



Fisiopatología de la hipertensión arterial

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Descripción matemática de los movimientos tubulares

$$F = \Delta P / R$$

Diferencia de presión entre los puntos de movimiento

Flujo de líquido

Resistencia periférica

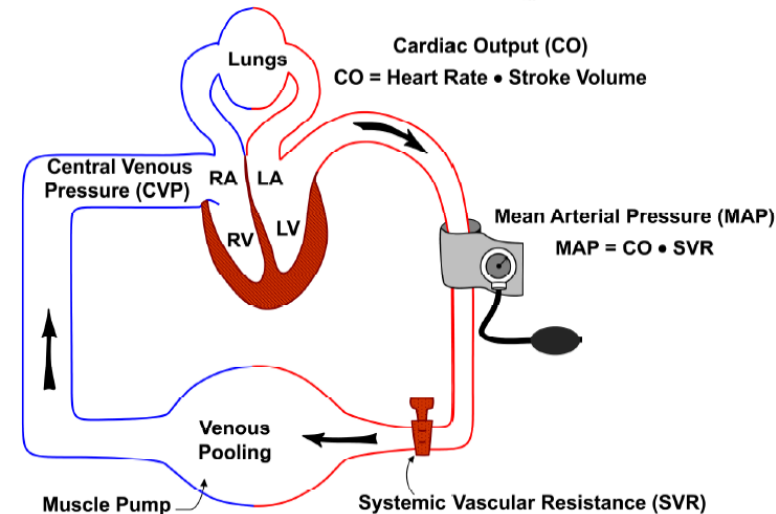
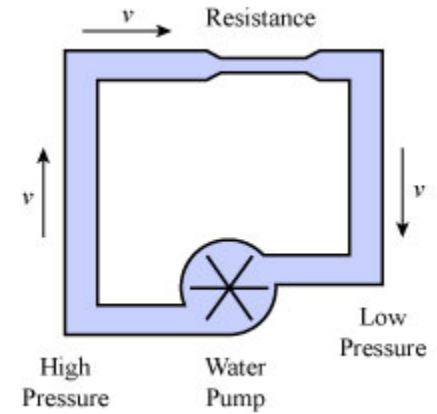
$$\Delta P = F \times R$$

$$MAP = CO \times SVR$$

Gasto cardíaco

Resistencia vascular sistémica

Presión arterial media



Resistencia vascular sistémica (SVR)

Resistencia periférica total
(sin considerar la circulación pulmonar)



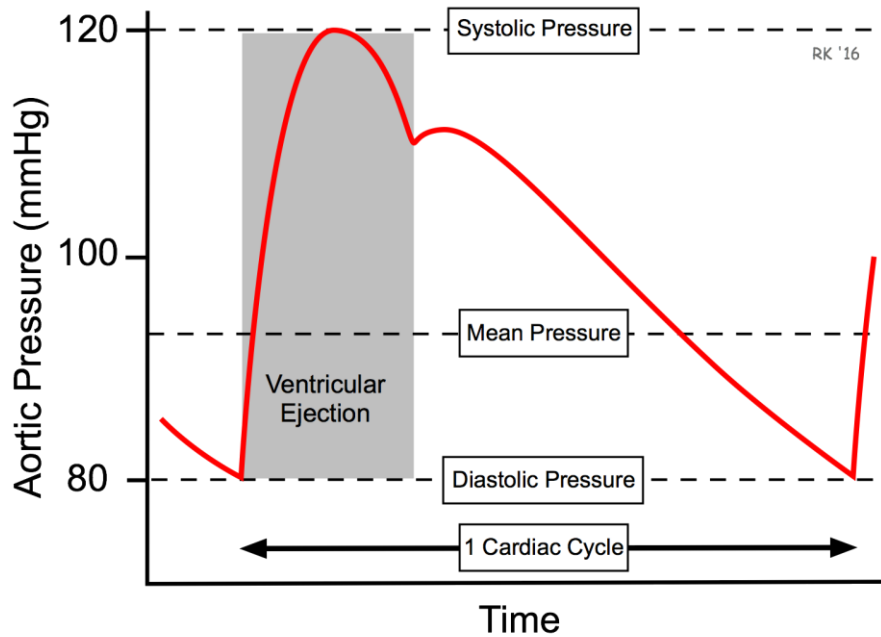
$$R \propto \frac{\eta L}{r^4}$$

Mayor viscosidad, mayor SVR

Mayor largo, mayor SVR

Menor diámetro de los vasos, mayor SVR

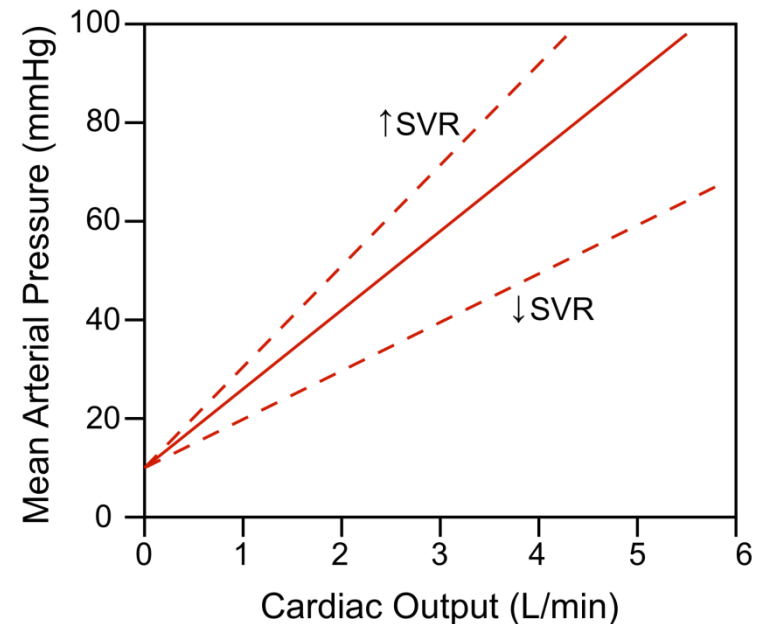
Presión arterial media (MAP)

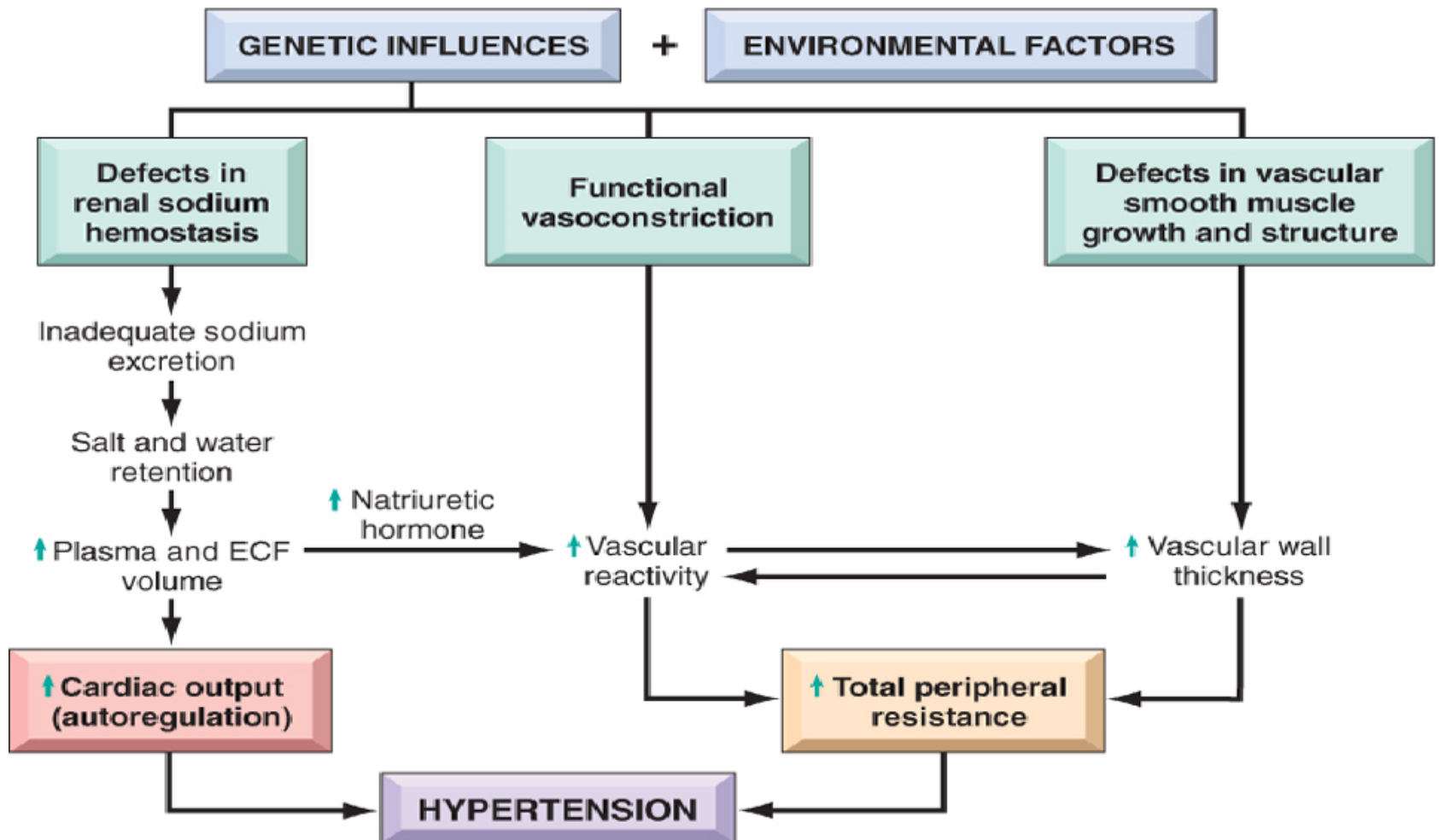


$$MAP = DBP + [1/3 \times (SBP - DBP)]$$

La presión es el factor dependiente (es el resultado de la modificación del flujo y/o la resistencia)

Valor normal: 93 mmHg



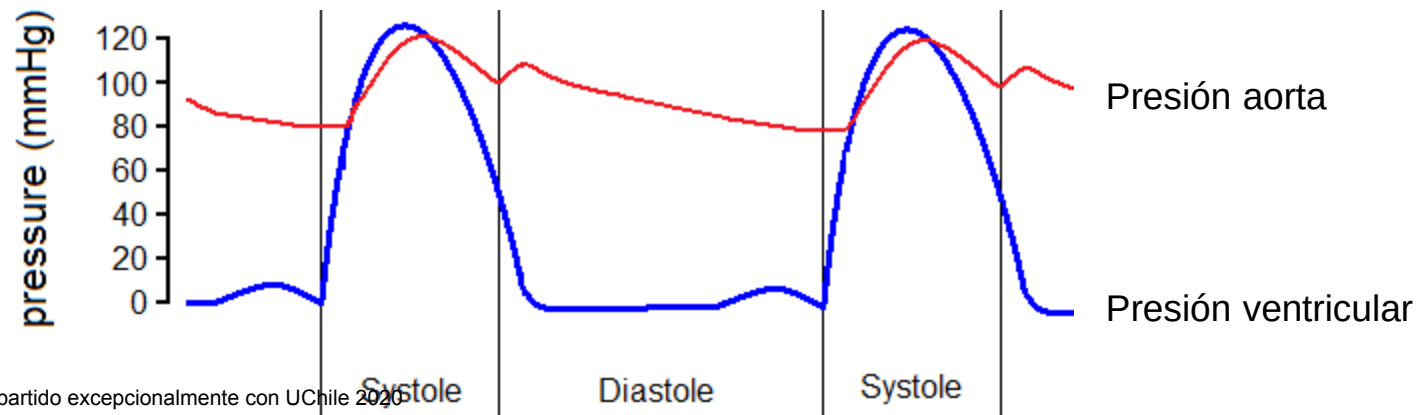


$$\text{CO} = \text{HR} \times \text{SV}$$

$$\text{BP} = \text{CO} \times \text{PR}$$

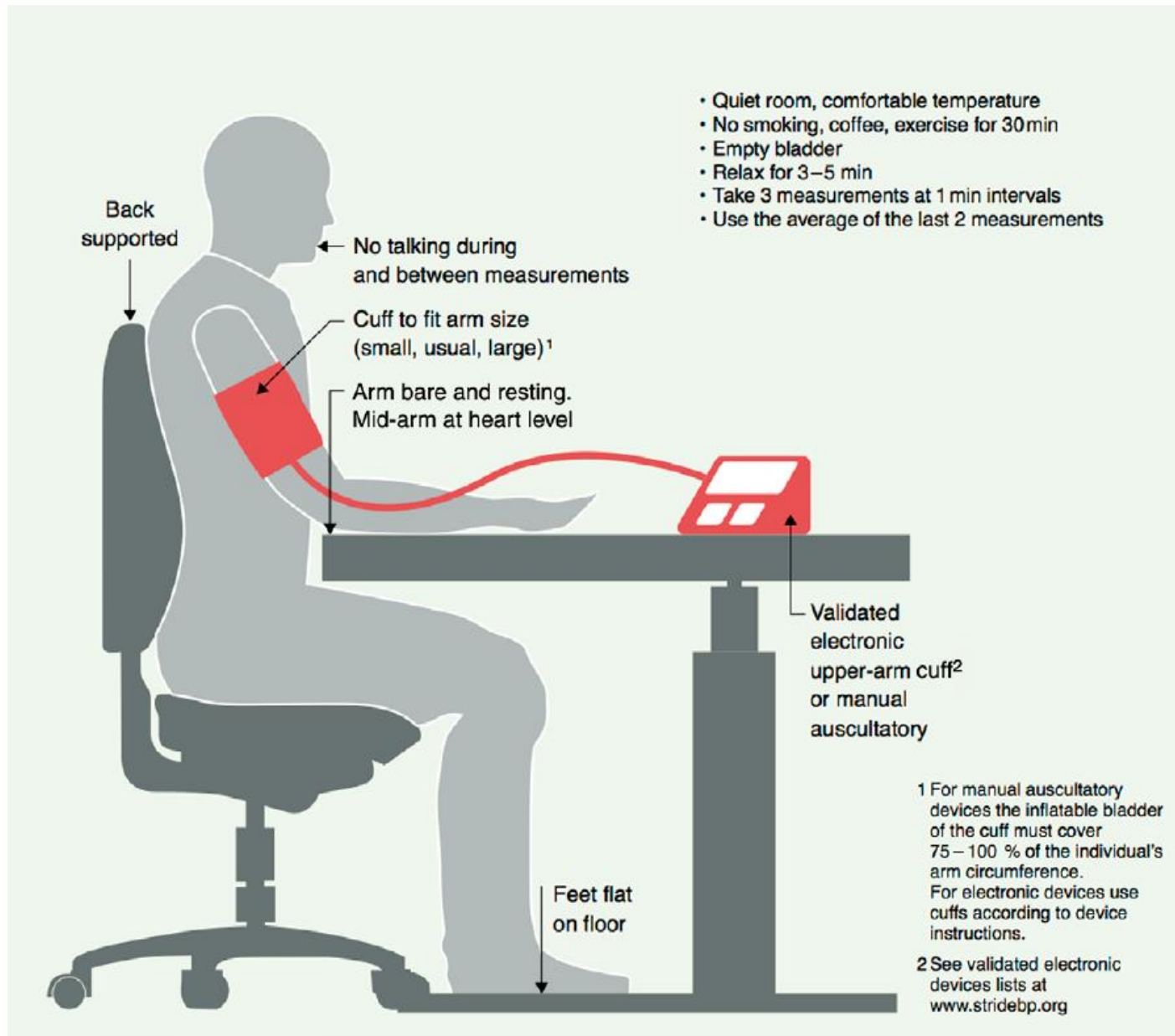
Valores de referencia de presión sanguínea (Criterio AHA)

BLOOD PRESSURE CATEGORY	SYSTOLIC mm Hg (upper number)		DIASTOLIC mm Hg (lower number)
NORMAL	LESS THAN 120	and	LESS THAN 80
ELEVATED	120 – 129	and	LESS THAN 80
HIGH BLOOD PRESSURE (HYPERTENSION) STAGE 1	130 – 139	or	80 – 89
HIGH BLOOD PRESSURE (HYPERTENSION) STAGE 2	140 OR HIGHER	or	90 OR HIGHER
HYPERTENSIVE CRISIS (consult your doctor immediately)	HIGHER THAN 180	and/or	HIGHER THAN 120



Criterio ISH

Category	Systolic (mm Hg)		Diastolic (mm Hg)
Normal BP	<130	and	<85
High-normal BP	130–139	and/or	85–89
Grade 1 hypertension	140–159	and/or	90–99
Grade 2 hypertension	≥160	and/or	≥100



What's the big deal about raised blood pressure?

It's the **No.1**
contributing risk
for global death

Around
10 Million
people die each year
needlessly

Only **1/2** of
people with high blood
pressure are aware of it

VISION LOSS

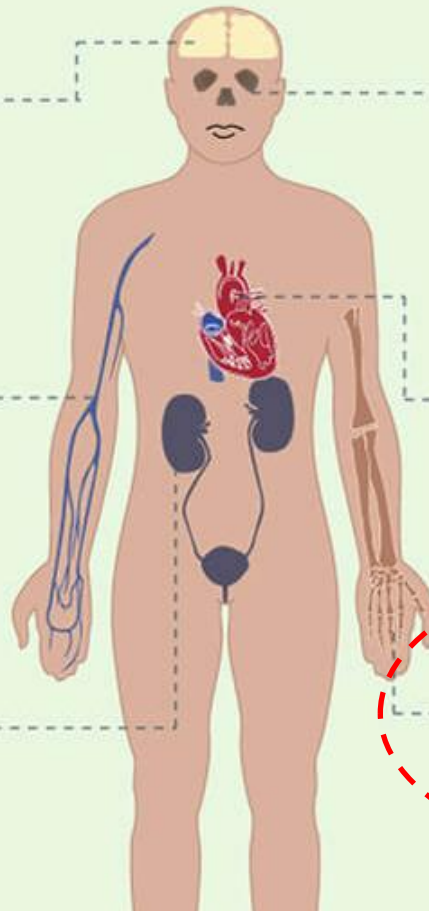
Hypertensive Retinopathy can damage blood vessels in the retina, resulting in loss of vision.

BLOOD VESSEL DAMAGE Atherosclerosis

Hypertension is a leading cause of atherosclerosis, the artery-narrowing process that can result in heart attack and stroke.

BONE LOSS

High blood pressure may increase the amount of calcium in your urine. That excessive elimination of calcium may lead to loss of bone density (osteoporosis).



BRAIN STROKE

Reduced blood supply to the brain lead to rapid loss of brain function or stroke.

HEART ATTACK

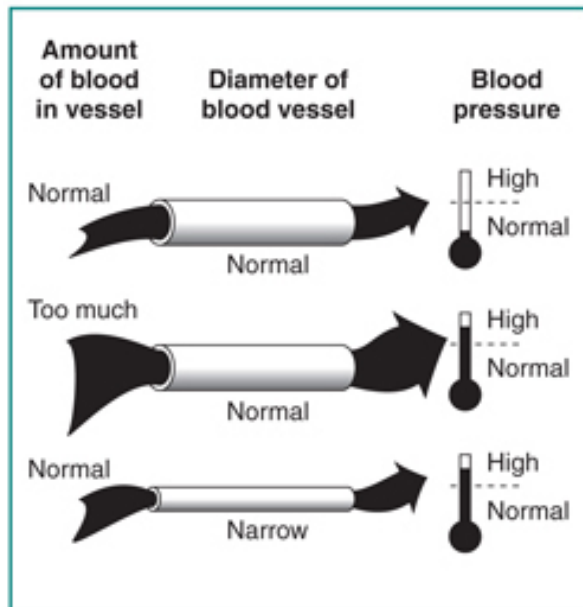
Hypertension causes the heart to pump against high blood pressure, making it work harder than necessary. Over time, this causes the heart muscle to thicken, restricting blood flow which can lead to heart failure.

KIDNEY FAILURE

Damaged blood vessels in the kidneys can't affectively filter your blood, resulting in a dangerous accumulation of fluid and waste.

Hipertensión primaria o esencial (90%). No hay una causa específica, puede ser una combinación genética, ambiental y estilo de vida.

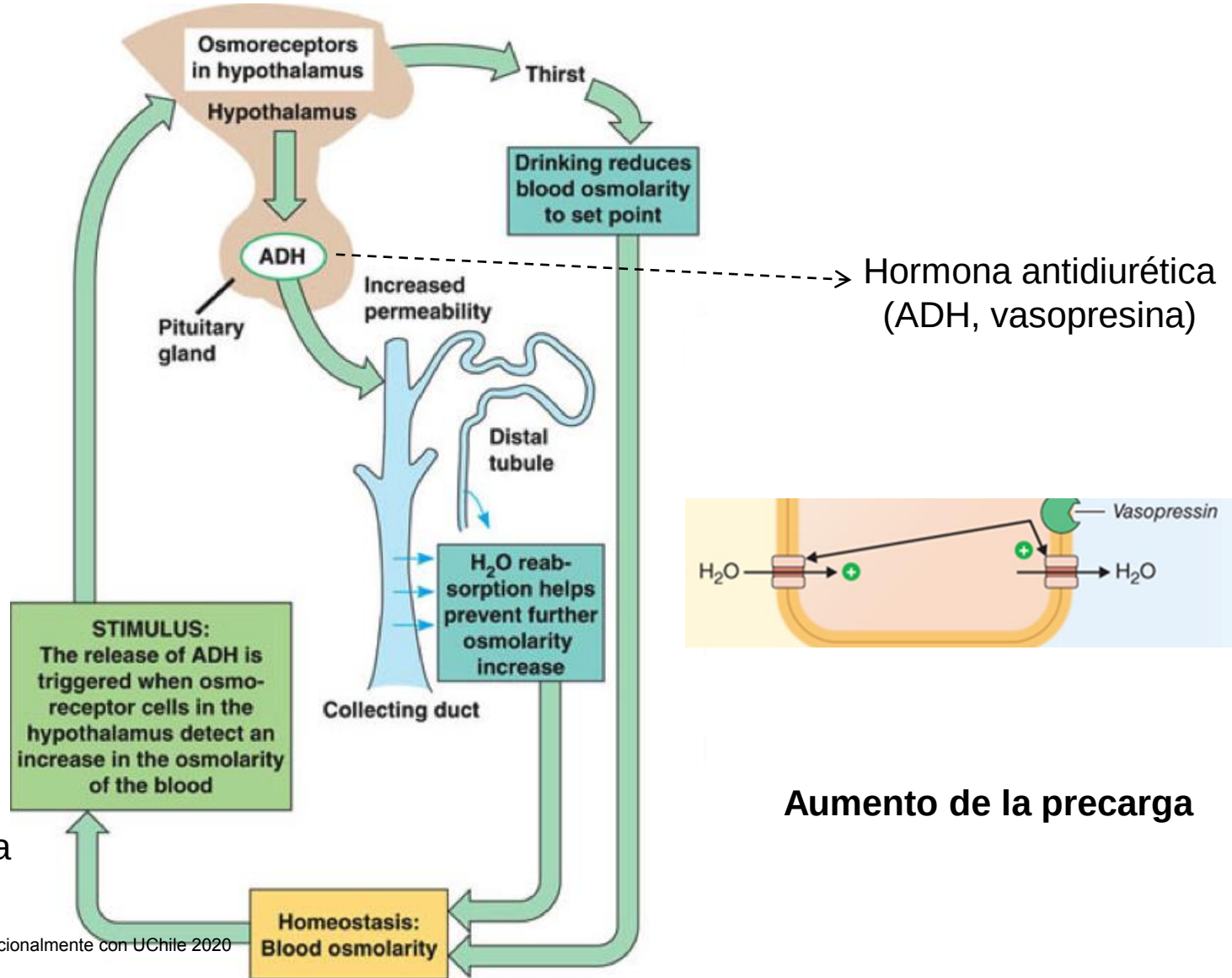
Hipertensión secundaria (10%). Condición subyacente que implica retención de sodio y/o vasocontracción periférica.



Factores de riesgo

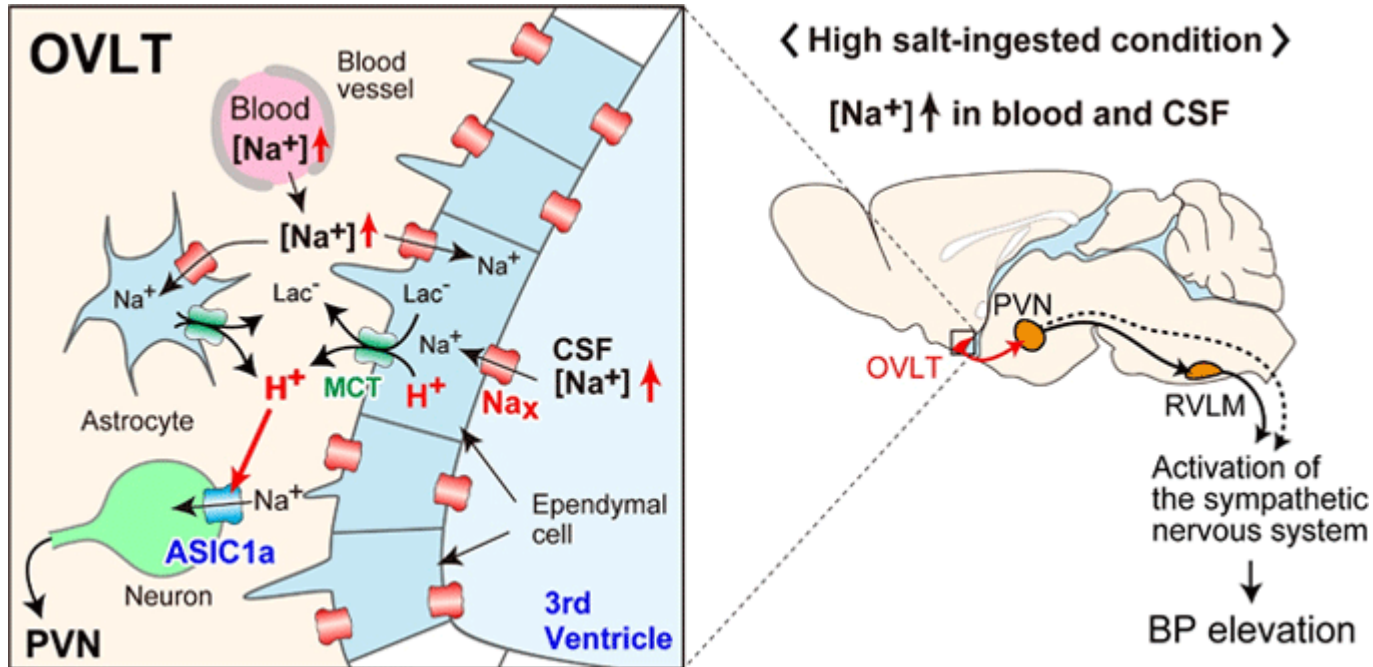


Aumento de presión por incremento de osmolaridad sanguínea

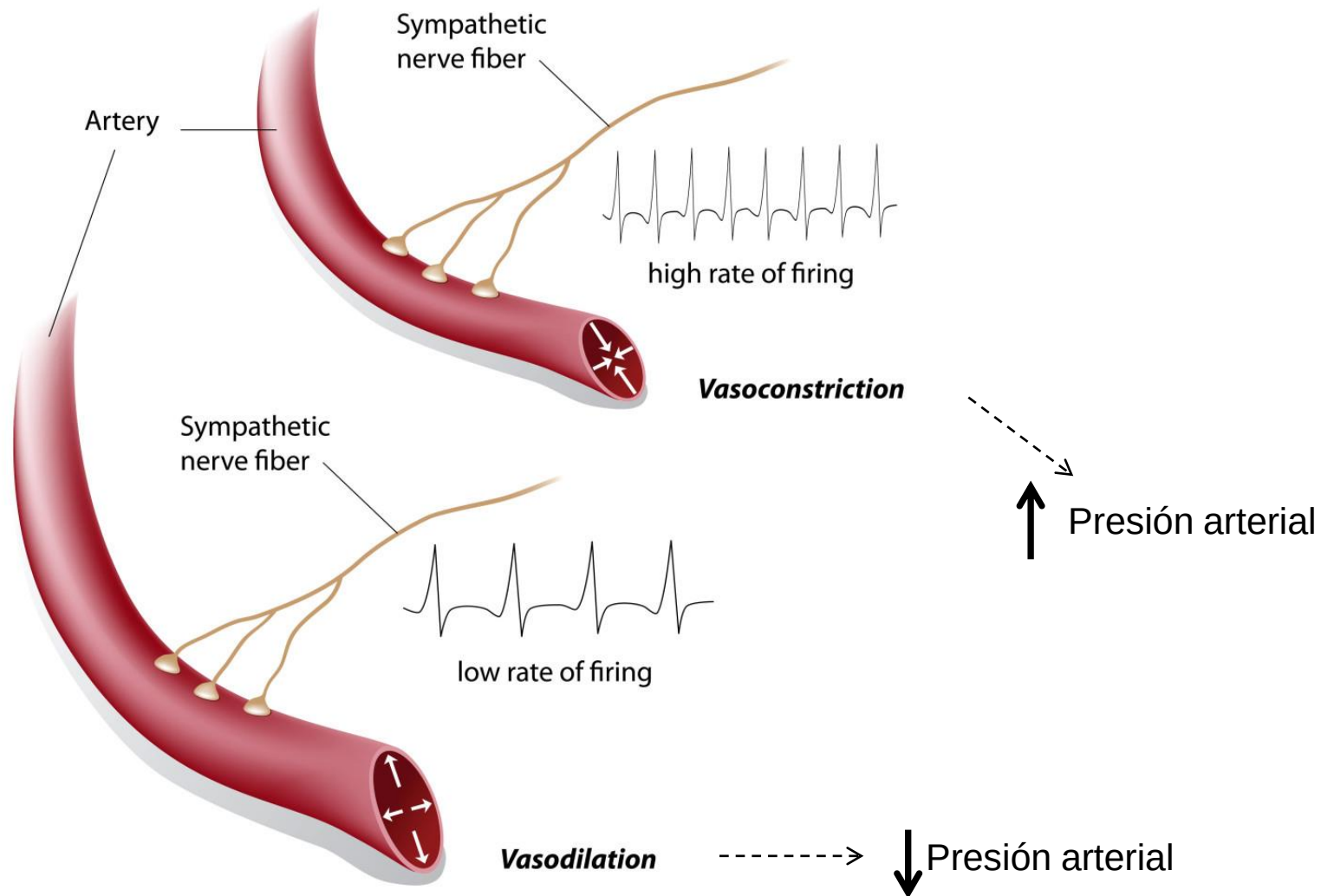


Aumento de la precarga

Efecto de la sal sobre el sistema simpático

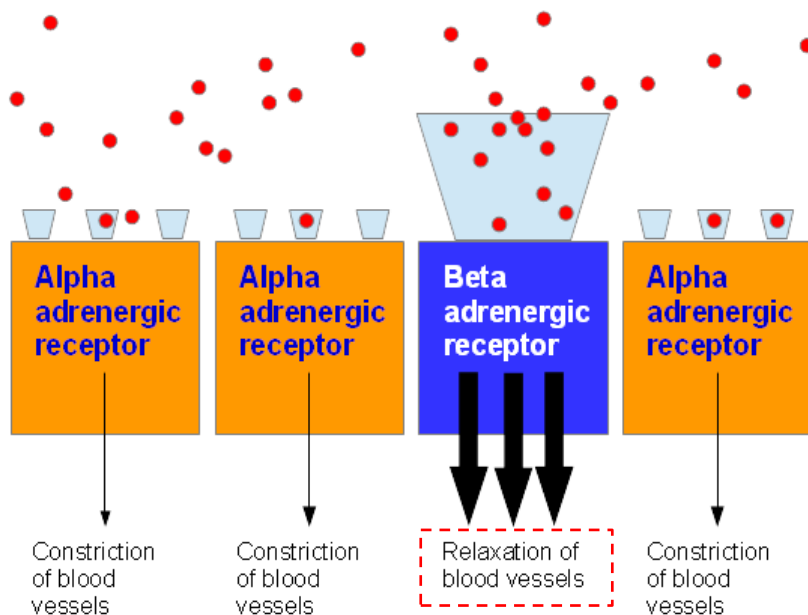


Inervación simpática y vasoconstricción



Inervación simpática y vasoconstricción

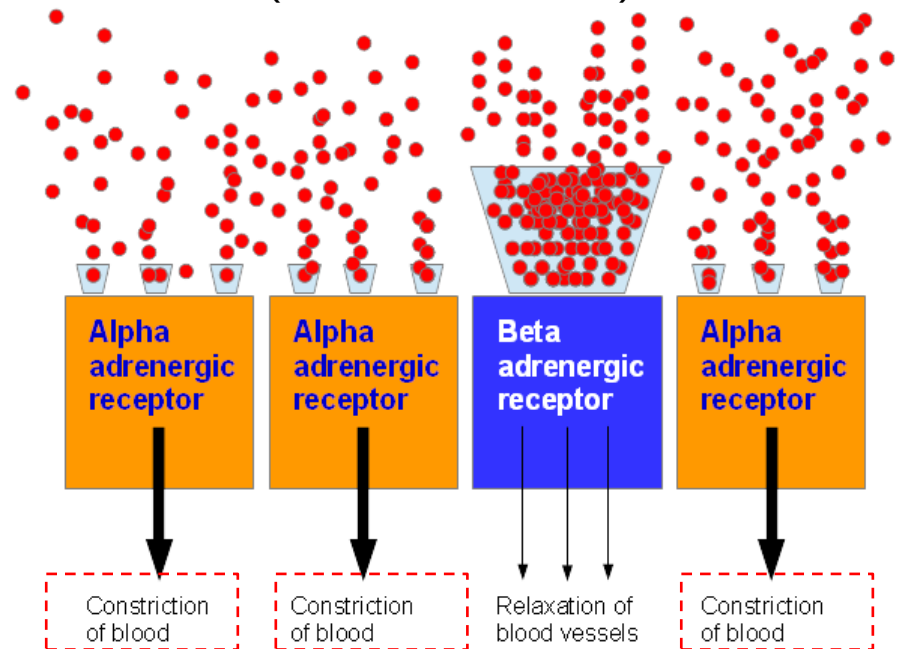
Baja estimulación simpática
(poca adrenalina)



$G_s \longrightarrow \text{AMPc}$

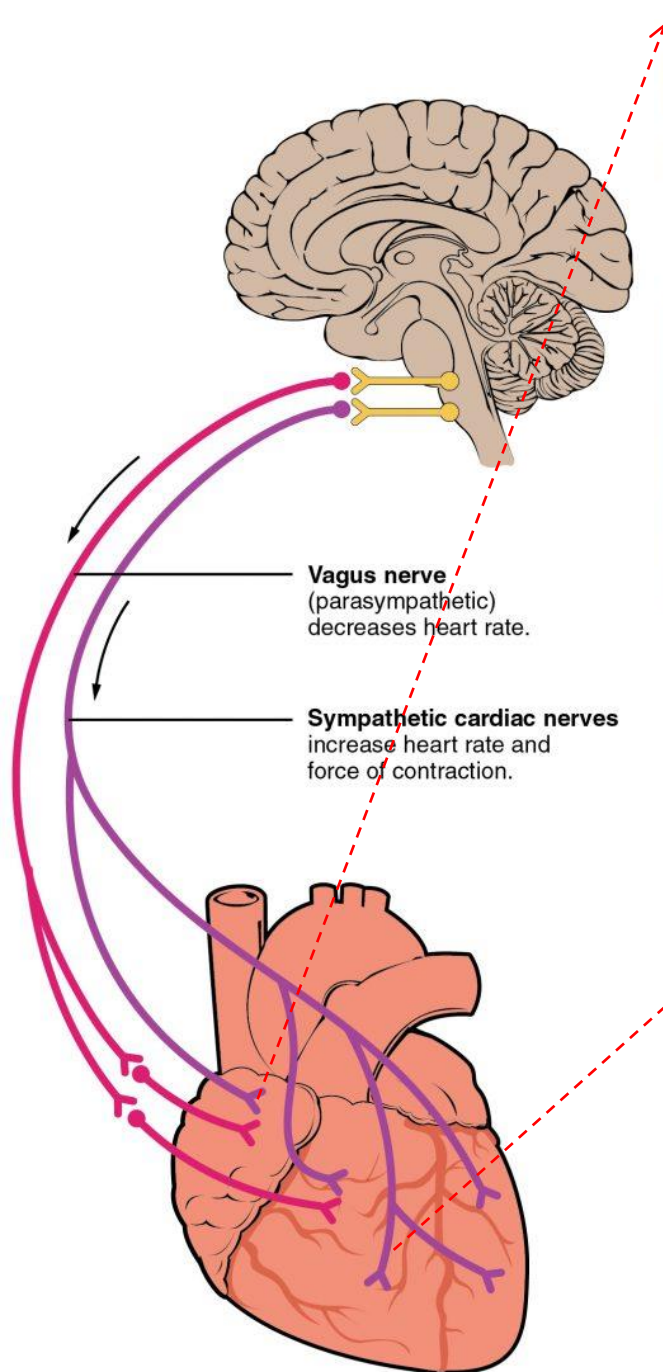
Relajación de la musculatura lisa

Alta estimulación simpática
(muchas adrenalina)

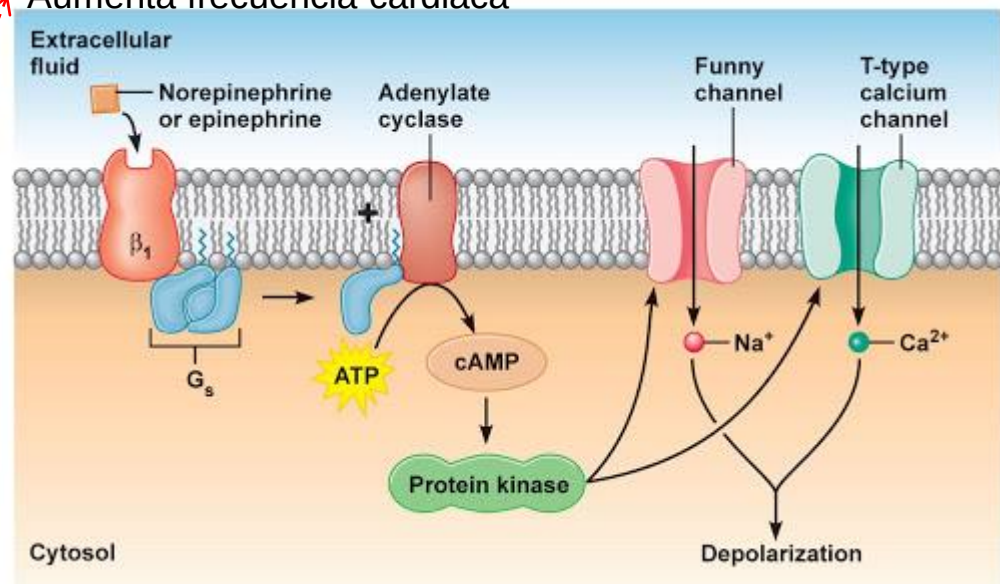


$G_q \longrightarrow \text{IP3/DAG} \longrightarrow \text{Ca}^{+2}$

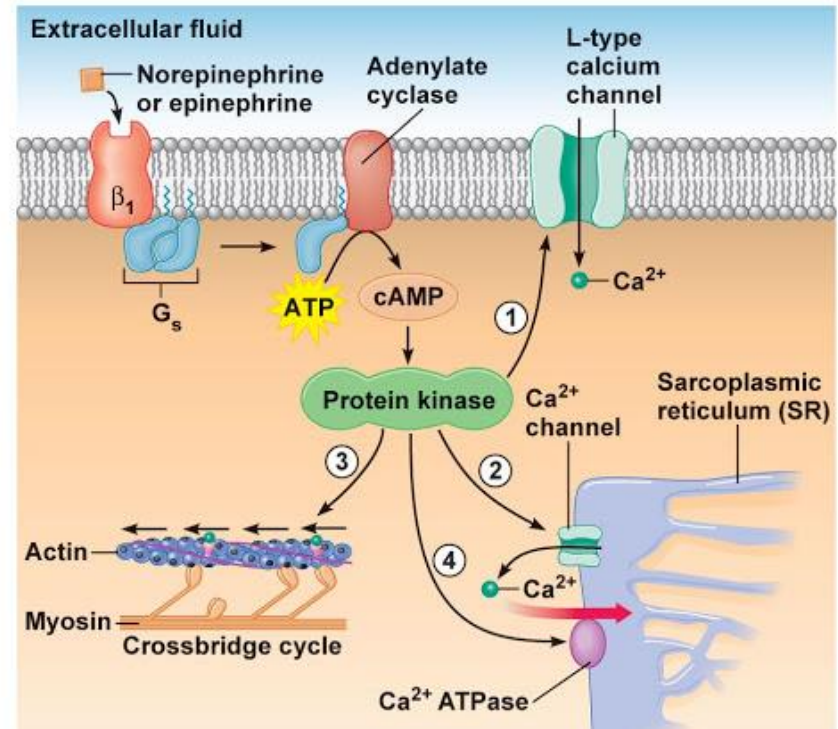
Contracción de la musculatura lisa



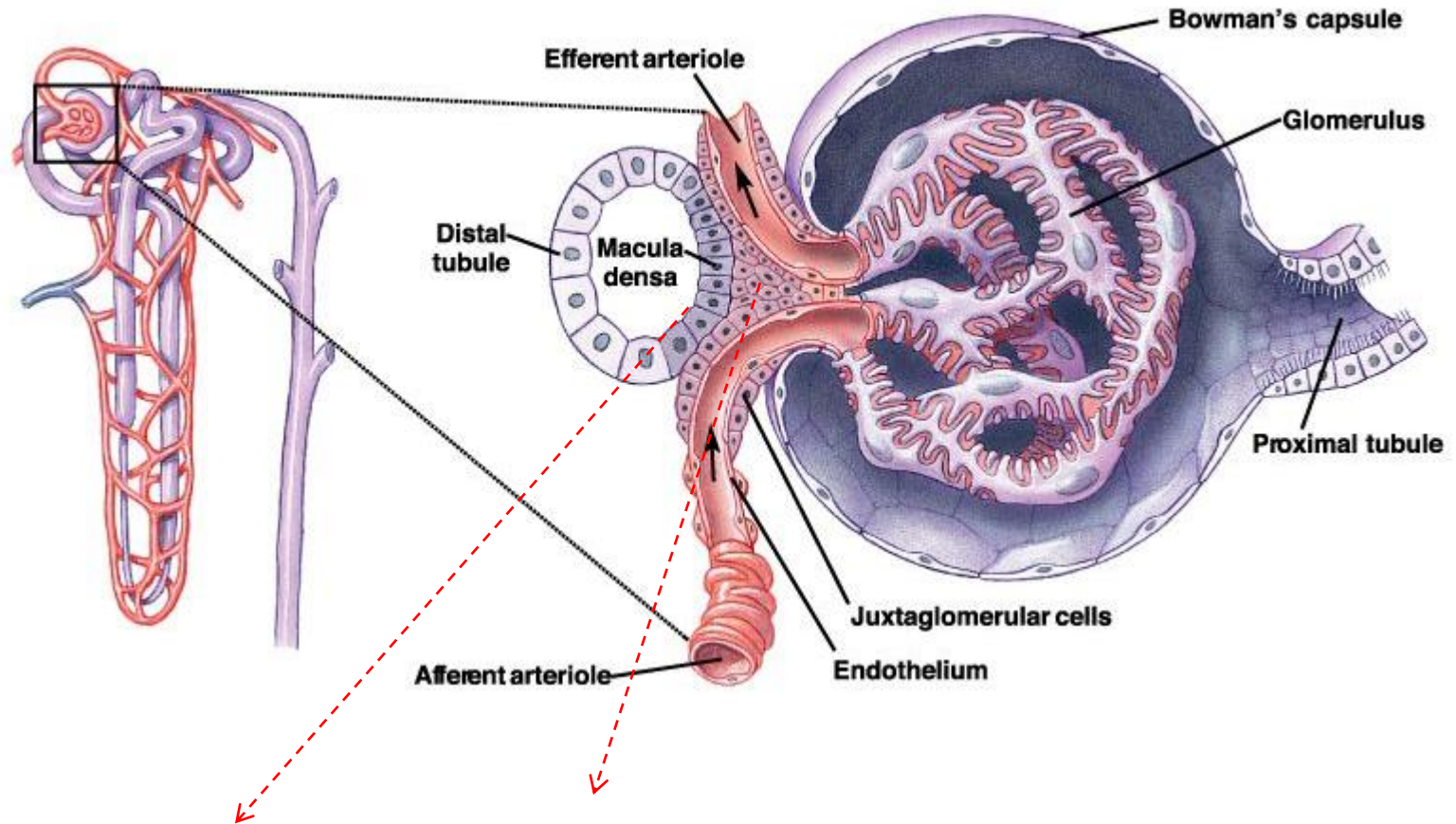
Aumenta frecuencia cardiaca



Aumenta contracción cardiaca



Aparato yuxtaglomerular



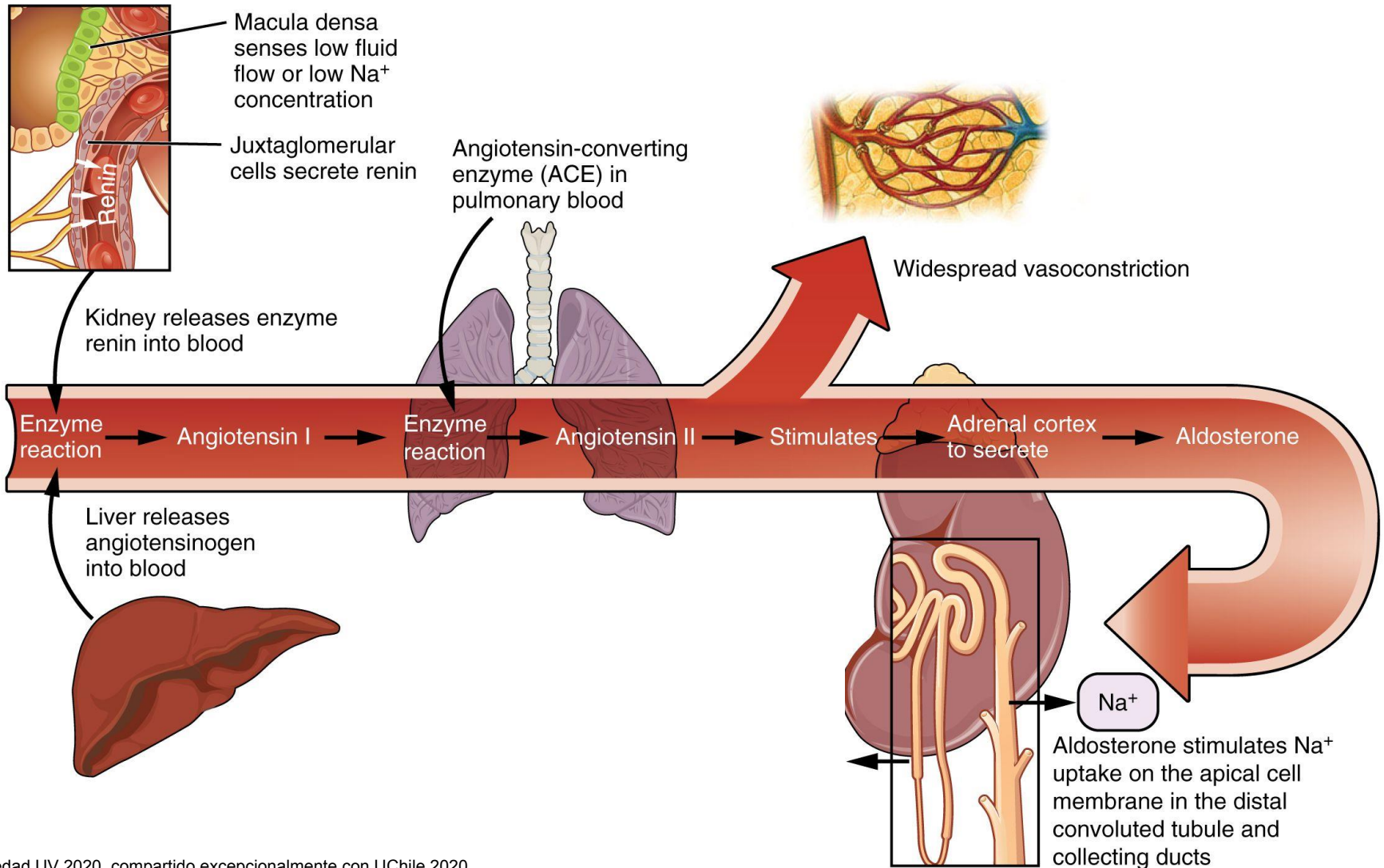
Detecta niveles bajos de
NaCl en túbulo

Células yuxtaglomerulares
liberan renina

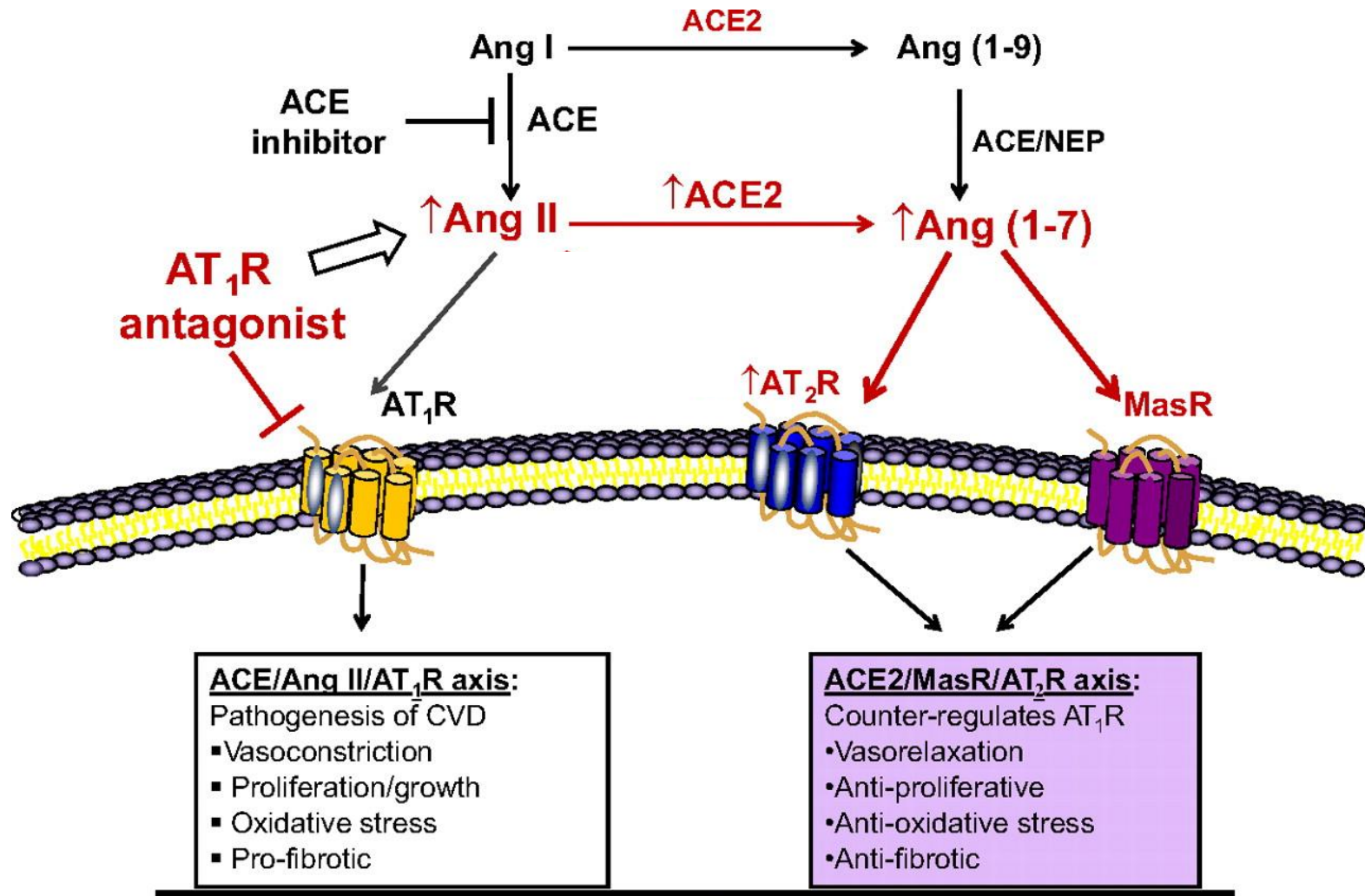


Produce contracción

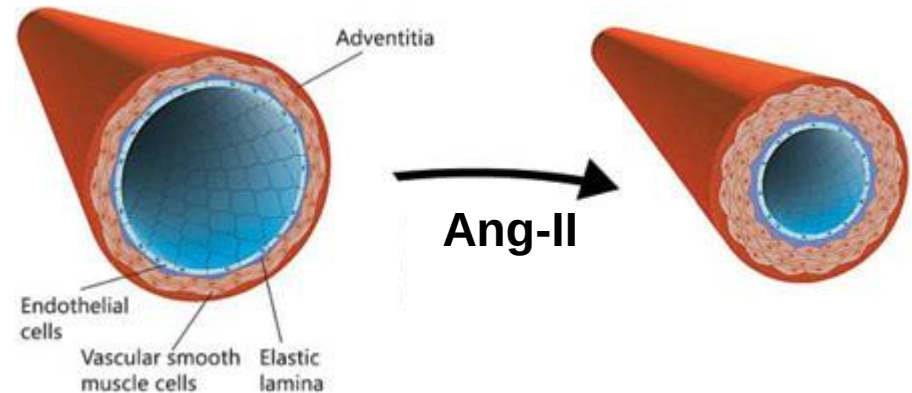
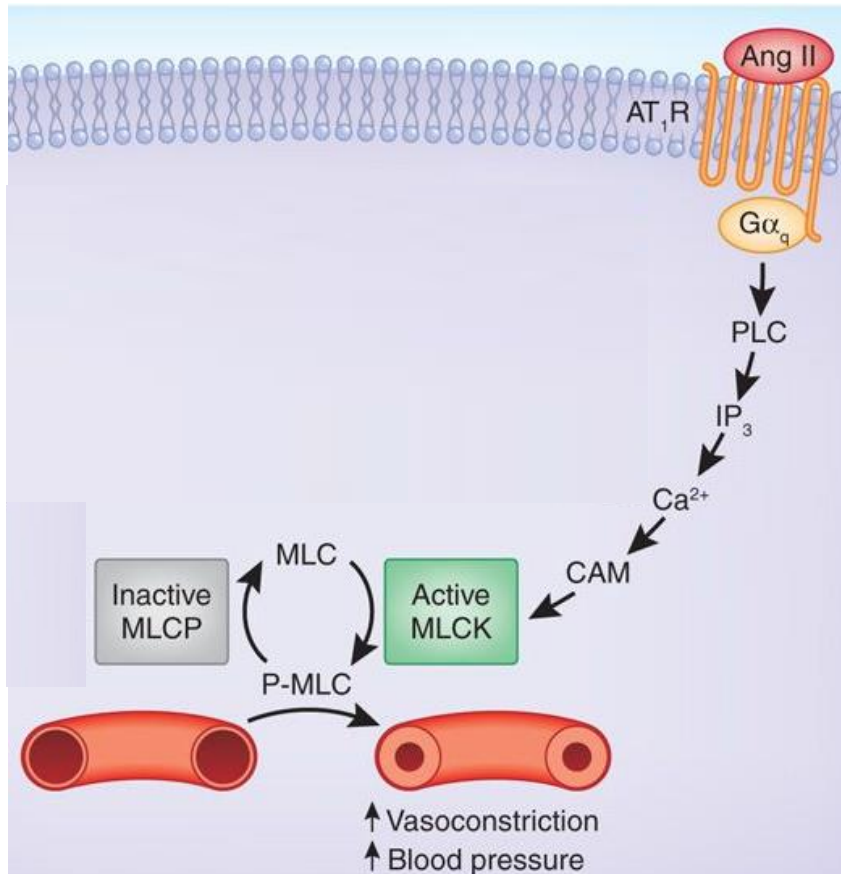
Sistema renina-angiotensina-aldosterona (RAA)



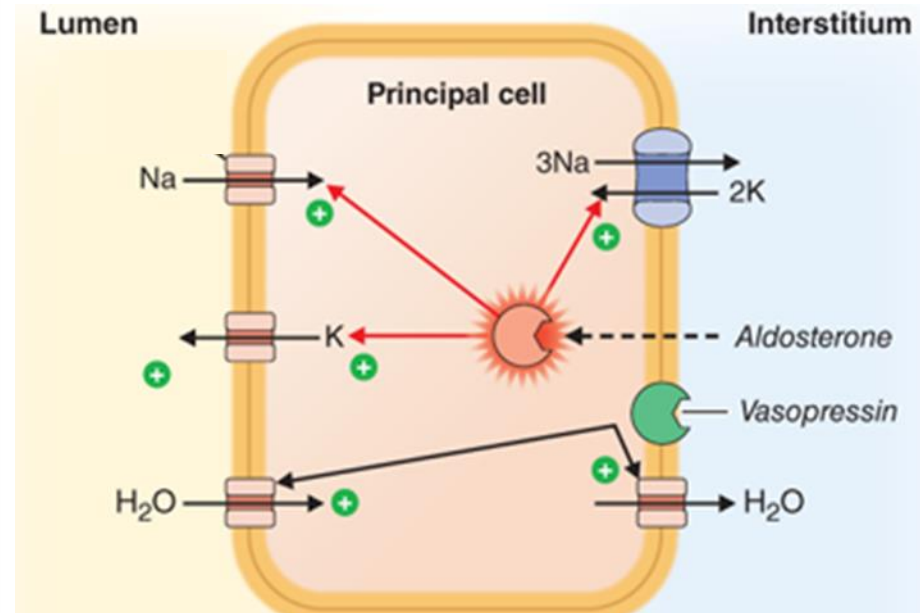
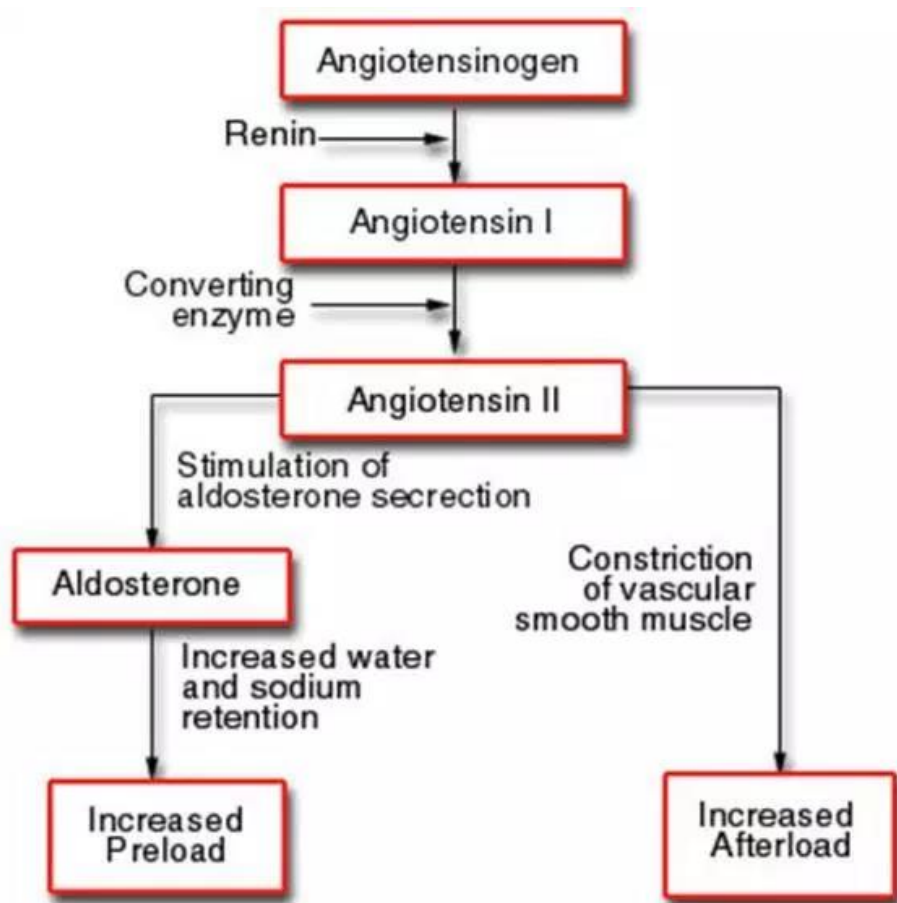
Las distintas formas de angiotensina



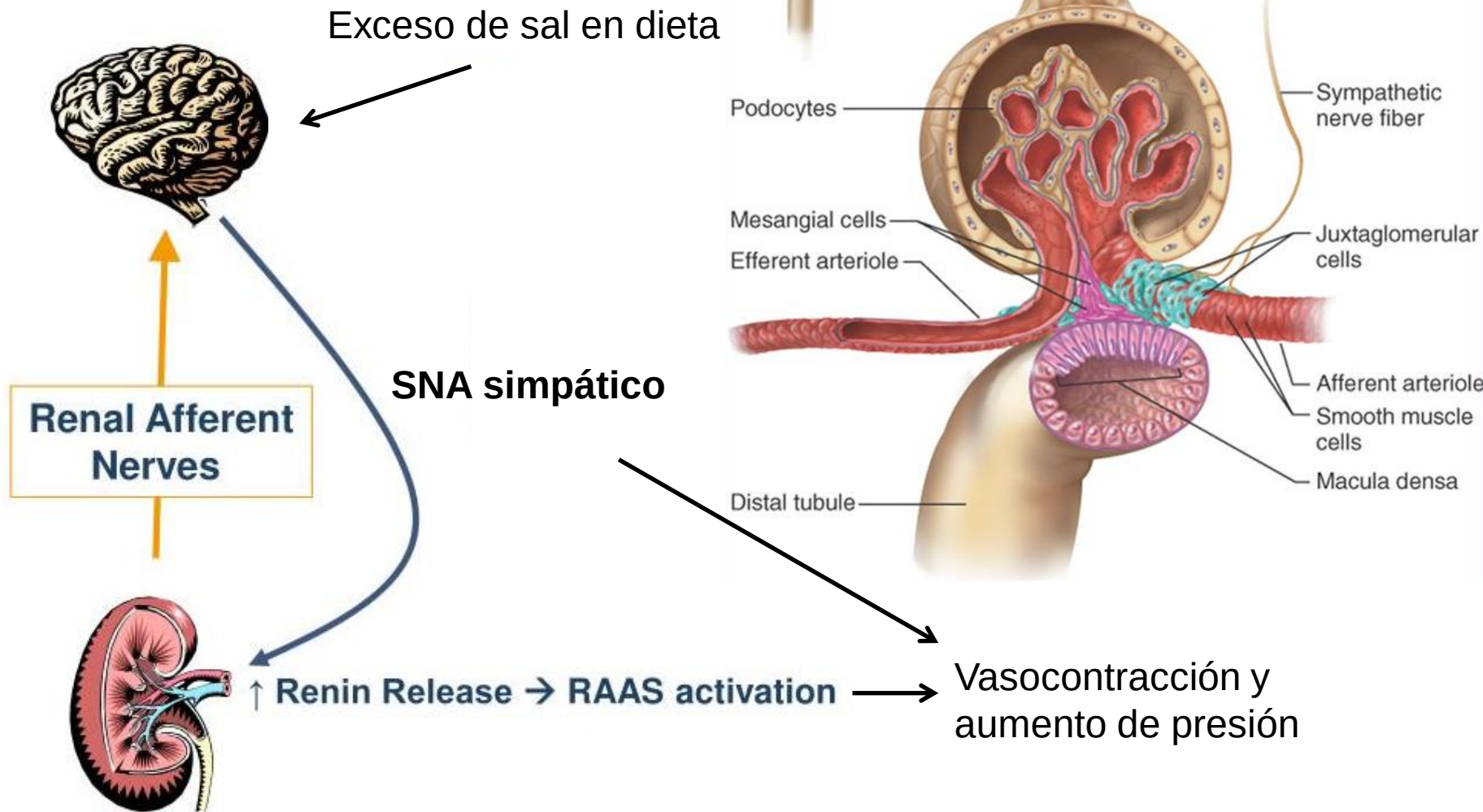
Efecto de la angiotensina-II sobre la musculatura vascular



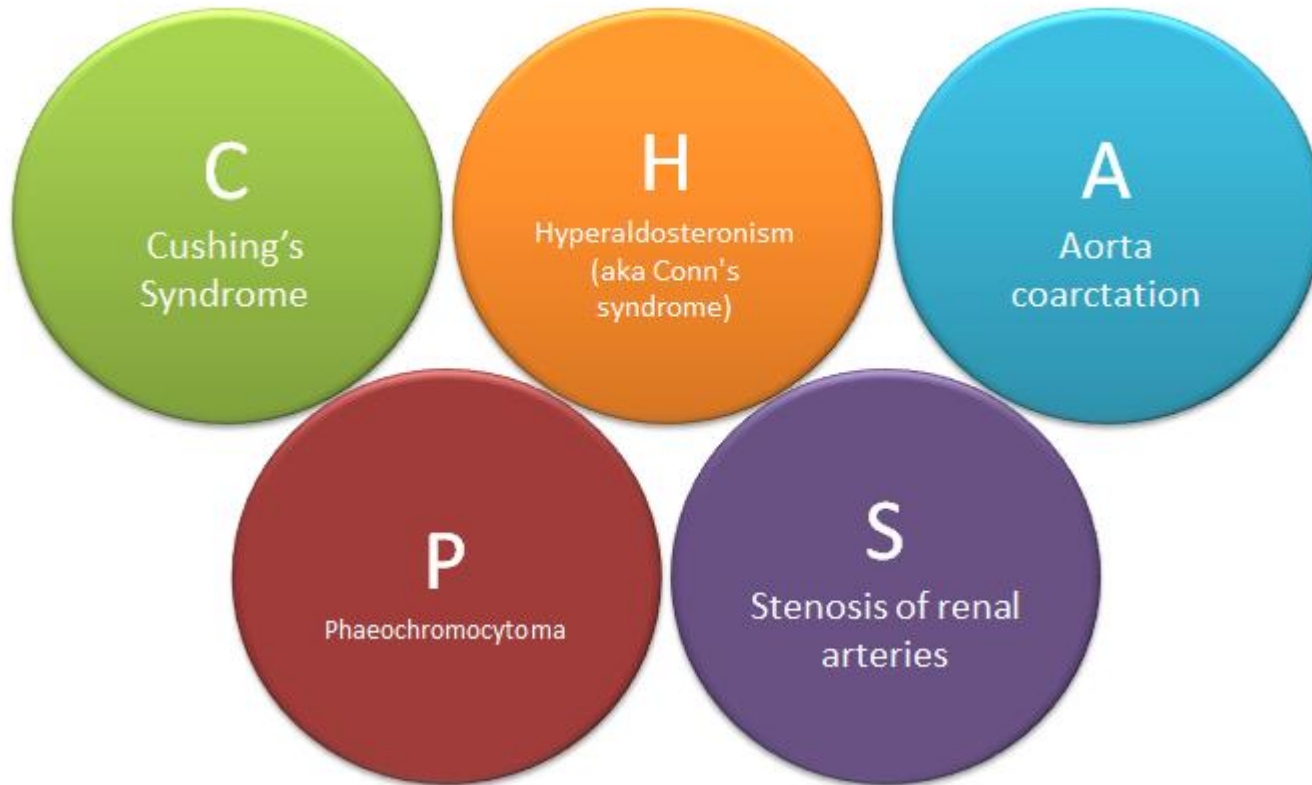
Sistema renina-angiotensina-aldosterona (RAA)



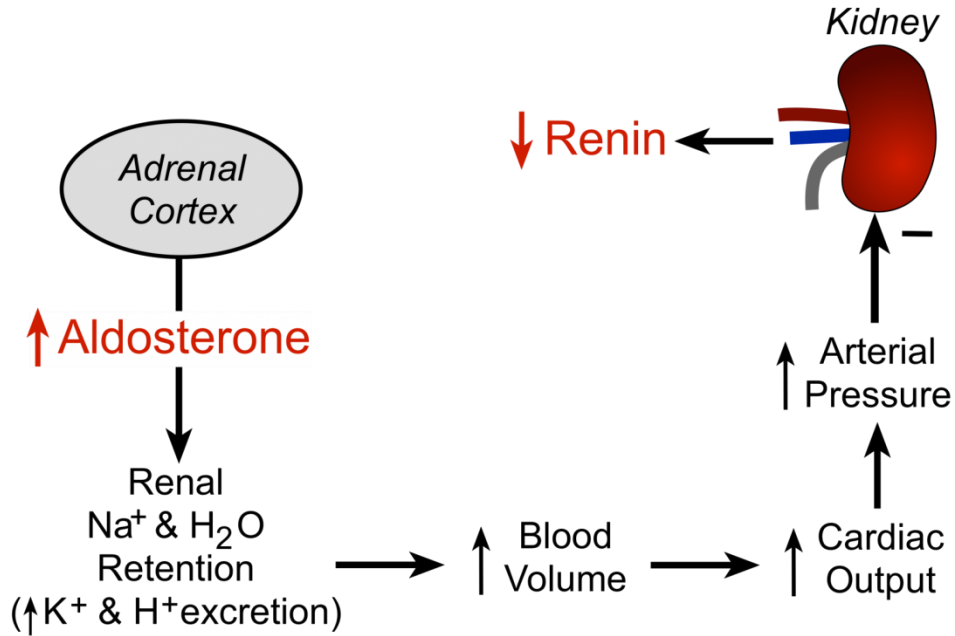
SNA simpático activa sistema RAA



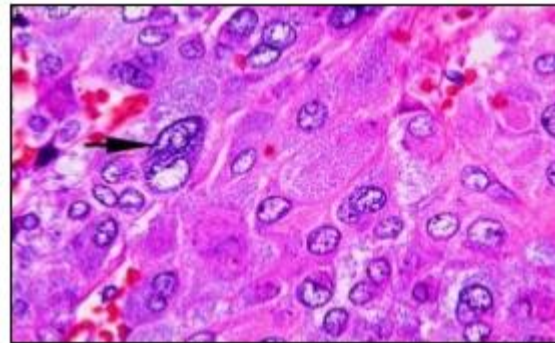
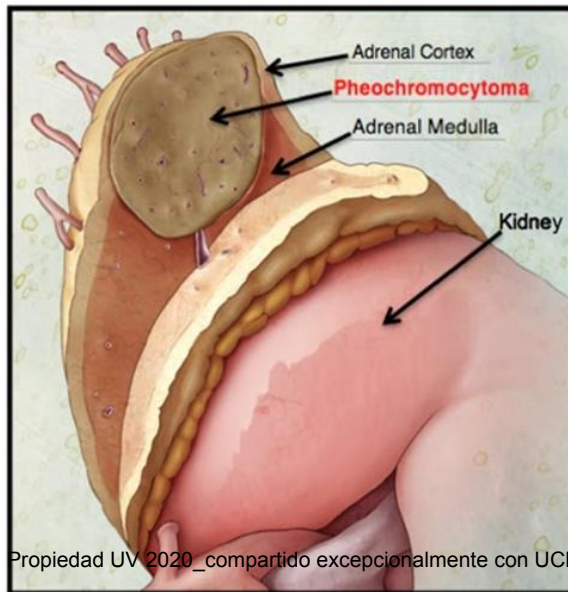
Hipertensión secundaria



Hipertensión secundaria



Síndrome de Conn
(Hiperaldosteronismo primario)



Clusters de cromocitos en la médula
adrenal con células de sostén
(Alveolar/Zellballen)

Presencia de gránulos (catecolaminas)

Feocromocitoma
(Paraganglioma adrenal)

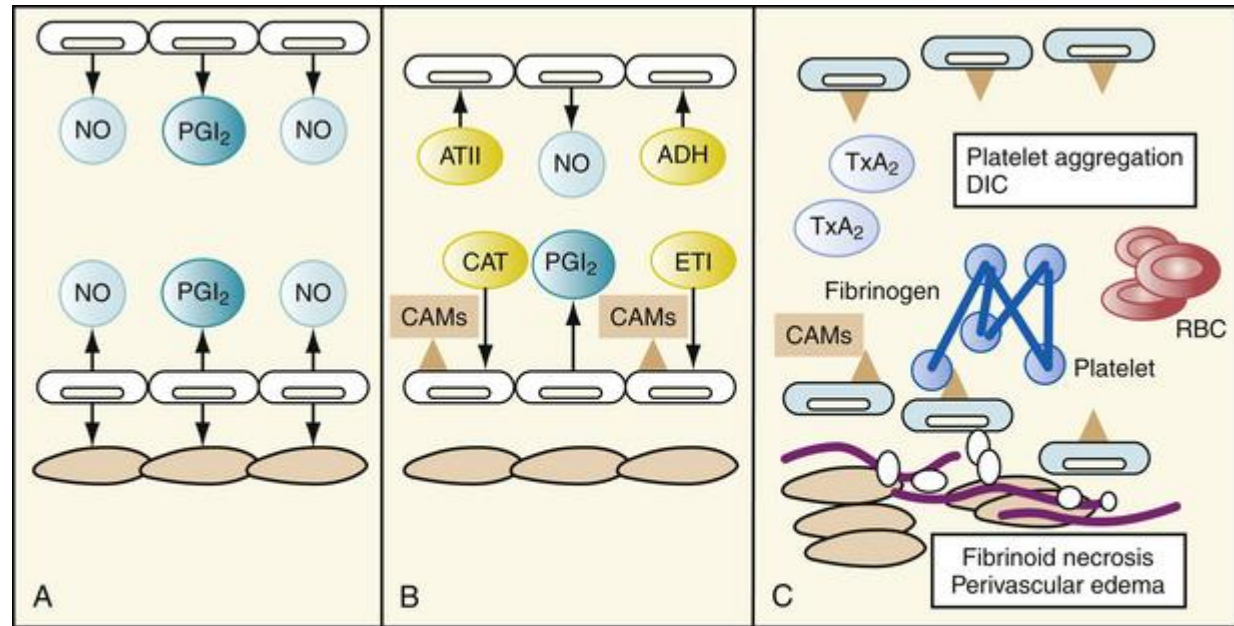
Crisis hipertensiva

Síntomas:

Dolor de cabeza

Edema

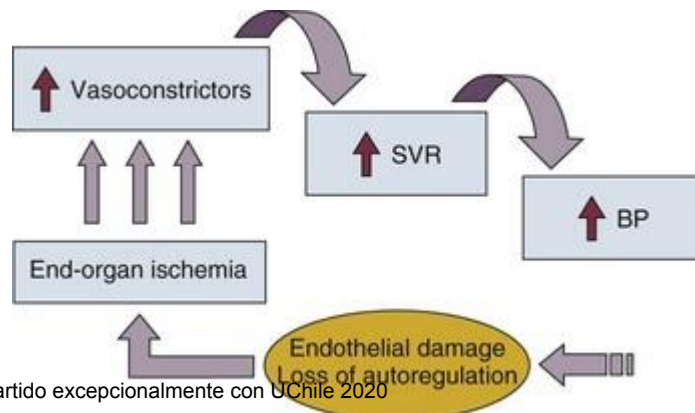
Dolor en pecho



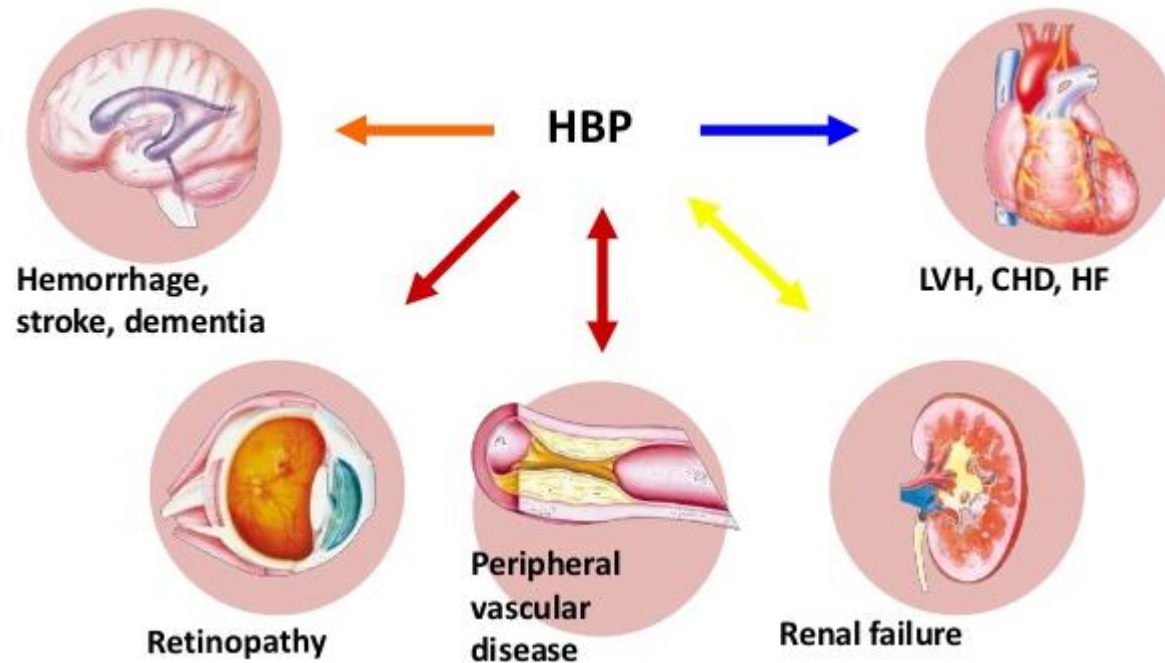
>180/120 mmHg

-Aumento de resistencia vascular sistémica (SVR) y presión (BP), que lleva a daño endotelial e isquemia en tejido de irrigación

-Pérdida de regulación



Tejidos blanco de daño por hipertensión



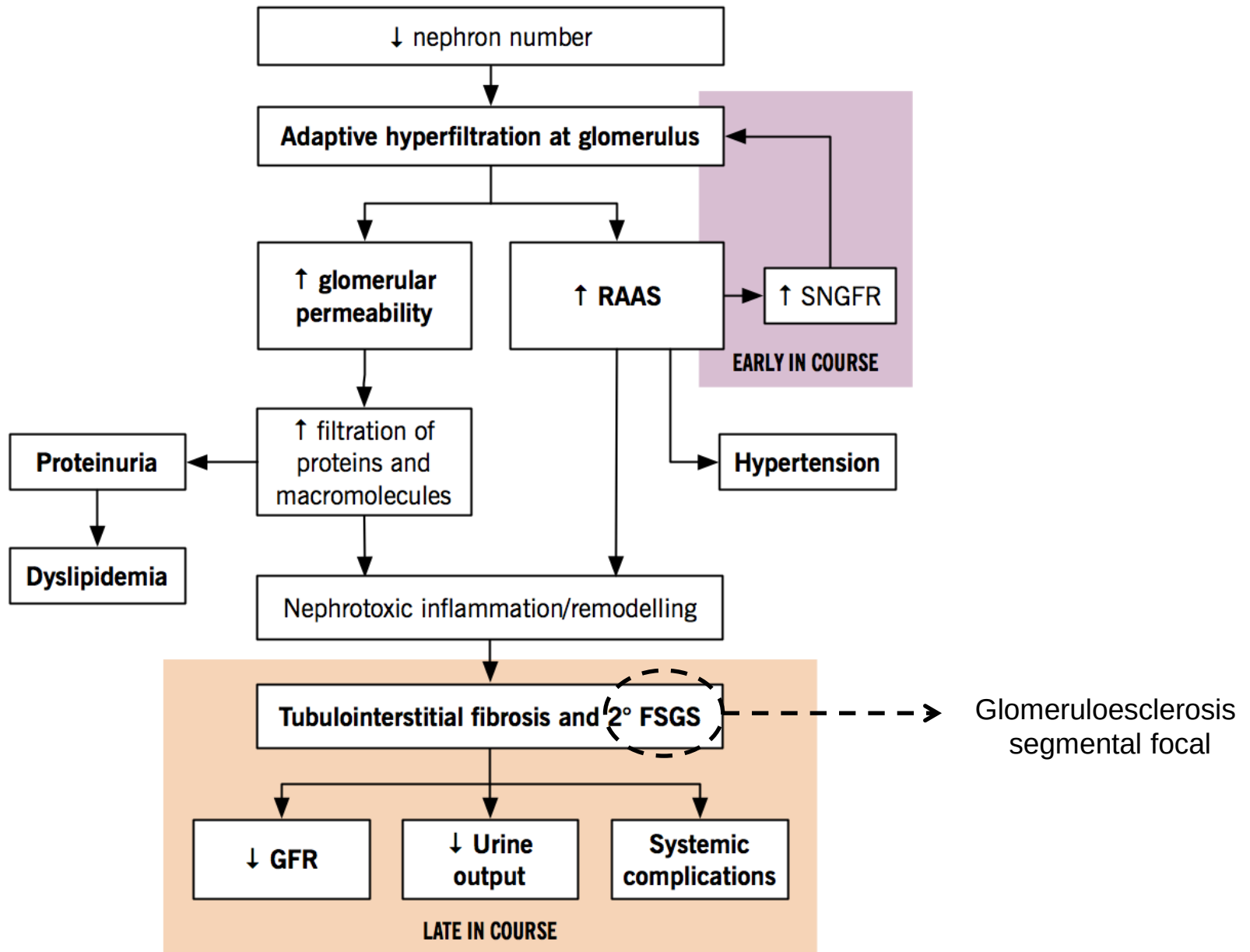
Progresión Hipertensión – Enfermedad renal crónica

PROGRESSION OF CHRONIC KIDNEY DISEASE (CKD)



Test	Complications Detected
Hemoglobin levels	Anemia
Red blood cell indexes, reticulocyte count, iron studies, fecal occult blood test	For ruling out other causes of anemia before erythropoietin therapy is started
Serum electrolyte levels	Hyperkalemia, hyponatremia, acidosis
Calcium, phosphorus, and parathyroid hormone levels	Hypocalcemia, hyperphosphatemia, secondary hyperparathyroidism
Serum albumin and total protein levels	Hypoalbuminemia, decreased levels of immunoglobulins in patients with nephritic levels of proteinuria or signs of malnutrition

- Nausea
- Vomiting
- Loss of appetite and weight loss
- Fatigue and weakness
- Insomnia
- Changes in urine output (polyuria → oliguria)
- Decreased mental sharpness
- Muscle twitches and cramps



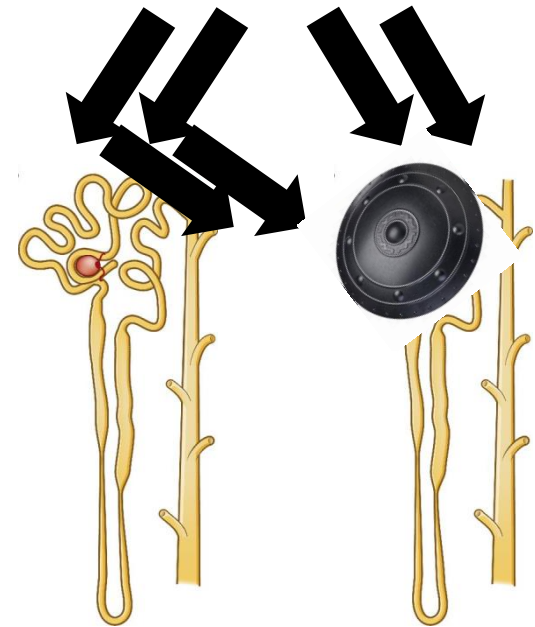
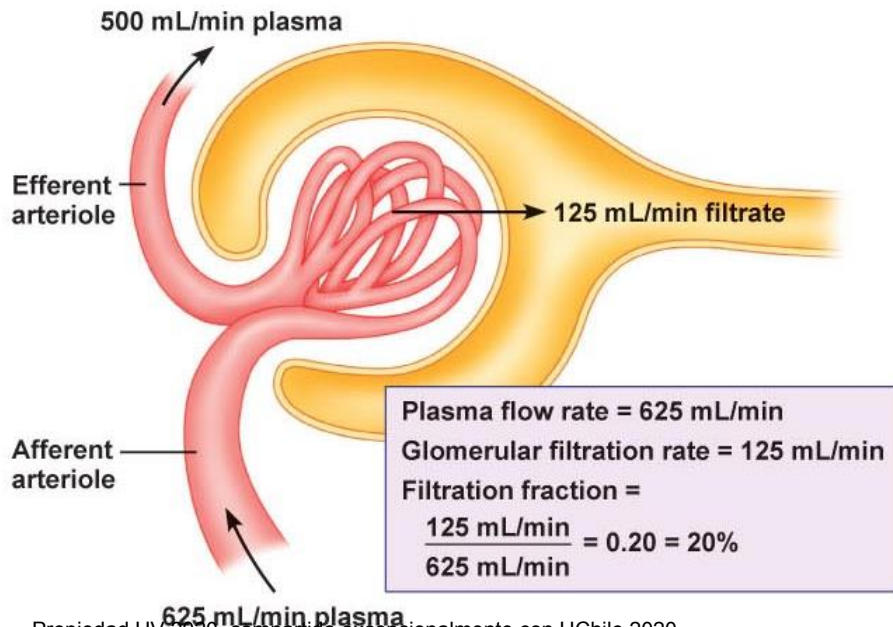
Función renal en Enfermedad Renal Crónica

- CREATININE CLEARANCE=
Urine creatinine in mg/dl x Total volume of urine

Serum creatinine in mg/dl x 1440

REF.RANGE: Male:125ml/mt

Female:115ml/mt



↕ GFR

Etapas de la Enfermedad Renal Crónica

Stage	Description	GFR (mL/min/1.73 m ²)
1	Kidney damage with normal or ↑ GFR	≥90
2	Kidney damage with mild ↓ GFR	60–89
3	Moderate ↓ GFR	30–59
4	Severe ↓ GFR	15–29
5	Kidney failure	<15 (or dialysis)

Chronic kidney disease is defined as either kidney damage or GFR <60 mL/min/1.73 m² for ≥3 months.

Hipertensión – Tratamientos

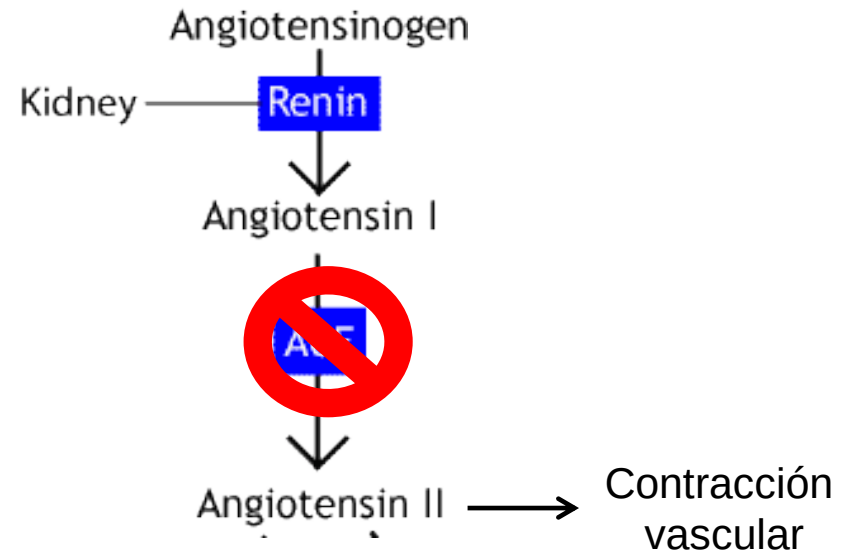
Tratamiento



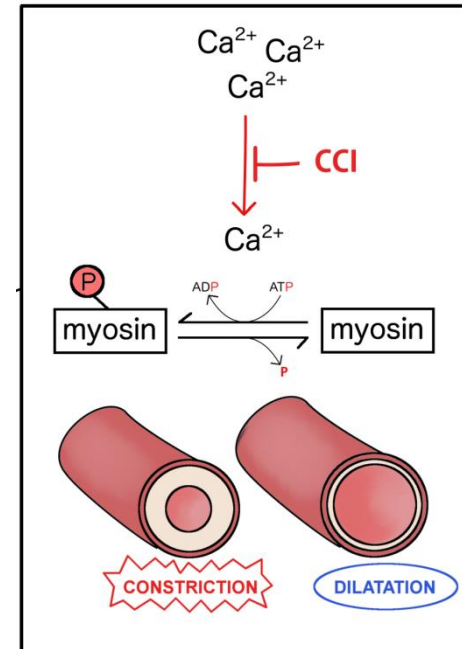
Inhibidor de ECA
(enzima convertidora de angiotensina)



Bloqueador de canales de calcio vasculares



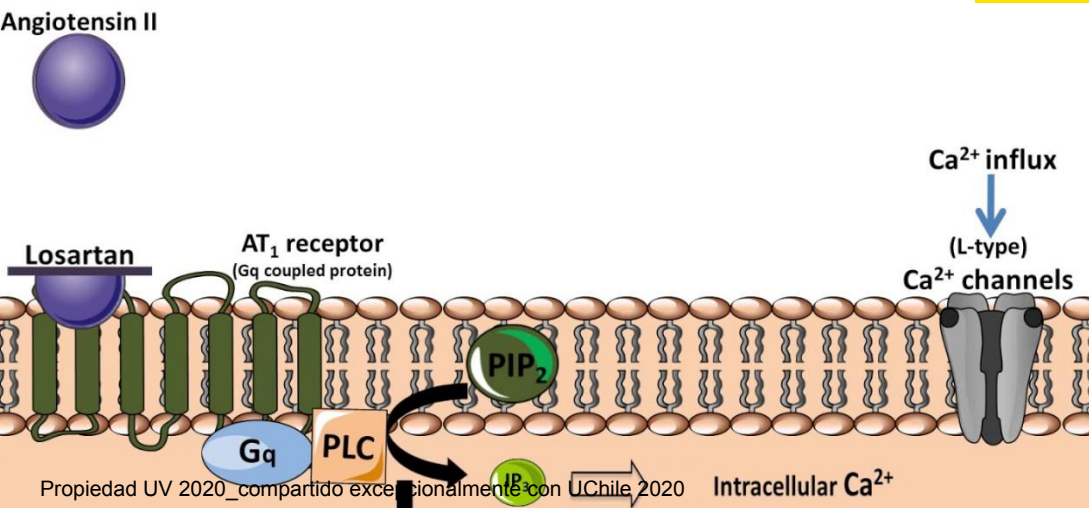
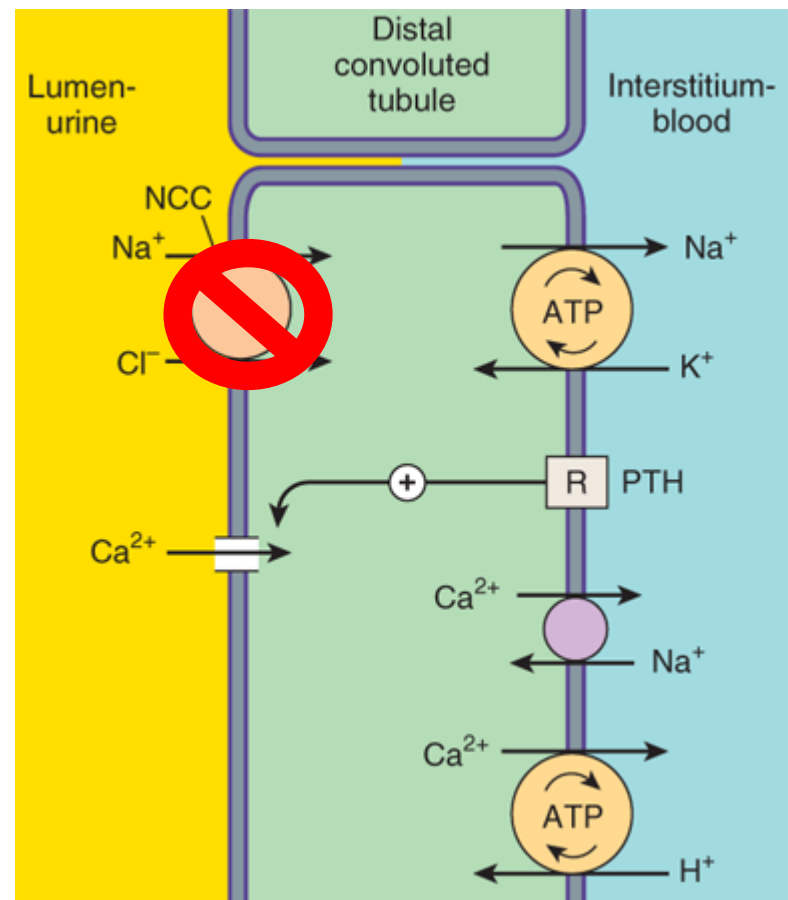
Vascular smooth muscle



Tratamiento



Diurético (bloqueador de transportadores sodio-cloruro NCC)



Antagonista de receptor de angiotensina-II (receptor AT1)

Cambios en estilo de vida

Salt reduction	There is strong evidence for a relationship between high salt intake and increased blood pressure. ⁴⁷ Reduce salt added when preparing foods, and at the table. Avoid or limit consumption of high salt foods such as soy sauce, fast foods and processed food including breads and cereals high in salt.
Healthy diet	Eating a diet that is rich in whole grains, fruits, vegetables, polyunsaturated fats and dairy products and reducing food high in sugar, saturated fat and trans fats, such as the DASH diet (http://www.dashforhealth.com). ⁴⁸ Increase intake of vegetables high in nitrates known to reduce BP, such as leafy vegetables and beetroot. Other beneficial foods and nutrients include those high in magnesium, calcium and potassium such as avocados, nuts, seeds, legumes and tofu. ⁴⁹
Healthy drinks	Moderate consumption of coffee, green and black tea. ⁵⁰ Other beverages that can be beneficial include karkadé (hibiscus) tea, pomegranate juice, beetroot juice and cocoa. ⁴⁹
Moderation of alcohol consumption	Positive linear association exists between alcohol consumption, blood pressure, the prevalence of hypertension, and CVD risk. ⁵¹ The recommended daily limit for alcohol consumptions is 2 standard drinks for men and 1.5 for women (10 g alcohol/standard drink). Avoid binge drinking.
Weight reduction	Body weight control is indicated to avoid obesity. Particularly abdominal obesity should be managed. Ethnic-specific cut-offs for BMI and waist circumference should be used. ⁵² Alternatively, a waist-to-height ratio <0.5 is recommended for all populations. ^{53,54}
Smoking cessation	Smoking is a major risk factor for CVD, COPD and cancer. Smoking cessation and referral to smoking cessation programs are advised. ⁵⁵
Regular physical activity	Studies suggest that regular aerobic and resistance exercise may be beneficial for both the prevention and treatment of hypertension. ^{56–58} Moderate intensity aerobic exercise (walking, jogging, cycling, yoga, or swimming) for 30 minutes on 5–7 days per week or HIIT (high intensity interval training) which involves alternating short bursts of intense activity with subsequent recovery periods of lighter activity. Strength training also can help reduce blood pressure. Performance of resistance/strength exercises on 2–3 days per week.

Preguntas que deberían poder responderse tras haber estudiado esta clase

- ¿Cómo el consumo de sal induce hipertensión? ¿Qué parámetros de las ecuaciones de flujo altera y cómo? (BP = ?)
- ¿Cómo la hipertensión produce falla renal?
- ¿En qué se basan los tratamientos farmacológicos de la hipertensión?