FLUID, ELECTROLYTES & ACID-BASE BALANCE

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Learning objectives:

1. To describe fluid, electrolytes and acid base disturbances.
2. To be able to calculate fluid and electrolytes maintenance requirements.
3. To be able to calculate fluid and electrolytes deficit requirements.
4. To be able to supplement postoperative parenteral fluid therapy; its routes and types, restrictions and complications.
5. To describe different types of acid base disturbances and their management.

Lecture outlines:

1. Water balance (depletion and intoxication).
2. Electrolyte balance (sodium balance, hypokalaemia, calcium balance and magnesium balance).
3. Parenteral fluid therapy.
4. Acid-base balance (respiratory and metabolic)

WATER BALANCE

DAILY WATER BALANCE OF 70 KG HEALTHY *ADULT*

2-3L. \24h. INTAKE	2-3L. \24h. OUTPUT
1200 ml. BEVERAGGE	*1500 ml. URINE*
1000 ml. SOLID FOOD	500+400 FROM SKIN & LUNG
300-500 ml.OXIDATION	100 ml. FAECES

WATER DEPLETION

- Pure Water Depletion ; As In Tracheostomy.
- Thirst, U.O↓,Sp. Gravity↑,pcv↑,s.Na+↑,bl. Urea↑.
- Relative Water Depletion; As In Diabetes Incipidus, After Head Injury, Diuretic Phase Of Acute Renal Failure, After Renal Transplantation.
- Treatment By Oral Fluid Or I.V. 5% Glucose Or Saline.
- *WATER DEFICIT(L.) = {0.6B.W.(Kg.)×(S.Na+ - 140)} ÷ 140*

WATER INTOXICATION

- Excessive Water Or Hypotonic Solutions Taken Orally, I.V. , S.C. , Rectally Or Transurethrally Also ADH-secreting Tumurs As Oat-cell Ca Of Bronchus.
- Vomit Clear Fluid, Mcv↑,pcv↓,s.Na^+↓,bl. Urea↓.
- Treatment By Stop Water Intake Or I.V. Appropriate Fluid Under CVP Control
- *WATER EXCESS(L.)={0.6B.W.(KG)×(140-S.Na^+)} / 140*

ELECTROLYTE BALANCE

SODIUM BALANCE

- TOTAL BODY Na^+ 5000 MMOL
  - 44% EXTRACELLULAR
  - 9% INTRACELLULAR
  - 47% IN BONE
- AVERAGE DAILY INTAKE 80-100MMOL OR 570ML. ISOTONIC SALINE
- EXCRETED IN URINE, FAECES & PERSPIRATION
- CONTROL BY ALDOSTERONE
- WITH CL^- & HCO_3^- MAKE 90% OF PLASMA OSMOTIC PRESSURE
  - S.Na^+ =137-147 MMOL/ L.
  - S. CL^- =95-105 MMO/ L.
  - S. HCO_3^- =25-30 MMOL./ L.
  - S. CL^- + S. HCO_3^- = 120-135 MMOL./ L.

SODIUM DEPLETION (HYPONATRAEMIA) :-

CAUSES :-

- LOSS FROM GIT DUE TO ANY CAUSE.
- ADRENAL INSUFFICIENCY.
- INAPPROPRIATE SECRETION OF ADH AS IN BRONCHIAL CA. , ELDERLY WITH ACUTE SURGICAL STRESS, OR HEAD INJURY.
- POSTOPERATIVE HYPONATRAEMIA ; IF CONTINUE GIVE FLUID WITHOUT SODIUM FOR > 48 H. AS THE POSTOPERATIVE Na^+ EXCRETION SHUTDOWN ENDS.

SODIUM DEPLETION (HYPONATRAEMIA) :-

- **CLINICAL FEATURES :- NO THIRSTY HERE (UNLIKE WATER DEPLETION)**
- **PCV GOOD INDICATOR OF DEHYDRATION IF Hb NORMAL BEFORE DEHYDRATION , S. Na^+↓, U.O.P.↓, URINARY Na^+↓ .**
- **TREATMENT :- I.V. 0.5-2 L. ISOTONIC SALINE OR RINGER SOLUTION (*PREVENTING HYPOPROTEINAEMIA)* OR PLASMA OR ITS SUBSTITUTE IN SEVERE CASES .**
- ***Na^+ DEFICIT (mEq)=0.6B.W.(Kg)×(140 – S.Na^+)***

SODIUM EXCESS (HYPERNATRAEMIA):-

- GIVE ISOTONIC SALINE EARLY POSTOPERATIVELY
- PUFFY FACE, OEDEMA AFTER 4.5 L. FLUID EXCESS, INCREASE WEIGHT, ELEVATED ANTERIOR FONTANELLE IN INFANTS
- TREAT BY STOP INFUSION OR AS PULMONARY OEDEMA

POTASSIUM BALANCE

- TOTAL BODY POTASSIUM IS 3500mmol.
- 3/4 OF IT IS IN SKELETAL MUSCLES
  - 98% INTRACELLULAR
  - 2 % EXTRACELLULAR
- ADULT DAILY INTAKE IS 52-78mmol.
- NORMAL S. POTASSIUM 3.5-5 mmol.\l.
- LOW INTRACELLULAR POTASSIUM MAY BE PRESENT WITH NORMAL S. POTASSIUM SO HYPOKALAEMIA ANTICIPATED IF ORAL INTAKE STOPPED FOR 4 DAYS.

POTASSIUM DEPLETION (HYPOKALAEMIA):-

CAUSES :-

- *SUDDENLY;* IN DIABETIC COMA TREATED WITH INSULIN & SALINE INFUSION
- *GRADUALLY;* IN DIARRHOEA, EXTERNAL GI FISTULAE, PROLONGED GASTRIC ASPIRATION + SALINE INFUSION, EXTENSIVE GI RESECTION FOR CA.

POTASSIUM DEPLETION (HYPOKALAEMIA):-

- **CLINICAL FEATURES :-**
- **TREATMENT :- ORAL 2gm kcl 6-HOURLY**
  - **I.V. POTASSIUM (U.O.P > 1000ml./ 24h. OR 40ml. /h.) WHEN NO ASSOCIATED ALKALOSIS GIVE 20mmol. KCL\L. OF 0.9% SALINE OR 5% DEXTROSE .**

0.1 FALL IN PH CAUSE 0.6mEq RISE IN PLASMA POTASSIUM & VICE VERSA *

CALCIUM :-

- EXTRACELLULAR CATION
- PLASMA CALCIUM 2.2-2.5 mmol.\l.
  - PROTEIN BOUND
  - FREE NON-IONISED
  - FREE IONISED ; WHICH FALLS WITH ALKALOSIS IN BLOOD OR URINE
- CALCIUM LEVEL AFFECTED BY VIT D , PHYTIC ACID , PARATHORMONE & CALCITONIN & STATE OF RENAL & SMALL BOWEL FUNCTION ALSO IN MASSIVE BLOOD TRANSFUSION.
- TREAT HYP*ER*CALCAEMIA BY REMOVE PARATHYROID TUMOUR.
- TREAT HYP*O*CALCAEMIA GIVING 10ml. OF 10% CALCIUM GLUCONATE I.V. SLOWLY,ORAL CALCIUM, ASPIRIN, HIGH CALCIUM LOW PHOSPHATE FOOD.

MAGNESIUM :-

- INTRACELLULAR CATION
- 0.7-0.9mmol./l.
- AVERAGE DAILY INTAKE 10 mmol.
- DEFICIENCY OCCUR IN DIARRHOEA, GI FISTULAE, CIRRHOSIS, PARATHYROID DISEASES, PROLONGED I.V. FLUID THERAPY WITHOUT MAGNESIUM SUPPLEMENT.
- CLINICAL FEATURES OF CNS IRRITABILITY, ECG CHANGES, LOW B.P. , LOW PROTEIN SYNTHESIS.
- TREAT BY 40mmol. MAGNESIUM SULPHATE IN 5% DEXTROSE OR SALINE OVER 24h.

PARENTERAL FLUID THERAPY

- ADMINISTRATION OF FLUID BY ROUTES OTHER THAN GIT AS I.V., I.M., S.C., OR TO BONE MARROW.

PARENTERAL FLUID THERAPY

TYPES OF FLUIIDS :-

1. PLASMA, ALBUMIN 4.5% 10% OR 25%, DEXTRANS & GELATIN
2. 5% DEXTROSE
3. 0.9% ISOTONIC SALINE(153,153)
4. 4% DEXTROSE IN 0.18% SALINE(1/5 DEXTROSE SALINE)
5. RINGER'S LACTATE SOLUTION(130,4,110,28)
6. DARROW'S SOLUTION(124,36,104,56)

PARENTERAL FLUID THERAPY

I.V. FLUID THERAPY REGIME:-

- **1st 24h. AFTER SURGERY 2L. 5% DEXTROSE**
  2nd 24h. 2L. DEXTROSE + 1L. 0.9% SALINE
  3rd24h. 2L. 5% DEXTROSE +1L. 0.9% SALINE + 20mmol. KCL IN EACH LITER

OR

- **3L. OF 1/5 DEXTROSE SALINE DAILY +20mmol. KCL ON 3rd POSTERATIVE DAY IN EACH LITER**

PARENTERAL FLUID THERAPY

- CONTRAINDICATIONS ARE HEART FAILURE & PULMONARY CONGESTION ON CXR
- IN DEHYDRATION
- IN SHOCK
- IN INFANTS WITH DEHYDRATION (1gm BODY WEIGHT = 1ml FLUID)
- CHARTING
- CLINICAL MONITORING
- HAEMATOLOGICAL BIOCHEMICAL MONITORING
- PATIENT SUBSISTING TOTALLY ON PARENTERAL FLUID LOSE DAILY 150gm. WEIGHT
- TWIN AMPOULES OF PARANTROVIT SHOUD BE GIVEN WEEKLY
- PROCTOCLYSIS (1PINT SALINE + 4PINTS TAP WATER NOT FASTER THAN 50 DROPPS \ MIN.)

ACID-BASE BALANCE:-

- NORMAL BLOOD PH = 7.36 - 7.44
- HCO_3^- : H_2CO_3 = 20 : 1
- $Co_2+H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$
- HCO_3^- ALTERED BY METABOLIC FACTORS, WHILE H_2CO_3 ALTERED BY RESPIRATORY FACTORS
- P_{CO_2} = 31-41 mmHg
- P_{O_2} = 80-110 mmHg
- STANDARD HCO_3^- (22- 25 meg/l.)
- BASE EXCESS OR BASE DEFICIT (+2.5)
- TOTAL EXTRACELLLAR BASE EXCESS OR BASE DEFICIT (mmol.) = BASE EXCESS OR BASE DEFICIT × 0.3 BODY WEIGHT IN Kg
- P_{O_2} & P_{CO_2} CHANGES INDICATE RESPIRATORY CAUSES WHILE STANDARD HCO_3^- & BASE EXCESS OR BASE DEFICIT CHANGES INDICATE METABOLIC CAUSES

ALKALOSIS :-

METABOLIC ALKALOSIS :-

CAUSES :

COMPENSATION :

*1mEq RISE IN HCO_3^- CAUSE 0.5-1mmHg RISE IN PCO_2 **

CLINICAL FEATURES :

HYPOKALAEMIC ALKALOSIS OR (PARADOXICAL ACIDUREA) :

*0.1 FALL IN PH CAUSE 0.6mEq\L. RISE IN PLASMA POTASSSIUM & VICE VERSA **

ALKALOSIS :-

RESPIRAORY ALKALOSIS :-

P_{CO_2} < 31 mmHg

CAUSES :

COMPENSATION :

- ***IN ACUTE RESPIRATORY ALKALOSIS : 10mmHg DROP IN PCO_2 CAUSE 2.5mEq\L. DROP IN HCO_3 WHICH IF < 18 IS NOT DUE TO ACUTE RESPIRATORY FAILURE ALONE ****

- ***IN CHRONIC RESPIRATORY ALKALOSIS: 10mmHg DROP IN PCO_2 CAUSE 5mEq\L. DROP IN HCO_3 WHICH IF < 12 IS NOT DUE TO CHRONIC RESPIRATORY ALKALOSIS ALONE ****

CLINICAL FEATURES :(DURING ANAESTHESIA)

TREATMENT :

ACIDOSIS :-

METABOLIC ACIDOSIS :-

Causes : Loss Of Base

Increase In Fixed Acids

Clinical Features :

Compensation :

- *1meq FALL IN HCO_3^- CAUSE 1-1.5 mmHg FALL IN PCO_2**

Treatment :

- *Hco_3^- Deficit(meq)=0.5b.W.(Kg)×(24 - PLASMA HCO_3^-)**

THE ANION GAP :-

- ANION GAP = (Na^+ + K^+)–(HCO_3^- + Cl^-)
  = 10-16 mmol./ l.
- INCREASE ANION GAP IN KETOACIDOSIS, LACTIC ACIDOSIS, SALICILATE POISONING & RENAL FAILURE.
- NORMAL ANION GAP IN RENAL TUBULAR ACIDOSIS, DIARRHOEA, INTESTINAL OBSTRUCTION OR FISTULA, HYPERCHLORAEMIC ACIDOSIS OF URETEROCOLIC ANASTOMOSIS .

ACIDOSIS :-

RESPIRATORY ACIDOSIS :-

P_{CO_2} > 41mmHg

CAUSES :

COMPENSATION:

- ***IN ACUTE RESPIRATORY ACIDOSIS : 10mmHg RISE IN P_{CO_2} CAUSE 1meq\l. Rise In Hco_3^- Which If > 30 Is Not Due To Acute Respiratory Acidosis Alone ****

IN CHRONIC RESPIRATORY ACIDOSIS : 10mmHg Rise In P_{co_2} Cause 3.5meq\l. Rise In Hco_3^- *

References

1. Bailey & Loves short practice of surgery 23rd edition
2. Current emergency diagnosis and treatment, middle east edition 1983