	7 (100%)	0.467
Total	10 (10%)	90 (90%)	

Figure 35. Comparision of Comorbidities with the Outcome



XXIX. Comparision of Clinical profile with the Outcome

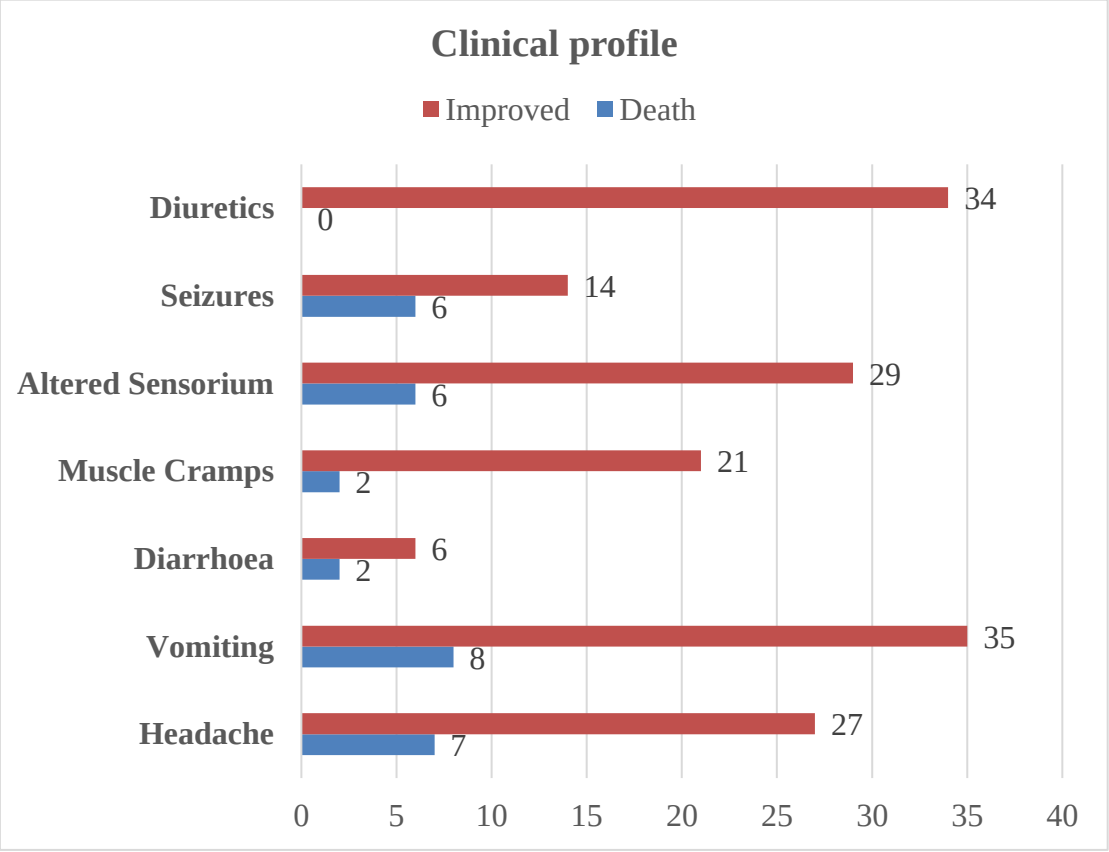
20.6% of the subjects with Headache and 18.6% of the subjects with Vomiting had death and the differences were statistically significant. 25% of the subjects with Diarrhoea, 8.7% of the subjects with Muscle Cramps and 17.1% of the subjects with Altered Sensorium had death but the differences were not statistically significant. 30% of the subjects with Seizures and none with Diuretics had death and the differences were statistically significant.

Table 32. Comparision of Clinical profile with the Outcome

Clinical profile	Outcome		Chi sq. p value
	Death	Improved	

Headache	7 (20.6%)	27 (79.4%)	0.014
Vomiting	8 (18.6%)	35 (81.4%)	0.013
Diarrhoea	2 (25%)	6 (75%)	0.151
Muscle Cramps	2 (8.7%)	21 (91.3%)	0.308
Altered Sensorium	6 (17.1%)	29 (82.9%)	0.063
Seizures	6 (30%)	14 (70%)	0.004
Diuretics	0 (0%)	34 (100%)	0.012
Total	10 (10%)	90 (90%)	

Figure 36. Comparision of Clinical profile with the Outcome



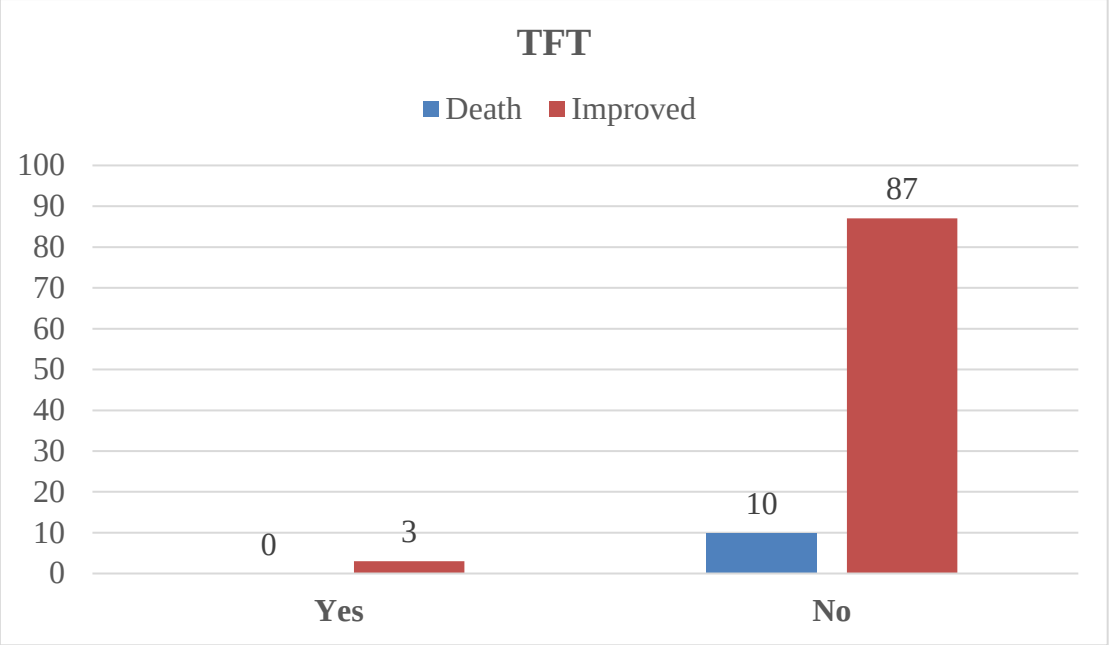
XXX. Comparision of TFT with the Outcome

Comparing the TFT with Outcome distribution, 0% of the subjects with TFT had death which is lower compared to those without TFT of whom 10.3% had death and the difference was not statistically significant ($p > 0.05$)

Table 33. Comparision of TFT with the Outcome

TFT	Outcome		Total	Fisher exact p value
	Death	Improved		
Yes	0 (0%)	3 (100%)	3 (100%)	0.727
No	10 (10.3%)	87 (89.69%)	97 (100%)	
Total	10 (10%)	90 (90%)	100 (100%)	

Figure 37. Comparision of TFT with the Outcome



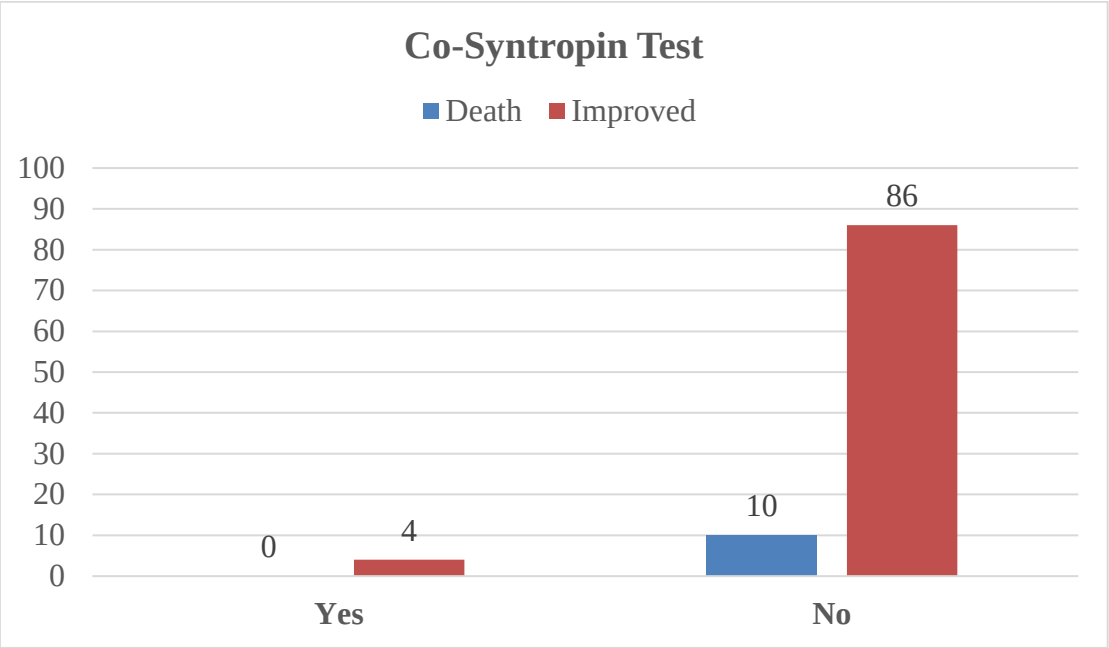
XXXI. Comparision of Co-Syntropin Test with the Outcome

Comparing the Co-Syntropin Test with Outcome distribution, 0% of the subjects with Co-Syntropin Test had death which is lower compared to those without Co-Syntropin Test of whom 10.41% had death and the difference was not statistically significant ($p > 0.05$)

Table 34. Comparision of Co-Syntropin Test with the Outcome

Co-Syntropin Test	Outcome		Total	Fisher exact p value
	Death	Improved		
Yes	0 (0%)	4 (100%)	4 (100%)	0.652
No	10 (10.41%)	86 (89.58%)	96 (100%)	
Total	10 (10%)	90 (90%)	100 (100%)	

Figure 38. Comparision of Co-Syntropin Test with the Outcome



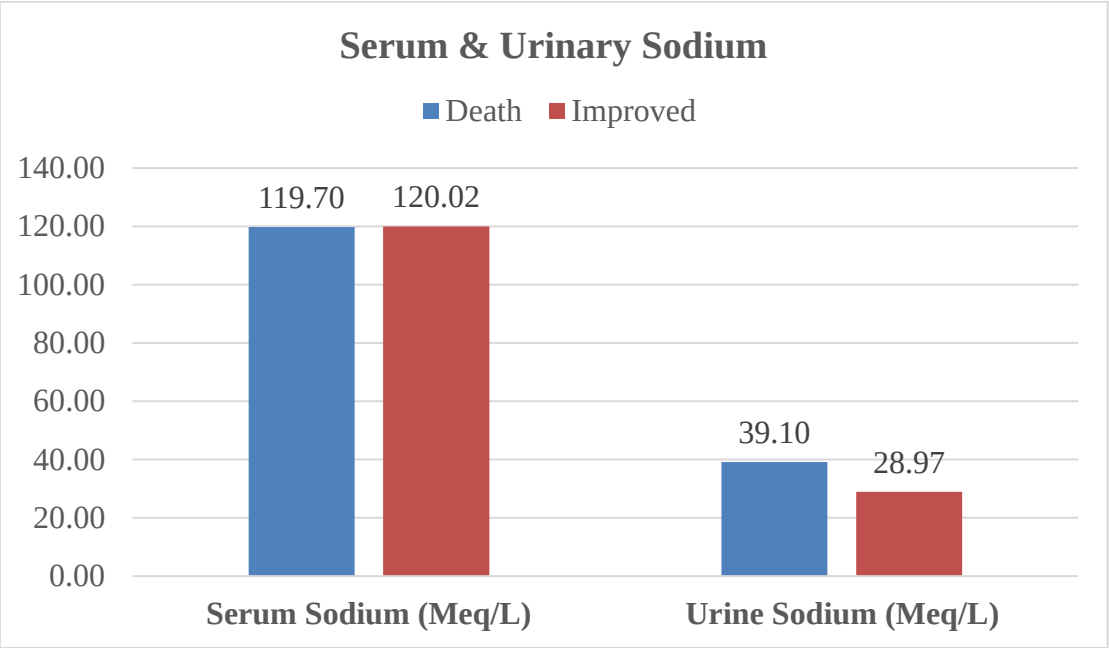
XXXII. Serum & Urinary Sodium (Meq/L) with Outcome

The mean Serum Sodium (Meq/L) among Death was 119.7 (± 7.82) which is lower by 0.32 but not statistically significant compared to 120.02 (± 7.83) in Improved. The mean Urine Sodium (Meq/L) among Death was 39.1 (± 8.23) which is higher by 10.13 and statistically significant compared to 28.97 (± 14.08) in Improved.

Table 35. Serum & Urinary Sodium (Meq/L) with Outcome

	Outcome	N	Mean	Std. dev.	Mean diff.	p value by 't' test
Serum Sodium (Meq/L)	**Death**	10	119.70	7.82	0.322	0.902
	Improved	90	120.02	7.83		
Urine Sodium (Meq/L)	**Death**	10	39.10	8.23	10.133	0.028
	Improved	90	28.97	14.08		

Figure 39. Serum & Urinary Sodium (Meq/L) with Outcome



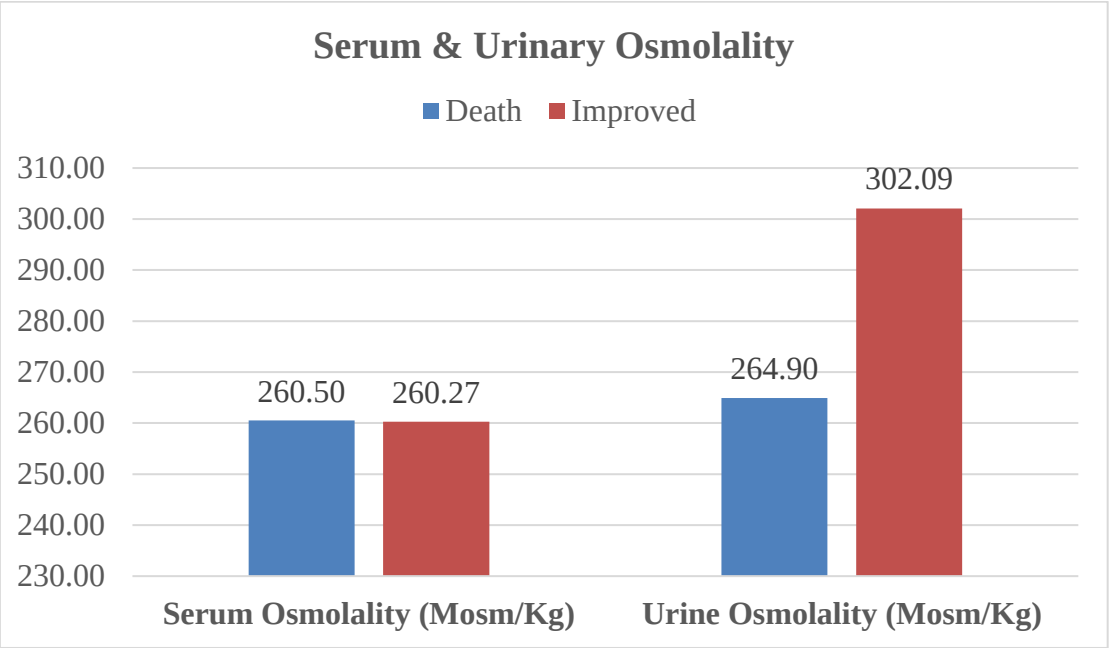
XXXIII. Serum & Urine Osmolality (Mosm/Kg) with Outcome

The mean Serum Osmolality (Mosm/Kg) among Death was 260.5 (± 9.69) which is higher by 0.23 but not statistically significant compared to 260.27 (± 10.77) in Improved. The mean Urine Osmolality (Mosm/Kg) among Death was 264.9 (± 91.25) which is lower by 37.19 but not statistically significant compared to 302.09 (± 108.76) in Improved.

Table 36. Serum & Urine Osmolality (Mosm/Kg) with Outcome

	Outcome	N	Mean	Std. dev.	Mean diff.	p value by 't' test
Serum Osmolality (Mosm/Kg)	**Death**	10	260.50	9.69	0.233	0.948
	Improved	90	260.27	10.77		
Urine Osmolality (Mosm/Kg)	**Death**	10	264.90	91.25	37.189	0.301
	Improved	90	302.09	108.76		

Figure 40. Serum & Urine Osmolality (Mosm/Kg) with Outcome



XXXIV. Renal function tests with Outcome

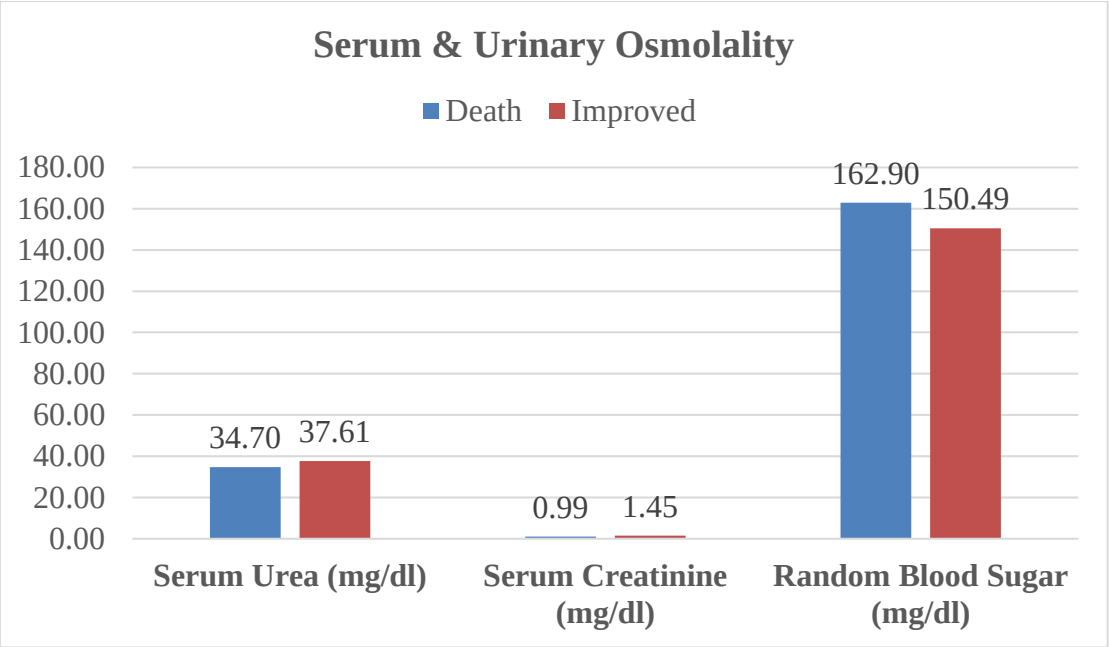
The mean Serum Urea (mg/dl) among Death was 34.7 (± 10.18) which is lower by 2.91 but not statistically significant compared to 37.61 (± 17.7) in Improved. The mean Serum Creatinine (mg/dl) among Death was 0.99 (± 0.3) which is lower by 0.46 and statistically significant compared to 1.45 (± 1.27) in Improved. The mean Random Blood Sugar (mg/dl) among Death was 162.9 (± 55.98) which is higher by 12.41 but not statistically significant compared to 150.49 (± 68.14) in Improved

Table 37. Renal function tests with Outcome

	Outcome	N	Mean	Std. dev.	Mean diff.	p value by 't' test
Serum Urea (mg/dl)	**Death**	10	34.70	10.18	2.911	0.612
	Improved	90	37.61	17.70		

Serum Creatinine (mg/dl)	**Death**	10	0.99	0.30	0.463	0.006
	Improved	90	1.45	1.27		
Random Blood Sugar (mg/dl)	**Death**	10	162.90	55.98	12.411	0.580
	Improved	90	150.49	68.14		

Figure 41. Renal function tests with Outcome



7 DISCUSSION

Hyponatremia remains poorly understood in many basic aspects, because of its connection with a plethora of underlying disease conditions, and its numerous aetiologies with differing pathophysiological conditions.(10) Without addressing this problem carefully and methodically, the prognostic implications of the problem are lethal and far-reaching.(11) Early recognition of hyponatremia and appropriate intervention would improve the outcome.

The main objective of the study is to study the aetiology, clinical presentation and associated factors of hyponatremia in patients admitted in Intensive Care Medical Unit. The understanding of the clinical presentation will help in prevention, early identification and appropriate management of the hyponatremia.

This is a hospital based cross sectional study, 100 patients admitted in IMCU admitted under the Department of General Medicine, Tirunelveli Medical College, with serum sodium less than 135 mmol/L. After the detailed history, thorough clinical examination, the following biochemical parameters are collected using a pre-structured proforma. Details of comorbidities, associated symptoms and blood and urine parameters were compared with outcomes of hyponatremia.

Baseline Characteristics:

Age: In this study, 35 (35%) were in 41 - 50 years followed by 23 (23%) were in 51 - 60 years and least 8 (8%) were in 20 - 30 years. Similar to our study, **Rahil A I et al**, observed that Elderly people were more likely than younger people to have hyponatremia.(49) In this study, > 60 years had higher proportion of death with 27.27% followed by 51 - 60 years with 13.04% and least in 20 - 30 years with 0%. The increased mortality rate among the elderly

age group was statistically significant ($p < 0.05$). Age is a factor associated with the increased prevalence and mortality in hyponatremia. The main confounding factor for this association will be probable intake of medications. (54,55)

Gender: Gender-related differences are documented in sodium (Na+) metabolism, Na+ transport into the cell membrane, intra-cellular concentration of Na+, and urinary excretion of Na+. (56,57) In this study, 55 (55%) were Males and 45 (45%) were Females. In this study, 14.54% of the Males had death which is higher compared to Females of whom 4.44% had death and the difference was not statistically significant ($p > 0.05$) Similar to our study, **Rahil A I et al**, observed that there were no significant gender-related differences or similarities detected..(49)

Volume Status: Presence of hypertriglyceridemia or increase in plasma proteins can result in euvolemic hyponatremia. (58–60) In this study, 45 (45%) were Euvolemic followed by 30 (30%) were Hypervolemic and least 25 (25%) were Hypovolemic hyponatremia. Similar to our study results, Prakash **Babaliche et al**, observed that the most typical form of hyponatremia was euvolemic hypo osmolar hyponatremia (50%).(51)

Similar to our study results, **Nandini Chatterjee et al**, in their study, Patients with Euvolemic hyponatremia made up the majority of the study group (102; 50.74%), followed by individuals with hypervolemic (54; 26.86%) and hypovolemic (45; 22.4%) type of hyponatremias.(53)

In this study, Euvolemic had higher proportion of death with 15.55% followed by Hypovolemic with 12% and least in Hypervolemic with 0%. The difference in Outcome distribution between different Volume Status was statistically significant ($p < 0.05$).

Comorbidities: Sumit Mohan et al, in their study observed that hyponatremia is common among individuals with comorbidities, and is an independent predictor of mortality.(61) In this study, 31 (31%) had Diabetes Mellitus, 34 (34%) had Hypertension, 15 (15%) had Coronary Artery Disease, 14 (14%) had Chronic Kidney Disease, 3 (3%) had Hypothyroidism, 7 (7%) had Chronic Liver Disease.

In this study, 16.1% of the subjects with Diabetes Mellitus, 17.6% of the subjects with Hypertension, 20% of the subjects with Coronary Artery Disease had death. Presence of diabetes, hypertension and coronary heart disease, were associated with the higher mortality in hyponatremia, but not statistically significant. None of the subjects with Chronic Kidney Disease, Hypothyroidism and Chronic Liver Disease had death. The differences were not statistically significant.

Associated symptoms: In this study, 34 (34%) had Headache, 43 (43%) had Vomiting, 8 (8%) had Diarrhoea, 23 (23%) had Muscle Cramps, 35 (35%) had Altered Sensorium, 20 (20%) had Seizures, 34 (34%) were on Diuretics, and 3 (3%) had abnormal TFT. **Chike M. Nzerue et al**, observed that more than half of the patients (52.9%) were symptomatic.(47) **Baran D et al**, observed that more than half of the patients (54%) were asymptomatic. (50) **Prakash Babaliche et al**, observed that Vomiting (28%) and disorientation (26%) were the two most typical presenting complaints with hyponatremia. (51)

In this study, 20.6% of the subjects with Headache and 18.6% of the subjects with Vomiting had death and the differences were statistically significant. 25% of the subjects with Diarrhoea, 8.7% of the subjects with Muscle Cramps and 17.1% of the subjects with Altered Sensorium had death but the differences were not statistically significant. 30% of the subjects with Seizures and none with Diuretics had death and the differences were

statistically significant. **Chike M. Nzerue et al**, observed that a higher mortality when the patients were symptomatic.(47)

Renal function tests: In this study, the mean Serum Urea (mg/Dl) among the subjects was 37.32 (± 17.08) ranging from 16 to 114. The mean Serum Creatinine (mg/Dl) among the subjects was 1.41 (± 1.22) ranging from 0.6 to 6.5. The mean Random Blood Sugar (mg/Dl) among the subjects was 151.73 (± 66.88) ranging from 87 to 450.

In this study, the mean Serum Urea (mg/dl) among Death was 34.7 (± 10.18) which is lower by 2.91 but not statistically significant compared to 37.61 (± 17.7) in Improved. The mean Serum Creatinine (mg/dl) among Death was 0.99 (± 0.3) which is lower by 0.46 and statistically significant compared to 1.45 (± 1.27) in Improved. This association can be possible, only when the death of the patients occurs without the renal compromise starts. The mean Random Blood Sugar (mg/dl) among Death was 162.9 (± 55.98) which is higher by 12.41 but not statistically significant compared to 150.49 (± 68.14) in Improved.

Hyponatremia parameters:

Cause of Hyponatremia: In this study, 40 (40%) were due to SIADH followed by 30 (30%) were due to Volume Overload and least 2 (2%) were due to Glucocorticoid Deficiency (Secondary Adrenal Insufficiency. **Rahil A I et al**, observed that the most frequent cause of hyponatraemia in their investigation was extra-renal loss.(49)

Similar to our study results, **Prakash Babaliche et al**, observed that the most frequent cause of hyponatremia was syndrome of inappropriate antidiuretic hormone secretion (SIADH) (46%). (51) Similar to our study results, **Kanchana S Pillai et al**, observed that the most common cause of hyponatremia was syndrome of inappropriate antidiuretic hormone secretion (SIADH). (52)

In this study, SIADH had higher proportion of death with 17.5% followed by Others with 10% and least in Volume overload with 0%. The difference in Outcome distribution between different Cause of Hyponatremia was not statistically significant ($p > 0.05$).

Serum & Urine Sodium (Meq/L): In this study, the mean Serum Sodium (Meq/L) among the subjects was 119.99 (± 7.79) ranging from 104 to 132. The mean Urine Sodium (Meq/L) among the subjects was 29.98 (± 13.92) ranging from 6 to 68.

In this study, the mean Serum Sodium (Meq/L) among Death was 119.7 (± 7.82) which is lower by 0.32 but not statistically significant compared to 120.02 (± 7.83) in Improved. This indicates that the severity of the hyponatremia was associated with the mortality rates in this study. The mean Urine Sodium (Meq/L) among Death was 39.1 (± 8.23) which is higher by 10.13 and statistically significant compared to 28.97 (± 14.08) in Improved.

Serum & Urine Osmolality (Mosm/Kg): In this study, the mean Serum Osmolality (Mosm/Kg) among the subjects was 260.29 (± 10.62) ranging from 234 to 286. The mean Urine Osmolality (Mosm/Kg) among the subjects was 298.37 (± 107.32) ranging from 118 to 651. In this study, the mean Serum Osmolality (Mosm/Kg) among Death was 260.5 (± 9.69) which is higher by 0.23 but not statistically significant compared to 260.27 (± 10.77) in Improved. The mean Urine Osmolality (Mosm/Kg) among Death was 264.9 (± 91.25) which is lower by 37.19 but not statistically significant compared to 302.09 (± 108.76) in Improved.

Outcome: In this study, 90 (90%) were Improved followed by 10 (10%) had Death, making the mortality rate to 10% or one tenth. **Chike M. Nzerue et al**, observed that Mortality rate was high, with nearly one-fifth of the patients expired. (20.2%).(47) **Marya D. Zilberberg et al**, observed that hyponatremia was independently associated with a 55 % increase in the risk of mortality and significantly increased hospital resource utilization and costs.(48)

Baran D et al, observed that Mortality rate was high, with nearly one-fourth of the patients expired. (27%). (50) **Kanchana S Pillai et al**, observed that the Mortality rate was high, with more than one-third of the patients expired. (34.6%). (52) **Chike M. Nzerue et al**, observed that Sepsis, respiratory failure/hypoxia and the presence of symptoms predicted poor outcomes among the hospitalized patients with severe hyponatremia.(47)

8 LIMITATIONS

The study results can be influenced by the Confounding factors.

The did not involve a follow-up period, to study the long-term complications of the hyponatremia.

The study design was a cross sectional one, hence the temporality of many associations were not made out.

The sample size was calculated based on the mortality rate in hyponatremia, the sample size was not adequate to study the associations.

The study was Hospital based study conducted in a tertiary care setting, hence the study results cannot reflect the situations of other health care settings.

The mortality rate was found to be 10%, and hence the statistical tests could not be applied to study the associations

9 STRENGTHS

In spite of the COVID pandemic and restrictions, affecting the conduct of the study, the minimum sample size was collected.

The study looked at the risk factors associated with the mortality, hence the possibility of prevention and early diagnosis is possible.

The data was collected by the principal investigator, hence the information bias will be minimal.

The study was conducted in a tertiary care centre, and hence the referrals were not present, thereby eliminating the attrition bias.

10 RECOMMENDATIONS

Careful management of the patients with Increased age, Euvolemic and hypovolemic hyponatremia, Presence of headache, seizures, and vomiting, and Higher urine sodium levels were needed, as these factors were significantly associated with the higher mortality in hyponatremia.

Further studies with increased sample size matching done for known confounding factors will represent the true relationship and associations of the factors associated with the mortality.

As the supplementation of the sodium cannot easily manage the hyponatremia, strategies aimed at preventing the arise of hyponatremia is mandated. This can be done through identification of the high risk population.

11 SUMMARY OF RESULTS

- **Study Population:** The study population comprise of 100 patients admitted in IMCU admitted under the Department of General Medicine, Tirunelveli Medical College, with serum sodium less than 135 mmol/L.
- **Baseline Characteristics:**
  - **Age:** 35 (35%) were in 41 - 50 years followed by 23 (23%) were in 51 - 60 years and least 8 (8%) were in 20 - 30 years.
  - **Gender:** 55 (55%) were Males and 45 (45%) were Females
  - **Volume Status:** 45 (45%) were Euvolemic followed by 30 (30%) were Hypervolemic and least 25 (25%) were Hypovolemic hyponatremia.
  - **Comorbidities:**
  - **Diabetes Mellitus:** Among the subjects, 31 (31%) had Diabetes Mellitus.
  - **Hypertension:** Among the subjects, 34 (34%) had Hypertension
  - **Coronary Artery Disease:** 15 (15%) had Coronary Artery Disease
  - **Chronic Kidney Disease:** 14 (14%) had Chronic Kidney Disease
  - **Hypothyroidism:** Among the subjects, 3 (3%) had Hypothyroidism
  - **Chronic Liver Disease:** 7 (7%) had Chronic Liver Disease
- **Associated symptoms:**
  - **Headache:** Among the subjects, 34 (34%) had Headache
  - **Vomiting:** Among the subjects, 43 (43%) had Vomiting
  - **Diarrhoea:** Among the subjects, 8 (8%) had Diarrhoea
  - **Muscle Cramps:** Among the subjects, 23 (23%) had Muscle Cramps
  - **Altered Sensorium:** Among the subjects, 35 (35%) had Altered Sensorium
  - **Seizures:** Among the subjects, 20 (20%) had Seizures

- ☞ **Diuretics:** Among the subjects, 34 (34%) had Diuretics
- ☞ **TFT:** Among the subjects, 3 (3%) had TFT
- ☞ **Co-Syntropin Test:** Among the subjects, 4 (4%) had Co-Syntropin Test.
- ☞ **Renal function tests:** The mean Serum Urea (mg/Dl) among the subjects was 37.32 (± 17.08) ranging from 16 to 114. The mean Serum Creatinine (mg/Dl) among the subjects was 1.41 (± 1.22) ranging from 0.6 to 6.5. The mean Random Blood Sugar (mg/Dl) among the subjects was 151.73 (± 66.88) ranging from 87 to 450.

- ➢ **Hyponatremia parameters:**
  - ☞ **Cause of Hyponatremia:** Among the subjects, 40 (40%) were due to SIADH followed by 30 (30%) were due to Volume Overload and least 2 (2%) were due to Glucocorticoid Deficiency (Secondary Adrenal Insufficiency.
  - ☞ **Serum & Urine Sodium (Meq/L):** The mean Serum Sodium (Meq/L) among the subjects was 119.99 (± 7.79) ranging from 104 to 132. The mean Urine Sodium (Meq/L) among the subjects was 29.98 (± 13.92) ranging from 6 to 68.
  - ☞ **Serum & Urine Osmolality (Mosm/Kg):** The mean Serum Osmolality (Mosm/Kg) among the subjects was 260.29 (± 10.62) ranging from 234 to 286. The mean Urine Osmolality (Mosm/Kg) among the subjects was 298.37 (± 107.32) ranging from 118 to 651.
- ➢ **Outcome:** Among the subjects, 90 (90%) were Improved followed by 10 (10%) had Death.
- ➢ **Comparision of Outcome with other factors:**
  - ☞ **Comparision of Age group with the Outcome:** > 60 years had higher proportion of death with 27.27% followed by 51 - 60 years with 13.04% and least

in 20 - 30 years with 0%. The difference in Outcome between different Age group was statistically significant ($p < 0.05$).

- **Comparision of Gender with the Outcome:** 14.54% of the Males had death which is higher compared to Females of whom 4.44% had death and the difference was not statistically significant ($p > 0.05$)
- **Comparision of Volume Status with the Outcome:** Euvolemic had higher proportion of death with 15.55% followed by Hypovolemic with 12% and least in Hypervolemic with 0%. The difference in Outcome distribution between different Volume Status was statistically significant ($p < 0.05$).
- **Comparision of Cause of Hyponatremia with the Outcome:** SIADH had higher proportion of death with 17.5% followed by Others with 10% and least in Volume overload with 0%. The difference in Outcome distribution between different Cause of Hyponatremia was not statistically significant ($p > 0.05$).
- **Comparision of Comorbidities with the Outcome:** 16.1% of the subjects with Diabetes Mellitus, 17.6% of the subjects with Hypertension, 20% of the subjects with Coronary Artery Disease had death. None of the subjects with Chronic Kidney Disease, Hypothyroidism and Chronic Liver Disease had death. The differences were not statistically significant.
- **Comparision of Clinical profile with the Outcome:** 20.6% of the subjects with Headache,18.6% of the subjects with Vomiting 30% of the subjects with Seizures and none with Diuretics had death and the differences were statistically significant. 25% of the subjects with Diarrhea, 8.7% of the subjects with Muscle Cramps and 17.1% of the subjects with Altered Sensorium had death but the differences were not statistically significant.

- **Comparision of TFT with the Outcome:** None of the subjects with TFT had death which is lower compared to those without TFT of whom 10.3% had death and the difference was not statistically significant ($p > 0.05$)
- **Comparision of Co-Syntropin Test with the Outcome:** None of the subjects with Co-Syntropin Test had death which is lower compared to those without Co-Syntropin Test of whom 10.41% had death and the difference was not statistically significant ($p > 0.05$).
- **Serum & Urinary Sodium (Meq/L) with Outcome:** The mean Serum Sodium (Meq/L) among Death was 119.7 (± 7.82) which is lower by 0.32 but not statistically significant compared to 120.02 (± 7.83) in Improved. The mean Urine Sodium (Meq/L) among Death was 39.1 (± 8.23) which is higher by 10.13 and statistically significant compared to 28.97 (± 14.08) in Improved.
- **Serum & Urine Osmolality (Mosm/Kg) with Outcome:** The mean Serum Osmolality (Mosm/Kg) among Death was 260.5 (± 9.69) which is higher by 0.23 but not statistically significant compared to 260.27 (± 10.77) in Improved. The mean Urine Osmolality (Mosm/Kg) among Death was 264.9 (± 91.25) which is lower by 37.19 but not statistically significant compared to 302.09 (± 108.76) in Improved.
- **Renal function tests with Outcome:** The mean Serum Urea (mg/dl) among Death was 34.7 (± 10.18) which is lower by 2.91 but not statistically significant compared to 37.61 (± 17.7) in Improved. The mean Serum Creatinine (mg/dl) among Death was 0.99 (± 0.3) which is lower by 0.46 and statistically significant compared to 1.45 (± 1.27) in Improved. The mean Random Blood Sugar (mg/dl) among Death was 162.9 (± 55.98) which is higher by 12.41 but not statistically significant compared to 150.49 (± 68.14) in Improved.

12 CONCLUSION

Among the study subjects, 45 (45%) were Euvolemic followed by 30 (30%) were Hypervolemic and least 25 (25%) were Hypovolemic hyponatremia. Diabetes Mellitus and Hypertension were the most common comorbidities. Vomiting (43%) altered sensorium (35%) and headache (34%) were the most common presenting symptoms. 40 (40%) were due to SIADH followed by 30 (30%) were due to Volume Overload were the common cause of hyponatremia. The mortality rate among our study population was 10%.

Increased age, Euvolemic and hypovolemic hyponatremia, Presence of headache, seizures, and vomiting, Higher urine sodium levels and lower creatinine levels were significantly associated with the higher mortality in hyponatremia. Male gender, Hyponatremia due to SIADH, Presence of diabetes, hypertension and coronary heart disease, presence of diarrhea and altered sensorium associated with the higher mortality in hyponatremia, but not statistically significant. TFT, Co-Syntropin Test, serum sodium, Serum & Urine Osmolality, Serum urea and Random blood sugar was not associated with the mortality in hyponatremia.

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14 ANNEXURES

14.1.1 PROFORMA

PROFORMA

A STUDY ON ETIOLOGY AND CLINICAL OUTCOME OF HYPONATREMIA PATIENTS ADMITTED IN ICU IN TIRUNELVELI MEDICAL COLLEGE HOSPITAL

S.No IP No. Name:

Age Sex DOA DOD

Weight

Primary diagnosis:

SYMPTOMS

S.No.	Symptoms	Status		Duration
1	Nausea	Y	N	
2	Vomiting	Y	N	
3	Headache	Y	N	
4	Altered Mental Status	Y	N	
5	Hiccups	Y	N	
6	Seizures	Y	N	
7	Others	Y	N	

If others, please specify

Diet Habits:

Fluid intake:

Decreased intake:

MEDICAL HISTORY

S.No.	Co-morbid conditions	Status		Duration	Specify
1	Diabetes Mellitus	Y	N		
2	Hypertension	Y	N		
3	Cardiovascular	Y	N		
4	Renal Problems	Y	N		
5	Endocrine	Y	N		
6	Respiratory	Y	N		
7	Neurological	Y	N		
8	Gasterointestinal	Y	N		
9	Others	Y	N		

If others, please specify

CURRENT MEDICATIONS

S.No.	Drug Name	Duration	Dosage/day	Causes Hyponatremia	
1				Y	N
2					
3					
4					
5					
6					

CLINICAL FINDINGS

Pulse Rate / min. Blood Pressure mmHg

Volume status at the time of admission: Hypovolemic / Hypervolemic / Euvolemic

Oedema: Y / N Ascites / Pedaledema

Dehydration: Y / N

BIOCHEMICAL PARAMETERS (At the time of admission)

Serum sodium level: Urine spot sodium:

Serum osmolality: Urine osmolality:

Na Urea Glucose

Random Serum Cortisol: Done / Not done Random serum cortisol level:

ACTH stimulation test:

TFT: Done / Not done TSH: Free T4:

Calculated sodium deficit: Diuretics Y / N

Infusion Plan: Fluid restriction Y / N

Specific drugs

Outcome: Asymptomatic / Symptomatically better / Same status

Discharged / Death / AMA / Transfer

Hyponatremia Cause

Possible secondary cause

Formula

Calculated serum osmolality: 2 x Na + Glu / 18 + Urea/6

14.1.2 **CONSENT FORM**

CONSENT FORM

Format for Informed Consent Form for Parent / Guardian of the Subjects

Informed Consent form to participate in a research study

Study Title:

Study Number: _____

Subject's Initials: _____ **Subject's Name:** _____

Date of Birth / Age: _____

(i) I confirm that I have read and understood the information sheet dated _____ for the above study and have had the opportunity to ask questions. [ ]

(ii) I understand that my son / daughter's participation in the study is voluntary and that he/she is free to withdraw at any time, without giving any reason, without his/her medical care or legal rights being affected. [ ]

(iii) I understand that the Ethics Committee and the regulatory authorities will not need my permission to look at my son / daughter's health records both in respect of the current study and any further research that may be conducted in relation to it, even if he/she withdraws from the trial. I agree to this access. However, I understand that my son / daughter identity will not be revealed in any information released to third parties or published. [ ]

(iv) I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s). [ ]

(v) I agree for the participation of my son/daughter in the above study. [ ]

Signature (or Thumb impression) of the Subject's parent /Legally Acceptable Guardian
Date: _____/_____/_____
Signatory's Name: _____
Signature: _____
Or
Representative: _____
Date: _____/_____/_____
Signatory's Name: _____

Signature or thumb impression of the Witness: _____
Date: _____/_____/_____
Name & Address of the Witness: _____

நோயாளிகளுக்கு அறிவிப்பு மற்றும் ஒப்புதல் படிவம்
(மருத்துவ ஆய்வில் பங்கேற்பதற்கு)

ஆய்வு செய்யப்படும் தலைப்பு:
பங்கு பெறுவரின் பெயர்:
பங்கு பெறுவரின் வயது:

		பங்கு பெறுவர் இதனை ✓ குறிக்கவும்
1.	நான் மேலே குறிப்பிட்டுள்ள மருத்துவ ஆய்வின் விவரங்களை படித்து புரிந்து கொண்டேன். என்னுடைய சந்தேகங்களை கேட்கவும், அதற்கான தகுந்த விளக்கங்களை பெறவும் வாய்ப்பளிக்கப்பட்டுள்ளது என அறிந்து கொண்டேன்.	☐
2.	நான் இவ்வாய்வில் தன்னிச்சையாக தான் பங்கேற்கிறேன். எந்த காரணத்தினாலோ எந்த கட்டத்திலும், எந்த சட்ட சிக்கலுக்கும் உட்படாமல் நான் இவ்வாய்வில் இருந்து விலகி கொள்ளலாம் என்றும் அறிந்து கொண்டேன்.	☐
3.	இந்த ஆய்வு சம்பந்தமாகவோ, இதை சார்ந்து மேலும் ஆய்வு மேற்காள்ளும் போதும் இந்த ஆய்வில் பங்குபெறும் மருத்துவர் என்னுடைய மருத்துவ அறிக்கைகளை பார்ப்பதற்கு என் அனுமதி தேவையில்லை என அறிந்து கொள்கிறேன். நான் ஆய்வில் இருந்து விலகிக் கொண்டாலும் இது பொருந்தும் என அறிகிறேன்.	☐
4.	இந்த ஆய்வின் மூலம் கிடைக்கும் தகவலையோ, முடிவையோ பயன்படுத்திக் கொள்ள மறுக்க மாட்டேன்.	☐
5.	இந்த ஆய்வில் பங்கு கொள்ள ஒப்புக் கொள்கிறேன் எனக்கு கொடுக்கப்பட்டஅறிவுரைகளின் படி நடந்து கொள்வதுடன், ஆய்வை மேற்கொள்ளும் மருத்துவ அணிக்கு உண்மையுடன் இருப்பேன் என்று உறுதியளிக்கிறேன். என் உடல் நலம் பாதிக்கப்பட்டாலோ, அல்லது எதிர்பாராத, வழக்கத்திற்கு மாறான நோய்குறி தென்பட்டாலோ உடனே இதை மருத்துவ அணியிடம் தெரிவிப்பேன் என உறுதி அளிக்றேன்.	☐

பங்கேற்பவரின் கையொப்பம் / ..... இடம் .....
கட்டைவிரல் ரேகை
பங்கேற்பவரின் பெயர் மற்றும் விலாசம் .....
ஆய்வாளரின் கையொப்பம் /..... இடம் .....
ஆய்வாளரின் பெயர் .....
மையம் .....
கல்வியறிவு இல்லாதவற்கு (கைரேகை வைத்தவர்களுக்கு) இது அவசியம் தேவை
சாட்சியின் கையொப்பம் /..... இடம் .....
பெயர் மற்றும் விலாசம் .....

Sl. no	AGE	SEX	VOLUME STATUS	PRIMARY DISORDER	CO MORBIDITIES						HEADACHE	VOMITING	SYMPTOMATOLOGY				DIURETICS	SERUM SODIUM(meq/L	SERUM OSMOLALITY(m	URINE SOIUM(meq/L)	URINE OSMOLALITY(mO	S.UREA(mg/dl)	S.CREATININE(mg/dl)	RBS(mg/dl)	TFT	CO SYNTROPIN TEST	CAUSE OF HYPONATRIMIA	OUTCOME
					DM	SHT	CAD	CKD	HYPOTHYROIDISM	CLD			DIARRHEA	MUSCLE CRAMPS	ALTERED SENSORIU	SEIZURES													
1	40	M	HYPOVOLEMIC	ACUTE TUBULAR NECROSIS	Y	N	N	N	N	N	N	Y	N	Y	N	N	N	120	275	25	460	50	1.5	160			RENAL LOSS(SALT LOSING NEPHROPATHY)	IMPROVED
2	52	M	EUVOLEMIC	CVA	Y	Y	Y	N	N	N	Y	Y	N	N	Y	Y	N	110	272	32	245	35	1	150			SIADH	DEATH
3	65	F	HYPOVOLEMIC	OBSTRUCTIVE UROPATHY	Y	N	N	N	N	N	N	Y	N	N	N	N	N	125	270	29	280	62	1.6	190			RENAL LOSS(SALT LOSING NEPHROPATHY)	DEATH
4	25	M	EUVOLEMIC	MENINGITIS	N	N	N	N	N	N	Y	Y	N	N	Y	N	N	106	265	40	230	30	0.7	167			SIADH	IMPROVED
5	31	M	HYPOVOLEMIC	DKA	Y	N	N	N	N	N	N	Y	N	Y	N	N	N	120	252	25	220	26	0.9	400			RENAL LOSS(KETONURIA)	IMPROVED
6	48	F	HYPOVOLEMIC	DKA	Y	N	N	N	N	N	Y	Y	Y	N	N	N	N	125	268	30	177	28	1	320			RENAL LOSS(KETONURIA)	IMPROVED
7	52	F	EUVOLEMIC	HYPOTHYROIDSM	N	N	N	N	Y	N	N	N	N	Y	Y	N	N	112	274	28	478	28	0.8	110	Y		HYPOTHYROIDISM	IMPROVED
8	65	M	HYPOVOLEMIC	CKD	N	N	N	Y	N	N	N	N	N	N	N	N	Y	128	269	32	250	56	2	121			RENAL LOSS(DIURETIC EXCESS)	IMPROVED
9	70	M	HYPERVOLEMIC	CKD	Y	Y	Y	Y	N	N	N	Y	N	N	Y	Y	Y	120	258	30	436	60	2.4	150			VOLUME OVERLOAD	IMPROVED
10	58	F	HYPERVOLEMIC	CCF	Y	N	Y	N	N	N	N	N	N	N	N	N	Y	130	246	7	425	26	1.2	130			VOLUME OVERLOAD	IMPROVED
11	20	F	HYPOVOLEMIC	ADDISONS	N	N	N	N	N	N	N	N	N	N	N	N	N	130	254	45	118	30	0.6	101		Y	RENAL LOSS(MINERALOCORTICOID DEFICIENCY)	IMPROVED
12	50	M	HYPERVOLEMIC	CKD	Y	Y	N	Y	N	N	N	N	N	Y	N	N	Y	124	261	28	130	80	4	168			VOLUME OVERLOAD	IMPROVED
13	56	M	HYPERVOLEMIC	CCF	N	Y	Y	N	N	N	N	N	N	N	N	N	Y	116	247	12	178	35	1.2	112			VOLUME OVERLOAD	IMPROVED
14	61	F	HYPOVOLEMIC	DKA	Y	Y	N	N	N	N	N	Y	N	N	Y	N	N	111	268	40	173	25	0.7	410			RENAL LOSS(KETONURIA)	IMPROVED

Sl. no	AGE	SEX	VOLUME STATUS	PRIMARY DISORDER	CO MORBIDITIES						HEADACHE	VOMITING	SYMPTOMATOLOGY				DIURETICS	SERUM SODIUM(meq/L	SERUM OSMOLALITY(m	URINE SOIUM(meq/L)	URINE OSMOLALITY(mO	S.UREA(mg/dl)	S.CREATININE(mg/dl)	RBS(mg/dl)	TFT	CO SYNTROPIN TEST	CAUSE OF HYPONATRIMIA	OUTCOME
					DM	SHT	CAD	CKD	HYPOTHYROIDISM	CLD			DIARRHEA	MUSCLE CRAMPS	ALTERED SENSORIU	SEIZURES												
15	49	M	EUVOLEMIC	CVA	Y	Y	N	N	N	N	N	N	N	N	N	N	N	118	272	35	256	27	0.6	200			SIADH	IMPROVED
16	55	M	EUVOLEMIC	PNEUMONIA	Y	Y	N	N	N	N	Y	N	N	Y	N	Y	N	127	271	38	172	22	0.9	150			SIADH	IMPROVED
17	54	F	EUVOLEMIC	MENINGITIS	N	N	N	N	N	N	Y	Y	N	N	Y	N	N	109	246	45	180	19	1	128			SIADH	IMPROVED
18	27	F	HYPOVOLEMIC	DKA	Y	N	N	N	N	N	N	Y	N	N	N	N	N	126	245	42	280	21	0.9	360			RENAL LOSS(KETONURIA)	IMPROVED
19	57	M	HYPERVOLEMIC	CKD	Y	N	N	Y	N	N	N	N	N	N	Y	N	Y	105	271	25	190	56	5.1	190			VOLUME OVERLOAD	IMPROVED
20	61	M	EUVOLEMIC	SUB ARACHNOID HAEMORRH	N	Y	N	N	N	N	Y	Y	N	N	Y	Y	N	111	274	50	220	28	1.2	160			SIADH	IMPROVED
21	62	M	HYPOVOLEMIC	CVA	Y	Y	N	N	N	N	Y	Y	N	N	Y	Y	N	117	273	30	205	39	1.3	210			RENAL LOSS(CEREBRAL SALT WASTING SYNDROME)	DEATH
22	65	M	HYPOVOLEMIC	OBSTRUCTIVE UROPATHY	N	N	N	N	N	N	N	Y	N	Y	N	N	N	130	269	25	150	50	1.4	110			RENAL LOSS(SALT LOSING NEPHROPATHY)	IMPROVED
23	72	M	HYPOVOLEMIC	CVA	Y	Y	Y	N	N	N	Y	Y	N	N	Y	Y	N	110	266	52	132	29	1	260			RENAL LOSS(CEREBRAL SALT WASTING SYNDROME)	DEATH
24	29	M	EUVOLEMIC	CORTICAL VENOUS THROMBOSI	N	N	N	N	N	N	Y	Y	N	N	Y	Y	N	128	254	37	205	36	1.1	176			SIADH	IMPROVED
25	50	M	EUVOLEMIC	VIRAL ENCEPHALITIS	N	N	N	N	N	N	Y	Y	N	N	Y	Y	N	132	255	39	400	32	1	154			SIADH	IMPROVED
26	59	F	HYPERVOLEMIC	CLD	N	N	N	N	N	Y	N	N	N	N	Y	N	Y	120	245	8	550	37	0.7	100			VOLUME OVERLOAD	IMPROVED
27	28	M	EUVOLEMIC	LYMPHOMA	N	N	N	N	N	N	N	N	N	N	N	N	N	116	262	42	380	25	0.7	123			SIADH	IMPROVED
28	52	F	HYPERVOLEMIC	NEPHROTIC SYNDROME	Y	N	N	N	N	N	N	N	N	N	N	N	Y	110	271	9	292	35	1	210			VOLUME OVERLOAD	IMPROVED

Sl. no	AGE	SEX	VOLUME STATUS	PRIMARY DISORDER	CO MORBIDITIES						HEADACHE	VOMITING	SYMPTOMATOLOGY				DIURETICS	SERUM SODIUM(meq/L	SERUM OSMOLALITY(m	URINE SOIUM(meq/L)	URINE OSMOLALITY(mO	S.UREA(mg/dl)	S.CREATININE(mg/dl)	RBS(mg/dl)	TFT	CO SYNTROPIN TEST	CAUSE OF HYPONATRIMIA	OUTCOME
					DM	SHT	CAD	CKD	HYPOTHYROIDISM	CLD			DIARRHEA	MUSCLE CRAMPS	ALTERED SENSORIU	SEIZURES													
29	32	F	HYPOVOLEMIC	DKA	Y	N	N	N	N	N	N	N	N	N	N	N	N	130	269	49	330	26	1.1	450			RENAL LOSS(KETONURIA)	IMPROVED
30	63	M	EUVOLEMIC	PULMONARY TUBERCULO	N	N	Y	N	N	N	Y	N	N	Y	N	N	N	118	251	47	307	29	0.6	100			SIADH	DEATH
31	67	M	EUVOLEMIC	CVA	N	Y	N	N	N	N	Y	Y	N	N	Y	Y	N	124	249	44	300	30	1	111			SIADH	DEATH
32	50	F	HYPERVOLEMIC	CKD	Y	Y	N	Y	N	N	N	N	N	N	N	N	Y	123	270	26	336	110	6.2	210			VOLUME OVERLOAD	IMPROVED
33	35	M	HYPOVOLEMIC	DKA	Y	N	N	N	N	N	N	Y	N	N	Y	N	N	124	264	50	373	34	0.7	290			RENAL LOSS(KETONURIA)	IMPROVED
34	65	F	EUVOLEMIC	HYPOTHYROIDSM	N	N	N	N	Y	N	N	N	N	Y	Y	N	N	118	234	27	274	40	0.9	150	Y		HYPOTHYROIDISM	IMPROVED
35	69	M	EUVOLEMIC	MESOTHELIOMA	N	N	N	N	N	N	N	Y	N	Y	N	N	N	116	254	56	392	38	0.9	123			SIADH	IMPROVED
36	37	M	EUVOLEMIC	LYMPHOMA	N	N	N	N	N	N	N	N	N	Y	N	N	N	124	270	36	367	31	1	121			SIADH	IMPROVED
37	71	M	HYPOVOLEMIC	AGE	Y	Y	N	N	N	N	N	Y	Y	Y	N	N	N	132	268	7	245	32	0.6	111			EXTRA RENAL(GI LOSS)	IMPROVED
38	48	M	EUVOLEMIC	VIRAL ENCEPHALITIS	N	N	N	N	N	N	Y	Y	N	N	Y	Y	N	116	277	38	317	27	1.2	130			SIADH	IMPROVED
39	31	F	EUVOLEMIC	SEVERE ASTHMA	N	N	N	N	N	N	N	N	N	Y	Y	N	N	124	258	37	345	21	1.1	156			SIADH	IMPROVED
40	53	F	HYPERVOLEMIC	CLD	N	N	N	N	N	Y	N	N	N	N	N	N	Y	118	263	11	486	28	1	97			VOLUME OVERLOAD	IMPROVED
41	57	F	EUVOLEMIC	BRAIN TUMOUR	N	Y	N	N	N	N	Y	Y	N	N	N	Y	N	127	279	42	220	34	1.3	160			SIADH	IMPROVED
42	47	M	HYPERVOLEMIC	CKD	N	N	N	Y	N	N	N	N	N	Y	Y	N	Y	120	249	38	340	114	2.8	90			VOLUME OVERLOAD	IMPROVED

Sl. no	AGE	SEX	VOLUME STATUS	PRIMARY DISORDER	CO MORBIDITIES						HEADACHE	VOMITING	SYMPTOMATOLOGY				DIURETICS	SERUM SODIUM(meq/L	SERUM OSMOLALITY(m	URINE SOIUM(meq/L)	URINE OSMOLALITY(mO	S.UREA(mg/dl)	S.CREATININE(mg/dl)	RBS(mg/dl)	TFT	CO SYNTROPIN TEST	CAUSE OF HYPONATRIMIA	OUTCOME
					DM	SHT	CAD	CKD	HYPOTHYROIDISM	CLD			DIARRHEA	MUSCLE CRAMPS	ALTERED SENSORIU	SEIZURES													
43	65	M	HYPERVOLEMIC	CCF	N	Y	Y	N	N	N	N	N	N	N	N	N	Y	110	257	6	265	27	1.3	120			VOLUME OVERLOAD	IMPROVED
44	68	M	HYPERVOLEMIC	CKD	Y	Y	N	Y	N	N	N	Y	N	N	N	N	Y	113	265	32	256	65	3.9	200			VOLUME OVERLOAD	IMPROVED
45	48	M	HYPOVOLEMIC	SHT	N	y	N	N	N	N	Y	N	N	N	Y	N	Y	130	250	52	225	18	0.8	120			RENAL LOSS(DIURETIC EXCESS)	IMPROVED
46	42	F	EUVOLEMIC	MENINGITIS	N	N	N	N	N	N	Y	Y	N	N	N	N	N	119	259	45	314	36	1	131			SIADH	IMPROVED
47	30	F	EUVOLEMIC	HYPOTHYRO IDSM	N	N	N	N	Y	N	N	N	N	Y	N	N	N	104	269	25	307	47	1	120	Y		HYPOTHYROIDISM	IMPROVED
48	55	F	HYPERVOLEMIC	CLD	Y	N	N	N	N	Y	N	Y	N	N	Y	Y	Y	106	256	15	277	36	0.8	130			VOLUME OVERLOAD	IMPROVED
49	41	M	HYPERVOLEMIC	CLD	N	N	N	N	N	Y	N	N	N	N	N	N	Y	118	251	16	300	38	1.2	90			VOLUME OVERLOAD	IMPROVED
50	47	M	EUVOLEMIC	PNEUMONI A	N	N	N	N	N	N	N	Y	N	Y	N	N	N	125	270	36	352	28	0.8	129			SIADH	IMPROVED
51	45	M	HYPERVOLEMIC	CKD	N	N	N	Y	N	N	N	N	N	Y	N	N	Y	128	272	29	320	68	2.6	101			VOLUME OVERLOAD	IMPROVED
52	48	F	HYPOVOLEMIC	VIRAL FEVER	N	N	N	N	N	N	Y	N	N	N	N	N	N	128	272	12	340	22	1.2	124			EXTRA RENAL(THIRD SPACE LOSS)	IMPROVED
53	47	M	HYPERVOLEMIC	CCF	N	N	Y	N	N	N	N	N	N	N	N	N	Y	131	275	8	345	31	1.1	115			VOLUME OVERLOAD	IMPROVED
54	50	M	EUVOLEMIC	GI MALIGNANC Y	N	Y	N	N	N	N	N	N	Y	N	N	N	N	130	255	47	451	32	0.7	138			SIADH	DEATH
55	39	F	EUVOLEMIC	CORTICAL VENOUS THROMBOSI	N	N	N	N	N	N	Y	Y	N	N	N	Y	N	126	245	32	367	35	0.6	134			SIADH	IMPROVED
56	60	F	EUVOLEMIC	CVA	N	Y	N	N	N	N	Y	Y	N	N	Y	N	N	124	262	38	256	41	0.7	136			SIADH	IMPROVED

Sl. no	AGE	SEX	VOLUME STATUS	PRIMARY DISORDER	CO MORBIDITIES						HEADACHE	VOMITING	SYMPTOMATOLOGY				DIURETICS	SERUM SODIUM(meq/L	SERUM OSMOLALITY(m	URINE SOIUM(meq/L)	URINE OSMOLALITY(mO	S.UREA(mg/dl)	S.CREATININE(mg/dl)	RBS(mg/dl)	TFT	CO SYNTROPIN TEST	CAUSE OF HYPONATRIMIA	OUTCOME
					DM	SHT	CAD	CKD	HYPOTHYROIDISM	CLD			DIARRHEA	MUSCLE CRAMPS	ALTERED SENSORIU	SEIZURES												
57	43	F	EUVOLEMIC	LUNG ABSCESS	N	N	N	N	N	N	N	N	Y	Y	Y	N	N	114	268	35	354	29	0.9	127			SIADH	IMPROVED
58	61	F	HYPOVOLEMIC	AGE	N	N	N	N	N	N	N	N	Y	Y	N	N	N	126	246	8	268	24	0.8	130			EXTRA RENAL(GI LOSS)	IMPROVED
59	43	M	EUVOLEMIC	PULMONARY TUBERCULO	Y	N	N	N	N	N	N	N	N	N	N	N	N	105	249	44	315	45	1	133			SIADH	IMPROVED
60	79	M	HYPERVOLEMIC	CKD	N	Y	N	Y	N	N	N	N	N	N	Y	N	Y	111	255	26	264	50	6.5	110			VOLUME OVERLOAD	IMPROVED
61	44	F	HYPERVOLEMIC	CLD	N	N	N	N	N	Y	N	N	N	N	N	N	Y	121	259	7	198	40	0.9	87			VOLUME OVERLOAD	IMPROVED
62	41	F	EUVOLEMIC	SARCOIDOSIS	N	N	N	N	N	N	N	Y	N	N	N	N	N	130	266	25	156	24	0.6	129		Y	GLUCOCORTICOID DEFICIENCY(SECONDARY ADRENAL INSUFFICIENCY)	IMPROVED
63	45	F	EUVOLEMIC	VIRAL ENCEPHALITIS	N	Y	N	N	N	N	Y	Y	N	N	Y	Y	N	129	260	46	127	28	0.6	111			SIADH	IMPROVED
64	40	F	HYPOVOLEMIC	INTERSTITIAl NEPHROPATHY	N	N	N	N	N	N	N	Y	N	Y	N	N	N	124	272	24	354	46	1.7	156			RENAL LOSS(SALT LOSING NEPHROPATHY)	IMPROVED
65	50	F	EUVOLEMIC	CRANIPHARYNGIOMA	Y	Y	N	N	N	N	Y	Y	N	N	N	N	N	124	270	27	258	35	0.9	100		Y	GLUCOCORTICOID DEFICIENCY(SECONDARY ADRENAL INSUFFICIENCY)	IMPROVED
66	55	M	EUVOLEMIC	SMALL CELL CARCINOMA LUNG	N	N	N	N	N	N	N	Y	Y	Y	N	N	N	129	255	37	157	27	1	110			SIADH	DEATH
67	49	M	EUVOLEMIC	PNEUMONIA	N	N	N	N	N	N	N	N	N	N	N	N	N	116	258	33	254	40	1.3	126			SIADH	IMPROVED
68	42	M	HYPERVOLEMIC	CKD	N	N	N	Y	N	N	N	N	N	N	N	N	Y	113	258	30	168	72	4.6	120			VOLUME OVERLOAD	IMPROVED
69	47	F	HYPOVOLEMIC	PANCREATITIS	N	N	N	N	N	N	N	N	N	N	N	N	N	126	247	6	265	26	0.7	147			EXTRA RENAL(THIRD SPACE LOSS)	IMPROVED
70	48	M	EUVOLEMIC	MENINGITIS	N	Y	N	N	N	N	Y	N	N	N	Y	Y	N	115	245	33	248	38	1.1	134			SIADH	IMPROVED

Sl. no	AGE	SEX	VOLUME STATUS	PRIMARY DISORDER	CO MORBIDITIES						HEADACHE	VOMITING	SYMPTOMATOLOGY				DIURETICS	SERUM SODIUM(meq/l	SERUM OSMOLALITY(m	URINE SOIUM(meq/L)	URINE OSMOLALITY(mO	S.UREA(mg/dl)	S.CREATININE(mg/dl)	RBS(mg/dl)	TFT	CO SYNTROPIN TEST	CAUSE OF HYPONATRIMIA	OUTCOME
					DM	SHT	CAD	CKD	HYPOTHYROIDISM	CLD			DIARRHEA	MUSCLE CRAMPS	ALTERED SENSORIU	SEIZURES													
71	41	M	HYPERVOLEMIC	CCF	Y	Y	Y	N	N	N	N	N	N	N	N	N	Y	120	241	8	267	41	1	180			VOLUME OVERLOAD	IMPROVED
72	36	F	HYPOVOLEMIC	CVA	N	Y	N	N	N	N	Y	Y	N	N	N	N	N	120	254	68	331	30	0.6	123			RENAL LOSS(CEREBRAL SALT WASTING SYNDROME)	IMPROVED
73	50	M	HYPERVOLEMIC	CKD	Y	Y	N	Y	N	N	N	Y	N	Y	N	N	Y	117	267	25	357	80	5.5	160			VOLUME OVERLOAD	IMPROVED
74	37	F	EUVOLEMIC	VIRAL ENCEPHALITIS	N	N	N	N	N	N	Y	N	N	N	Y	Y	N	110	266	36	369	36	1	140			SIADH	IMPROVED
75	56	F	EUVOLEMIC	SUB ARACHNOID HAEMORRH	N	Y	N	N	N	N	Y	Y	N	N	Y	Y	N	124	265	41	324	32	0.7	130			SIADH	DEATH
76	31	F	HYPOVOLEMIC	AGE	N	N	N	N	N	N	N	N	Y	N	N	N	N	130	271	9	458	32	0.8	156			EXTRA RENAL(GI LOSS)	IMPROVED
77	58	F	EUVOLEMIC	CVA	Y	Y	N	N	N	N	Y	N	N	N	N	N	N	126	269	40	324	29	0.8	126			SIADH	IMPROVED
78	51	M	EUVOLEMIC	GI MALIGNANCY	N	Y	N	N	N	N	Y	N	N	N	N	N	N	114	255	36	268	21	0.6	129			SIADH	IMPROVED
79	61	F	EUVOLEMIC	CVA	N	Y	N	N	N	N	Y	Y	N	N	Y	N	N	112	286	35	482	43	1.3	115			SIADH	IMPROVED
80	52	M	EUVOLEMIC	PNEUMONIA	N	N	N	N	N	N	N	N	N	N	Y	N	N	106	254	39	168	32	1	128			SIADH	IMPROVED
81	27	M	HYPOVOLEMIC	ADDISONS	N	N	N	N	N	N	N	N	N	N	N	N	N	130	250	52	257	34	0.9	141		Y	RENAL LOSS(MINERALOCORTICOID DEFICIENCY)	IMPROVED
82	48	F	EUVOLEMIC	CORTICAL VENOUS THROMBOSI	N	N	N	N	N	N	Y	Y	N	N	Y	Y	N	118	259	44	364	35	0.9	137			SIADH	IMPROVED
83	49	F	HYPERVOLEMIC	CLD	N	N	N	N	N	Y	N	N	N	N	Y	N	Y	116	253	10	258	29	1.1	104			VOLUME OVERLOAD	IMPROVED
84	53	M	EUVOLEMIC	PNEUMONIA	N	N	Y	N	N	N	N	N	N	Y	N	N	N	125	249	33	478	29	0.7	154			SIADH	IMPROVED

Sl. no	AGE	SEX	VOLUME STATUS	PRIMARY DISORDER	CO MORBIDITIES						HEADACHE	VOMITING	SYMPTOMATOLOGY				DIURETICS	SERUM SODIUM(meq/L	SERUM OSMOLALITY(m	URINE SOIUM(meq/L)	URINE OSMOLALITY(mO	S.UREA(mg/dl)	S.CREATININE(mg/dl)	RBS(mg/dl)	TFT	CO SYNTROPIN TEST	CAUSE OF HYPONATRIMIA	OUTCOME
					DM	SHT	CAD	CKD	HYPOTHYROIDISM	CLD			DIARRHEA	MUSCLE CRAMPS	ALTERED SENSORIU	SEIZURES												
85	57	M	EUVOLEMIC	CVA	Y	N	N	N	N	N	Y	N	N	N	N	N	N	126	242	36	315	16	0.8	150			SIADH	IMPROVED
86	28	F	HYPOVOLEMIC	VIRAL FEVER	N	N	N	N	N	N	Y	N	N	N	N	N	N	131	259	10	248	21	0.9	100			EXTRA RENAL(THIRD SPACE LOSS)	IMPROVED
87	35	M	EUVOLEMIC	PULMONARY TUBERCULO	N	N	N	N	N	N	N	N	N	Y	N	N	N	128	248	38	367	28	1	140			SIADH	IMPROVED
88	58	M	HYPERVOLEMIC	CKD	N	Y	N	Y	N	N	N	N	N	N	N	N	Y	130	265	26	156	56	4.8	104			VOLUME OVERLOAD	IMPROVED
89	63	F	HYPERVOLEMIC	CCF	N	N	Y	N	N	N	N	N	N	N	N	N	Y	120	248	11	254	24	1.2	126			VOLUME OVERLOAD	IMPROVED
90	49	F	HYPERVOLEMIC	CKD	N	Y	N	Y	N	N	N	N	N	N	Y	N	Y	116	268	29	268	64	3.6	97			VOLUME OVERLOAD	IMPROVED
91	41	M	HYPOVOLEMIC	SHT	N	y	N	N	N	N	Y	N	N	N	N	N	Y	132	274	24	482	35	1.2	97			RENAL LOSS(DIURETIC EXCESS)	IMPROVED
92	58	M	EUVOLEMIC	LUNG ABSCESS	N	Y	Y	N	N	N	N	Y	N	N	N	N	N	114	271	35	314	30	1.1	134			SIADH	IMPROVED
93	48	F	HYPERVOLEMIC	CLD	N	N	N	N	N	Y	N	N	N	N	Y	N	Y	115	265	13	257	28	1.3	100			VOLUME OVERLOAD	IMPROVED
94	70	M	EUVOLEMIC	CVA	Y	N	N	N	N	N	Y	Y	N	N	Y	Y	N	110	249	32	248	32	1	230			SIADH	DEATH
95	67	M	HYPERVOLEMIC	NEPHROTIC SYNDROME	Y	N	N	N	N	N	N	N	N	N	N	N	Y	120	255	12	651	32	1.4	250			VOLUME OVERLOAD	IMPROVED
96	65	M	HYPERVOLEMIC	CKD	N	Y	N	Y	N	N	N	Y	N	N	N	N	Y	108	246	27	557	70	2.9	110			VOLUME OVERLOAD	IMPROVED
97	47	F	EUVOLEMIC	BRAIN ABSCESS	Y	N	Y	N	N	N	Y	Y	N	N	N	Y	Y	106	265	40	574	31	1.1	211			SIADH	IMPROVED
98	51	F	HYPOVOLEMIC	AGE	N	N	N	N	N	N	N	Y	Y	N	N	N	N	125	271	8	258	36	1.3	120			EXTRA RENAL(GI LOSS)	IMPROVED

Sl. no	AGE	SEX	VOLUME STATUS	PRIMARY DISORDER	CO MORBIDITIES						HEADACHE	VOMITING	SYMPTOMATOLOGY				DIURETICS	SERUM SODIUM(meq/L	SERUM OSMOLALITY(m	URINE SOIUM(meq/L)	URINE OSMOLALITY(mO	S.UREA(mg/dl)	S.CREATININE(mg/dl)	RBS(mg/dl)	TFT	CO SYNTROPIN TEST	CAUSE OF HYPONATRIMIA	OUTCOME
					DM	SHT	CAD	CKD	HYPOTHYROIDISM	CLD			DIARRHEA	MUSCLE CRAMPS	ALTERED SENSORIUI	SEIZURES													
99	43	M	HYPERVOLEMIC	CCF	N	Y	Y	N	N	N	N	N	N	N	N	N	Y	110	240	6	128	30	1.1	130			VOLUME OVERLOAD	IMPROVED
100	42	F	HYPERVOLEMIC	CCF	N	N	Y	N	N	N	N	N	N	N	N	N	Y	115	250	13	250	27	0.9	124			VOLUME OVERLOAD	IMPROVED