Acid-base disorders

A bicarbonate of 2.3 mmol/l

- 78 yrs old male
  -PMHx: diabetes mellitus, hypertension
  -admission in very poor condition: desoriented, Kussmaul-breeding, BP 88/52 mmHg, oligo-anuric
- Serum Na 139 mmol/l, K 5,8 mmol/l, Cl 99 mmol/l
  BUN 39 mmol/l, creatinine 504 umol/l,
  bicarb 2,3 mmol/l
- **What should we do?**

A bicarbonate of 2.3 mmol/l

- Blood-gas analysis:
  pH 6,97
  HCO_3^- 2,3 mmol/l
  pCO_2 10,2 mmHg

- **What kind of acid-base disorder is this?**

A bicarbonate of 2.3 mmol/l

- Decrease in bicarbonate
  25-2,3 = 22,7 mmol/l
- Respiratory compensation: delta pCO_2
  40 - pCO_2 = 40-10,2 = 29,8 mmHg
- Anion gap
  Na^+-(Cl^-+HCO_3^-)=139-(99+2,3)= 37,7 mmol/l

A bicarbonate of 2.3 mmol/l

- The patient has:
  - high anion gap metabolic acidosis
- His lactate level:
  - 12,2 mmol/l
- He was taking metformin, which caused lactic acidosis
- He was dialysed, survived, but remained dialysis dependent

Types of anion gap acidosis

Gain of acids

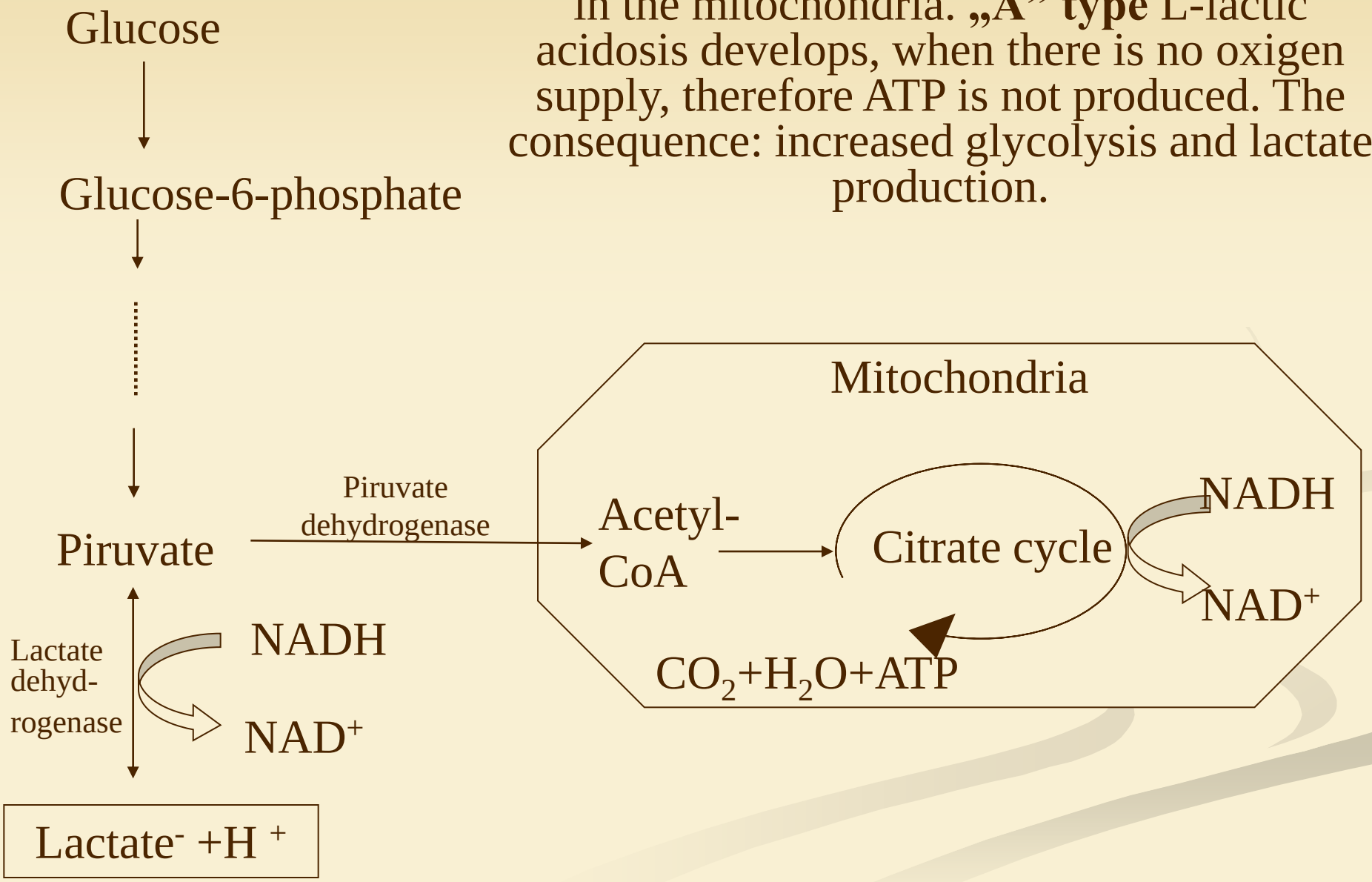
Endogenous acid production

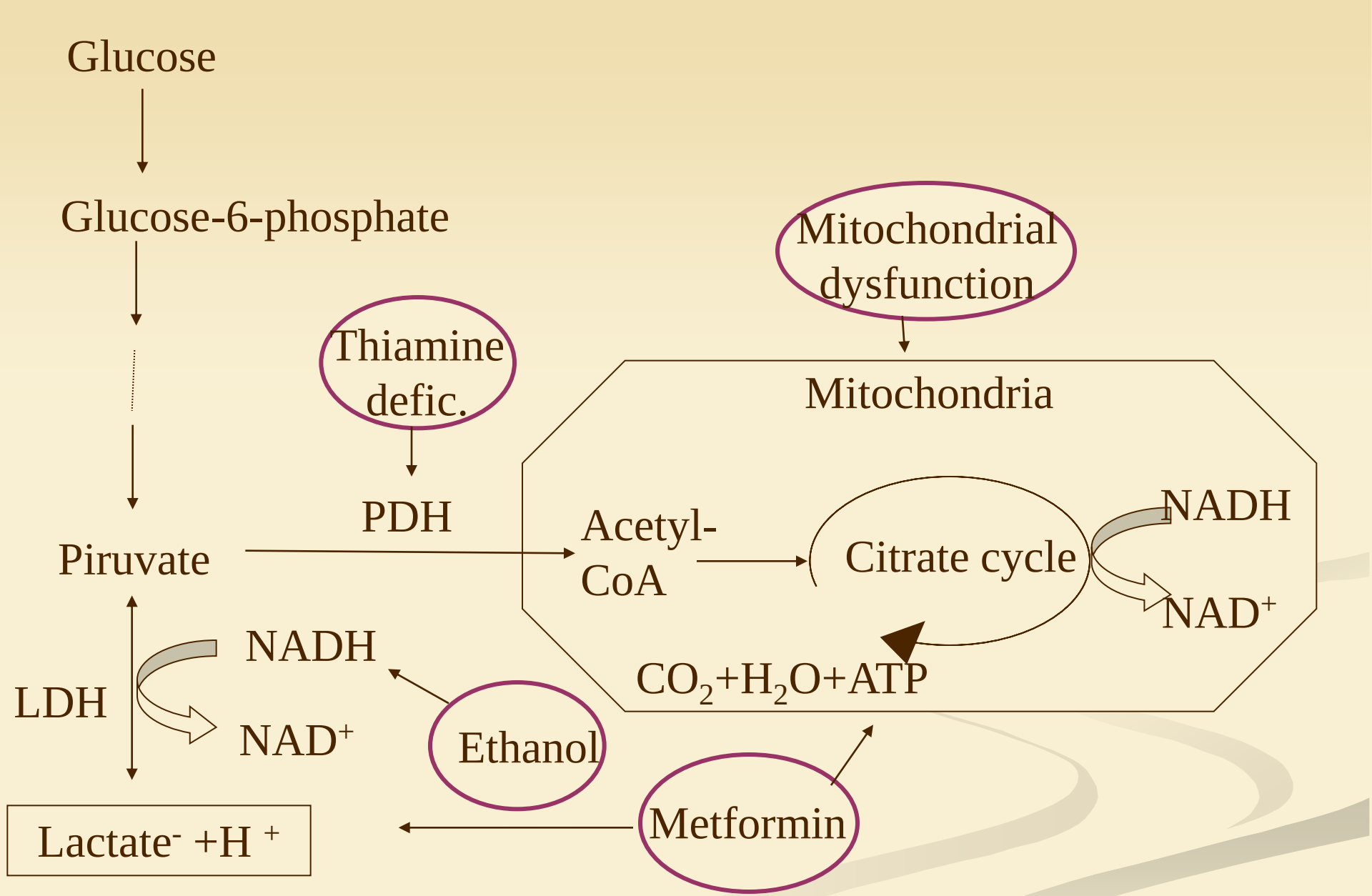
- ketoacidosis
-L-lactic acidosis (A and B-types)
- D-lactic acidosis
- advanced renal failure

Exogenous acids

-ethylene glycol
-methanol

Oxygen is necessary for the ATP production in the mitochondria. **„A" type** L-lactic acidosis develops, when there is no oxigen supply, therefore ATP is not produced. The consequence: increased glycolysis and lactate production.





The most frequent causes of „B" type L-lactic acidosis

Acidosis
pH ↓

HCO_3^- ↓
metabolic acidosis

↓

pCO_2 ↓
respiratory compensation
1:1

pCO_2 ↑
respiratory acidosis

↓

$HCO3^-$ ↑
metabolic compensation
1:0,3

Alkalosis
pH ↑

HCO3- ↑
metabolic alkalosis
↓
pCO2 ↑
respiratory compensation
1:0,7

pCO_2 ↓
respiratory alkalosis
↓
HCO3- ↓
metabolic compensation
1:0,5

Deteriorating pH

- A 42 yrs old male patient
- He was admitted to the gastroenterology department in rapidly deteriorating physical condition
- Medical Hx: joint problems, hip replacement, on NSAIDs, aethyl abusus
- Labs on admission:
  -Serum Na 138 mmol/l, K 2,9 mmol/l, Cl 121 mmol/l, BUN 24,8 mmol/l, creatinine 432 umol/l, Hgb 9,6 g%
  -Blood gas analysis:
  pH 7,3, bicarbonate 11 mmol/l, pCO_2 14 mmHg
- Gastroscopy revealed bleeding from gastric ulcers
- **What kind of acid-base disorder is this?**

Deteriorating pH

- Decrease in bicarbonate
  25-11 = 14 mmol/l
- delta pCO_2
  40 - pCO_2 = 40-14 = 26 mmHg
- Anion gap
  Na^+-(Cl^-+HCO_3^-)=138-(121+10,8)= 6,2 mmol/l

Deteriorating pH

- Treatment: he got proton pump inhibitor, Na-bicarbonate infusion and furosemide, but did not improve
- Blood gas analysis few hours later:
  pH 7,2, bicarb 9 mmol/l, pCO_2 24 mmHg
  (previous: pH 7,3, bicarb 11 mmol/l, pCO_2 14 Hgmm)
- **What happend to the pH?**

Deteriorating pH

- Next day:
  pH 6,84 bicarb 9 mmol/l, pCO_2 58 mmHg
  (previous: pH 7,3, bicarb 11 mmol/l, pCO2 14 Hgmm
  pH 7,2, bicarb 9 mmol/l, pCO2 24 mmHg)
- **What kind of acid-base disorder is this now?**

A complicate case with dRTA

- 33 yrs old male patient
- PMHx: ileocecal reticulosarcoma, ileum and colon resection, irradiation colitis, moderate chronic renal failure,
  recently: suspected distal renal tubular acidosis
- Medical Hx: has usually 3-4 bowel movements/day
  Had several GI tests performed recently, and severe, watery diarrhoea developed
  Admitted in a very poor condition, severly volume depleted
- Labs: Serum Na 142 mmol/l, K 2,99 mmol/l, Cl 119 mmol/l, BUN 7,6 mmol/l, creatinine 224 umol/l,
- Blood gas analysis:
  pH 7,2, bicarb 12 mmol/l, pCO_2 32 mmHg

A complicate case with dRTA

- What kind of acid-base disorder is this?
- Why is he hypokalemic?

A complicate case with dRTA

- Combined metabolic and respiratory acidosis
  -delta bicarbonate: 25 - 12 = 13 mmol/l
  -delta pCO2: 40 - 32 = 8 mmHg
- Anion gap: 142-(119+12) = 9
  (lactate level 1,03 mmol/l)
- Urinary K excretion 9,9 mmol/day
  - non-renal K loss
- **Is this acidosis due to gastrointestinal bicarbonate loss or renal abnormality?**

Differential diagnosis of non-anion gap metabolic acidosis

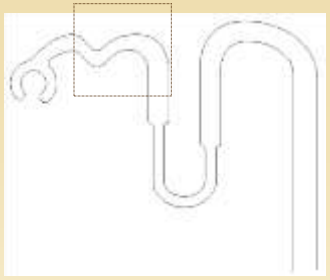
Low plasma bicarbonate level

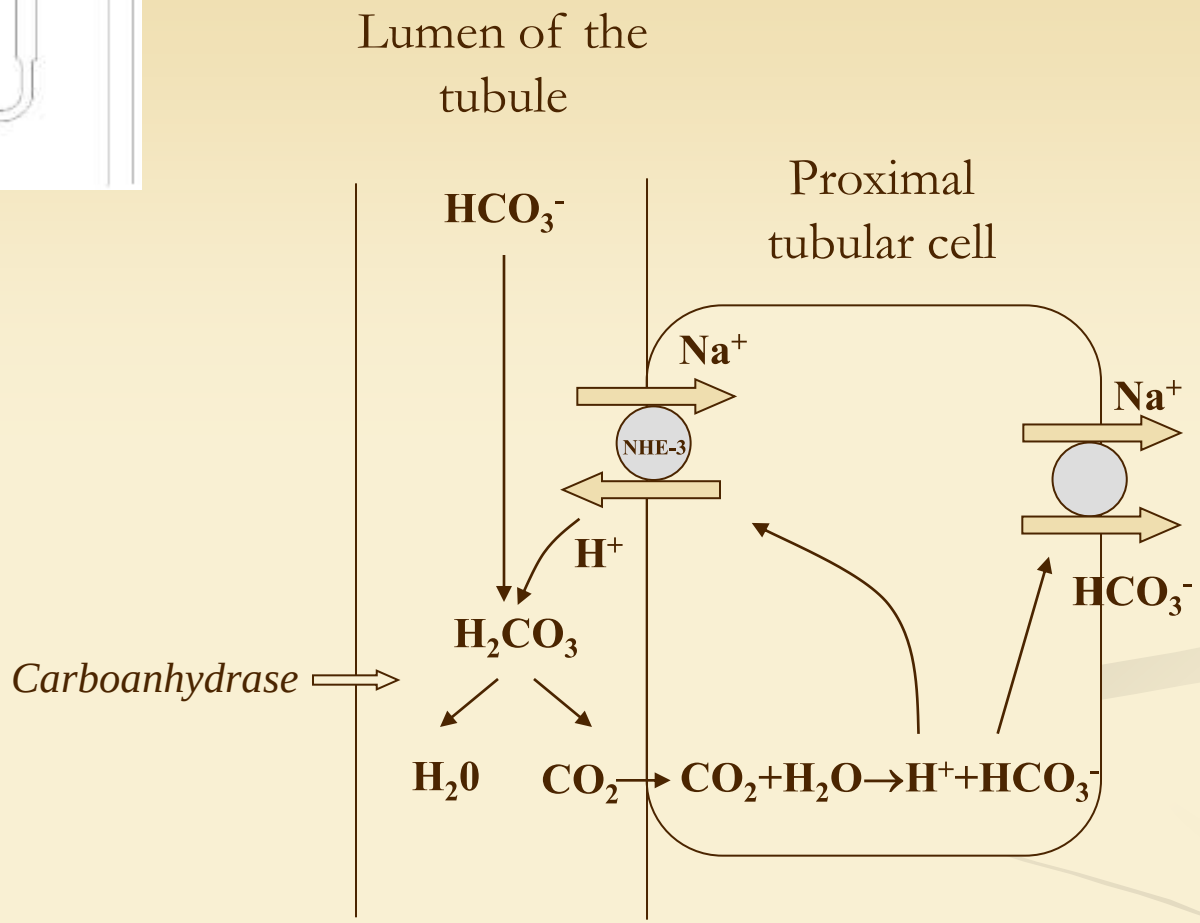
Gastrointestinal bicarbonate loss

Urine Cl^- >> $Na^+ + K^+$
(refers to NH_4^+ production)

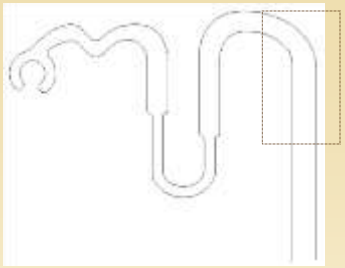
Renal tubular abnormality

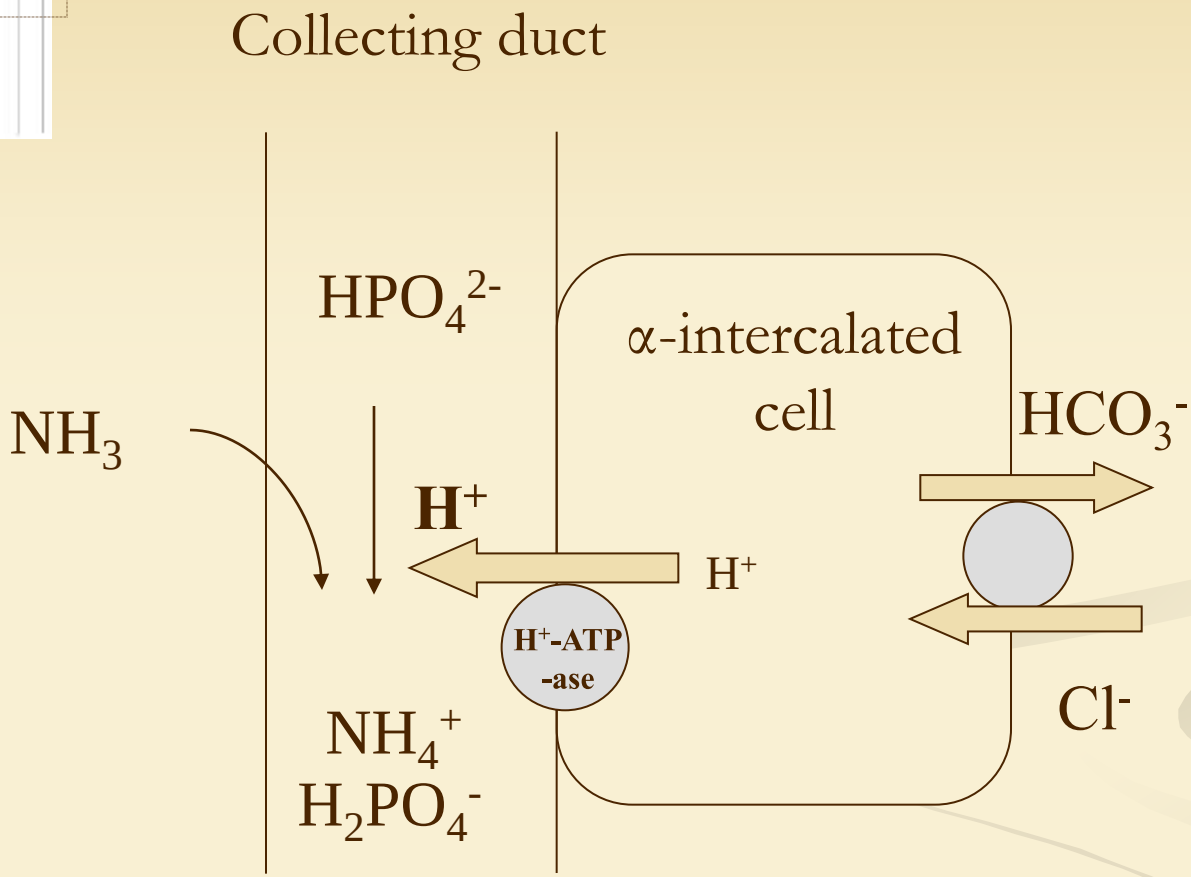
-pRTA
-dRTA
-insufficient NH_4^+ production



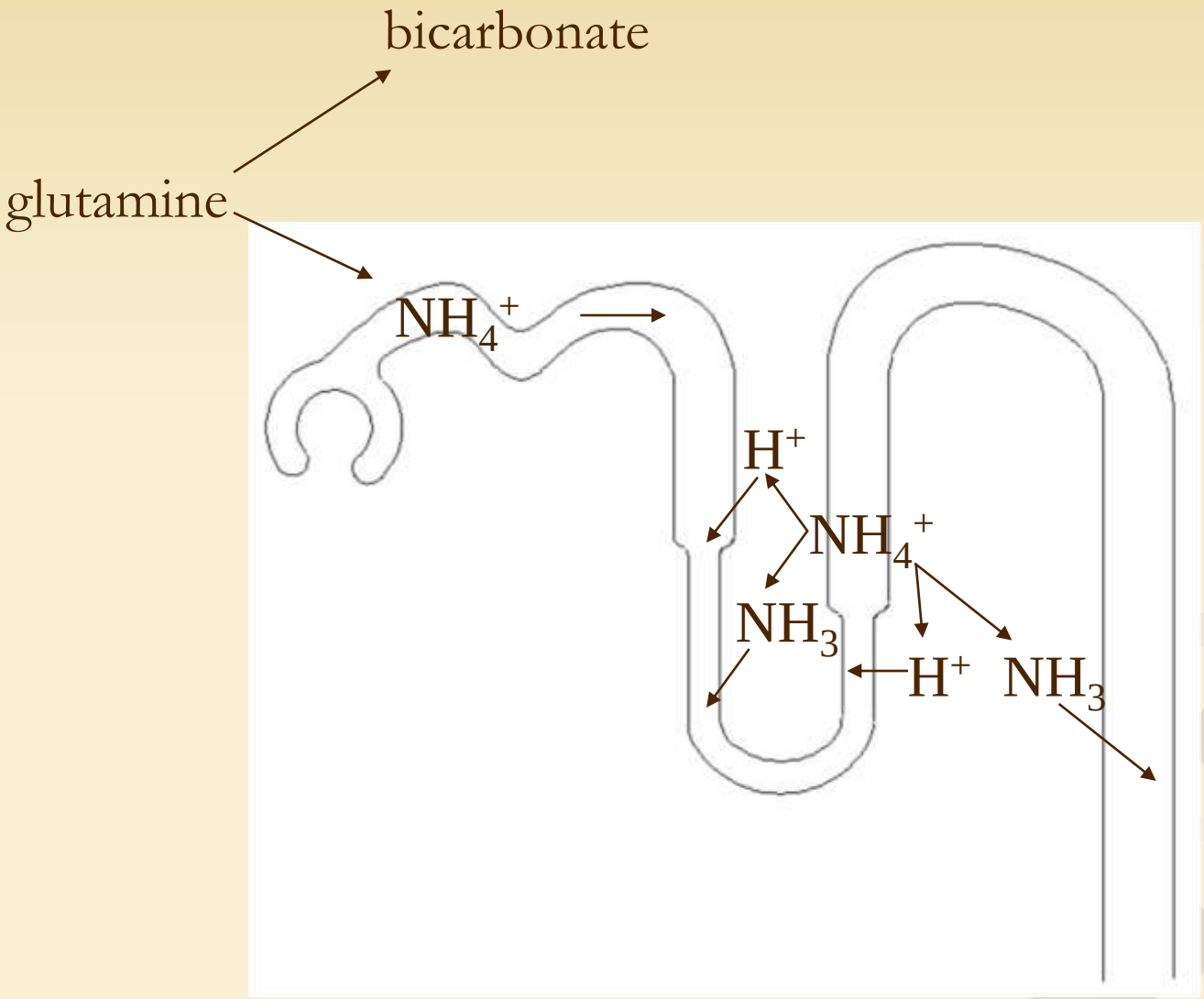


Physiologic bicarbonate reabsorption in the proximal tubule. pRTA develops due to reduced indirect bicarbonate reabsorption.





dRTA develops if the H^+ secretion is disturbed in the collecting duct



Bicarbonate-ammonia production is necessary for H^+ excretion

Severe hypokalemia due to dRTA

- 40 years old female, admitted to intensive care unit with fever, pneumonia, respiratory failure
- Serum Na 138 mmol/l, K 2,4 mmol/l, Cl 110 mmol/l
  pH 7,32, HCO_3 14,8 mmol/l, pCO_2 28 Hgmm
  AG 13,2 mmol/l
  U_{Na} 244 mmol/day, U_K 52 mmol/day

- Bicarbonate loading test:
  Baseline urine: pH 6,8, HCO_3 6 mmol/l, pCO_2 35 Hgmm
  Urine after loading: 7,1 12 36
  Blood after loading 7,3 22 37
- Urine pCO_2 – blood $pCO_2 \approx 0$

Gastrointestinal disease diagnosed by blood pH

- A 41 year-old male patient, admitted to hospital secondary to nausea, vomiting and epigastric pain
- On admission he looked severly volume depleted, had a BP of 96/58 mmHg
- Labs: serum Na 123 mmol/l, K 3,5 mmol/l, BUN 24 mmol/l, creatinine 355 umol/l,
- Blood gas analysis: pH 7,65, bicarb 43 mmol/l, pCO_2 55 mmHg.
- **What is your diagnosis?**

Gastrointestinal disease diagnosed by blood pH

- Metabolic alkalosis, hyponatremia and hypokalemia, acute renal failure
- According to the clinical picture – suspicion of pylorus stenosis
- Gastroscopy confirmed this abnormality (ulcer causing pylorus stenosis)

Are both the patient and the doctor anxious?

- 70 years old male pt, HTN, stroke few months ago
- Presented with dizziness, fever and chills, shortness of breath
- Blood gas analysis:
  pH 7,70, pCO_2 11 mmHg, HCO_3 14 mmol/l
- **What is the differential diagnosis?**

Differential diagnosis of respiratory alkalosis

- Hypoxia
  -pulmonary disease, congestive heart failure
- Pulmonary receptor stimulation
  - pneumonia, pulmonary embolism, asthma, fibrosis
- Drugs
  -salicylates, theophylline, catecholamines
- CNS disorders
- Miscellaneous
  -psychogenic hyperventilation, fever, Gram-negative sepsis, cirrhosis
- In our pt: CRP 182 mg/l, likely Gram-neg. sepsis+anxiety

The most difficult case for me

Sylvia

- 40 years old female, lives with severe hypotension (BP 78/53 mmHg)
- Serum potassium 1,4-1,8 mmol/l for 8 years
  Cl 80 mmol/l, Mg 0,43 mmol/l, Ca 2,33 mmol/l, uric acid 830 umol/l
- Urinary electrolytes:
  Na 94 mmol/day, K 31 mmol/day, uric acid 1159 umol/day, Ca 0,25 mmol/day
- Blood gas analysis:
  pH 7,6-7,7, HCO_3 36-51 mmol/l

Bartter and Gitelman syndromes

- Urinary potassium wasting → hypokalemia
- Salt diuresis → volume depletion, low BP
- Metabolic alkalosis
- Urinary magnesium wasting → hypomagnesemia

Bartter syndrome:

- like „taking continuously furosemide”
- high Ca excretion

Gitelman syndrome

- like „taking continuously thiazide”
- low Ca excretion