I. Anatomie générale du cœur

A. Grechez

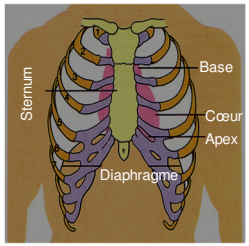
1

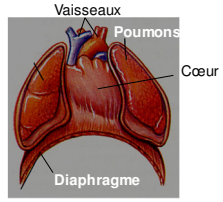
1

Caractéristiques :

- Taille	12 cm de long sur 9 cm de large
- Poids	250 – 350 g (0,4 à 0,5% MC)
- Fréquence	60 – 80 batt / min (bpm)
- Batt. / jour	100 000
- Batt. / vie	3 milliards
- Vol. éjection	80 ml / battement
- VE / jour	8000 litres / jour

Localisation du cœur chez l'homme





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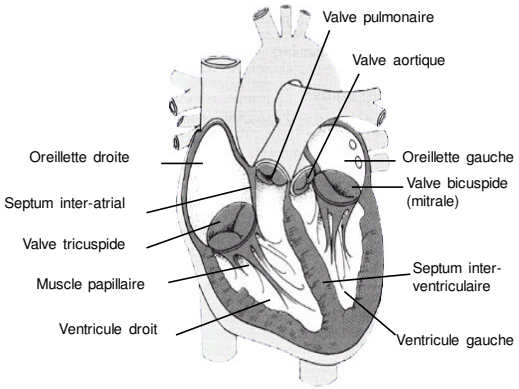
Anatomie interne du cœur



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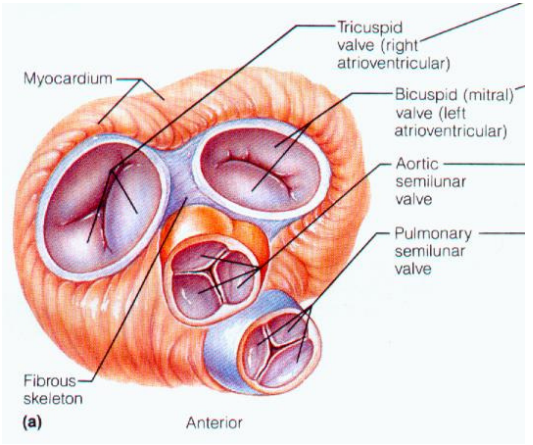
Valves cardiaques



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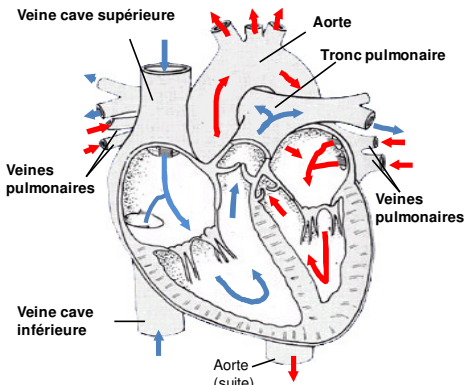
La circulation du sang dans le cœur



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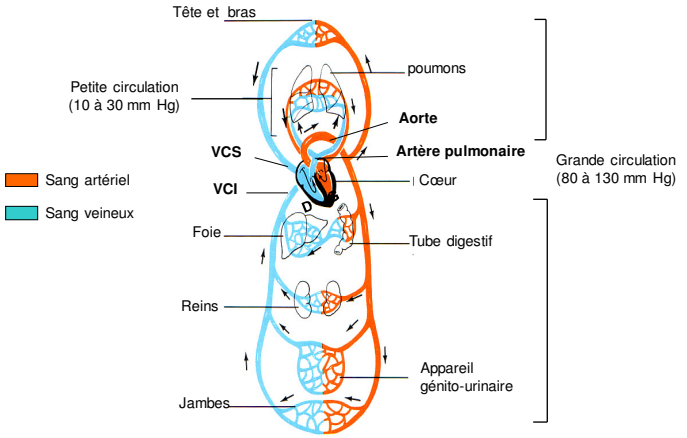
Circulation pulmonaire et circulation systémique



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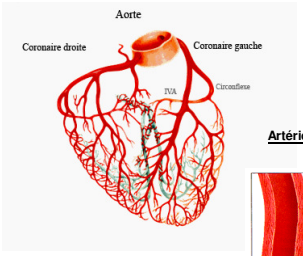
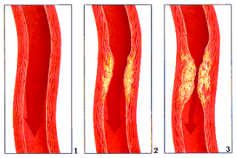
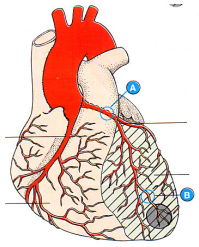
La circulation coronaire

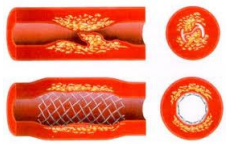


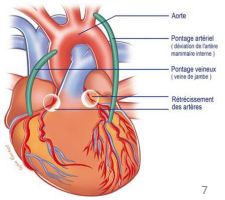
- Métabolisme aérobie
  - 2/3 acides gras et corps cétoniques
  - 1/3 glucose et lactate
- Perfusion diastolique du VG

Artériosclérose : dépôt lipidique sur la paroi entraînant une diminution de la circulation sanguine









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II. Activité électrique

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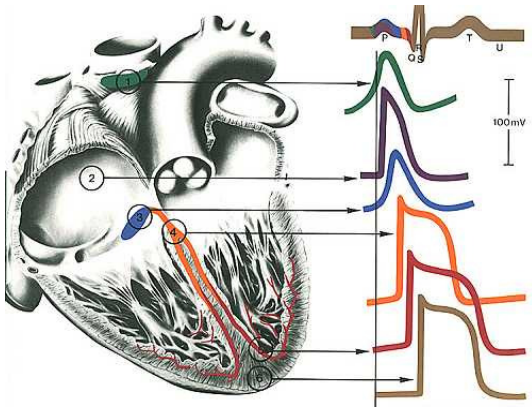
Potentiels d'action selon les différentes régions du cœur



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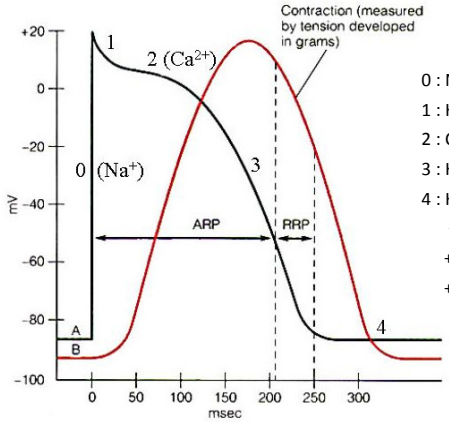
Phases du potentiel d'action myocardique



0 : Na
1 : K_{TO}
2 : Ca + K_{DR}
3 : K_{DR}
4 : K_{IR}
+ ATPase Na(3)/K(2)
+ ATPase Ca
+ Echangeur Na(3)/Ca(1)

10

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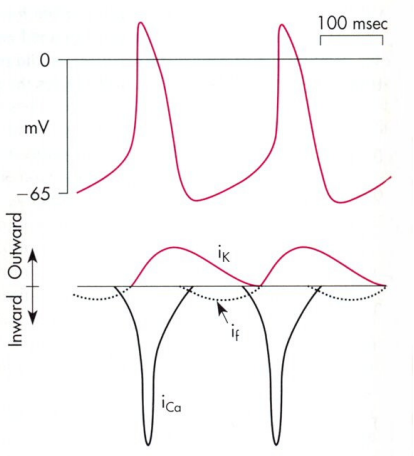
Potentiel d'action du pacemaker



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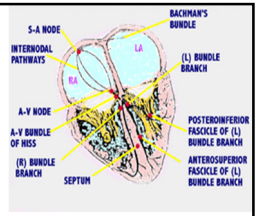
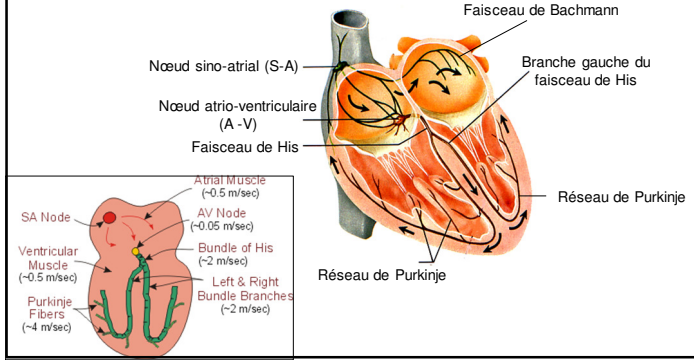
Activité électrique du cœur
(de type myogénique)

Système pacemaker et système de conduction
- tissu nodal (nœuds SA et AV)
- tissu conducteur (His et Purkinje)





stop

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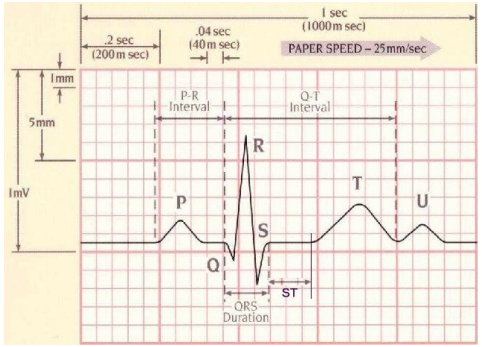
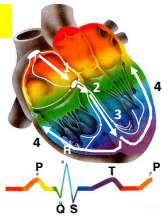
Electrocardiogramme (ECG)





P : dépol auriculaire
PR : propag SA – AV - His (0,12-0,2 s)
QRS : dépol ventriculaire (0,06-0,1 s)
ST : V complètement dépolarisés
QT : ↔ durée moy du PA ventriculaire (~ 0,4 s)
T : repol ventricules
U : repol Purkinje ?

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III. Activité musculaire

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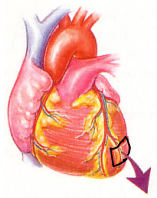
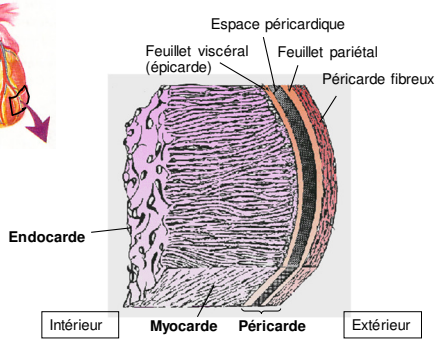


La paroi du cœur



Endocarde : endothélium constitué de tissu conjonctif contenant fibres élastiques, collagène, vaisseaux sanguins et fibres spécialisées

Myocarde : muscle, tissu conjonctif, vaisseaux sanguins et fibres nerveuses

Péricarde : couche fibreuse

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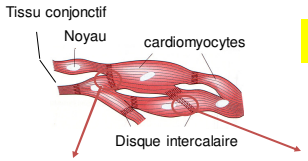
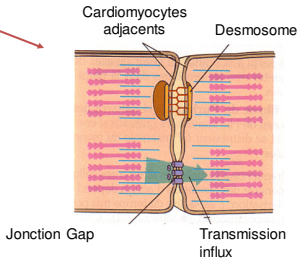
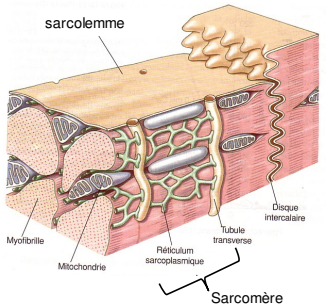
Morphologie de la fibre musculaire cardiaque







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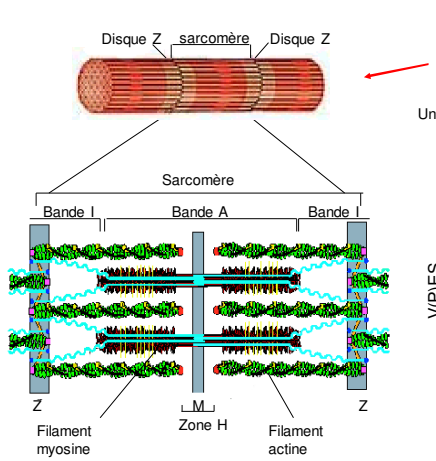
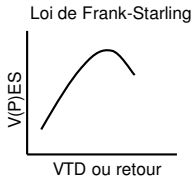
Sarcomère = unité de contraction de la fibre musculaire cardiaque





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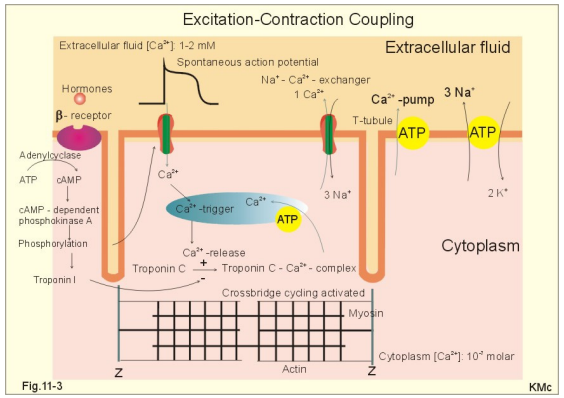
Couplage excitation-contraction



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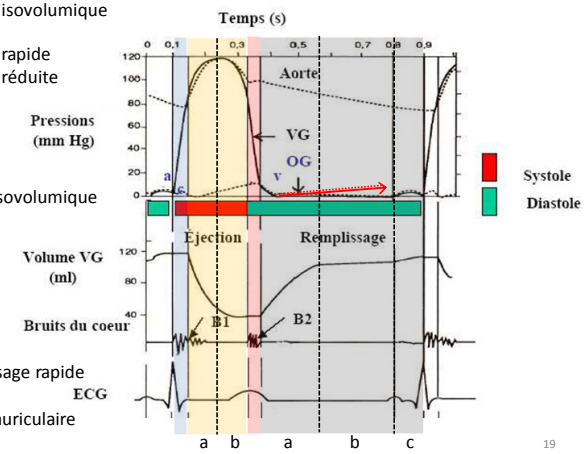
Cycle cardiaque

I Contraction isovolumique

II
a. Ejection rapide
b. Ejection réduite

III Relaxation isovolumique

IV
a. Remplissage rapide
b. Diastase
c. Systole auriculaire



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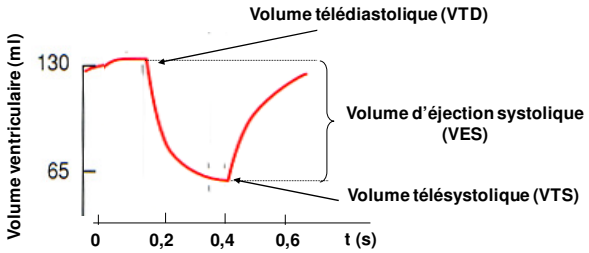
Volume ventriculaire au cours du cycle cardiaque

ΔV = VES = VTD – VTS

Fraction d'éjection = VES / VTD



Q = VE x FC

(70 ml x 70 bpm ≈ 5 l / min)

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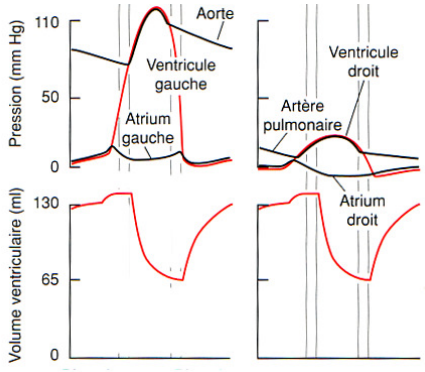
Evolution des pressions et des volumes au cours du cycle cardiaque



$P = Q \times R(PT)$

(R en mm Hg / L / min)

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Mesure du débit cardiaque

$$Q = \frac{VO_2\ (LO_2\ /\ min)}{CaO_2 - CvO_2\ (LO_2\ /\ L_{sang})}$$

$VO_2 = VO_2$ inspiré – VO_2 expiré

$CaO_2 - CvO_2$ = différence artério-veineuse en O_2

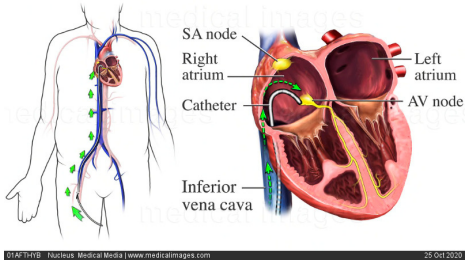

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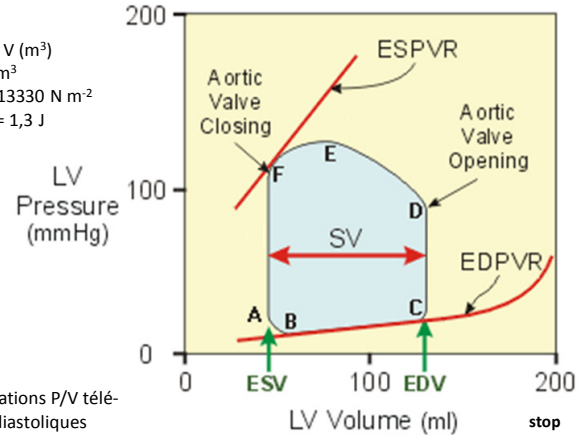
Diagramme de travail

W (J) = N x m
= P (N m^{-2}) x V (m^3)
V = 100 ml = 10^{-4} m^3
P = 100 mm Hg = 13330 N m^{-2}
W = 13330 x 10^{-4} = 1,3 J



E(S)DPVR : relations P/V télé- (systoliques) diastoliques

stop

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IV. Régulations

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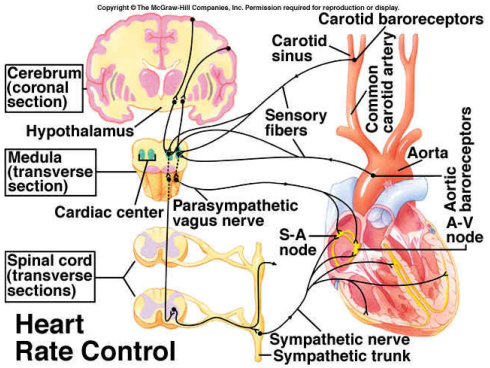
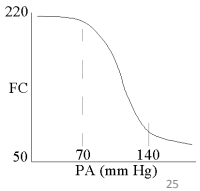
Régulation par le SNA





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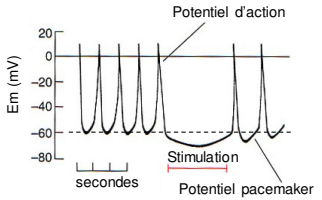
Système parasympathique

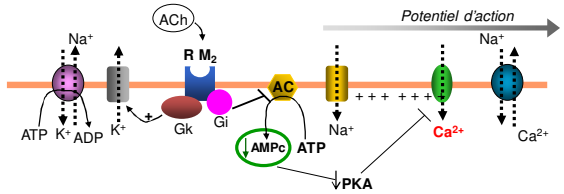
Stimulation du nerf vague



Bradycardie

Final : effets chronotrope, dromotrope et inotrope négatifs

Modulation cholinergique de l'excitabilité cardiaque.



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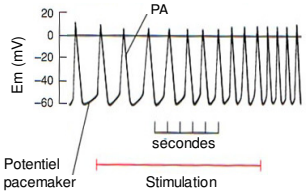
Système (ortho)sympathique

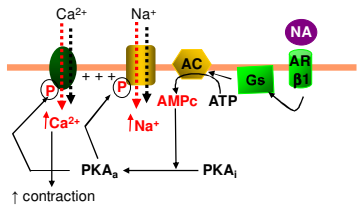
Stimulation des fibres nerveuses sympathiques



Tachycardie

Final : effets chronotrope, dromotrope et inotrope positifs

Modulation adrénergique de l'excitabilité cardiaque.



Au niveau des tissus nodal et myocardique

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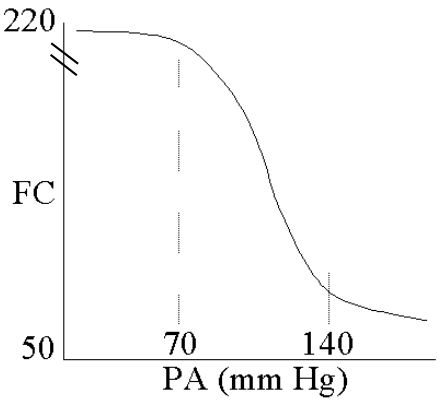
Régulation de la fréquence

1. Réflexe barorécepteur



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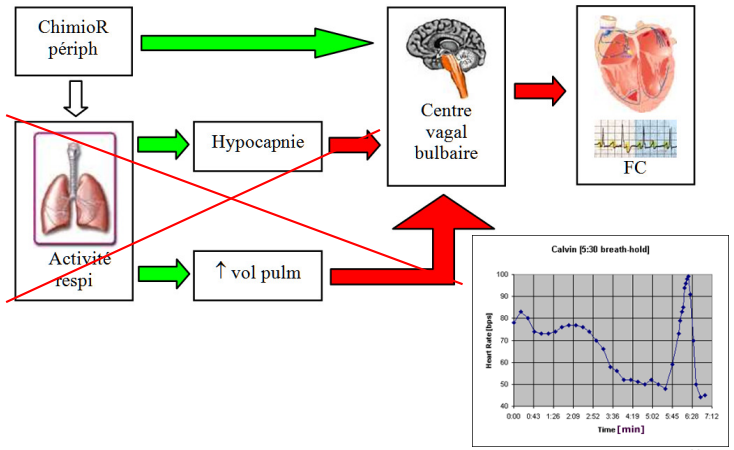
Régulation de la fréquence

2. Réflexe chimiorécepteur



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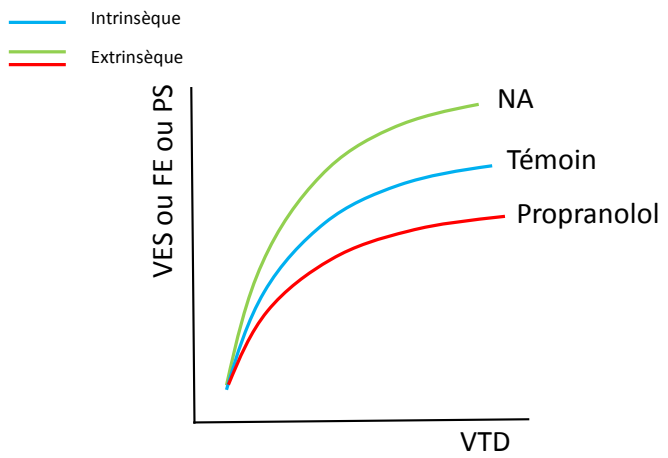
Régulation intrinsèque de la contractilité

1. Frank - Starling



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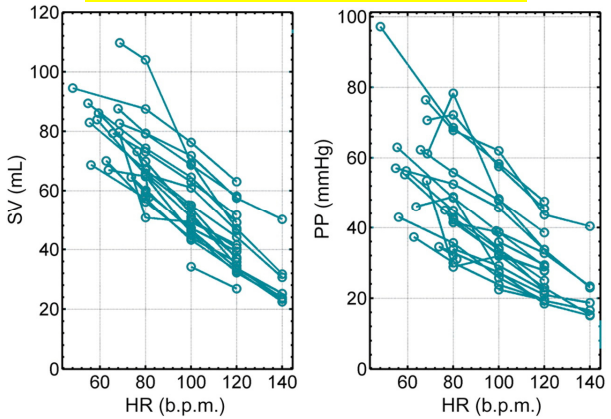
Régulation intrinsèque de la contractilité

2. Fréquence



Bocchiardo M et al. Europace 2010;12:702-707

Europace

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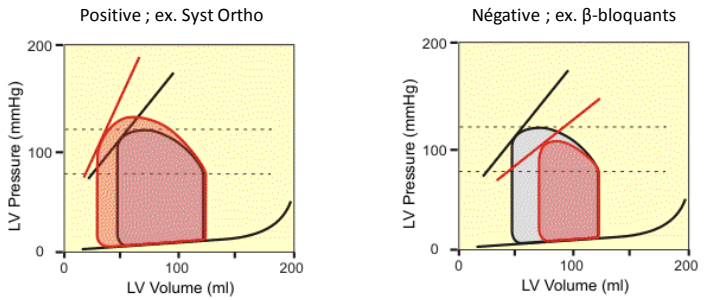
Régulation extrinsèque de la contractilité

1. Inotropie



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Régulation extrinsèque de la contractilité

2. Hormones

- Adrénaline (Médullosurrénales)
- Corticostéroïdes (cf. Addison)
- T3 (cf. Graves)
- Insuline
- Glucagon
- GH (↑ T4)

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V. Système vasculaire

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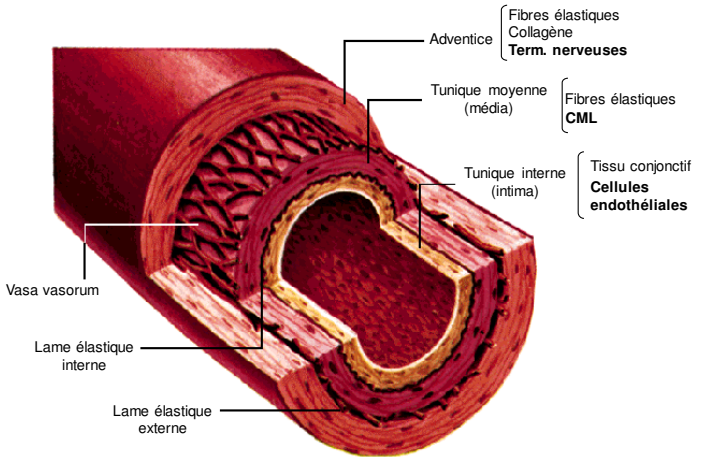
Les 3 tuniques d'un vaisseau sanguin



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Structure de la paroi vasculaire

	Mean diameter	Mean wall thickness	Endothelium	Elastic tissue	Smooth muscl	Fibrous tissue	
Artery	4.0 mm	1.0 mm					
Arteriole	30.0 µm	6.0 µm					
Capillary	8.0 µm	0.5 µm					
Venule	20.0 µm	1.0 µm					
Vein	5.0 mm	0.5 mm					

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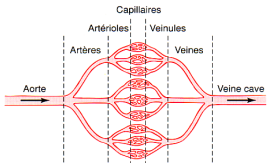
Quelques caractéristiques du système vasculaire

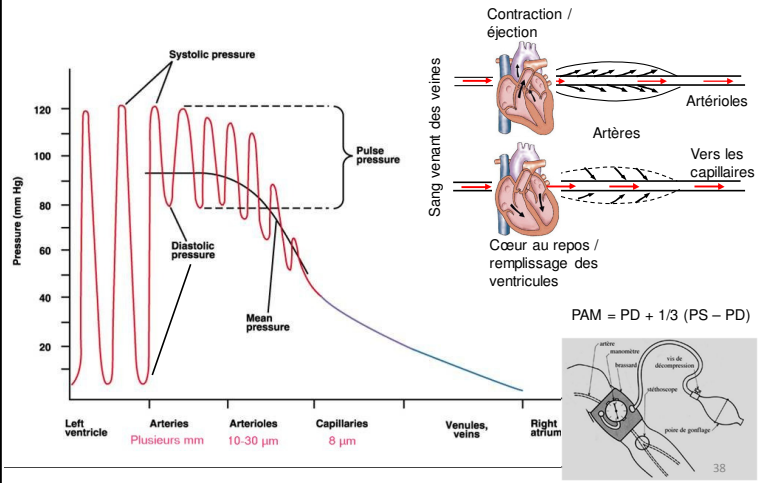
Vaisseau	Nombre	Diamètre de la lumière	Section (cm^2)	Longueur (cm)	Vitesse (cm/s)
Aorte	1	2 cm	3	40	100
Artères	40 - 2400	1 cm – 1 mm	3 – 5	5 – 20	40 – 10
Artérioles	4 x 10^7	20 – 30 µm	125	0,2	10 – 0,1
Capillaires	3-5 x 10^9	5 – 10 µm	1500	0,1	≈ 0,1
Veinules	8 x 10^7	30 – 50 µm	570	0,2	< 0,3
Veines	40 - 2400	1 – 0,6 cm	11 – 30	5 – 20	0,3 – 5
Veines caves	2	1,2 cm	1,2	40	5 - 20



Vitesse d'écoulement du sang = Dc / S

(avec V (m/s), Dc (m^3/s) et S (m^2)

Artères et pression pulsatile



PAM = PD + 1/3 (PS – PD)

Résistance vasculaire

(obstacles à l'écoulement dus à la friction entre le sang en mouvement et les parois fixes)

Poiseuille : $R_h = 8\ L\ \eta\ /\ \pi\ r^4$ **(mm Hg / ml / min)**

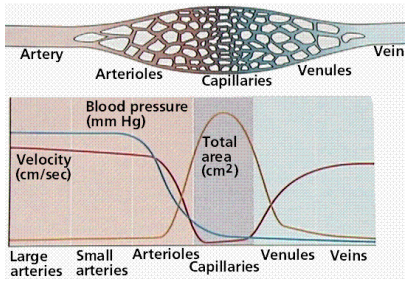
L = Longueur du vaisseau

η = Viscosité (= 4 pour le sang ; 1,8 pour le plasma)

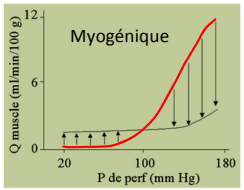
r = Rayon → régulation via la compliance (C = V / P) (avec V en ml ; P en mm Hg)

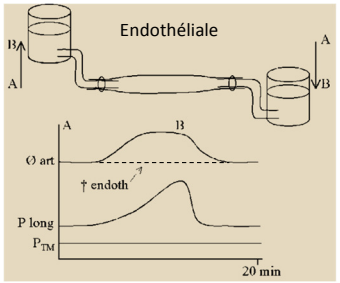
→ régulation active via les CML

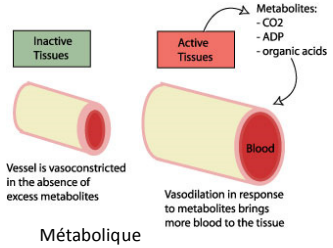
MAIS : RPT ∝ 1 / A^2 x n...



Régulation intrinsèque de la circulation périphérique

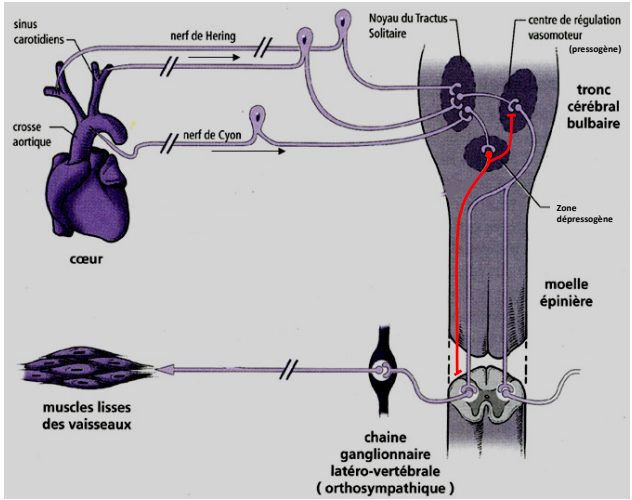






Métabolique

Régulation extrinsèque de la circulation périphérique



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Réflexe barorécepteur

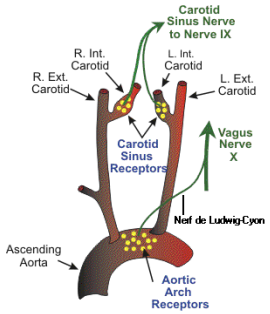
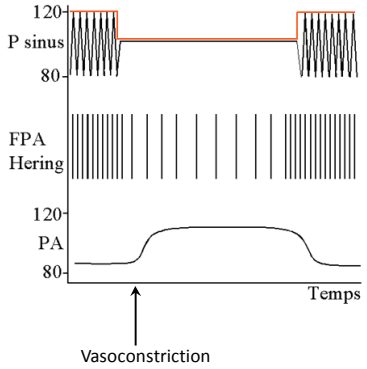


Figure 1. Location and innervation of arterial baroreceptors.



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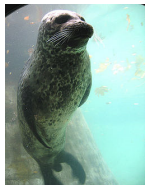
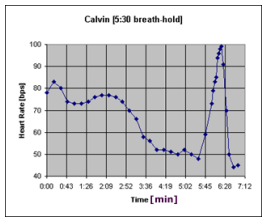
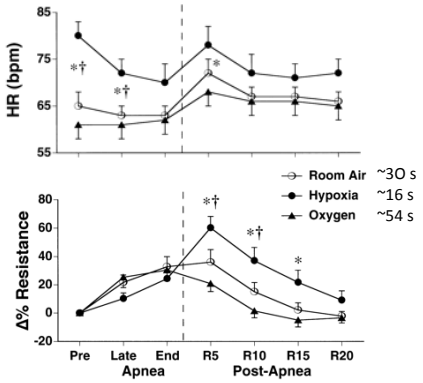
Réflexe chimiorécepteur







Leuenberger et al, *J Appl Physiol* 90: 1516-1522, 2001

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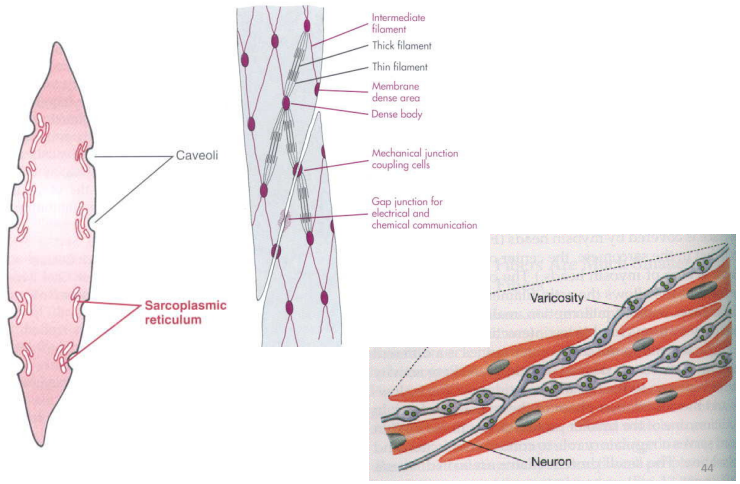
Les CML des vaisseaux sanguins



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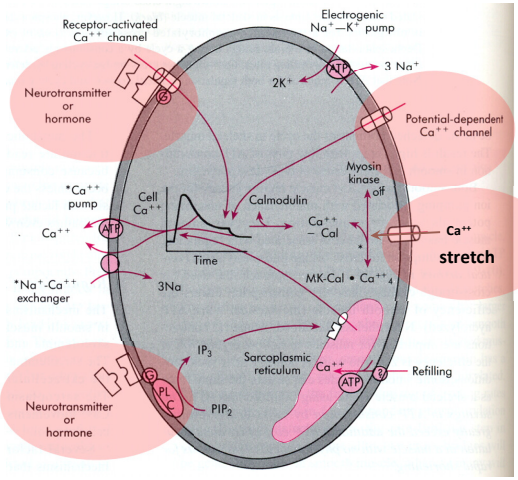
4 voies de signalisation calcique dans la CML



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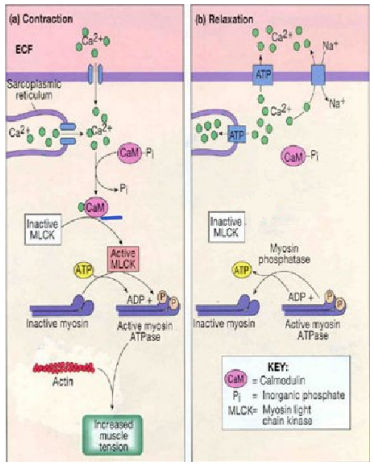
Biochimie de la contraction des CML



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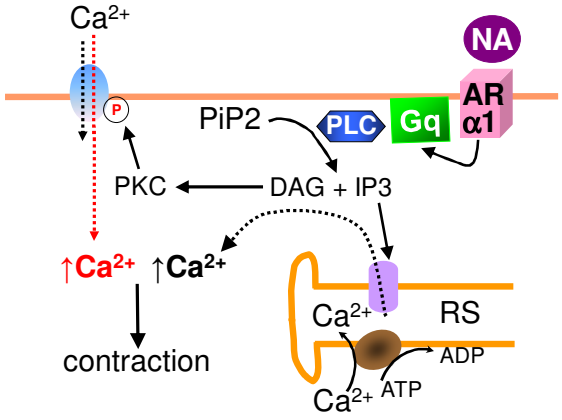
Mécanisme de la vasoconstriction sympathique



stop

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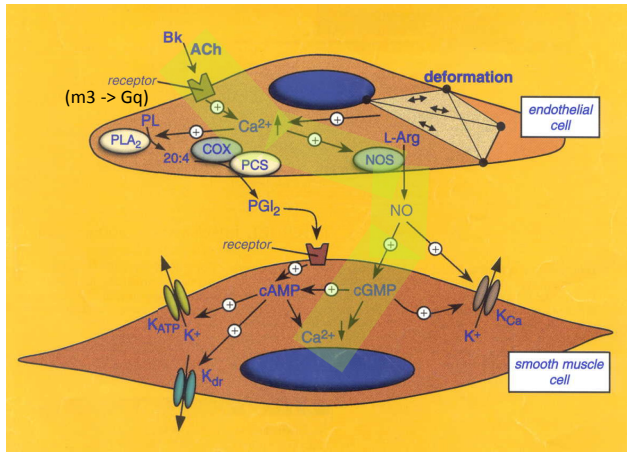
Mécanismes de relaxation des CML (ex. vasodilatation parasympathique)



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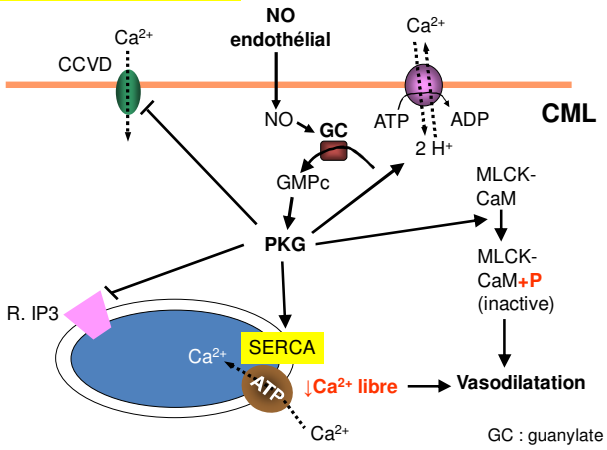
Mode d'action du NO



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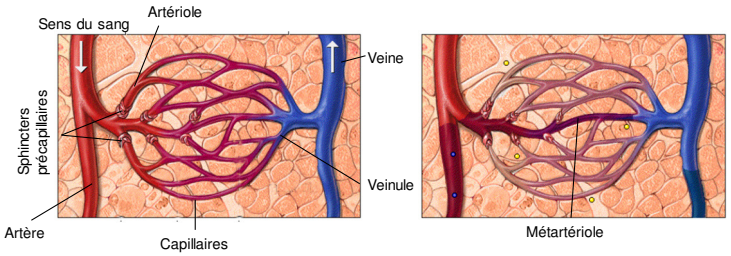
Les capillaires sanguins

- Diamètre : 5-10 µm (taille GR)
- Pas de CML, ni fibre élastique
- Paroi : monocouche de cellules endothéliales, épaisseur 1 µm
- Présence ± selon activité métabolique
(absents dans cartilage, cornée, cristallin, tendons…)

Lit capillaire

(10 – 100 capillaires)



Sphincters précapillaires ouverts

Sphincters précapillaires fermés

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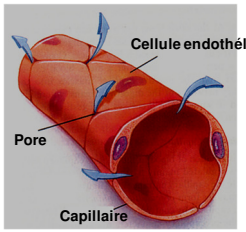
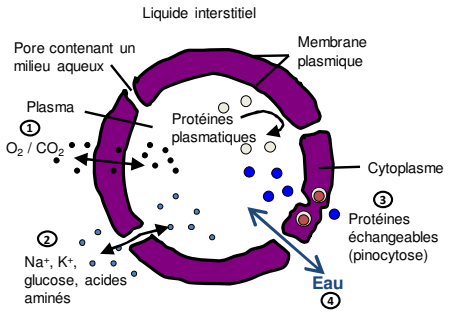
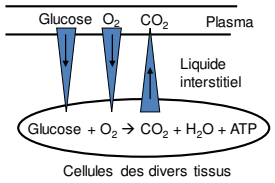
Transfert capillaire







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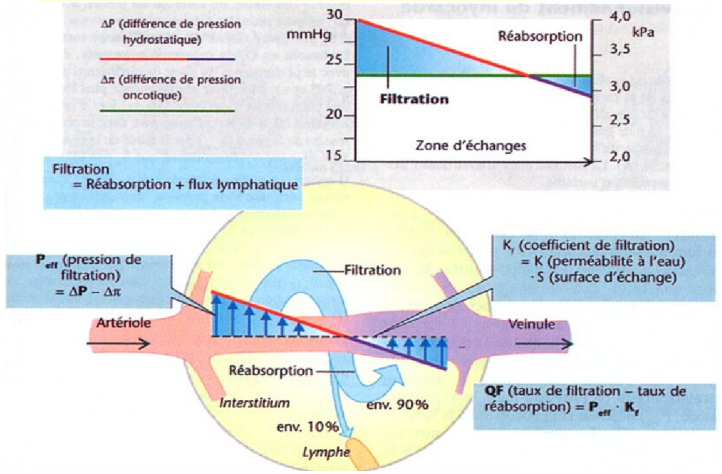
Echanges liquidiens au niveau des capillaires et des veinules



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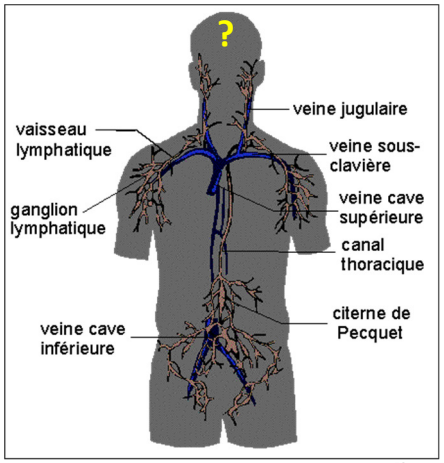
Le système lymphatique

Rôles :

- Récupération de l'excédent de liquide filtré
- Récupération des protéines filtrées
- Transport des graisses absorbées par le tube digestif
- Défense de l'organisme



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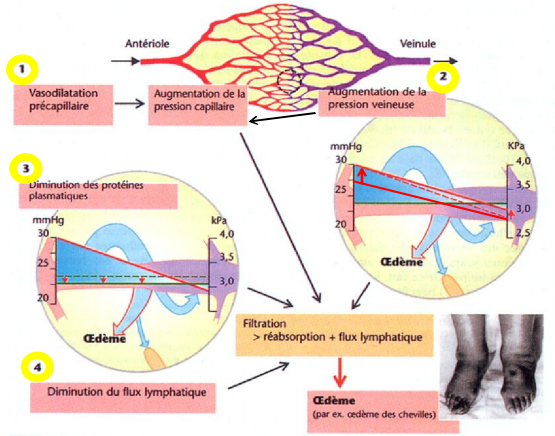
Causes de l'oedème



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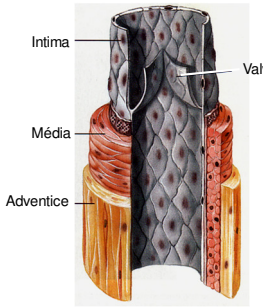
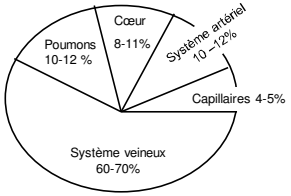
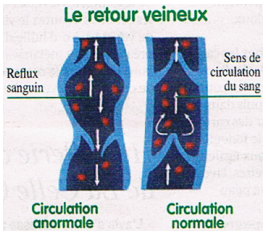
Le système veineux

Faible pression : 15 mm Hg en moyenne



Réserve de sang





- Paroi similaire à celle des artères
- Média moins épaisse et contenant moins de CML et plus de fibres élastiques → Compliance importante
- Important diamètre → résistance faible

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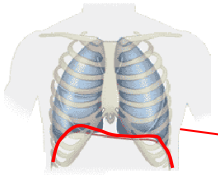
Pompe auxilliaire

Mouvements respiratoires

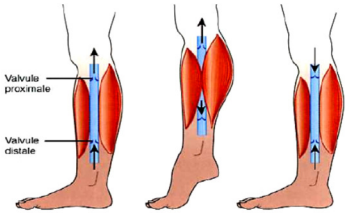


Stimulation sympathique → veinoconstr

Pression VCI : 2 mm Hg
OD : 0 mm Hg

Pompe cardiaque

Pompe musculaire + valves



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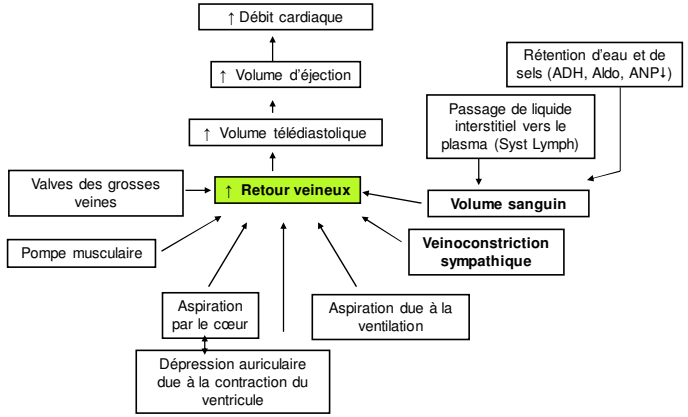
Facteurs influençant le retour veineux



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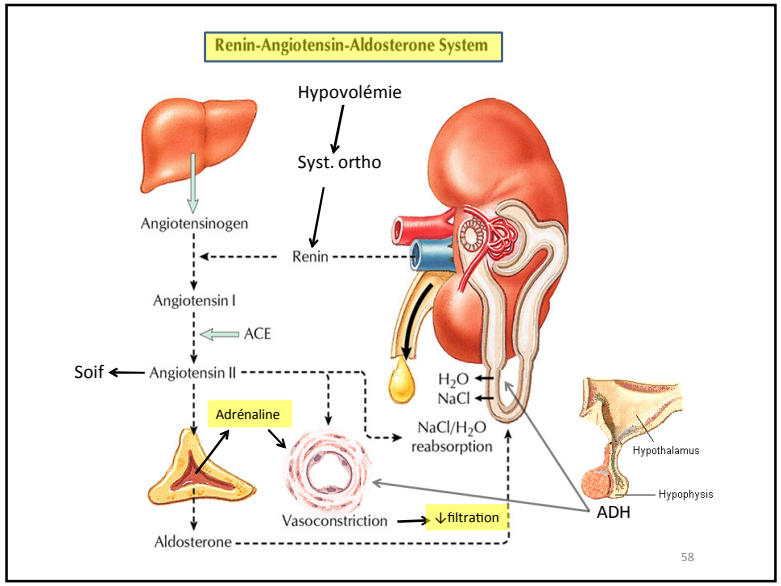

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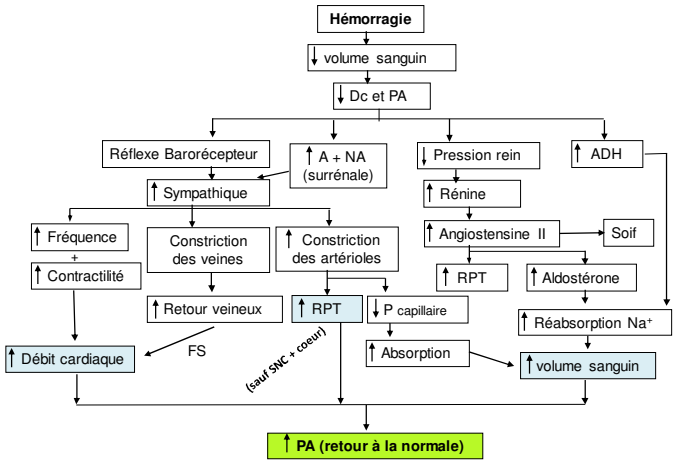
Exemple de régulation de la PA - 1



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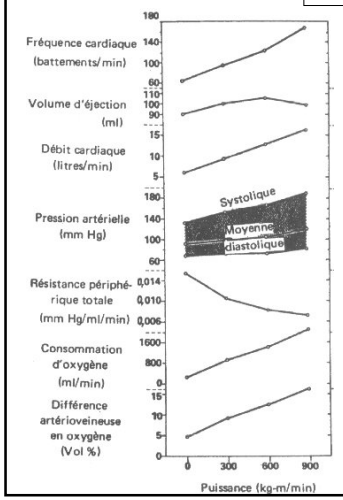
Exemple de régulation de la PA - 2



Travail (W)	0	100	200	300
Débit systémique (l/min)	5	9	17	25
Débit cérébral	0,8	0,8	0,8	0,8
Débit myocarde	0,25	0,35	0,75	1
Débit muscles	1	5	12	22
Débit rein	1,1	0,9	0,6	0,4
Fréquence cardiaque	70	100	140	190
Pressions artérielles	120/70	140/80	170/90	200/90
Saturation veineuse en O_2 (%)	75	65	50	40

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