Évaluation instrumentale de la fonction sexuelle chez l'homme

Dr Prévinaire JG, Dr Soler JM

Département médullaire
Centre Calvé, 62600 Berck-sur-Mer

- Penile erection is controlled by **spinal autonomic centres**, the activity of which is dependent on **input from supraspinal centres and genitalia**.
- From a neurophysiological viewpoint, penile erection is a culmination of **multiple successful nerve reflexes** that initiate a **vascular event**.
- The maintenance of erection and rigidity is an intriguing combination of neurovascular cavernosal reactivity, venous occlusion, and rhythmic perineal muscle contraction.

Tajkarimi and Burnett, JSM 2011

- **The dorsal nerve of penis** is considered by some experts to be the single most important nerve in male sexual function and satisfaction. **The cavernous nerve** is very important, although it is a conduit for brain-induced and reflexogenic instructions to reach the penis. This efferent system cannot function independently, and **afferent pathways** play a critical role.

Tajkarimi and Burnett, JSM 2011

Sexual reflexes

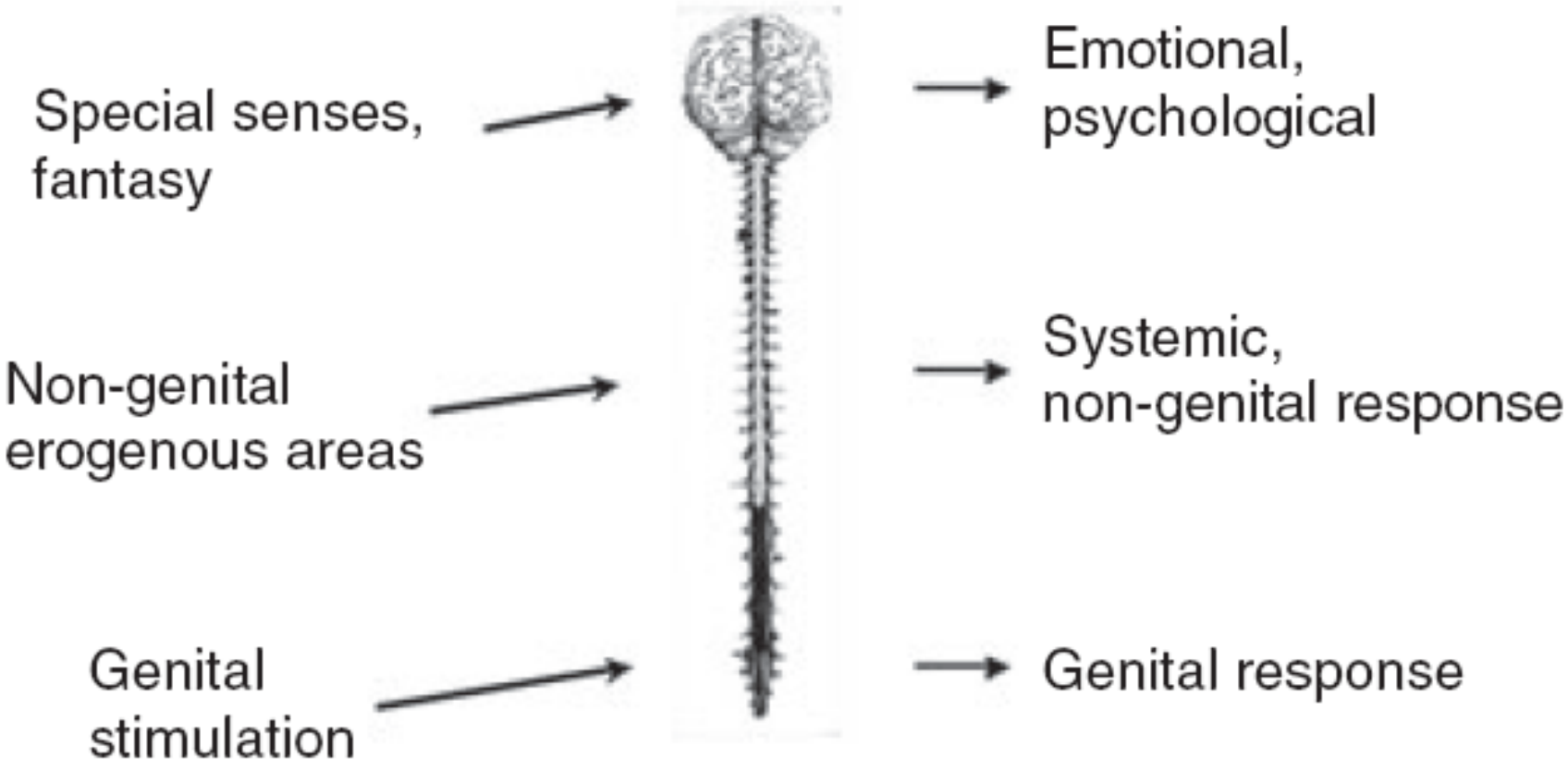
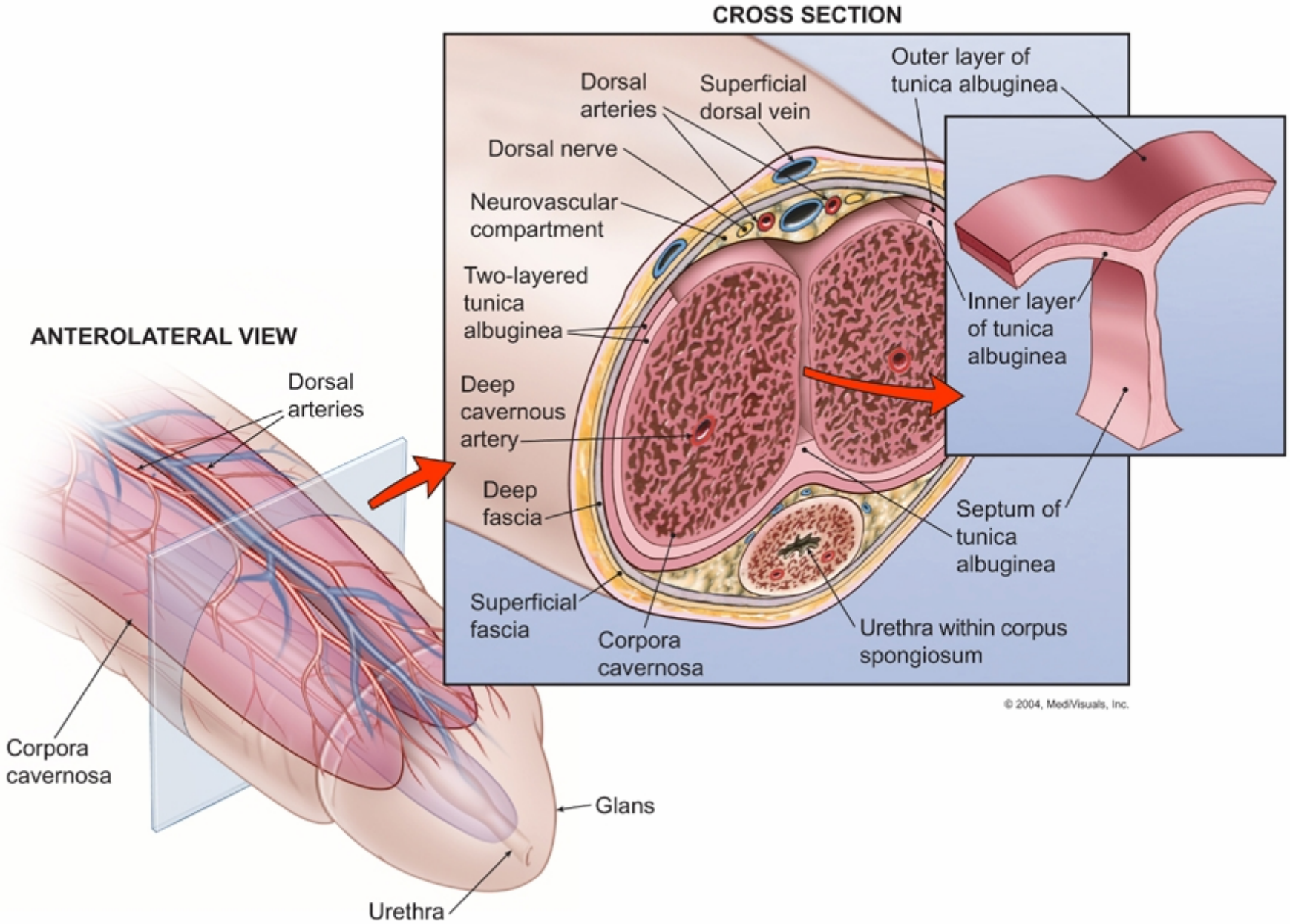
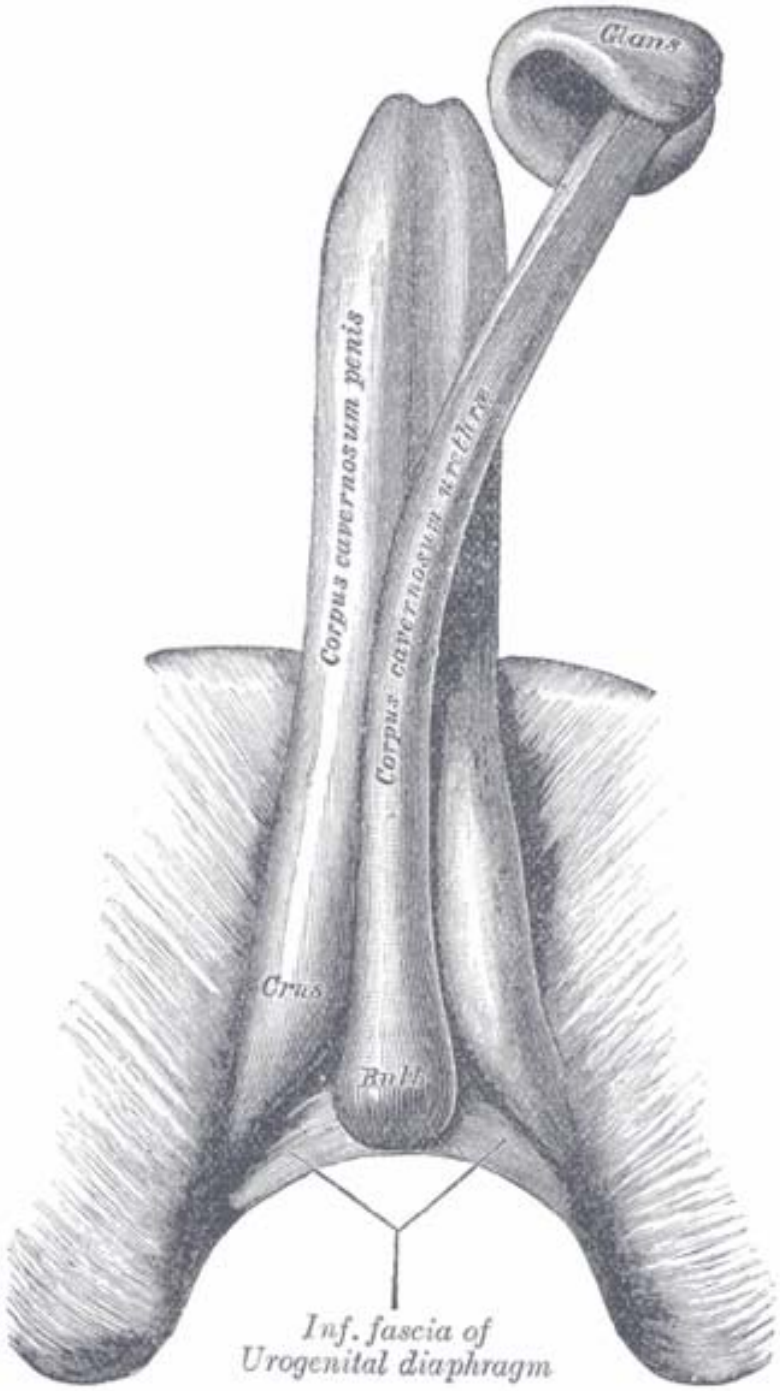
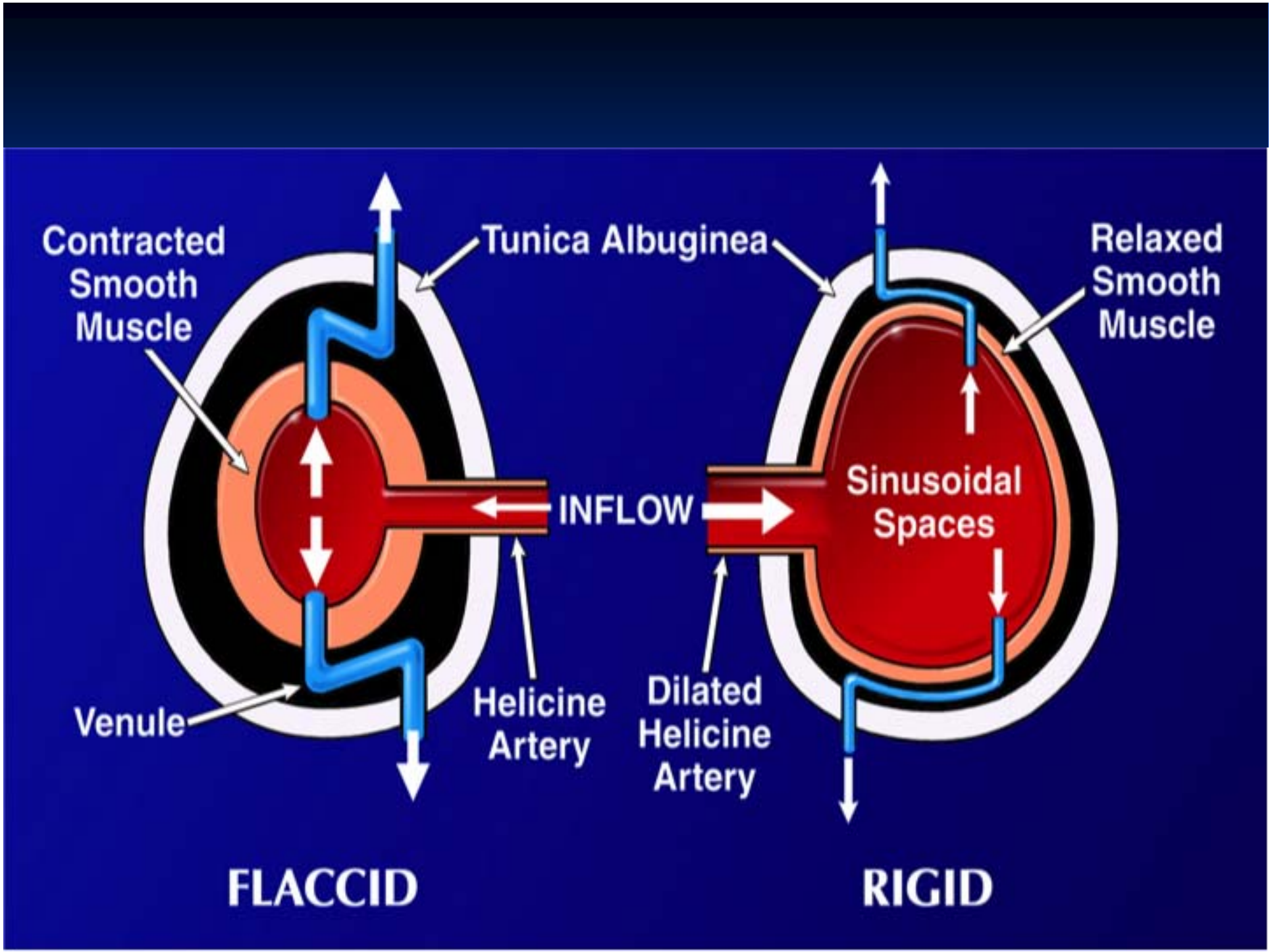


Figure 2 Sexual reflex arcs diagrammatically represented. The afferent arms of the arcs are depicted on the left side of the brain and spinal cord, and the right side shows the efferent arms of the reflexes.

The Anatomy


CROSS SECTION
Dorsal arteries
Superficial dorsal vein
Outer layer of tunica albuginea
Dorsal nerve
Neurovascular compartment
Two-layered tunica albuginea
Inner layer of tunica albuginea
ANTEROLATERAL VIEW
Dorsal arteries
Deep cavernous artery
Deep fascia
Septum of tunica albuginea
Superficial fascia
Corpora cavernosa
Urethra within corpus spongiosum
Corpora cavernosa
Glans
Urethra
© 2004, MediVisuals, Inc.

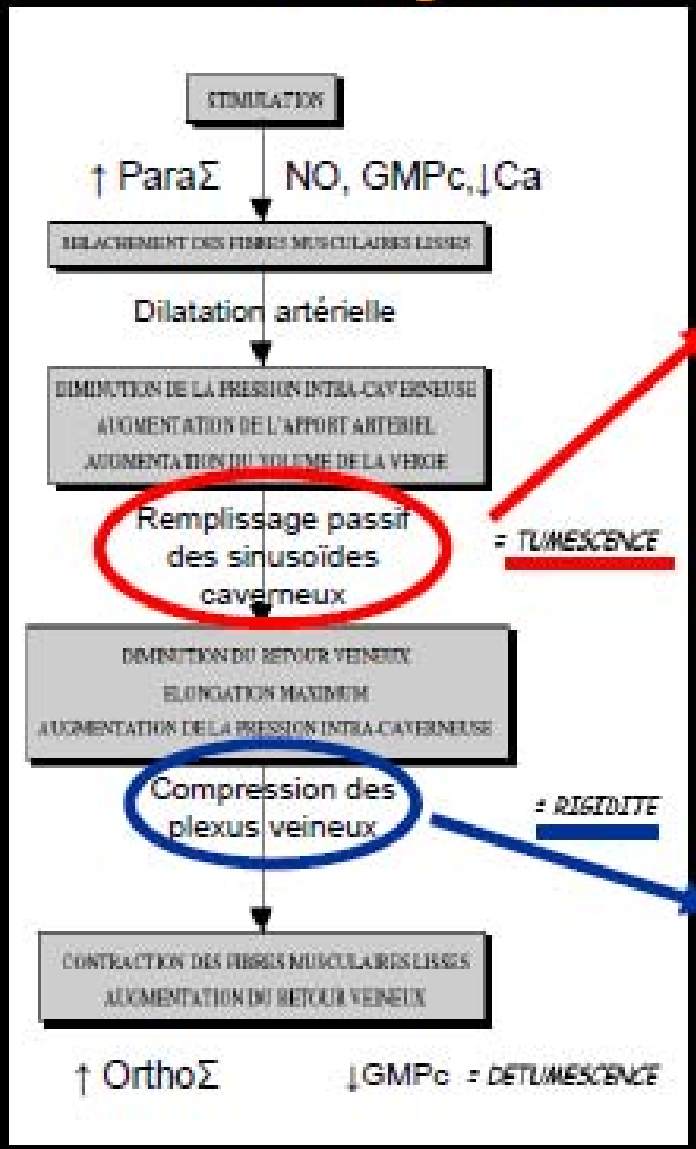

Glans
Corpus cavernosum penis
Corpus cavernosum urethræ
Crus
Bulb
Inf. fascia of
Urogenital diaphragm

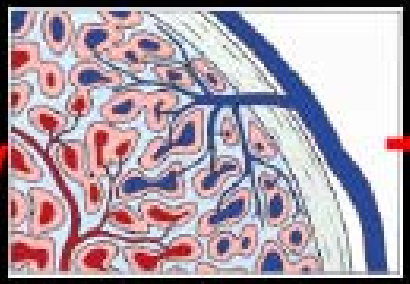

Contracted Smooth Muscle
Tunica Albuginea
Relaxed Smooth Muscle
INFLOW
Sinusoidal Spaces
Venule
Helicine Artery
Dilated Helicine Artery
FLACCID
RIGID

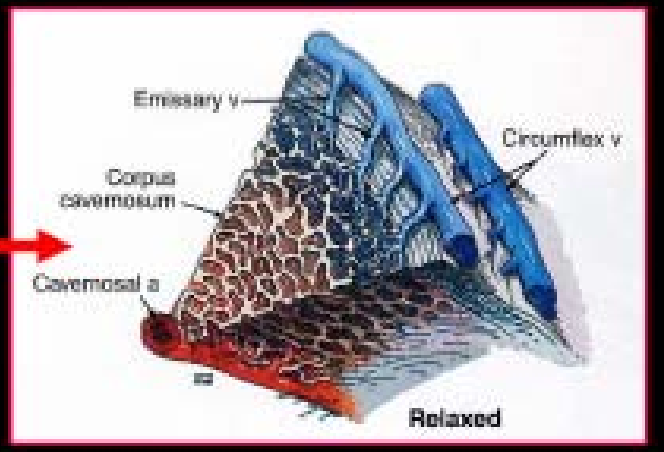
Pathologie traumatique pénienne
Apport de l'imagerie

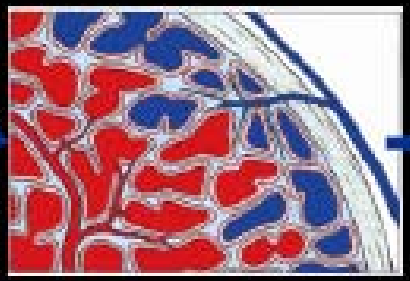
F Cornelis, R Hubrecht, M Bouzgarrou,
Y Le Bras, N Grenier
CHU Bordeaux

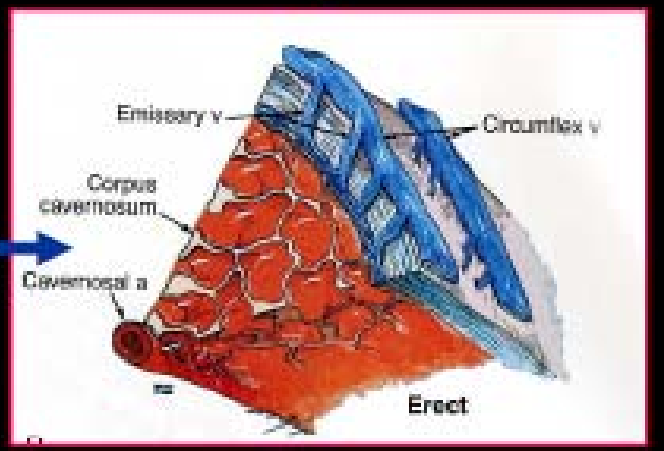
Physiolo tion



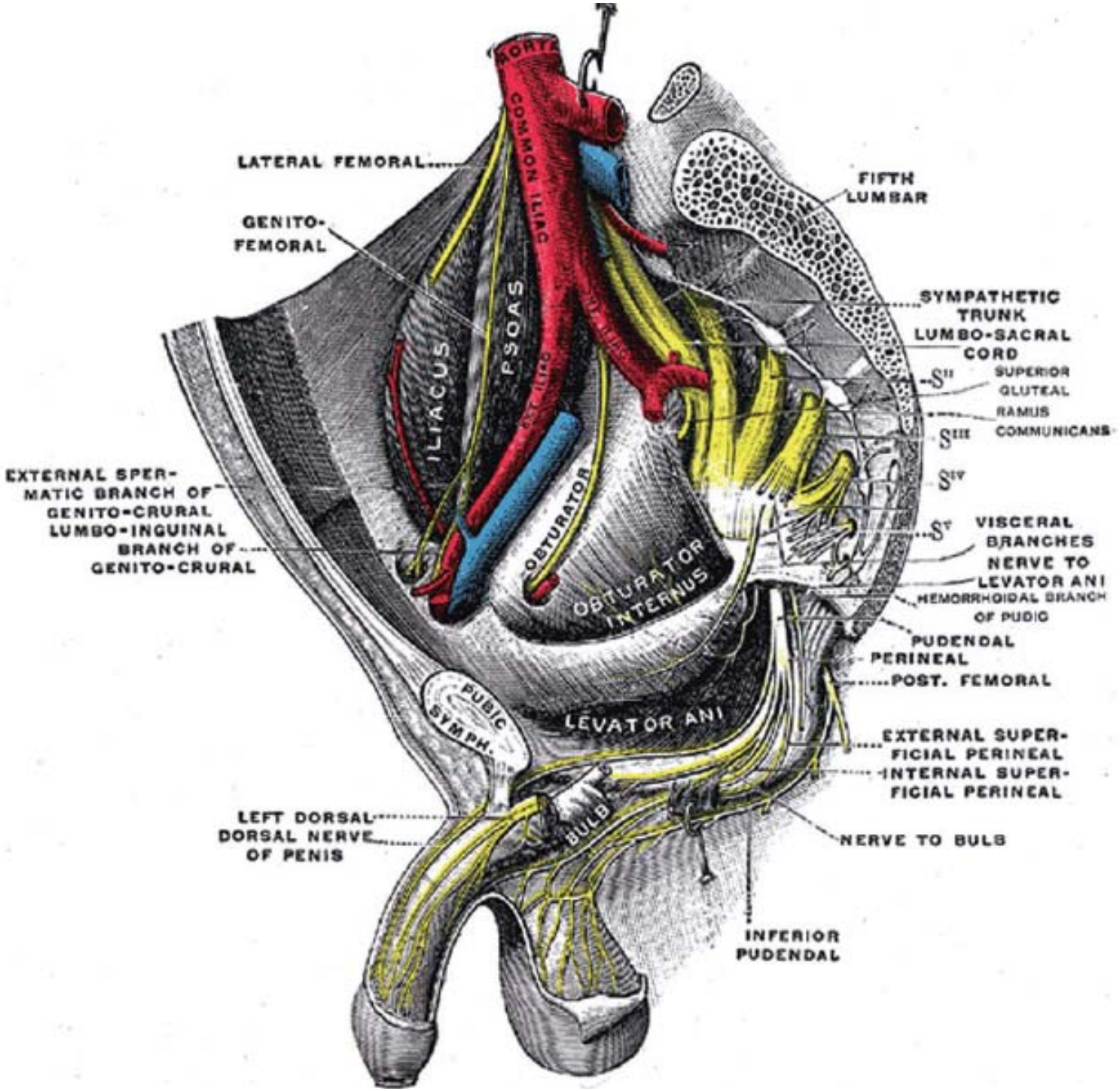








Hattery et al, Radiol Clin N orth Am 1991


LATERAL FEMORAL
GENITO-FEMORAL
EXTERNAL SPERMATIC BRANCH OF GENITO-CRURAL
LUMBO-INGUINAL BRANCH OF GENITO-CRURAL
AORTA
COMMON ILIAC
ILIACUS
PSOAS
OBTURATOR
OBTURATOR INTERNUS
PUBIC SYMPH.
LEVATOR ANI
LEFT DORSAL DORSAL NERVE OF PENIS
BULB
INFERIOR PUDENDAL
NERVE TO BULB
EXTERNAL SUPERFICIAL PERINEAL
INTERNAL SUPERFICIAL PERINEAL
PUDENDAL
PERINEAL
POST. FEMORAL
HEMORRHOIDAL BRANCH OF PUDIC
NERVE TO LEVATOR ANI
VISCERAL BRANCHES
SV
SIV
SIII
SII
RAMUS COMMUNICANS
SUPERIOR GLUTEAL
LUMBO-SACRAL CORD
SYMPATHETIC TRUNK
FIFTH LUMBAR

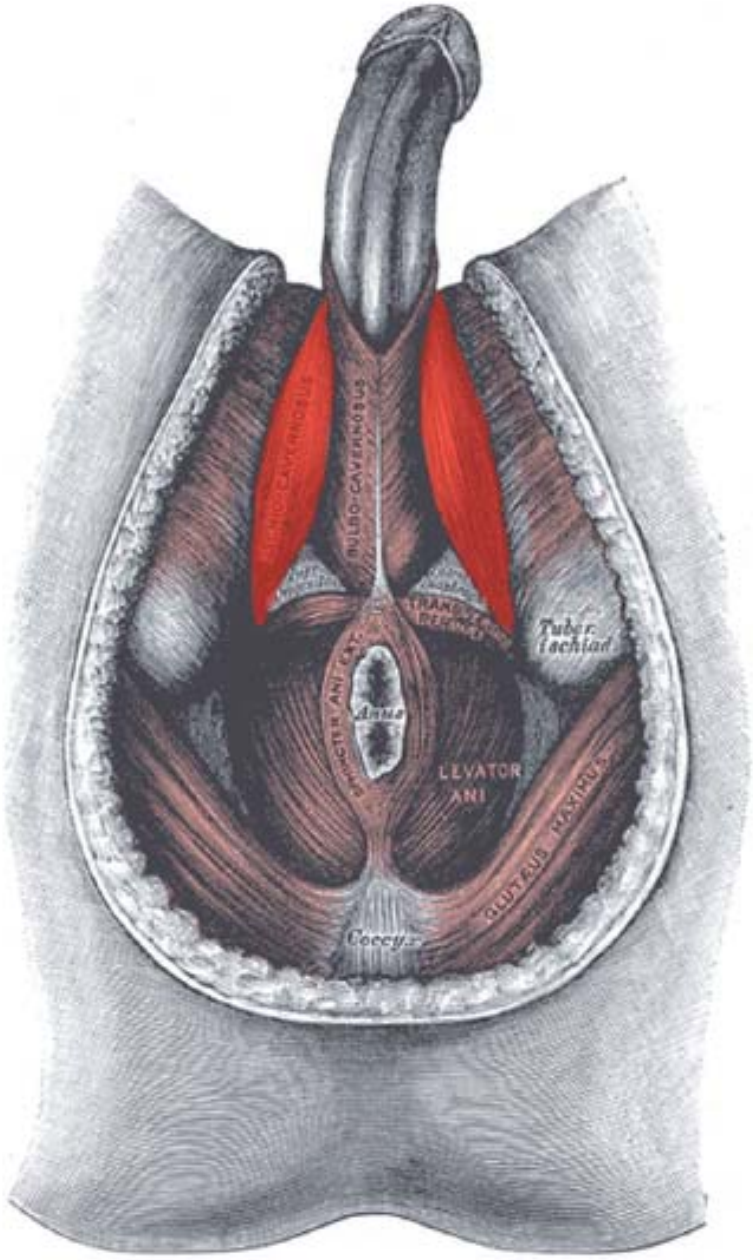
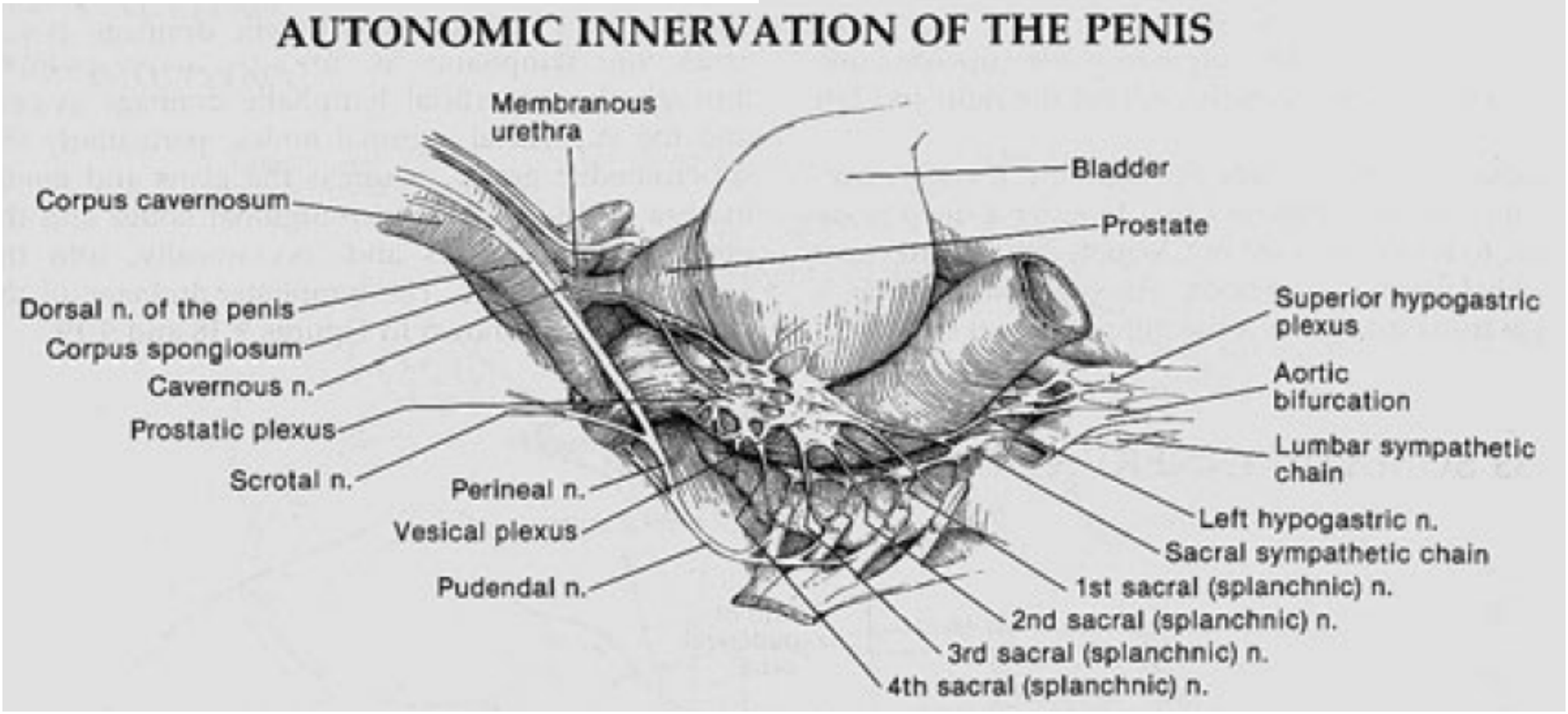
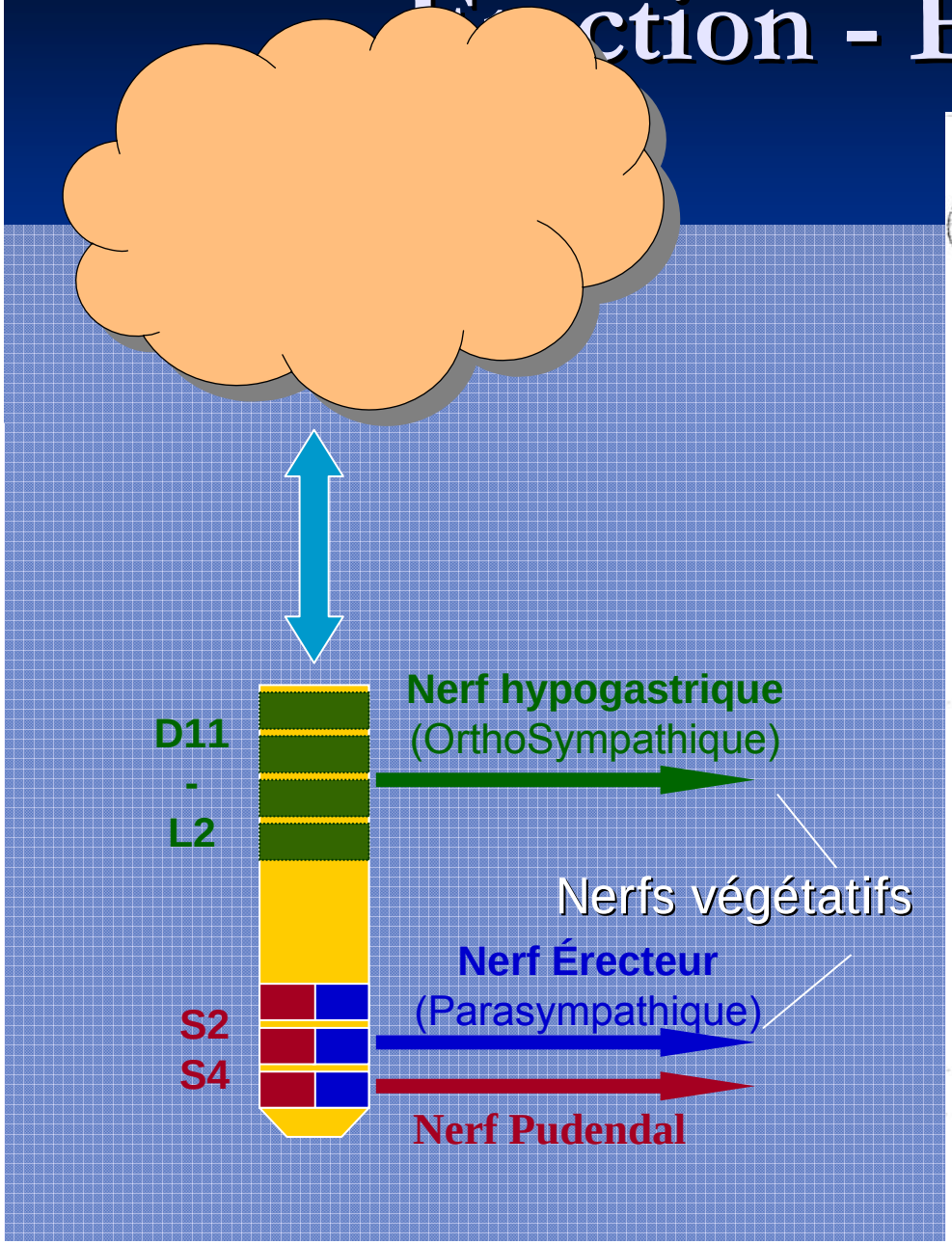


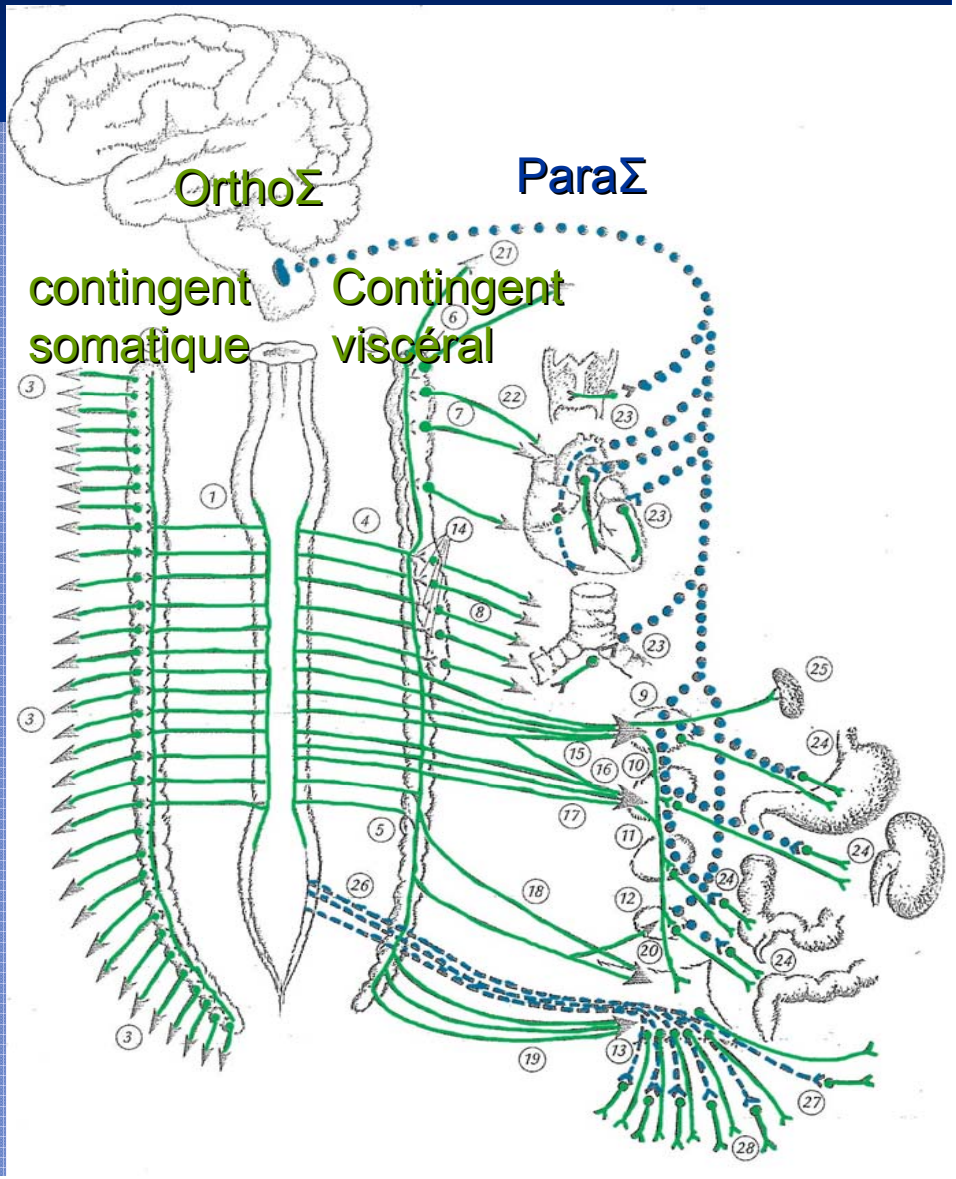
Figure 3 Anatomical relationship of penile corpora with ischiocavernosus (red color) and bulbocavernosus muscles.

Figure 1 Autonomic fibers from the sympathetic and parasympathetic outflow converge in the pelvic plexus between the bladder and rectum, and then distribute to the penis as the cavernous nerve. Somatic innervation is mediated through the branches of the pudendal nerve (reproduced from Hinman (1993), *The Atlas of Urosurgical Anatomy*, with permission from W.B. Saunders Co.).

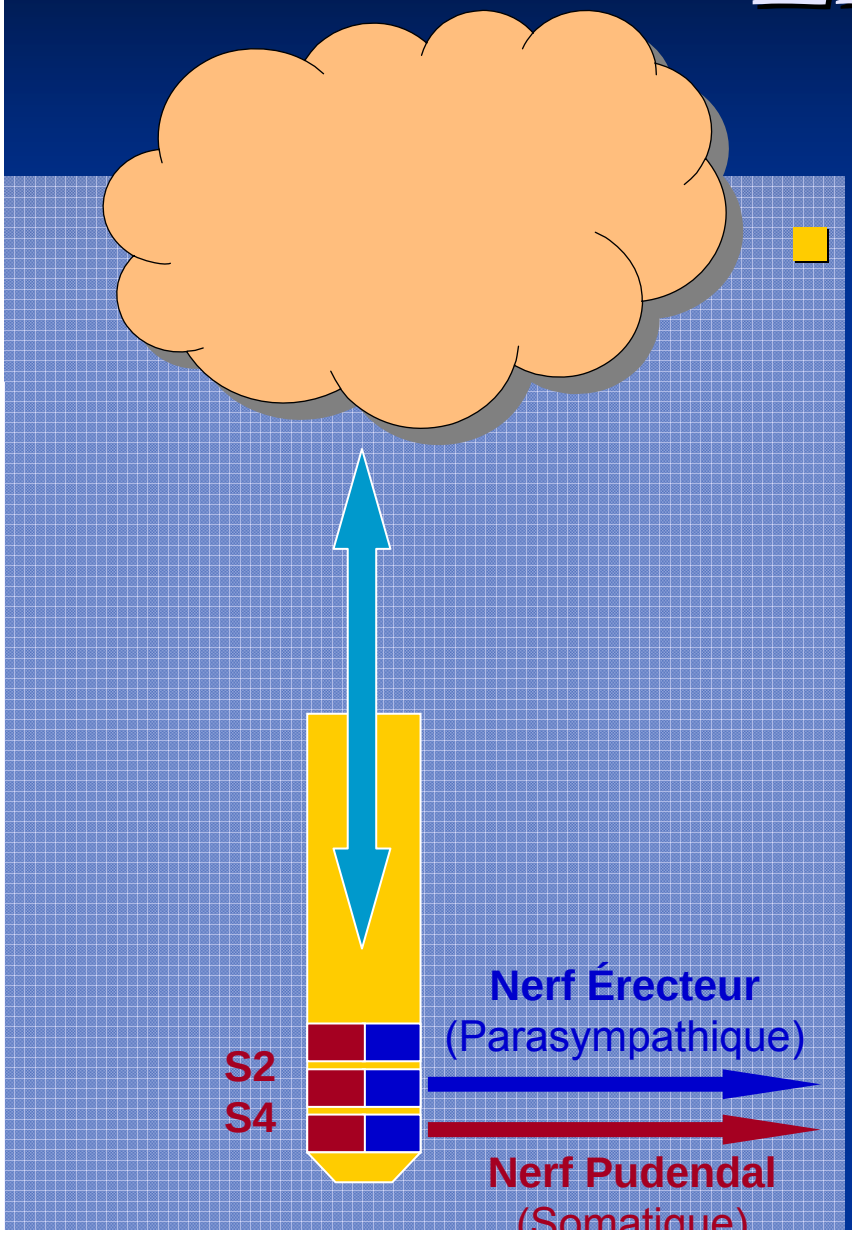


Érection - Éjaculation



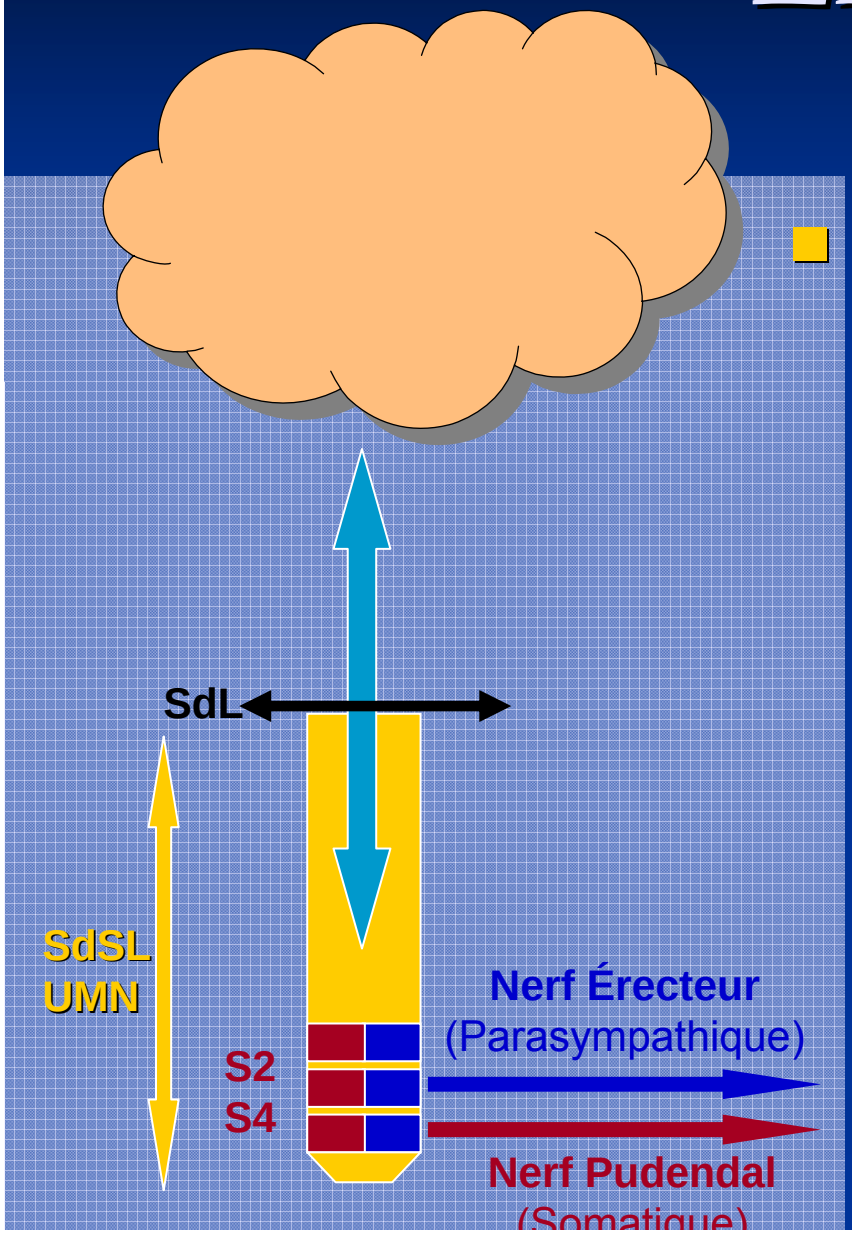


Érection



- Érection réflexe
  - Moelle sacrée
  - Par stimulation
  - Qualité optimale

Érection



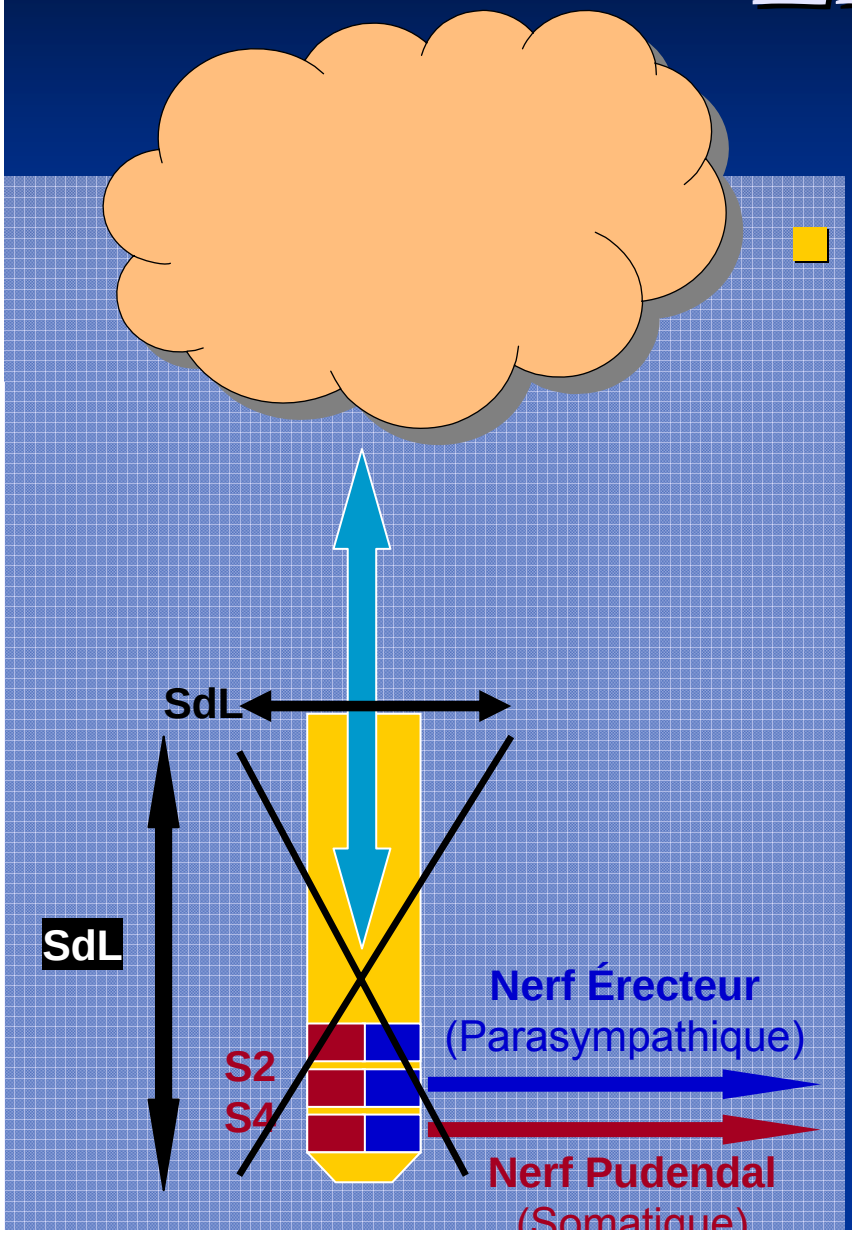
- Érection réflexe

Tétraplégie – Paraplégie

- moelle sacrée « réflexe »

- Érection lors de stimulation
- Possibilité de rapport

Érection



- Érection réflexe

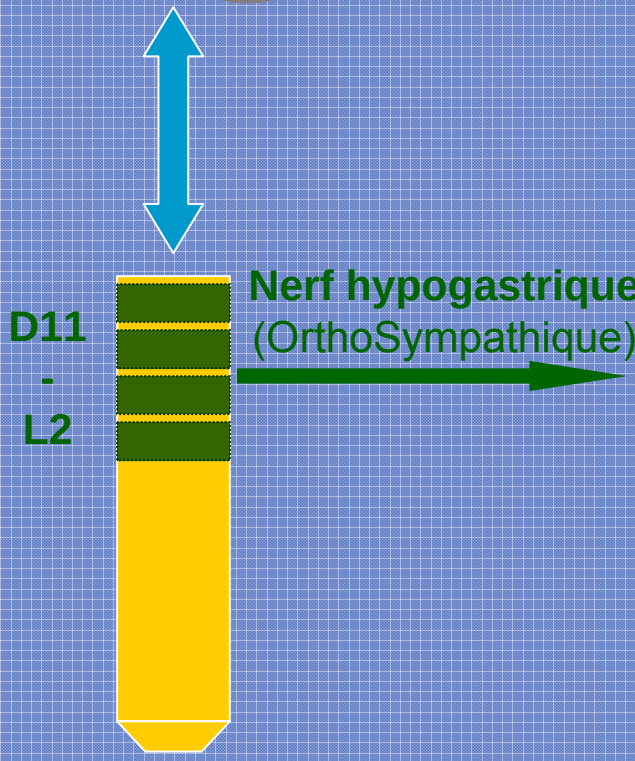
Paraplégie (queue de cheval)

- moelle sacrée « aréflective »

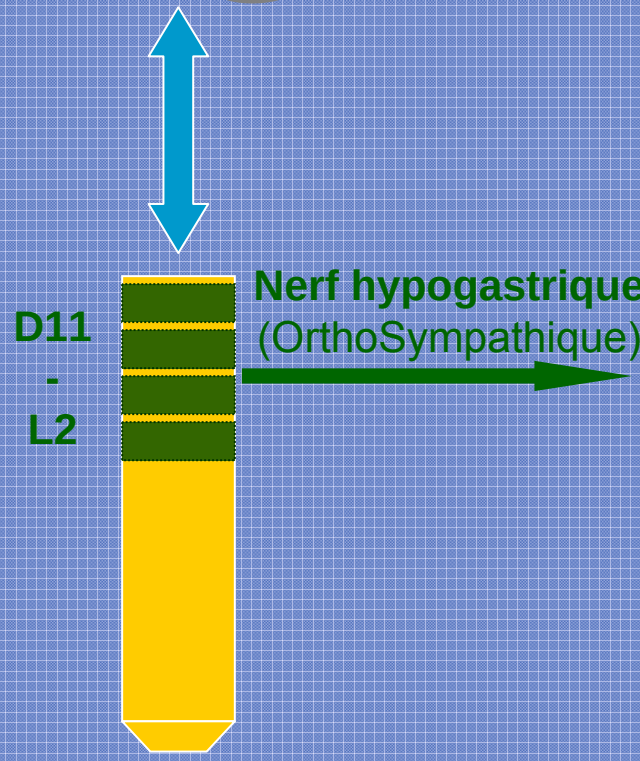
- Érection absente
- Pas de possibilité de rapport

Érection

- Érection psychogène

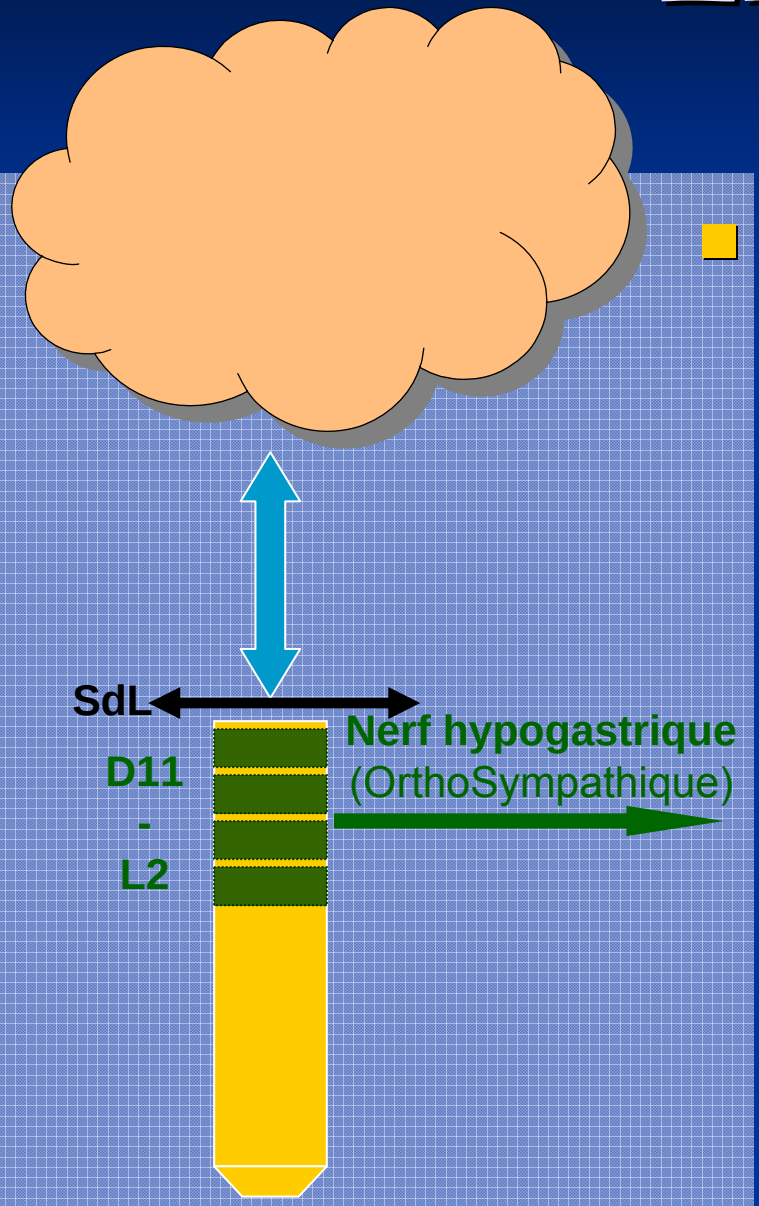


Érection



- Érection psychogène
  - Moelle Dorso-Lombaire
  - Érection lors de libido
  - Qualité variable

Érection



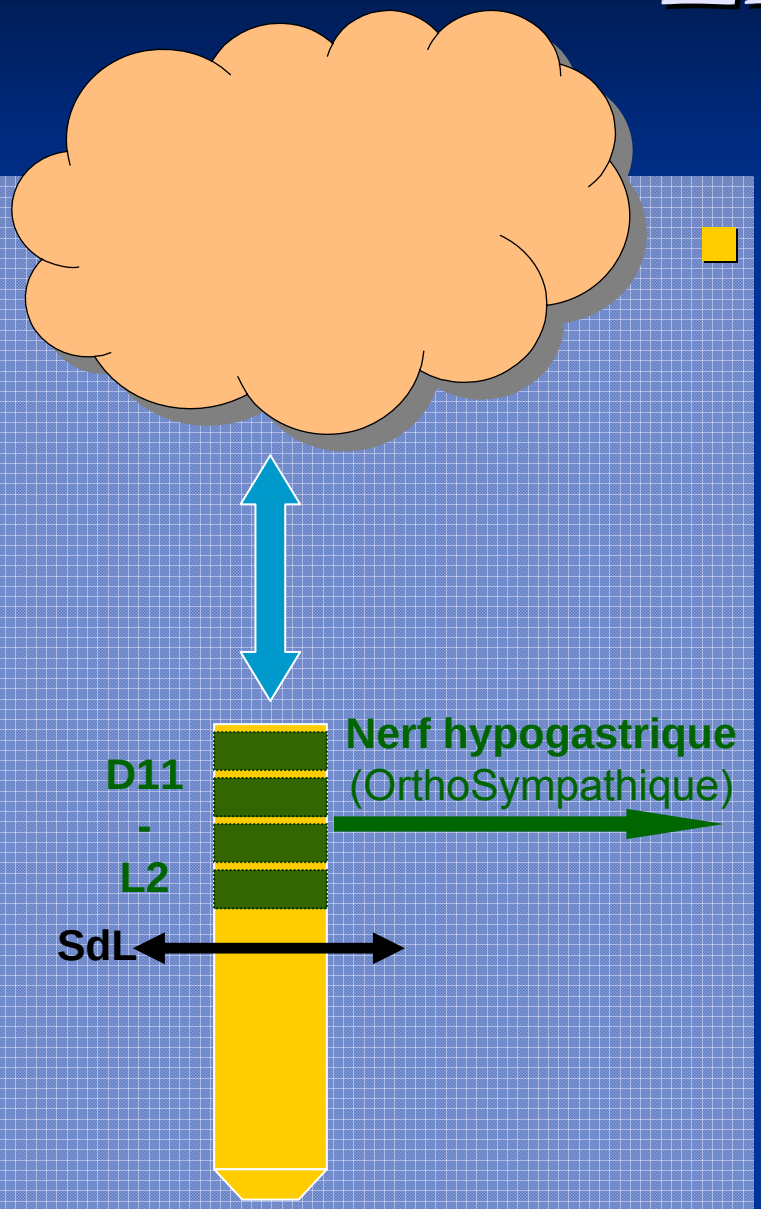
- Érection psychogène

Tétraplégie – Paraplégie

- moelle Dorso-Lombaire « déconnectée »

- Érection absente

Érection



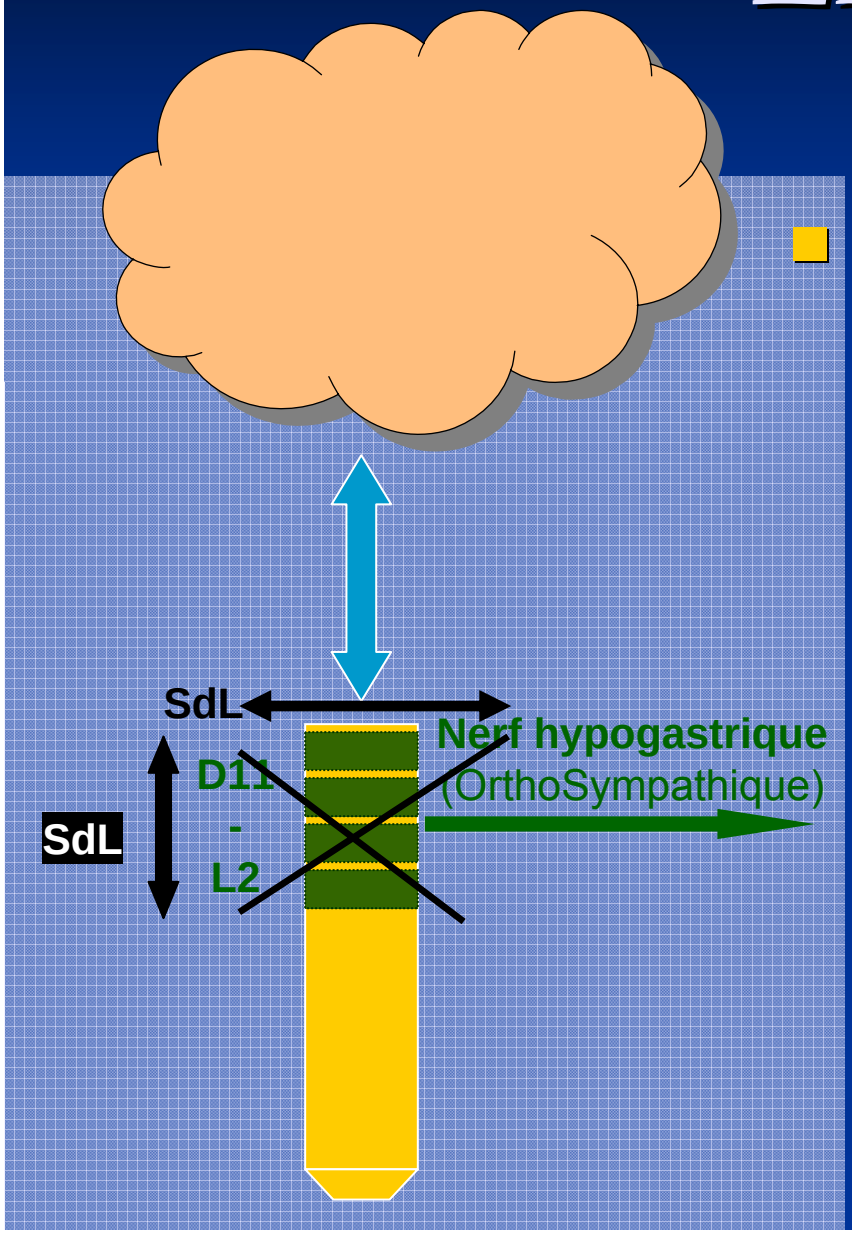
- Érection psychogène

Paraplégie

- moelle Dorso-Lombaire « connectée »

- Érection présente
- Pas de possibilité d'intromission

Érection



- Érection psychogène

Paraplégie

- moelle Dorso-Lombaire « détruite »

- Érection psychogène absente
- Éjaculation absente

- Érections nocturnes
  - Pendant phase REM
  - Excitation parasympathique?
  - Phénomène neurovasculaire influencé par des facteurs hormonaux
  - NB: absentes chez blessé médullaire complet

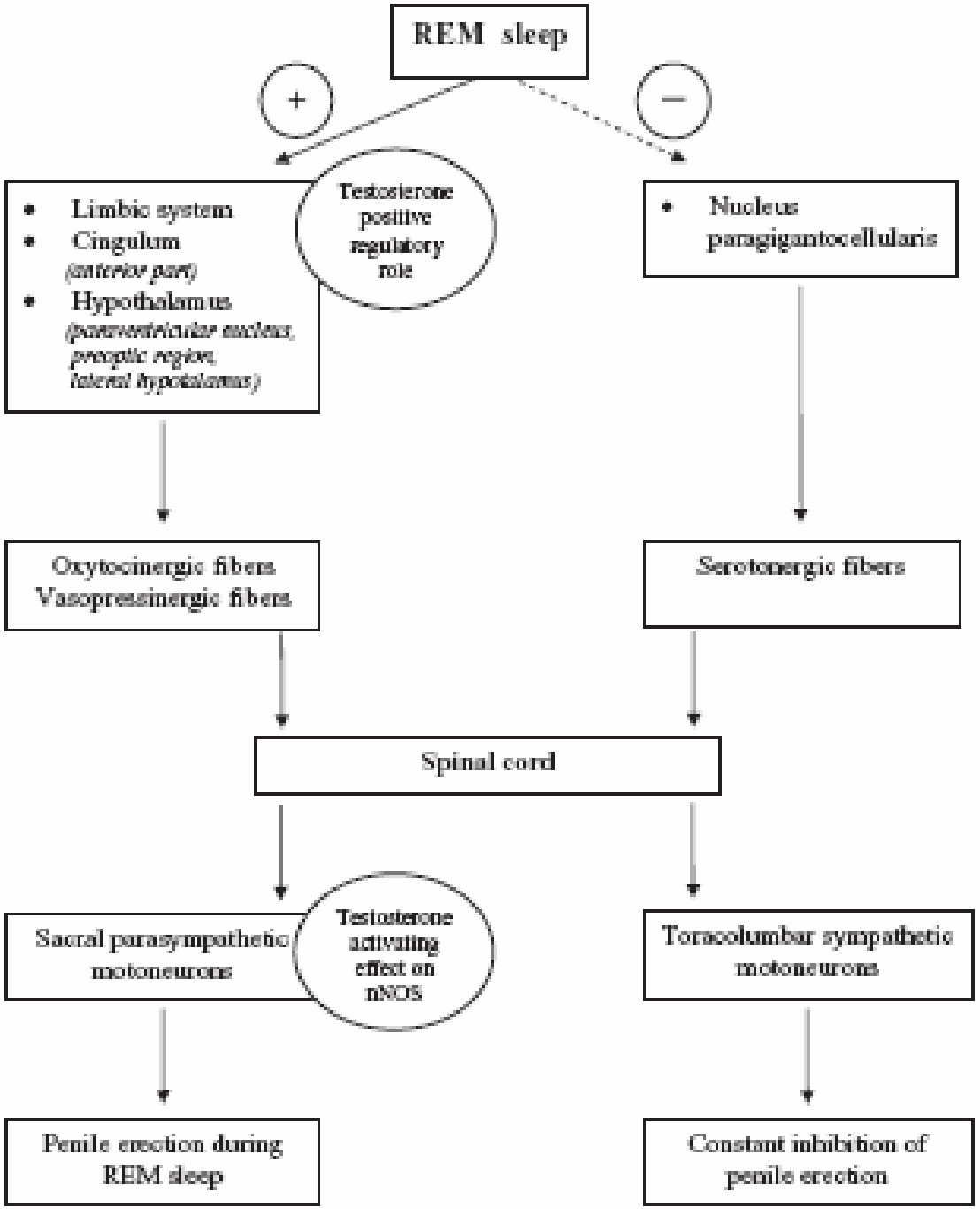
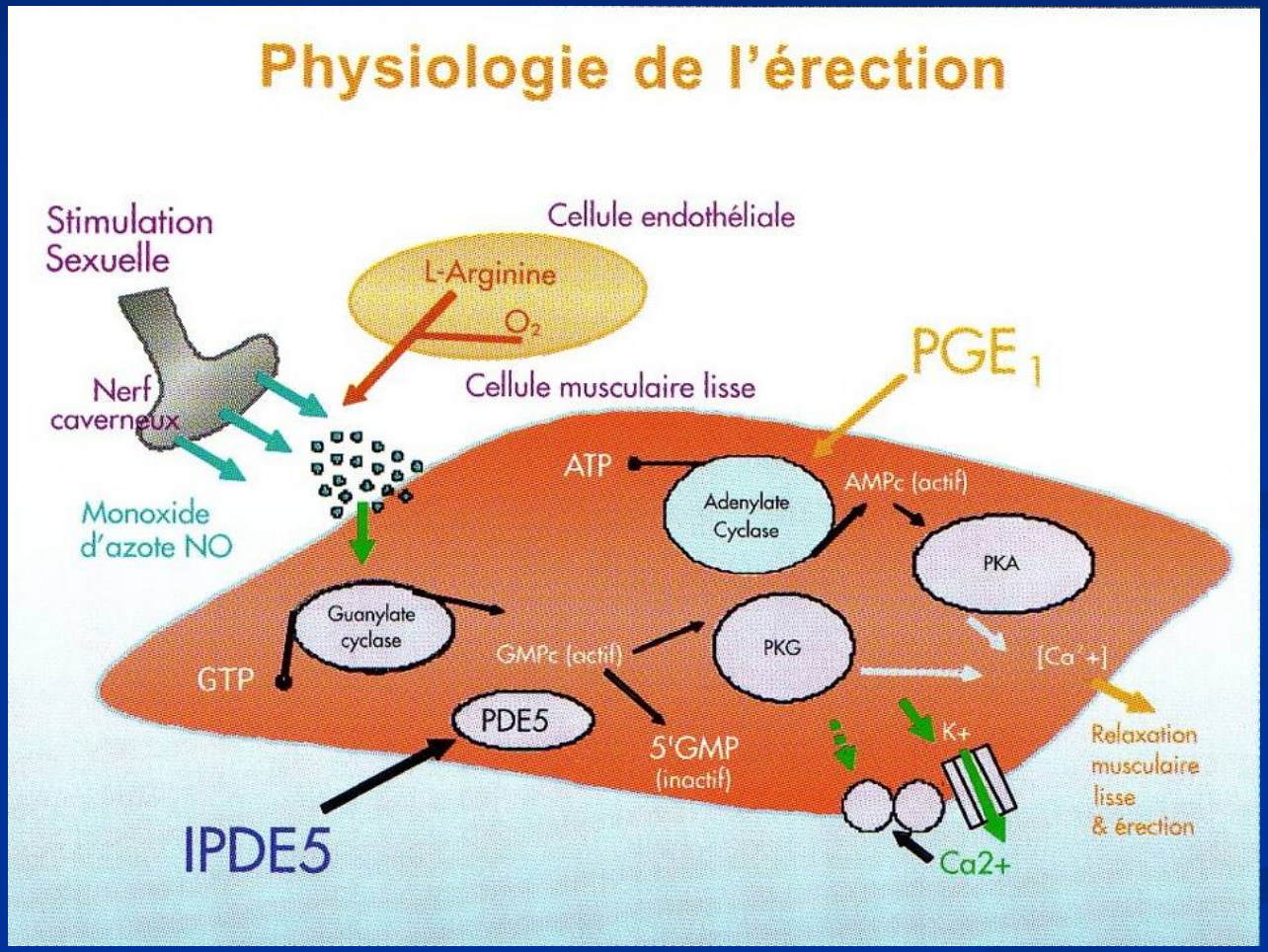
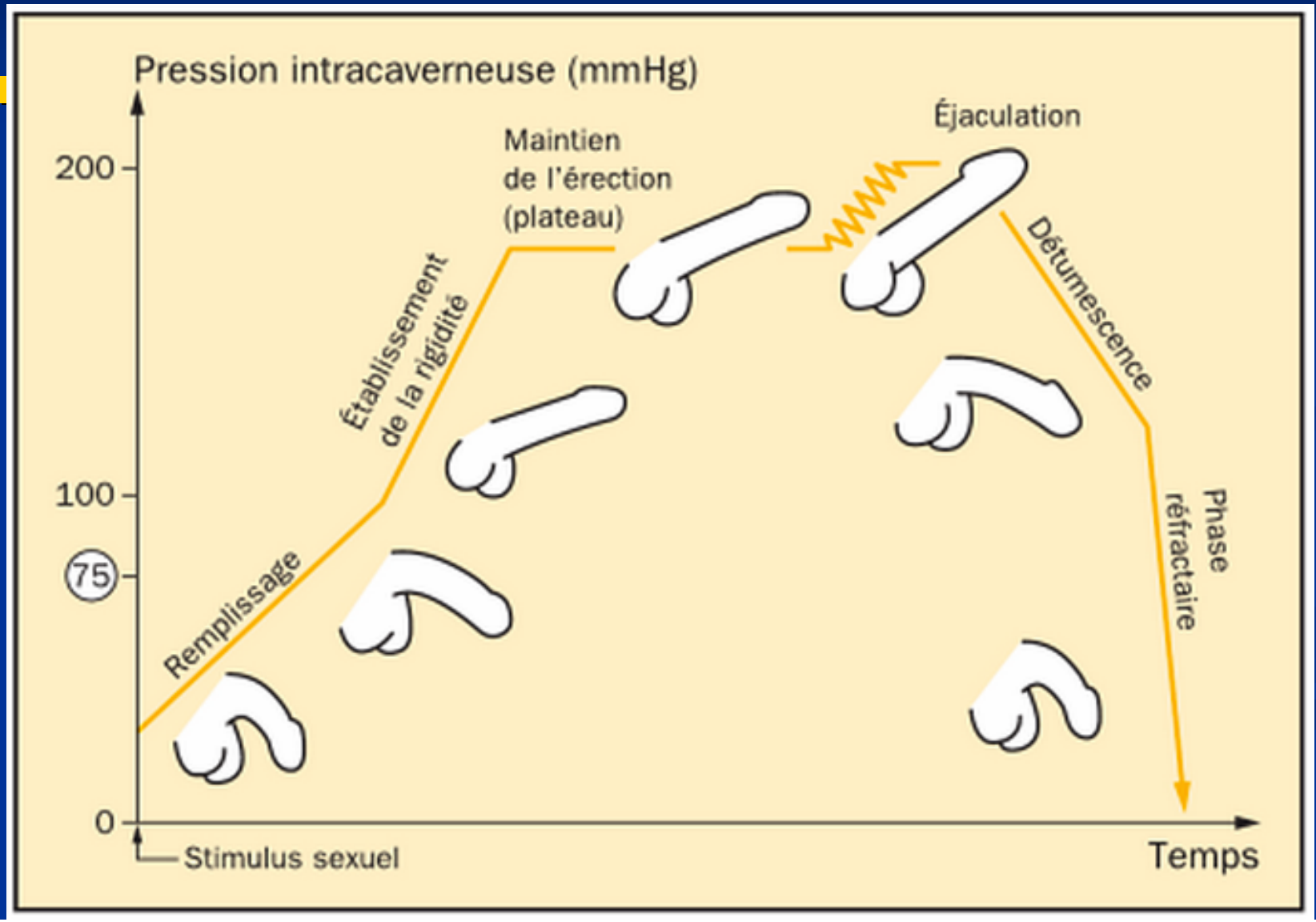


Figure 1 Hypothesis for the central and peripheral nervous system involvement in sleep-related erections. nNOS = neuronal nitric oxide synthase; REM = rapid eye movement; "+" = activating effect; "–" = inhibiting effect.

Physiologie




Pression intracaverneuse (mmHg)
200
100
75
0
Maintien
de l'érection
(plateau)
Éjaculation
Établissement
de la rigidité
Détumescence
Remplissage
Phase
réfractaire
Stimulus sexuel
Temps

- Préliminaires
  - Nocturnal Penile Tumescence Monitoring with Stamps
  - 4 timbres poste enroulés autour de la verge, 2 à 3 nuits
    - 22 jeunes hommes : 93,5% déchirés
    - 11 hommes dysérection: 1 seul déchiré
  - Distinction entre dysfonction érectile psychogène et organique
  - 30 cents *vs.* $500 (Rigiscan)

Barry, Urology 1980; Glina, JSM 2011

Évaluation Fonction Érectile

- Évaluation Fonction Érectile
  - Vasculaire
  - Psychophysiologique
  - Neurophysiologique et Système Nerveux Autonome
- Fonctionnelle
  - Rigiscan
  - Clinique
  - Autre (timbre poste)

Table 6: Specific diagnostic tests

NTPR using Rigiscan
Vascular studies
- Intracavernous vasoactive drug injection
- Duplex Doppler study of the penis
- Dynamic Infusion Cavernosometry and Cavernosography (DICC)
- Internal pudendal arteriography
Neurological studies, e.g., bulbocavernosus reflex latency, nerve conduction studies
Endocrinological studies
Specialised psychodiagnostic evaluation

2.2.5 *Guidelines for the diagnostic evaluation of ED*

	LE	GR
Clinical use of validated questionnaire related to ED may help to assess all sexual function domains and the effect of a specific treatment modality.	3	B
Physical examination is needed in the initial assessment of men with ED to identify underlying medical conditions that may be associated with ED.	4	B
Routine laboratory tests, including glucose-lipid profile and total testosterone, are required to identify and treat any reversible risk factors and lifestyle factors that can be modified.	4	B
Specific diagnostic tests are indicated by only a few conditions.	4	B

Wespes, EAU 2013

- ***Specialised diagnostic tests***
- *Nocturnal penile tumescence and rigidity test*
  - The nocturnal penile tumescence and rigidity (NPTR) assessment should be done on at least two nights. A functional erectile mechanism is indicated by an erectile event of at least 60% rigidity recorded on the tip of the penis that lasts for > 10 min.

Wespes, EAU 2013

- *Intracavernous injection test*
  - The intracavernous injection test gives limited information about vascular status. A positive test is a rigid erectile response (unable to bend the penis) that appears within 10 min after the intracavernous injection and lasts for 30 min. This response indicates a functional, but not necessarily normal, erection, and the erection may coexist with arterial insufficiency and/or veno-occlusive dysfunction. **A positive test shows that a patient will respond to the intracavernous injection programme**. **The test is inconclusive as a diagnostic procedure** and **duplex Doppler study** of the penis should be requested, if clinically warranted.

Wespes, EAU 2013

- *Duplex ultrasound of the penis*
  - A peak systolic blood flow > 30 cm/s, an end-diastolic velocity of < 3 cm/s and a resistance index > 0.8 are generally considered normal. **Further vascular investigation is unnecessary when a Duplex examination is normal.**

- *Arteriography and dynamic infusion cavernosometry or cavernosography*
  - They should be performed **only in patients who are being considered for vascular reconstructive surgery.**

Wespes, EAU 2013

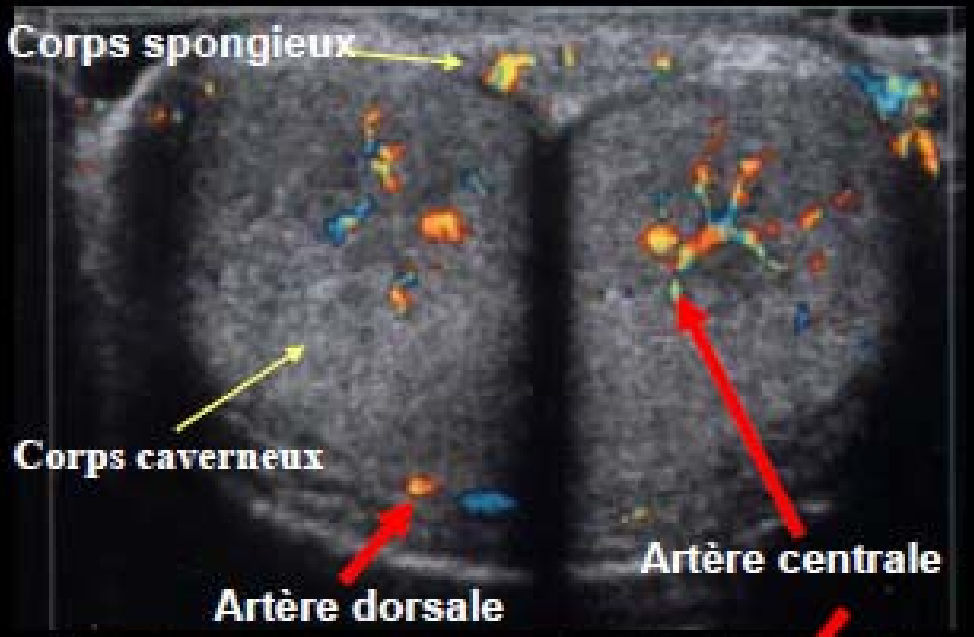
Fonction érectile

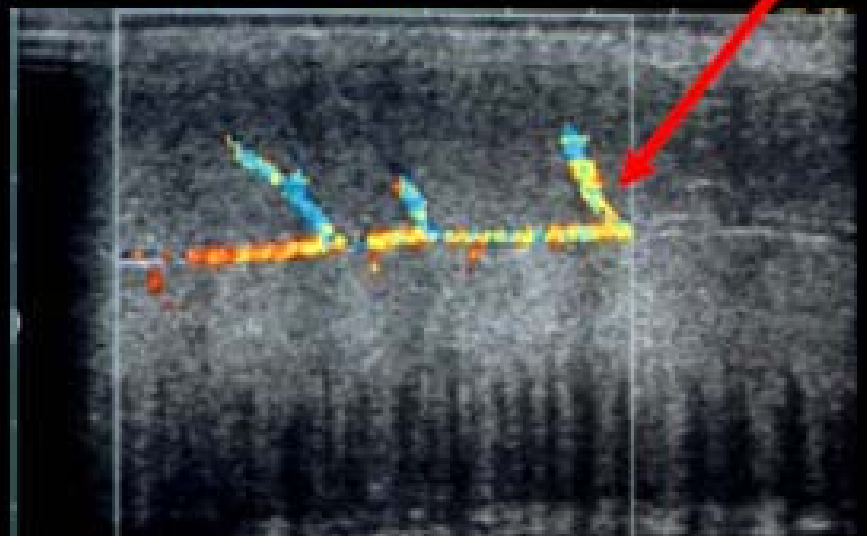
- Evaluation Fonctionnelle Vasculaire
  - Echo-Doppler (B)
  - Artériographie / Angiographie pudendale sélective (B)
  - Cavernosographie Cavernosographie (B)

  La visualisation des structures et vaisseaux est améliorée par la tumescence provoquée
  - Injections intracaverneuse (IIC)
  - Stimulation Pénienne vibratoire
  - Stimulation érotique (film)
  - iPde5

  Meuleman JSM 2010

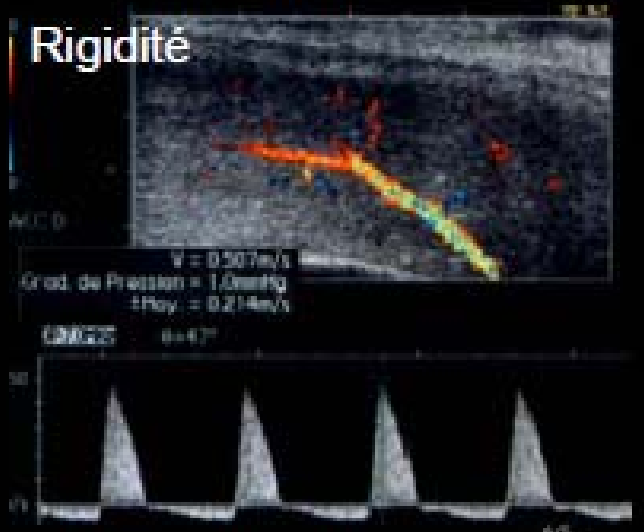
Echo-Doppler de la verge



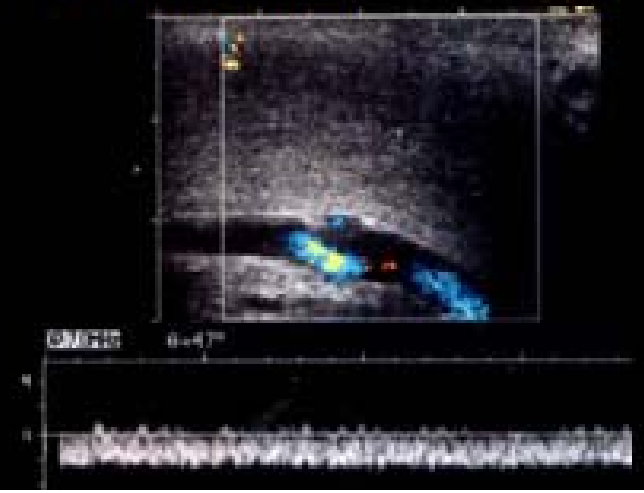


- Artère centrale

Rigidité

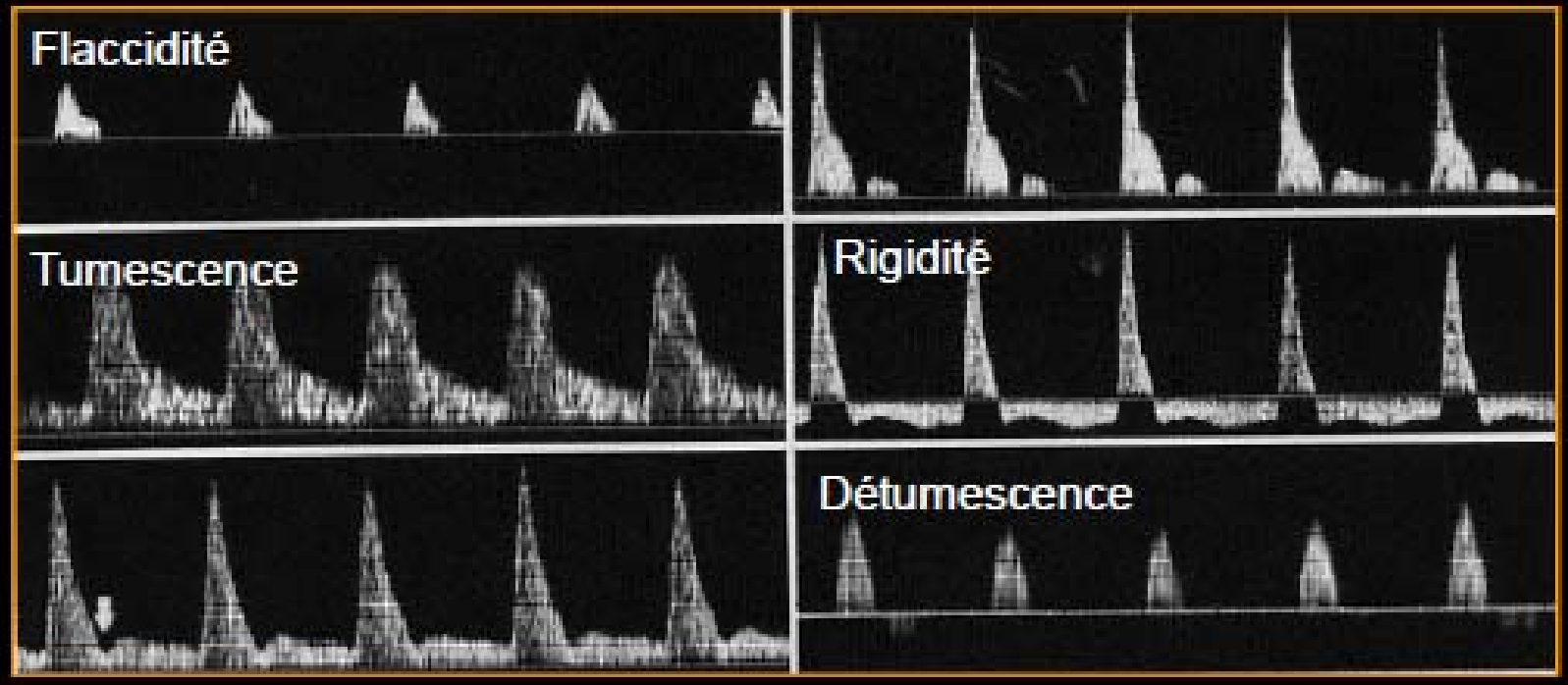


- Veine dorsale



Echo-Doppler de la verge

Phases hémodynamiques de l'érection normale



- EchoDoppler

  5 minutes après IIC

  - ↑° diamètre a. caverneuse > 75%
  - Pic systolique > 25cm/sec

  Pleine rigidité

  - P sanguine IC >= Pdiastolique
    - Flux sanguin pdt diastole proche de 0

- EchoDoppler
  - Pic systolique sur les artères centro-caverneuses
    - Si > 35 cm /sec : apport artériel normal
  - Vitesse diastolique (flux télédiastoliques)
    - < 3cm /sec
  - Index de Résistance = (PVS – Pfin D)/PVS
    - > 0,8

Blood Flow Assessment in Cavernosal Arteries						
Date and time of ICI -						
Nature of vasoactive agent(s) used for ICI -						
Dose of vasoactive agent(s) used for ICI -						
Penile Ultrasound findings: None, tunica, corpus cavernosum structure, arteries						
	Velocity (cm/second)					
	Peak systolic (PSV)		End diastolic (EDV)		Resistive index (RI)* *(RI) = (PSV – EDV)/PSV*	
Assessment Time	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**
Pre-ICI						
6–10 minutes post-ICI						
11–15 minutes post-ICI						
16–20 minutes post-ICI						
30 minutes post-ICI (if necessary)						

Time of peak systolic velocity post-ICI:				
Intraluminal Diameter (cm) of cavernosal arteries	**Pre-ICI (flaccid)**		**At peak systolic velocity post-ICI**	
	Left	**Right**	**Left**	**Right**
Sagittal (Longitudinal) view				
Transverse (Cross-sectional) view				

Penile measurements (cm)	**Pre-ICI**	**At peak systolic velocity post-ICI**
Length		
Circumference		
Erection* (%)—patient's self-assessment		
Investigator's assessment (%)		
Correlation with current sexually induced erections		

Sikka, JSM 2012

- EchoDoppler
  - Pic systolique
    - > 35cm/sec associé à artériographie normale
    - < 25 cm/sec: 95-100% anomalie artériographie
  - Mais
    - Variation cut off de 22 à 35 cm/sec
    - Dépendant de la qualité de la relaxation musculaire lisse

- EchoDoppler
  - Dysfonctionnement occlusion veineuse (DOV)
    - > 5 minutes après IIC
    - Persistance flux diastolique + un index de résistance faible
  - Mais
    - DOV présent chez 30% sujets normaux
    - Incapable de différencier entre DOV organique et fonctionnel (relaxation musculaire lisse incomplète liée à l'anxiété)
    - La qualité de la relaxation musculaire lisse ne peut être documentée

- EchoDoppler

  Le moins invasif, mais

  - Pas de méthodologie de référence
  - Invasif (IIC)
  - Faux positifs (abaissée chez sujets jeunes)
  - Rôle de l'anxiété (décharge sympathique)
  - Opérateur dépendant

  Ghanem, JSM 2008

tive agent. Additionally, different values may be obtained for the peak systolic velocities and end-diastolic velocities during the same test depending upon the timing of the examination, the experience of the examiner, and the position of the probe of the device on the penis. In a study of 30 men

- Artériographie / Angiographie pudendale sélective
  - Indications
    - Avant embolisation de fistule artério-caverneuse causant un priapisme à haut débit
    - Après trauma périnéal, avant revascularisation
  - Mais
    - Variations anatomiques a. pénienne fréquentes
    - Image au moment de la réponse vasculaire maximale?

Ghanem, JSM 2008

- Dynamic Infusion Cavernosometry and Cavernosography (DICC)

  Couplée à IIC pour rigidité

  1 aiguille 30 G dans chaque corps caverneux

  - Pompe servo-contrôlée
  - Capteur de pression

  Vardi,, JSM 2008

- DICC
  - Phase 1: Pression d'équilibre
    - Pintracaverneuse (mmHg)
  - Phase 2: Occlusion veineuse

    Infusion graduelle de solution saline dans le CC (10 mmHg)
    - Flux de maintien de Pression PiC (mL/min)
    - Chute de PiC 150 mmHg / 30 sec
  - Phase 3: Gradient de Pression
    - PiC disparition flux diastolique
    - PiC – P brach Syst

- DICC
  - Relation linéaire entre flux de solution et PiC
  - ↓° de 45mmHg en 30 secondes: fuite veineuse
  - Cavernosographie permet de localiser la fuite

  - Permet d'obtenir rigidité optimale
    - Indépendante stress
    - Limite les faux positifs

    Vardi,, JSM 2008

- DICC
  - invasif
  - Indications limitées (Peyronie's, fracture pénienne, trauma périnéal et chirurgie envisagée
  - Faux négatif population normale?
  - Pas standardisée

Ghanem, JSM 2008

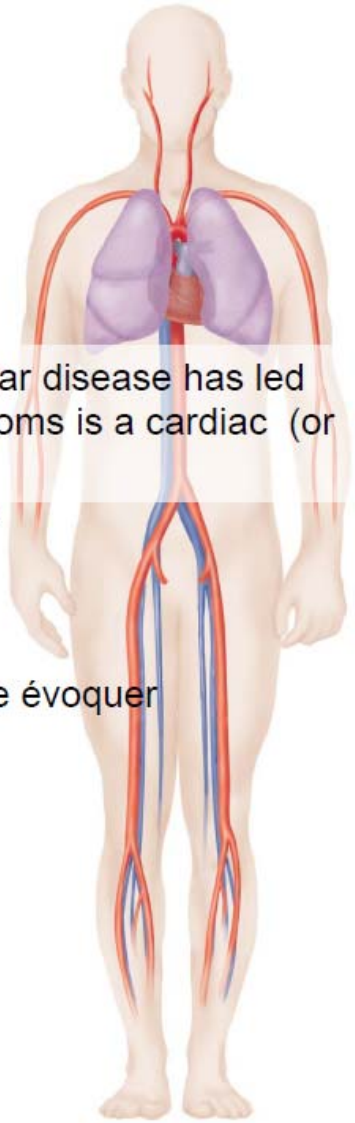
- Évaluation vasculaire
  - Opérateur dépendant
  - Peu standardisée
  - Relaxation muscles lisses maximale
    - Stress patient
  - DOV problème multifactoriel = résultat dégénérescence muscle lisse

"The recognition of ED as a warning sign of silent vascular disease has led to the concept that a man with ED and no cardiac symptoms is a cardiac (or vascular) patient until proven otherwise."

Princeton II: Jackson G et al. 2006. *J Sex Med 3:28-36*

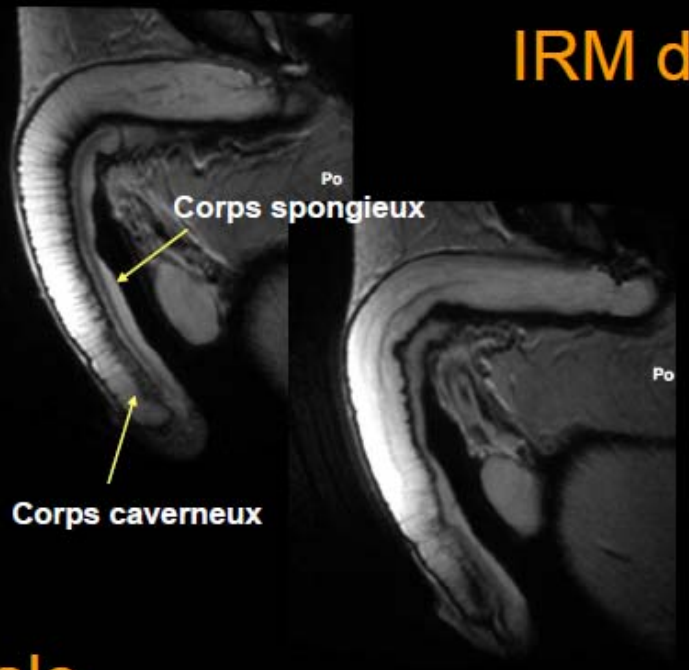
Une DE chez un patient avec facteurs de risque doit faire évoquer la possibilité d'une atteinte vasculaire systémique :

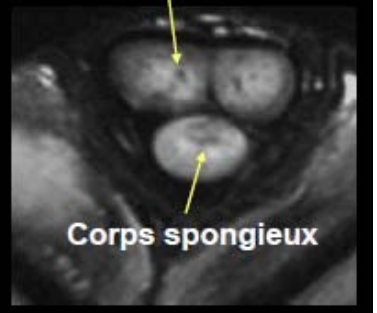
- coronarienne
- carotides
- membres inférieurs



- IRM

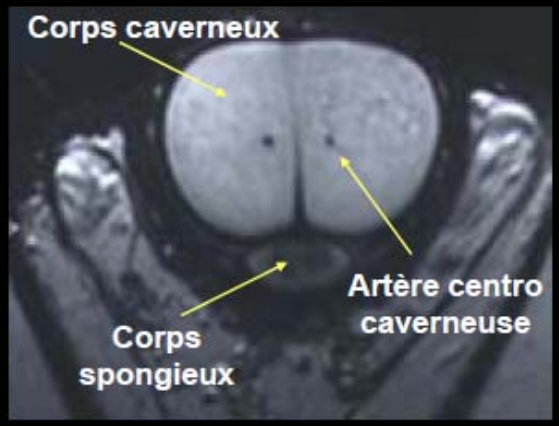
IRM de la verge normale

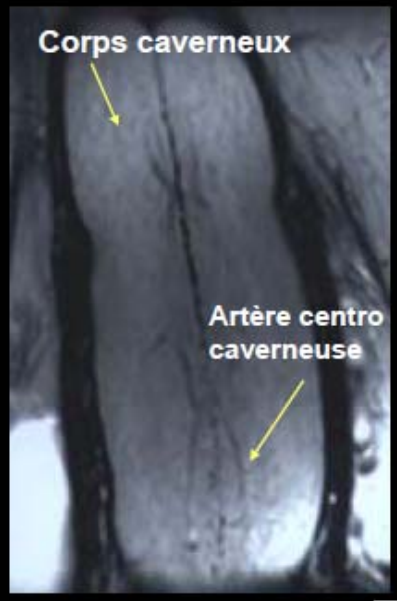




T2W en flaccidité

IRM de la verge normale





Séquences T2W en érection

- Évaluation Psychophysiologique
  - Érection stimulation visuelle
    - Vidéo érotique
  - Érection liée au sommeil
    - Rigiscan
    - Timbre poste

- Évaluation Psychophysiologique
  - Érection stimulation visuelle
    - Vidéo érotique
    - Si positif: cause somatique peu probable
    - Mais
      - En laboratoire
      - Relation négative avec âge
    - Intérêt
      - Évaluer effet antiérectogène de certains médicaments

Meuleman, JSM 2010


DACOMED
RIGISCAN
Plus

- Rigiscan

  Rigidité nocturne pénienne

  - Au moins 3 nuits (mauvaise qualité de sommeil)
  - Au moins 6 heures de sommeil
  - Pas d'alcool, somnifères
  - Durée et intensité NPT fonction âge
  - Dépendante de l'activité de la journée précédente et de la présence d'érection
  - Corrélée au taux de testostérone, lui-même lié au niveau d'activité sexuelle

  Jannini, JSM 2009

- Érections nocturnes « normales »
  - Rigidité >= 70%
  - 3 à 6 érections nocturnes, 10 à 15 minutes

  - Tumescence Activity Units (TAU)
  - Rigidity Activity Units (RAU)

  Jannini, JSM 2009

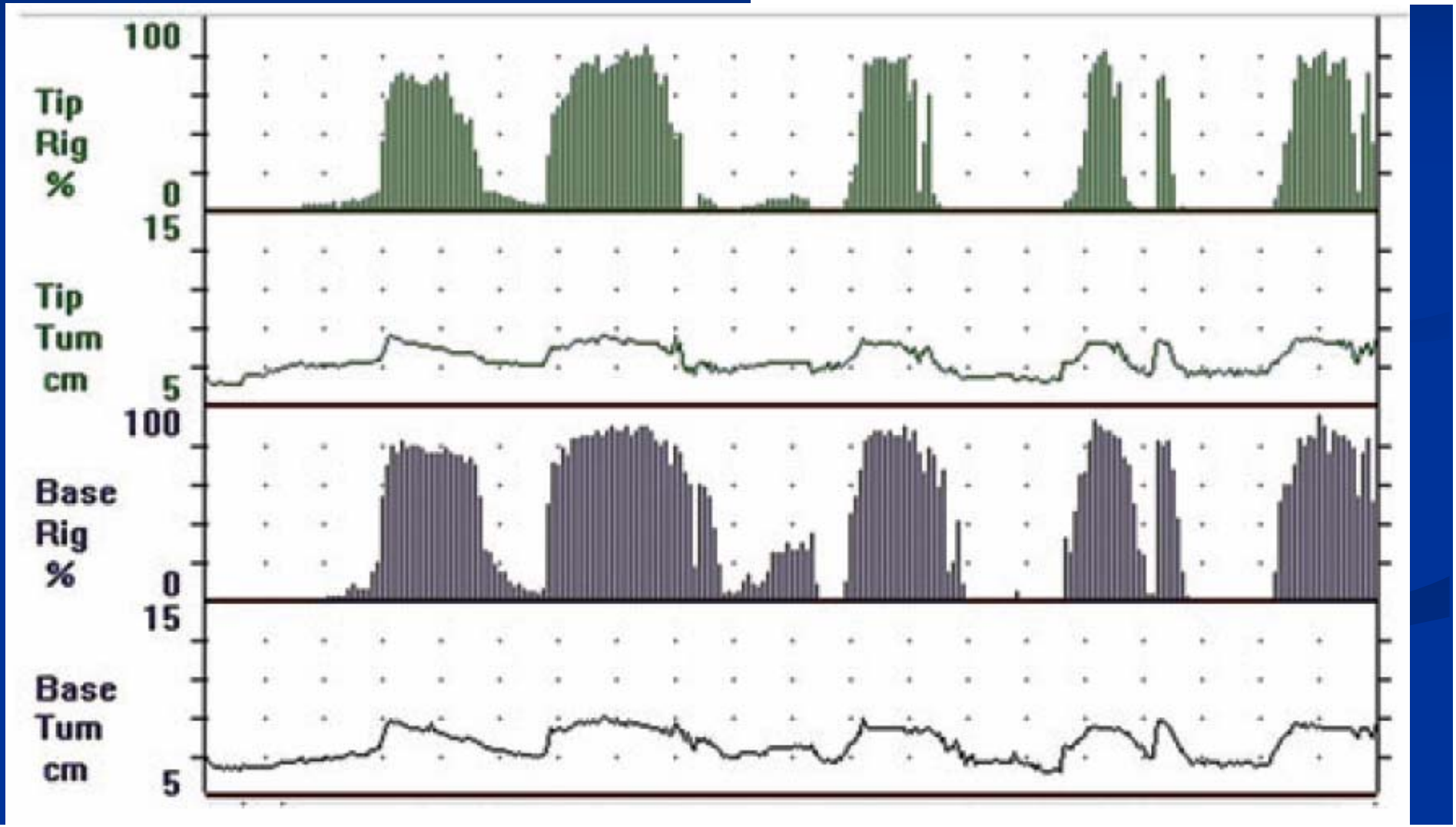
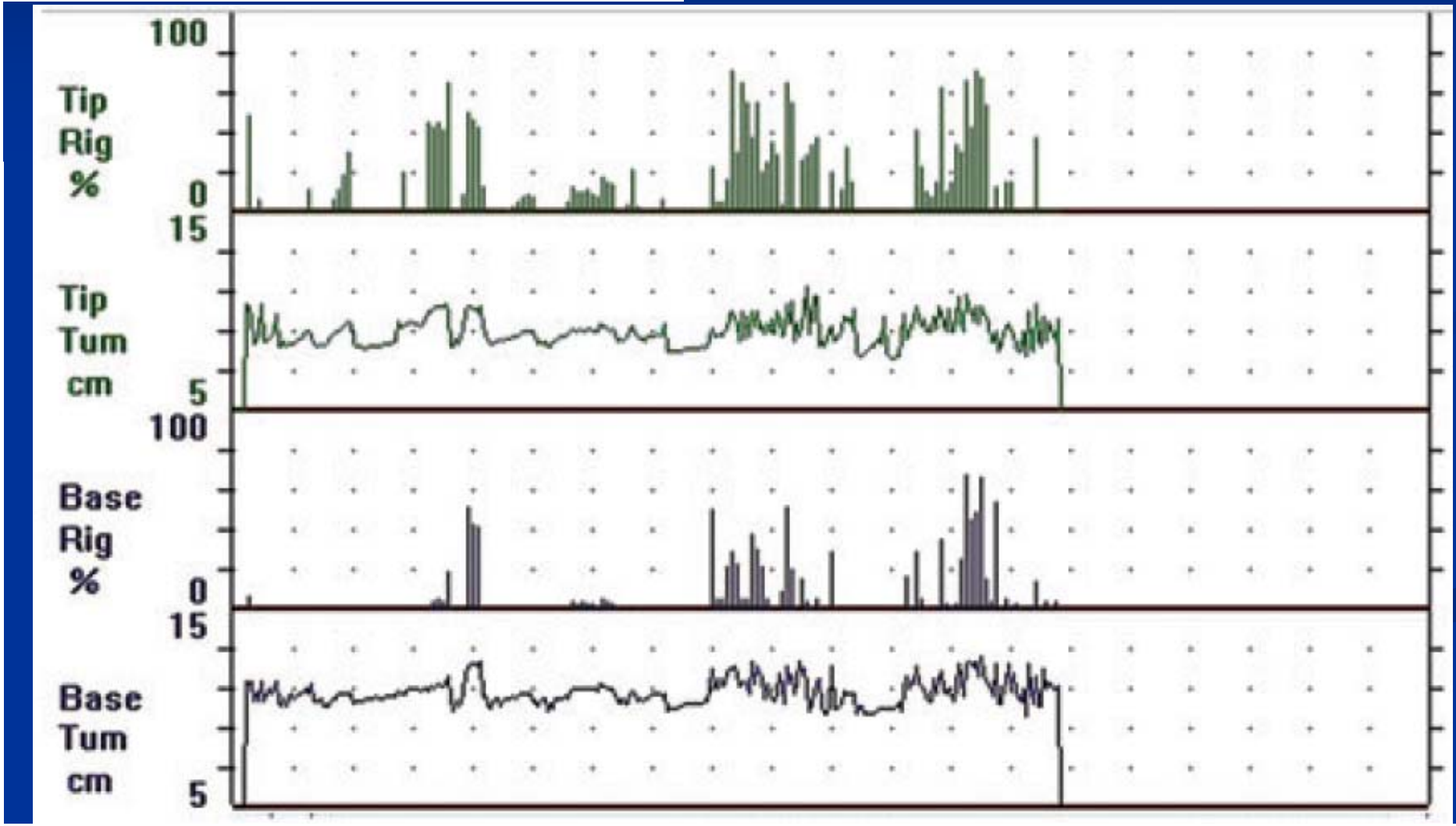


Figure 2 NPTR recording in a 36-year-old man with psychogenic erectile dysfunction. Five well-defined erectile events are recorded with more than 10 minutes duration and rigidity at the tip of the penis more than 70% (in 4/5 events). This is a "classic normal" recording in psychogenic cases.

Figure 3 NPTR recording in a 54-year-old man with mixed vasculogenic erectile dysfunction. Although the recording included three erectile events, these are not well defined and they do not meet the definition of normal events. This is a "classic abnormal" recording in vasculogenic cases.



- Postulat: Pas de facteur psychologique
  - Si érection nocturne présente, et dysfonction érectile: cause est psychogène

  Faux (-): Toubles du sommeil, tabac

  Faux (+): neuropathies, jeune patient SEP

  Yang, MS 2001; Jannini, JSM 2009; Meuleman, JSM 2010

- Relations
  - Intromission possible si rigidité *Guay, U 1996*
    - base >= 55-60% et gland >= 50%
  - IIEF EF normal et NTPR normal *Tokatli, IJIR 2006*
  - Mais NTPR pas prédictif de IIEF EF *Yang 2006*
    - Perception de la fonction érectile vs. capacité physiologique
  - NTPR normal et écho-Doppler normal, mais n'exclut pas atteinte organique *McMahon, JU 1998*
  - Mauvaise corrélation avec Minnesota Multiphasic Personality Inventory MMPI *Jefferson ASB 1989*

- Rigiscan
  - Outil important pour enregistrer les modifications d'un individus (avant / après traitement), cad les modifications individuelles de pression intraCaverneuse
  - Intérêt
    - Évaluer effet (anti)érectogène de certains médicaments
  - Mais n'enregistre que la rigidité radiale

- Rigidité radiale *vs.* axiale
  - Sont dépendants de la pression IC
  - Radiale (Rigiscan, timbre)
    - Dépendants des propriétés mécaniques tunique albuginée
    - Faux (+): bonne rigidité radiale NPTR et mauvaise rigidité axiale
  - Axiale
    - Dépendants de la géométrie (ratio diamètre / longueur) ou propriétés mécaniques pénis

Jannini, JSM 2009

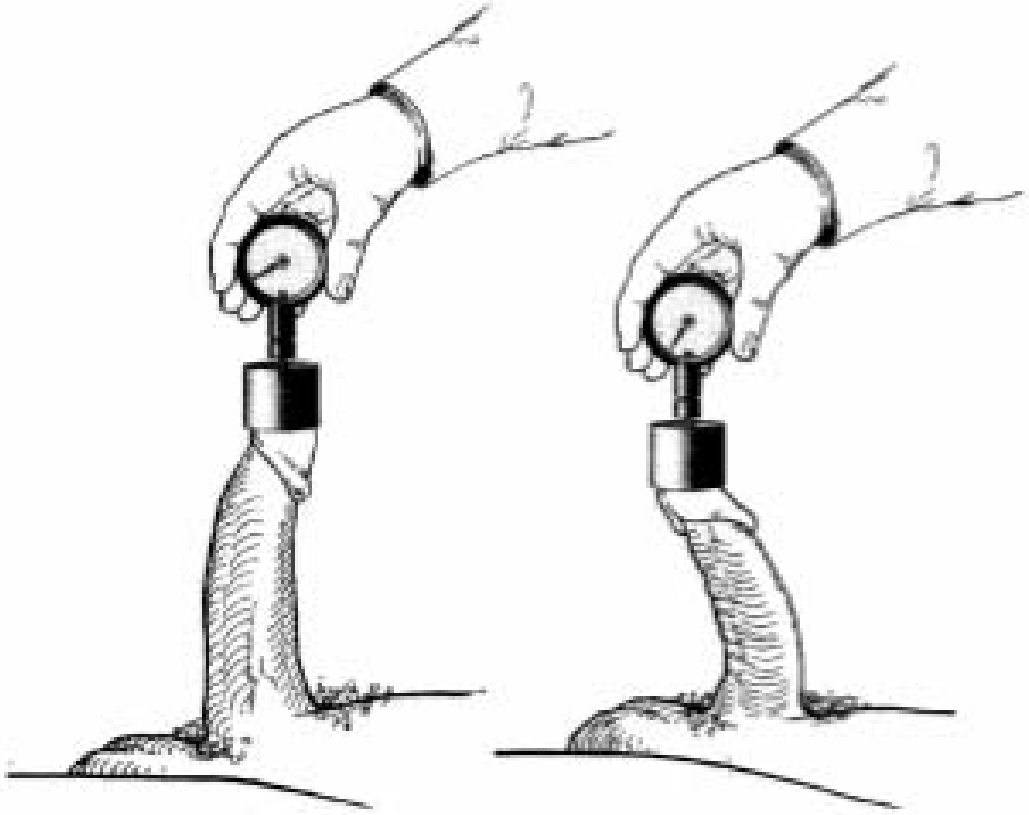


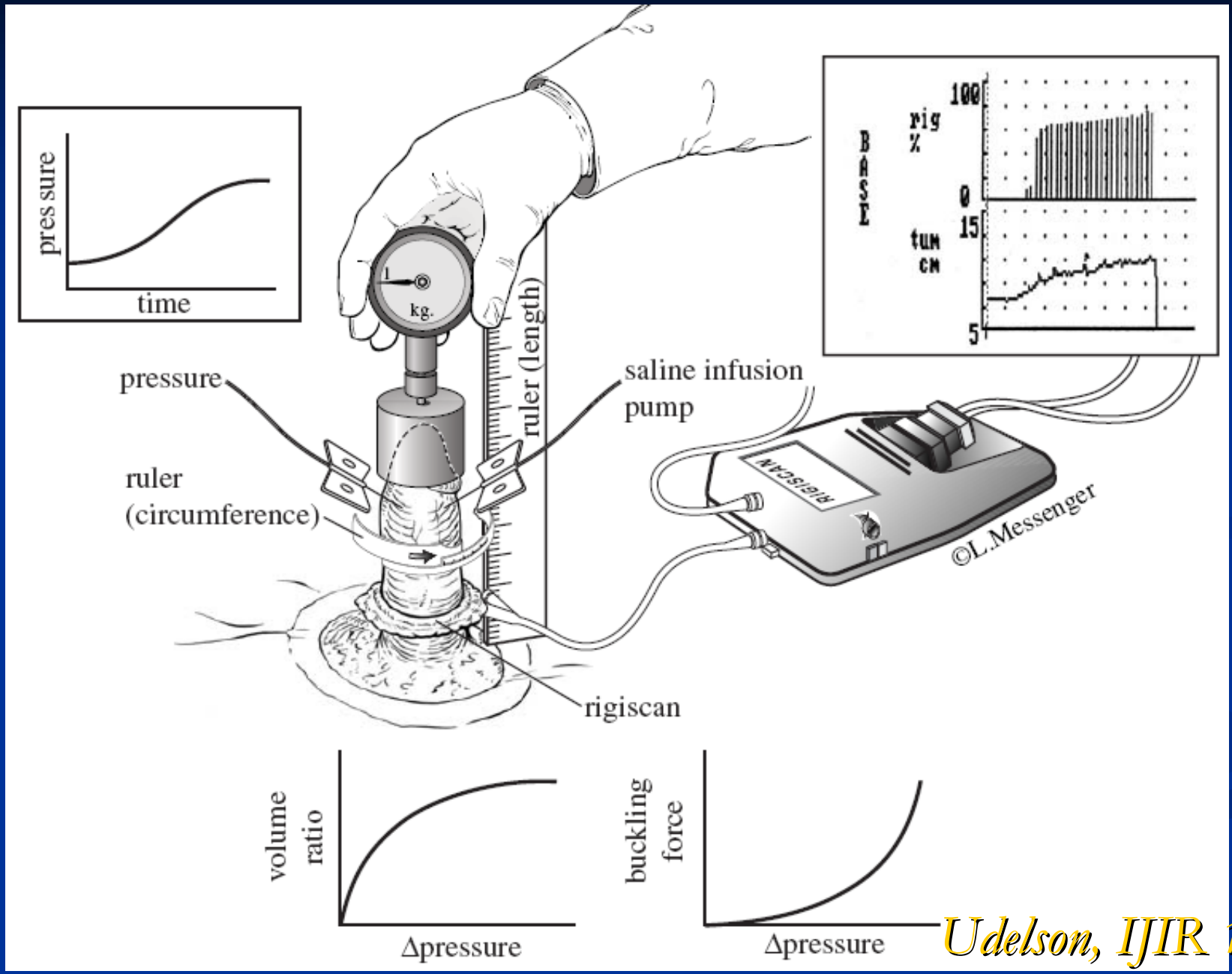
Figure 1 Illustration of buckling test. (Left) Positive test. Application of axial load of 1 kg *does not* result in penile shaft deformation. (Right) Negative test. Application of axial load of less than 1 kg (in this example 0.5 kg) *does* result in penile shaft deformation.

Goldstein, IJIR 2000

- Étude de Karacan *Sleep Research 1985*

  Force nécessaire pour pénétration vaginale

  - Toujours possible si force >= 1,5 Kg
  - Jamais possible si force < 0,5 Kg



Udelson, IJIR 1999

- Neurophysiologique
  - Somatique
    - NDV, PES, RBC, EMG
  - Autonome
    - SSR
    - EMG corps caverneux
    - Seuils thermiques

    Giuliano, JSM 2013

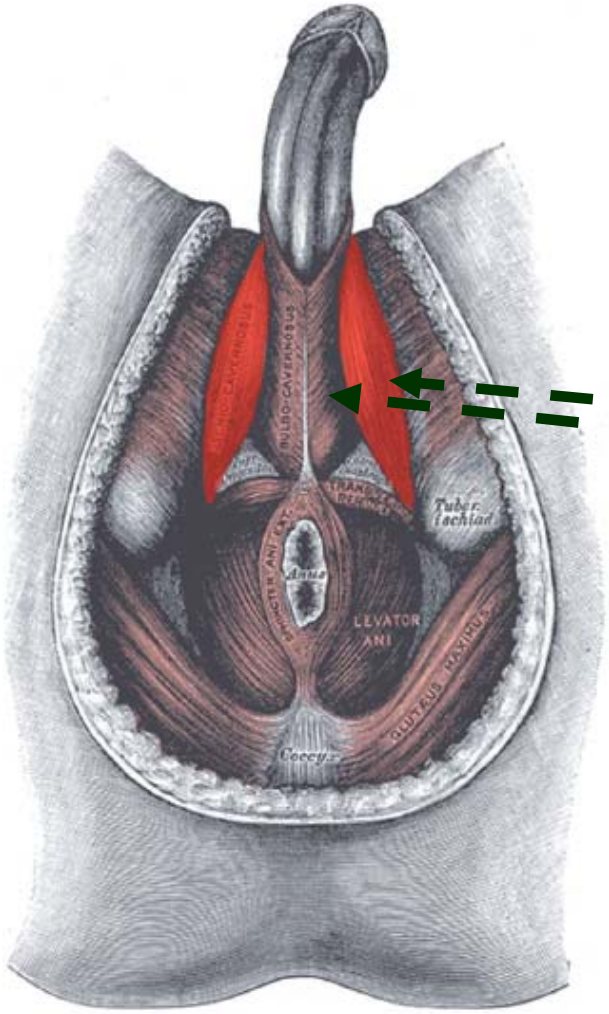
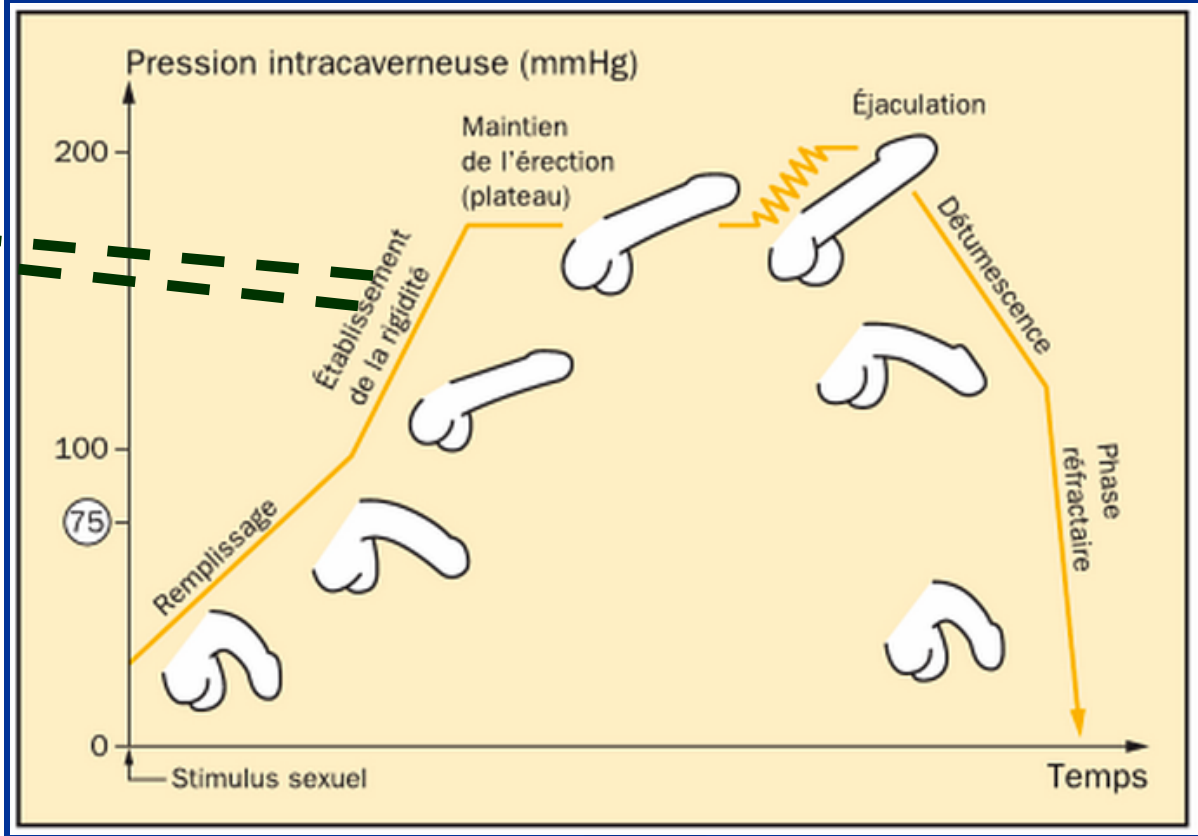
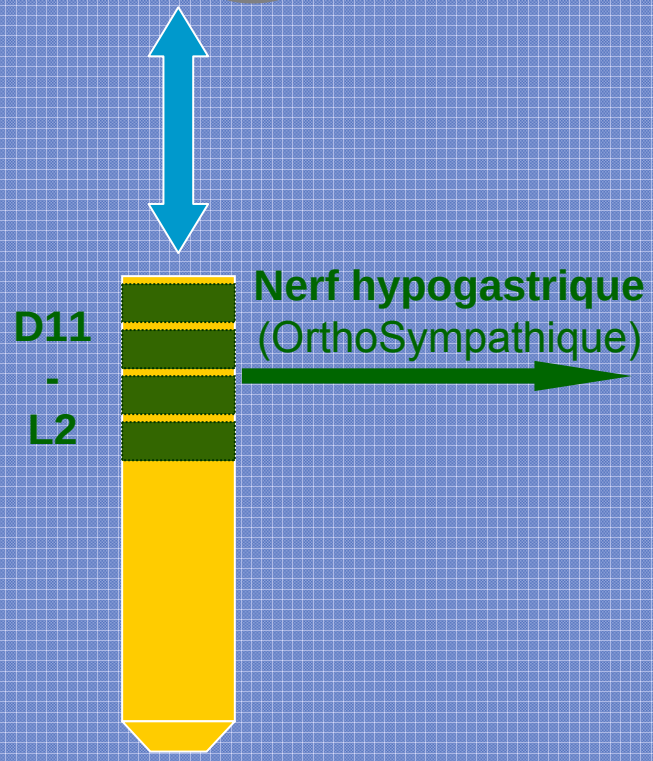


Figure 3 Anatomical relationship of penile corpora with ischiocavernosus (red color) and bulbocavernosus muscles.



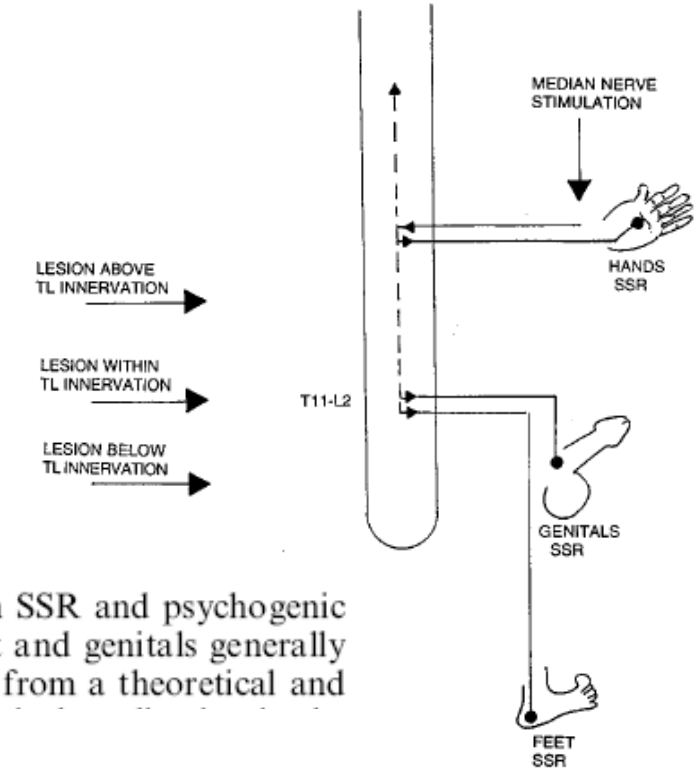
Érection



- Érection psychogène
  - Moelle Dorso-Lombaire
  - Érection lors de libido
  - Qualité variable

- Réponse cutanée sympathique
  - Intégrité colonne thoraco-lombaire T10-L2
  - Présence érection psychogène (médullaire incomplet)

Courtois, SC 1998



cord injured subjects. The results support a general association between SSR and psychogenic erection and show that subjects who maintain SSR responses in the feet and genitals generally maintain psychogenic erections as well. Inconsistent cases are discussed from a theoretical and

- EMG corps caverneux
  - Aiguille bipolaire/monopolaire CC

Normal

  - Présence activité électrique au repos (flaccide)
  - ↓° activité électrique pendant érection

Dysfonction érectile (diabète)

  - Persistance Activité électrique pdt tumescence

On enregistre activité électrique du muscle lisse

tile function [9]. It may be concluded that CC-EMG can detect abnormalities in cavernous muscle to a certain extent, although these pathologic alterations can be attributed to both damage to autonomic penile innervation and to degenerative processes of the cavernous smooth muscle.

- Critique
  - Mouvement de rétraction du pénis
  - Modification volume pénis
  - Réponse électrodermale
  - Manque de standardisation

- Stimulation mécanique
  - Viberect: 75Hz
  - Rigiscan:
    - Tumescence > 60% chez 4 patients / 5
  - EHS
    - 4/4 : 2 patients
    - 3/4 : 2 patients
    - 2/4 : 1 patient

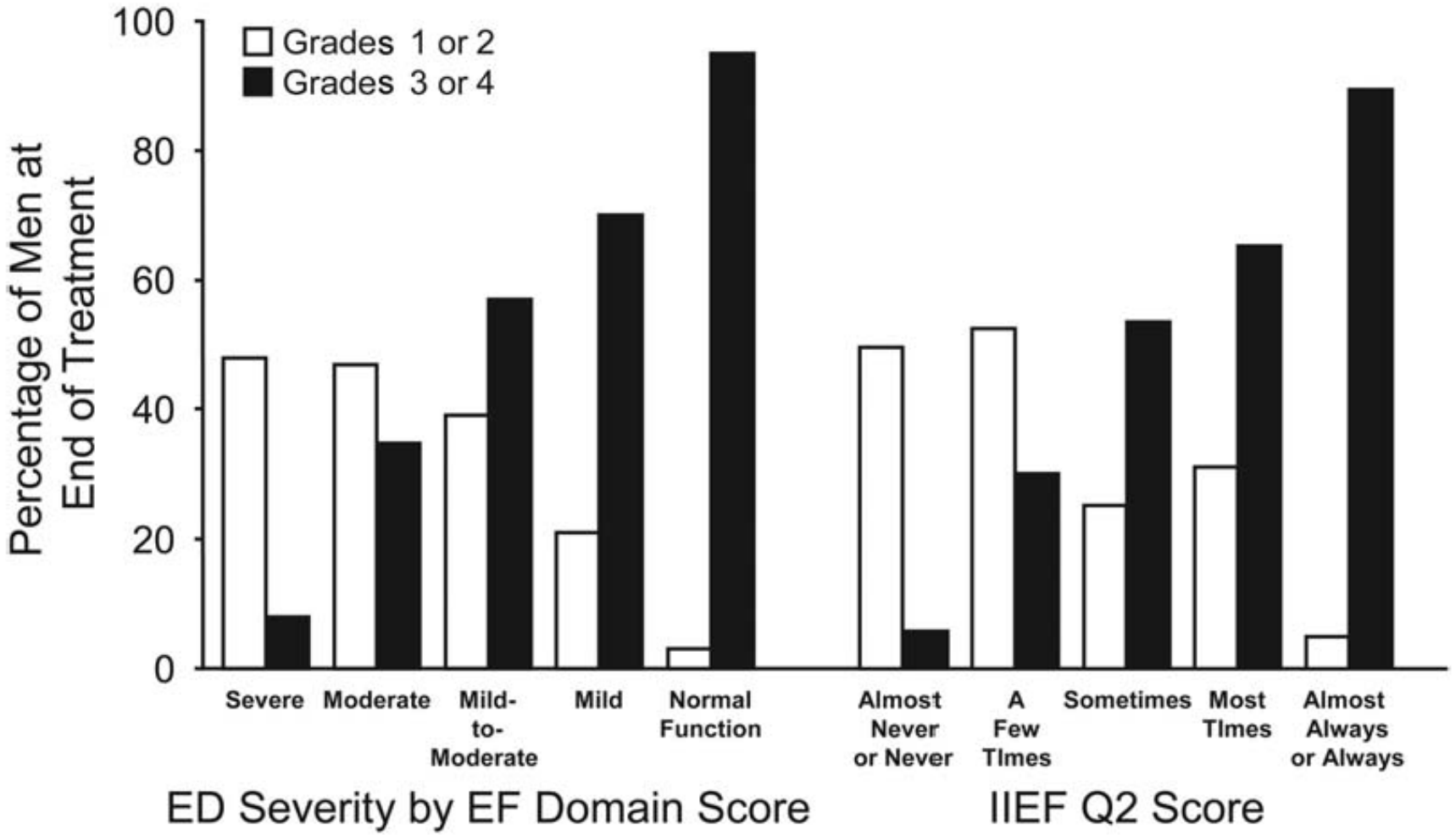
Segal, CJU 2013

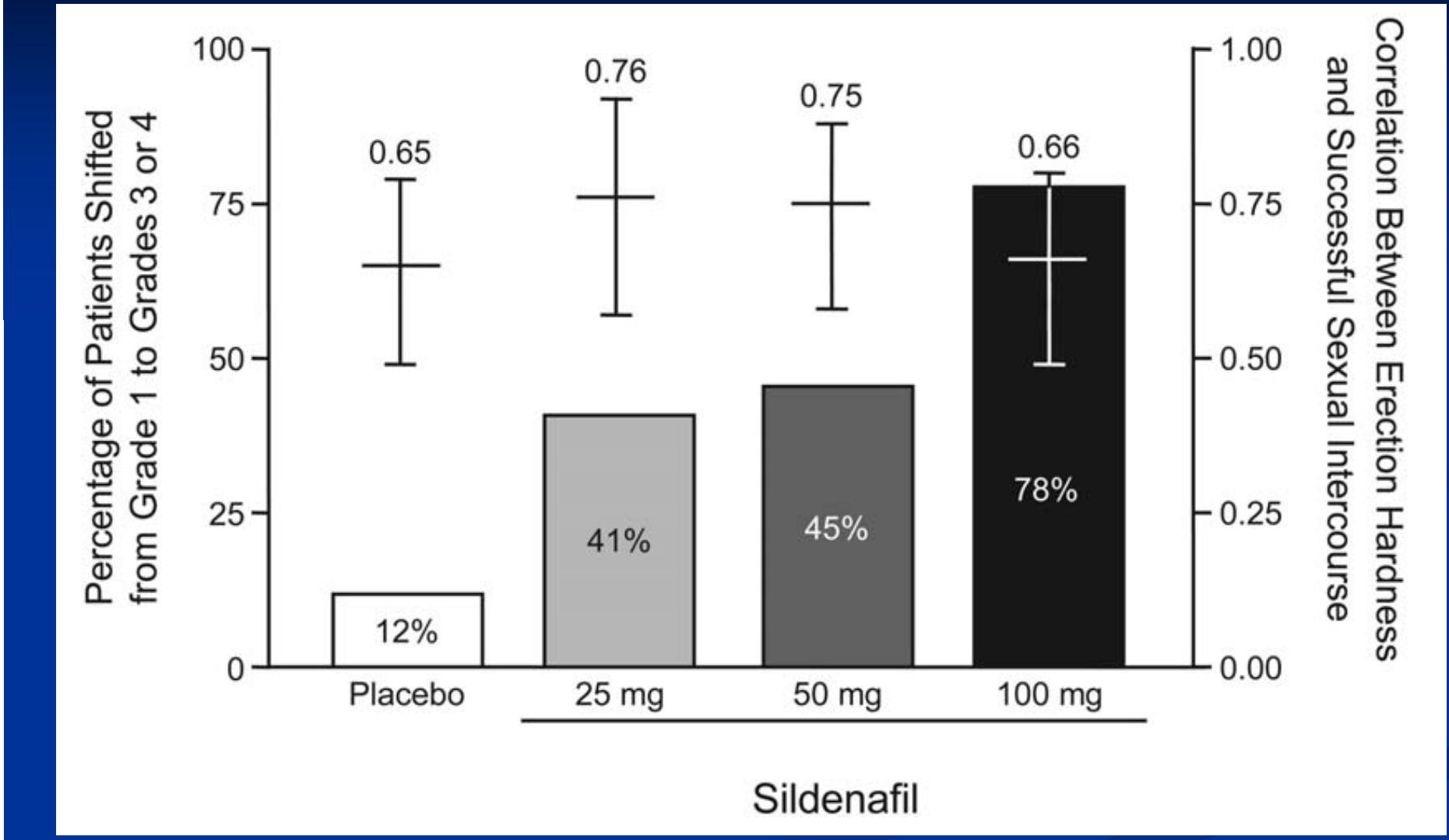
Figure 1. The Viberect handheld penile vibratory stimulatory device.

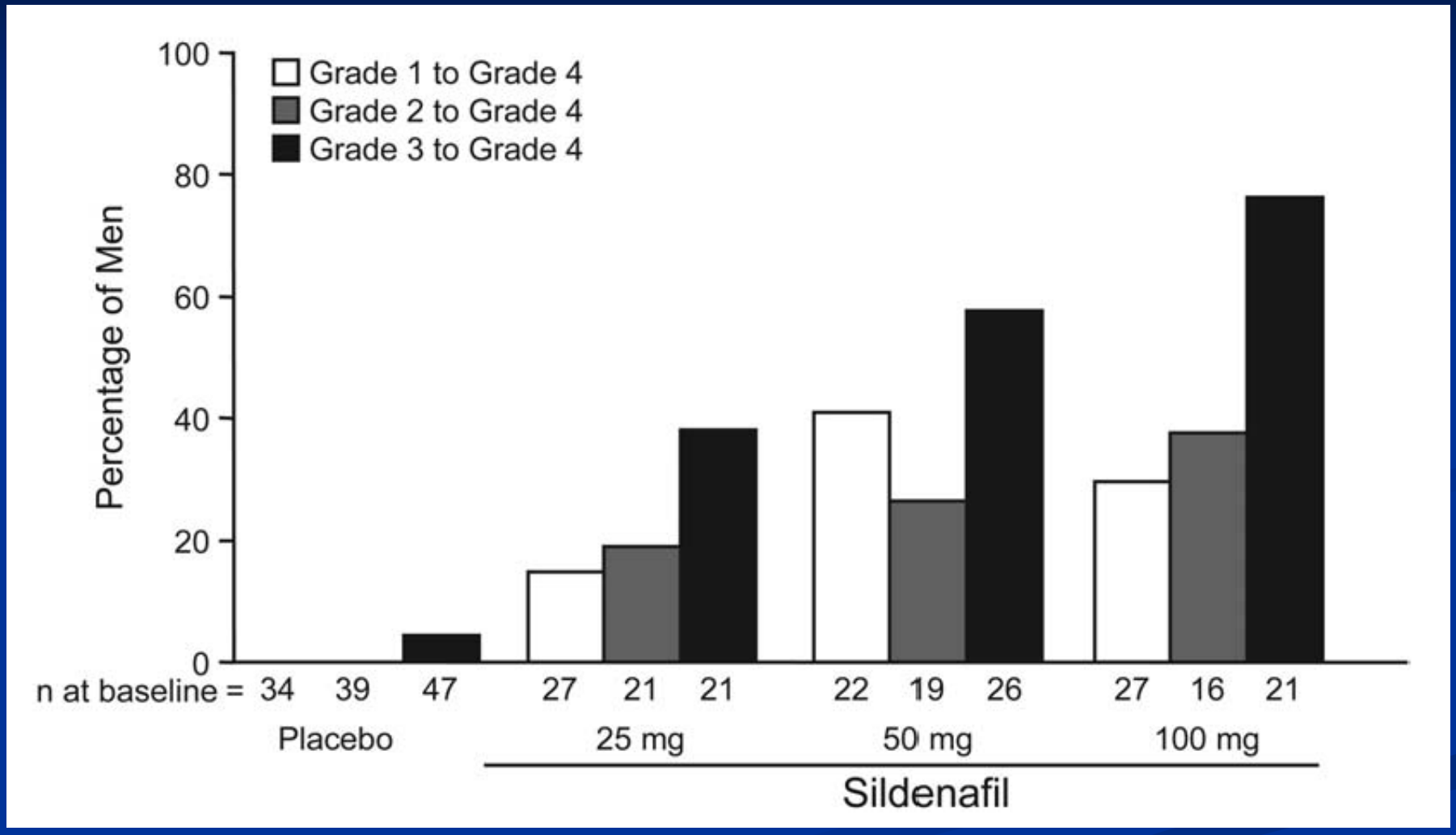
Grade of Erection *Schramekb BJCP 1989*	Erection Hardness Grading Scale *Mulhall JSM 2007*
1: absence érection	
2: intumescence	1: intumescence
3: plein volume, pas de rigidité	2: rigidité insuffisante pour pénétration
4: rigidité incomplète, suffisante pour rapport sexuel	3: rigidité suffisante pour pénétration
5: rigidité (érection) maximale	4: pleine érection (rigidité et dure)

Érection

- Rappels
  - Anatomie
    - Nerfs somatiques et autonomes
  - Physiologie
    - Pression intracaverneuse (PIC)
  - Types d'érection
    - Réflexe
    - Psychogènes
    - Nocturnes
  - Analogies avec blessés médullaires


Grades 1 or 2
Grades 3 or 4
Percentage of Men at End of Treatment
100
80
60
40
20
0
Severe
Moderate
Mild-to-Moderate
Mild
Normal Function
Almost Never or Never
A Few TImes
Sometimes
Most TImes
Almost Always or Always
ED Severity by EF Domain Score
IIEF Q2 Score


Percentage of Patients Shifted from Grade 1 to Grades 3 or 4
100
75
50
25
0
1.00
0.75
0.50
0.25
0.00
Correlation Between Erection Hardness and Successful Sexual Intercourse
0.65
0.76
0.75
0.66
12%
41%
45%
78%
Placebo
25 mg
50 mg
100 mg
Sildenafil


Grade 1 to Grade 4
Grade 2 to Grade 4
Grade 3 to Grade 4
Percentage of Men
100
80
60
40
20
0
n at baseline = 34 39 47 27 21 21 22 19 26 27 16 21
Placebo
25 mg
50 mg
100 mg
Sildenafil

We have demonstrated that the IIEF EF domain and the frequency of erections hard enough for penetration (IIEF Q2) were good surrogate end points for erection hardness, which correlated positively with successful sexual intercourse during the last 4 weeks of treatment. Hence, achievement of hard erections may be considered a unifying factor that defines response in ED treatment. Completely hard and fully rigid erections should be recognized as the optimal goal of an ED therapy. Sildenafil treatment can improve erectile function and erection hardness in men with ED, and a dose-response relation was noted in the proportion who achieved erections that were hard enough for penetration or were completely hard and fully rigid.

- *Mulhall U 2006*

- Clinique
  - Échelle de rigidité *Schramek, BJCP 1989*
    - 1: absence érection
    - 2: intumescence
    - 3: plein volume, pas de rigidité
    - 4: rigidité incomplète, suffisante pour rapport sexuel
    - 5: rigidité (érection) maximale

the EHGS, on which grade 1 represents increase in size but not hardness, grade 2 represents hard but not hard enough for penetration, grade 3 represents hard enough for penetration but not completely hard, and grade 4 represents completely hard and fully rigid.[9]

Table 2 Grade of erection achieved (1- no erection, 2- slight tumescence, 3- full volume without rigidity, 4- incomplete rigidity sufficient for sexual intercourse, 5- full erection) after intracavernous application of the four different solutions

	Number of subjects achieving stated grade of erection				
Treatment	*1*	*2*	*3*	*4*	*5*
Saline	20	–	–	–	–
Preservative	20	–	–	–	–
5 μg PGE_1	–	2	3	4	11
10 μg PGE_1	–	–	3	–	17

- Pourquoi évaluer ?
  - Diagnostic (psychogénique vs. organique)
  - Thérapeutique