Spinal Vascular Malformation

Farhan Anwary , Dr SpRad(K), Sub.Sp, NKL,MHKes

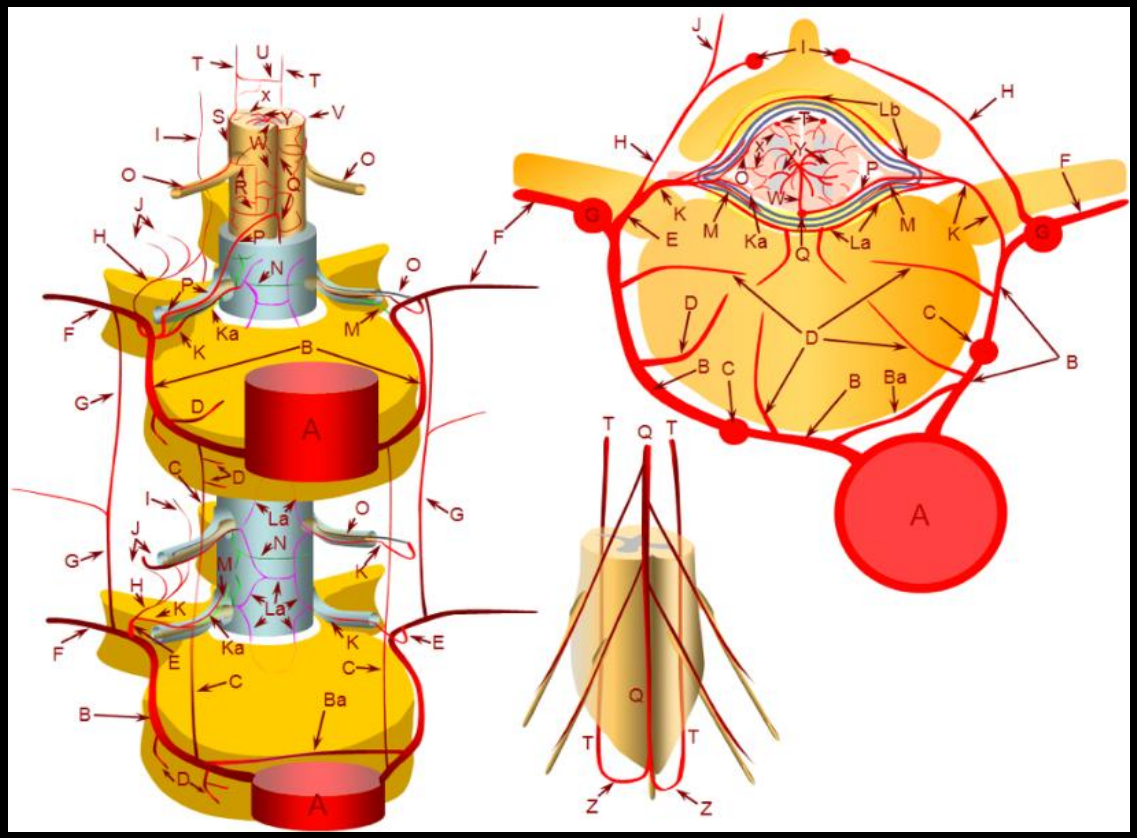
ANATOMI VASKULAR MEDULLA SPINALIS

- SISTEM **ARTERI**
- SISTEM **VENA**

ARTERI

- Arteri yang memberi suplai medula spinalis berasal dari **arteri segmental**.
- **Arteri segmental** memiliki **suplai** yang **berbeda-beda** tergantung **regio**.
  - **Cervical :**
    - Arteri vertebralis
    - Arteri cervicalis ascendens (*ascending cervical artery*)
    - Arteri cervicalis profunda (*deep cervical artery*),
    - Arteri pharyngea ascendens (*ascending pharyngeal artery*)
    - Arteri oksipital.
  - **Torakal:**
    - Arteri interkosta posterior (*posterior intercostal artery*)
    - Arteri interkosta superior (*superior/supreme intercostal artery*).
  - **Lumbosakral:**
    - Arteri lumbalis
    - Arteri iliolumbalis
    - Arteri sakralis media
    - Arteri sakralis lateral

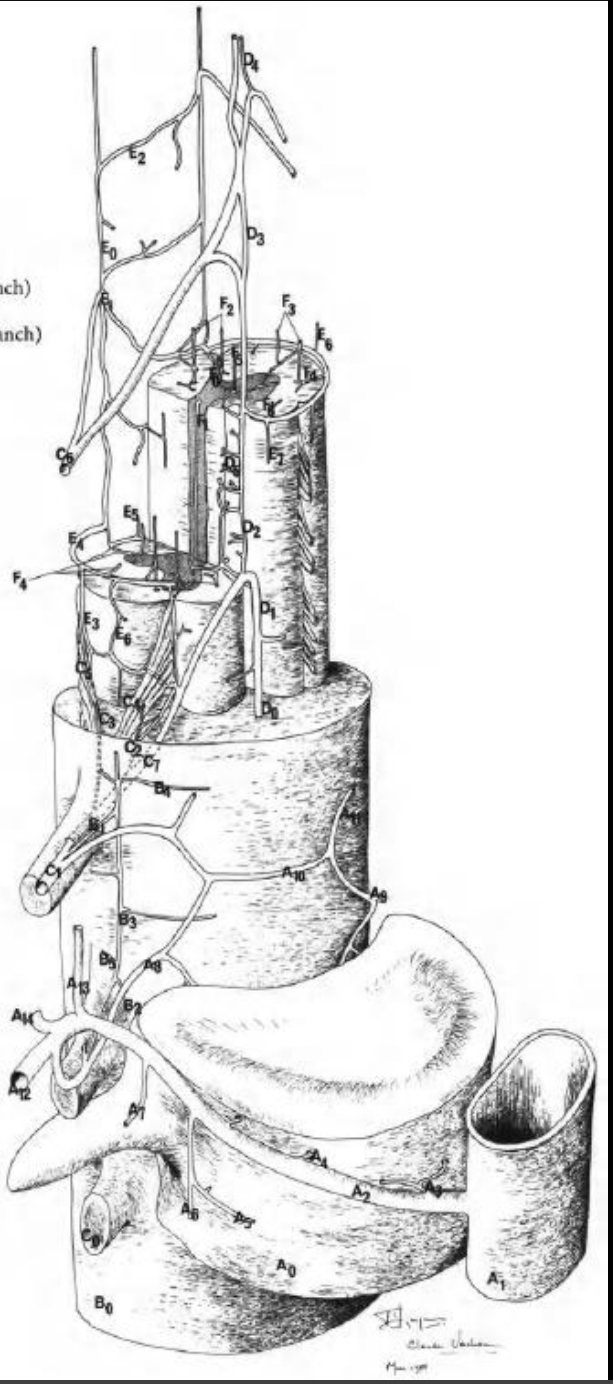
Mandalapu S. 2017, Miyasaka K, et al. 2000, Lasjaunias P, et al. 2001



Keterangan: A – aorta; B – segmental artery; Ba – intersegmental arterial anastomosis; C – prevertebral anastomotic network; D – direct vertebral body feeding arteries; E – dorsal spinal artery; F – intercostal/muscular artery; G – pretransverse anastomotic network; H – dorsal division of the dorsal spinal artery; I – post-transverse anastomotic network; J – muscular branches of the post-transverse anastomotic network; K – ventral division of the dorsal spinal artery; Ka – radicular artery; La – ventral epidural arcade; Lb – dorsal epidural arcade; M – nerve root sleeve dural branch of the ventral division dorsal spinal artery; N – dural branch of the ventral division dorsal spinal artery; O – radiculopial artery; P – radiculomedullary artery; Q – anterior spinal artery; R – mesh-like pial arterial network; S, T – posterior spinal artery; U, V – pial arterial network (a.k.a. vasocorona) anastomoses between anterior and posterior spinal arterial systems, W – sulco-commissural artery, X – rami perforantes of the peripheral (centripetal) system, Y – central (centrifugal) system of sulcal arteries, originating from pial network of the cord; altogether, the pial network and rami perforantes (R+Y) are called the vasocorona or corona vasorum; Z – rami cruciantes (a.k.a. crux vasculosa, a.k.a. rami anastomotici arcuati)

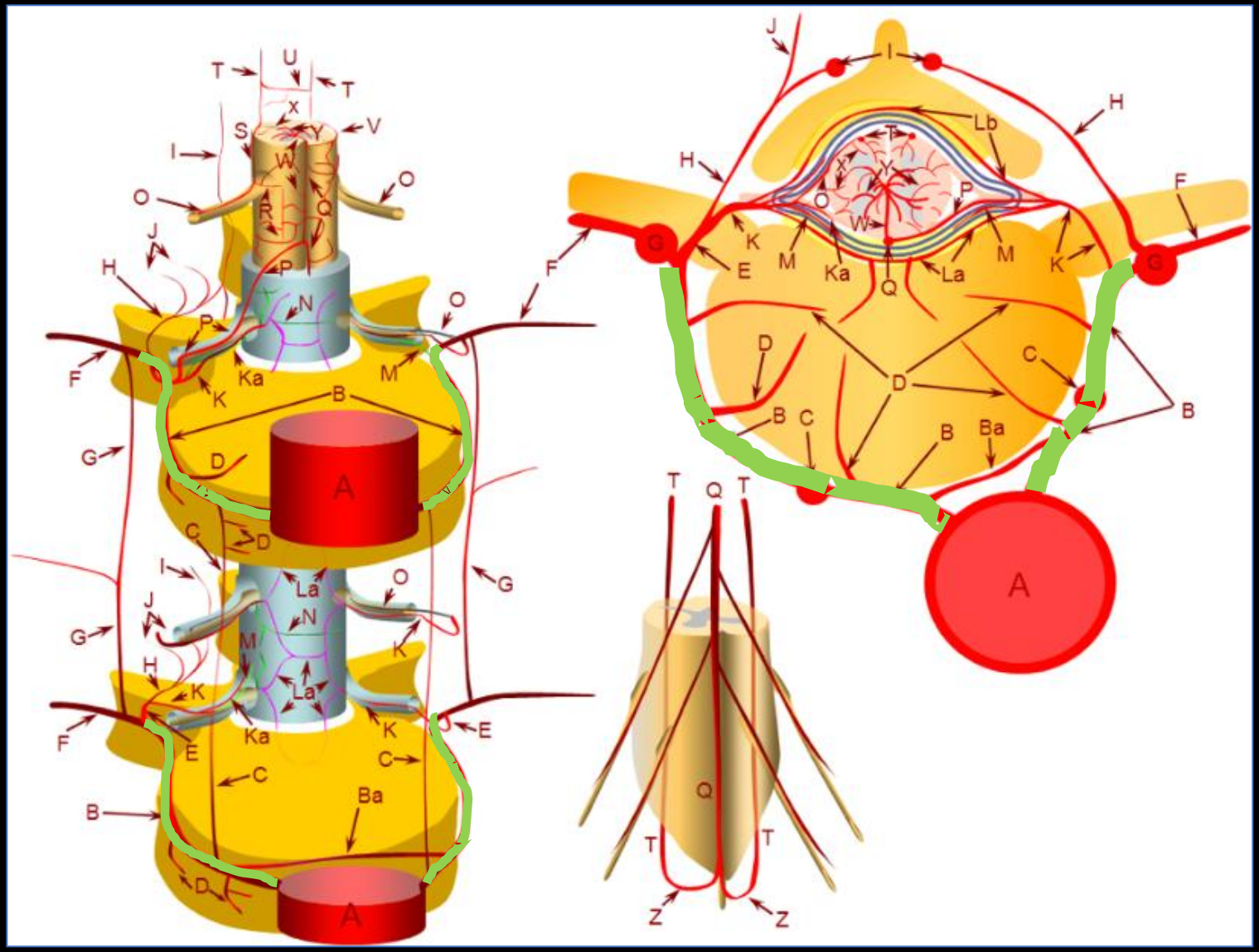
Fig. 2.12. Schematic representation of the spine and spinal cord supply at the upper thoracic level:

- *A0* Vertebral body
  - *A1* Aorta
  - *A2* Lumbar or intercostal artery
  - *A3* Ventral somatic branch
  - *A4* Ventromedial somatic branch
  - *A5* Ventrolateral somatic branch
  - *A6* Prevertebral anastomosis
  - *A7* Osseous branch
  - *A8* Dorsal somatic branch
  - *A9* Dorsal somatic anastomosis (ascending branch)
  - *A10* Dorsal somatic anastomosis
  - *A11* Dorsal somatic anastomosis (descending branch)
  - *A12* Intercostal artery
  - *A13* Paravertebral anastomosis
  - *A14* Dorsal trunk
- *B0* Dural sheath
  - *B1* Dural artery
  - *B2* Descending dural branch
  - *B3* Ascending dural branch
  - *B4* Transverse dural branch
  - *B5* ventrodorsal branch
- *C0* Spinal nerve
  - *C1* Radicular artery
  - *C2* Ventral branch (radiculopial)
  - *C3* Dorsal branch (radiculopial)
  - *C4* Ventral root
  - *C5* Dorsal root
  - *C6* Common ventral and dorsal radiculo-spinal artery (radiculopial and radiculomedullary artery)
  - *C7* Radiculo-medullary artery
- *D0* Ventral spinal axis
  - *D1* Descending branch
  - *D2* Ascending branch
  - *D3* Fenestrated ventral axis
  - *D4* Duplicated ventral axis
  - *D5* Perforating branch
- *E0* "Posterospinal artery"
  - *E1* "Bilateral posterospinal trunk"
  - *E2* Dorsal medullary anastomosis
  - *E3* Lateral spinal artery
  - *E4* Coronary anastomosis
  - *E5* Dorsal funicular artery
  - *E6* Lateral funicular artery
  - *E7* Ventral funicular artery
- *F0* Dorsal horn
  - *F1* Ependymal canal
  - *F2* Longitudinal dorsal intramedullary anastomosis
  - *F3* Longitudinal lateral intramedullary anastomosis
  - *F4* Perforating artery
  - *F5* Longitudinal medial intramedullary anastomosis
  - *F6* Longitudinal ventral intramedullary anastomosis



Lasjaunias P, Berenstein A, Ter Brugge KG. 2001. Surgical Neuroangiography. 2nd edition. Springer-Verlag. Berlin. p.73-164.

ARTERI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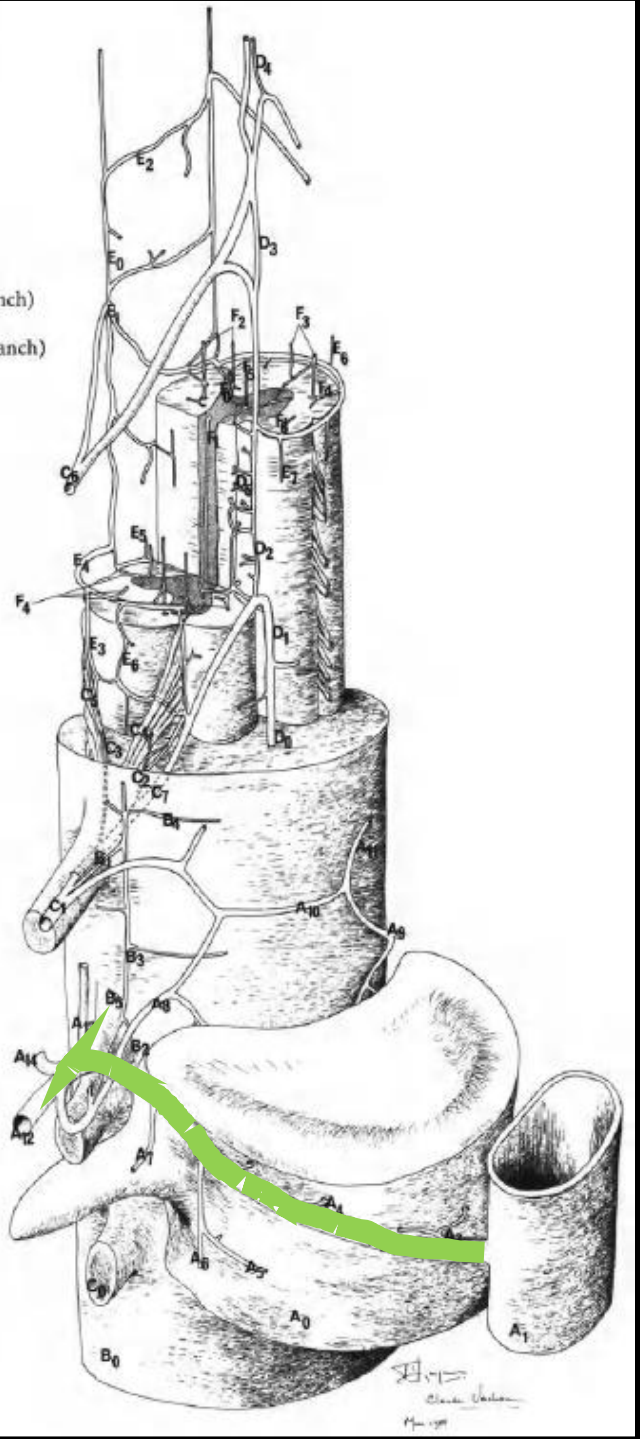

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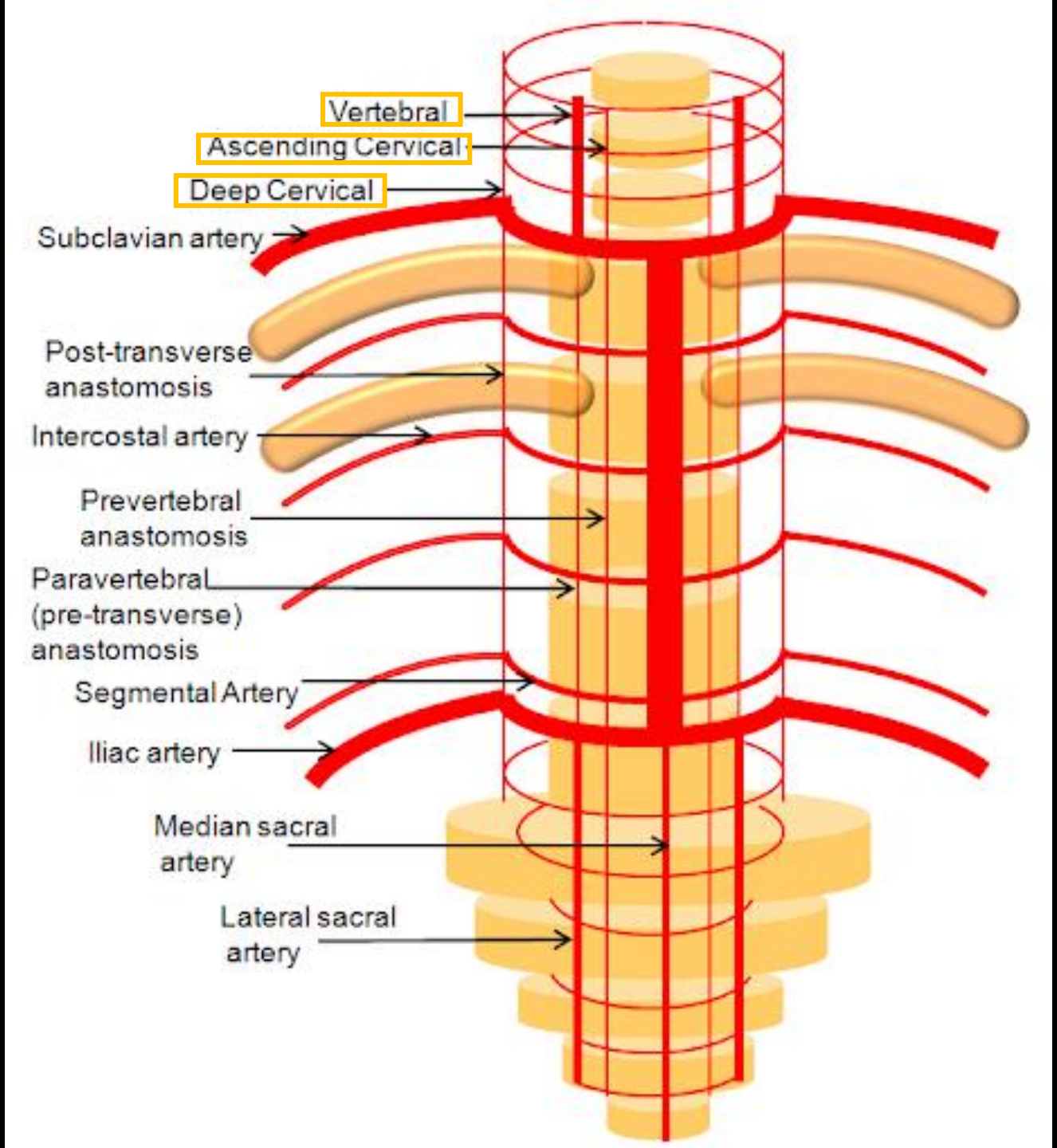
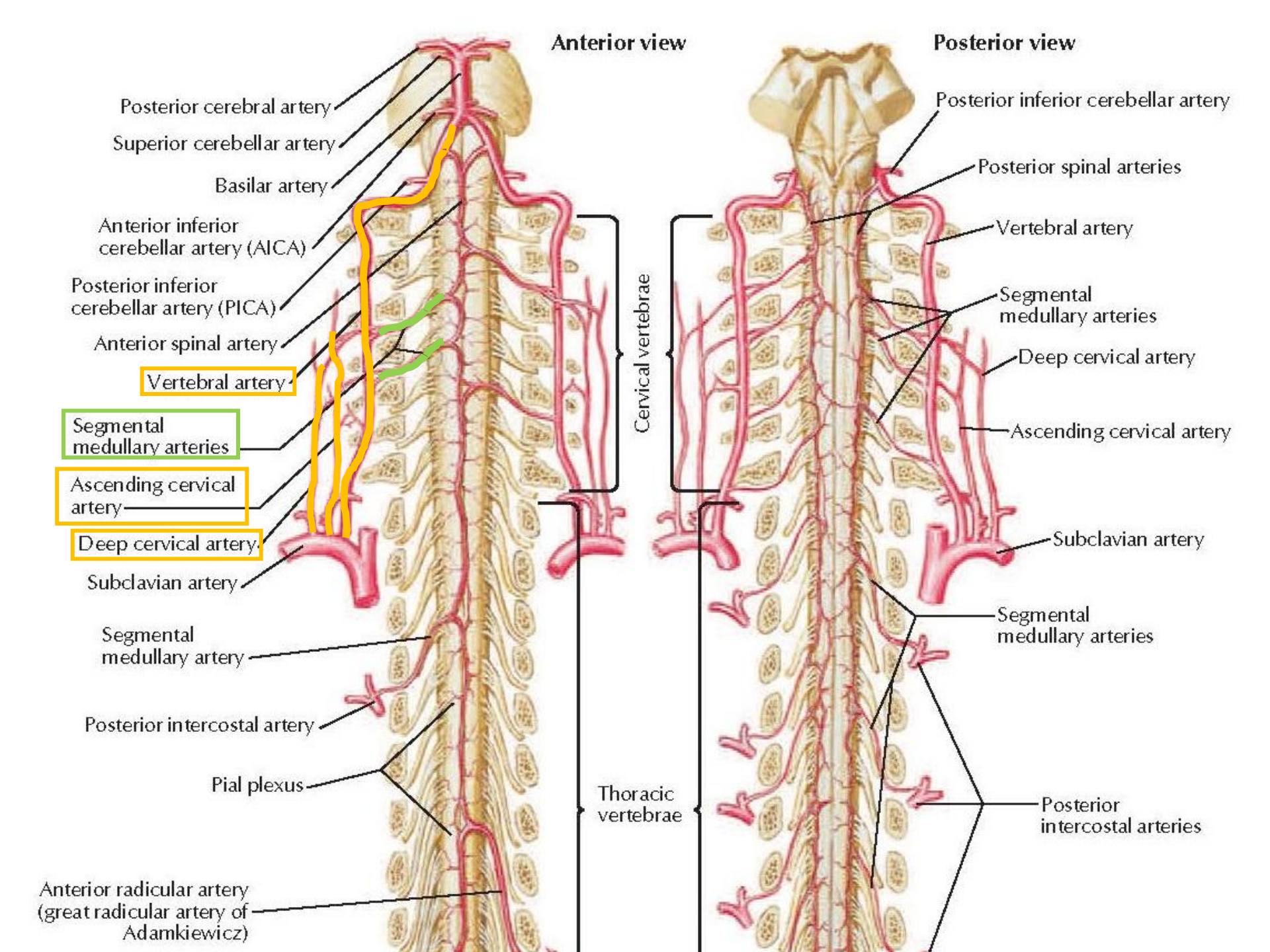
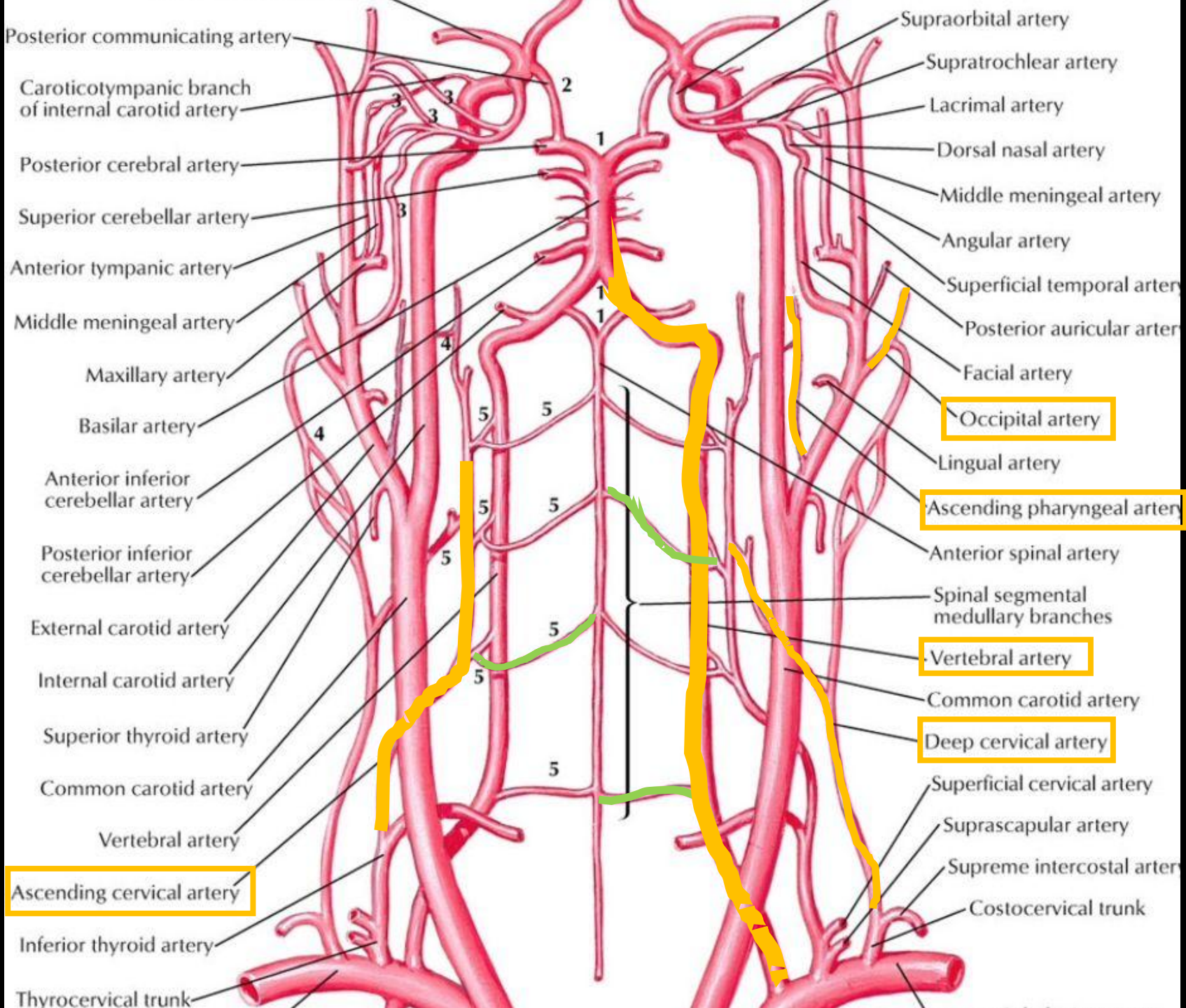

Vertebral
Ascending Cervical
Deep Cervical
Subclavian artery
Post-transverse anastomosis
Intercostal artery
Prevertebral anastomosis
Paravertebral (pre-transverse) anastomosis
Segmental Artery
Iliac artery
Median sacral artery
Lateral sacral artery


Anterior view
Posterior view
Posterior cerebral artery
Superior cerebellar artery
Basilar artery
Anterior inferior cerebellar artery (AICA)
Posterior inferior cerebellar artery (PICA)
Anterior spinal artery
Vertebral artery
Segmental medullary arteries
Ascending cervical artery
Deep cervical artery
Subclavian artery
Segmental medullary artery
Posterior intercostal artery
Pial plexus
Anterior radicular artery (great radicular artery of Adamkiewicz)
Cervical vertebrae
Thoracic vertebrae
Posterior inferior cerebellar artery
Posterior spinal arteries
Vertebral artery
Segmental medullary arteries
Deep cervical artery
Ascending cervical artery
Subclavian artery
Segmental medullary arteries
Posterior intercostal arteries


Posterior communicating artery
Caroticotympanic branch of internal carotid artery
Posterior cerebral artery
Superior cerebellar artery
Anterior tympanic artery
Middle meningeal artery
Maxillary artery
Basilar artery
Anterior inferior cerebellar artery
Posterior inferior cerebellar artery
External carotid artery
Internal carotid artery
Superior thyroid artery
Common carotid artery
Vertebral artery
Ascending cervical artery
Inferior thyroid artery
Thyrocervical trunk
Supraorbital artery
Supratrochlear artery
Lacrimal artery
Dorsal nasal artery
Middle meningeal artery
Angular artery
Superficial temporal artery
Posterior auricular artery
Facial artery
Occipital artery
Lingual artery
Ascending pharyngeal artery
Anterior spinal artery
Spinal segmental medullary branches
Vertebral artery
Common carotid artery
Deep cervical artery
Superficial cervical artery
Suprascapular artery
Supreme intercostal artery
Costocervical trunk

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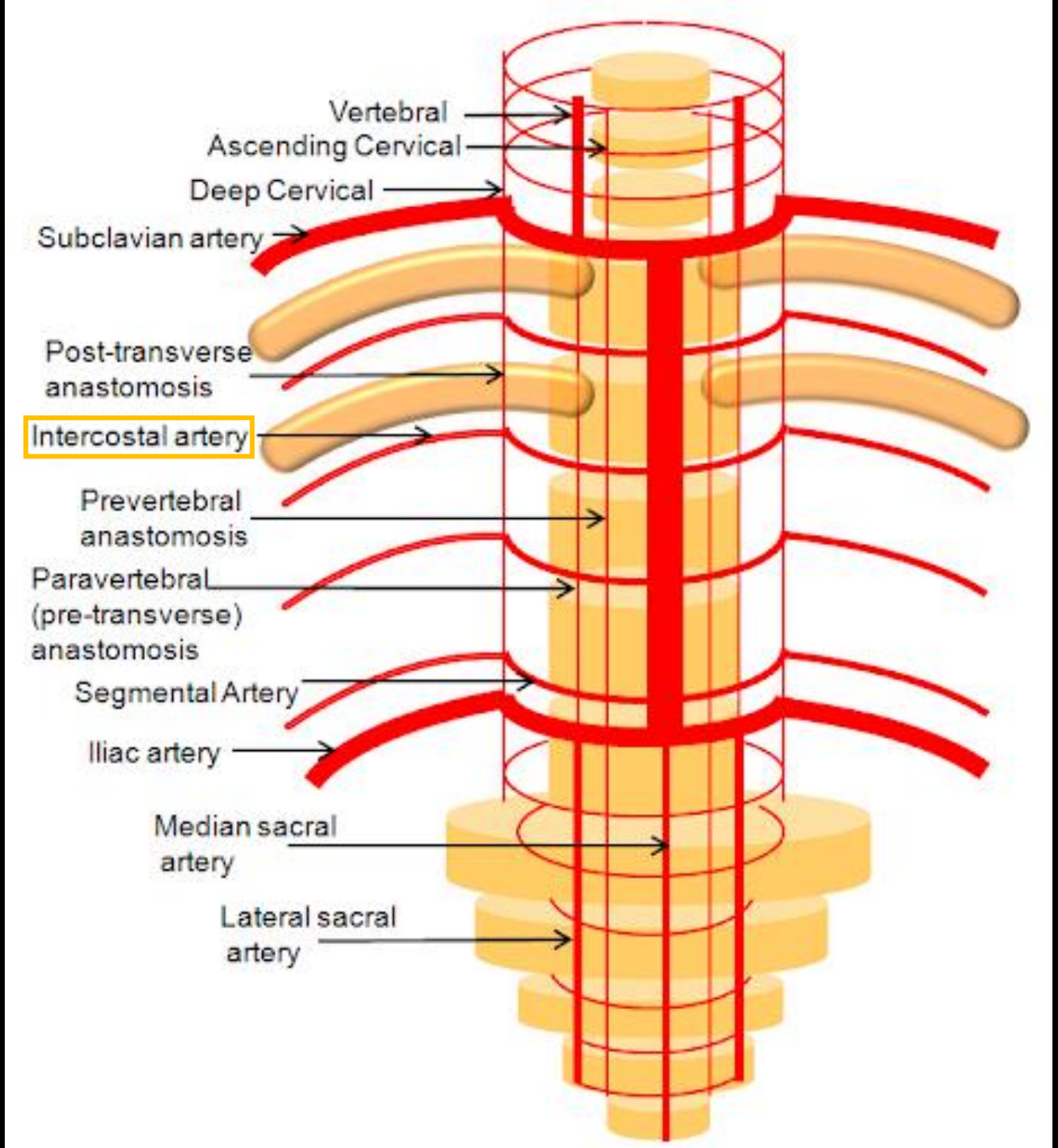
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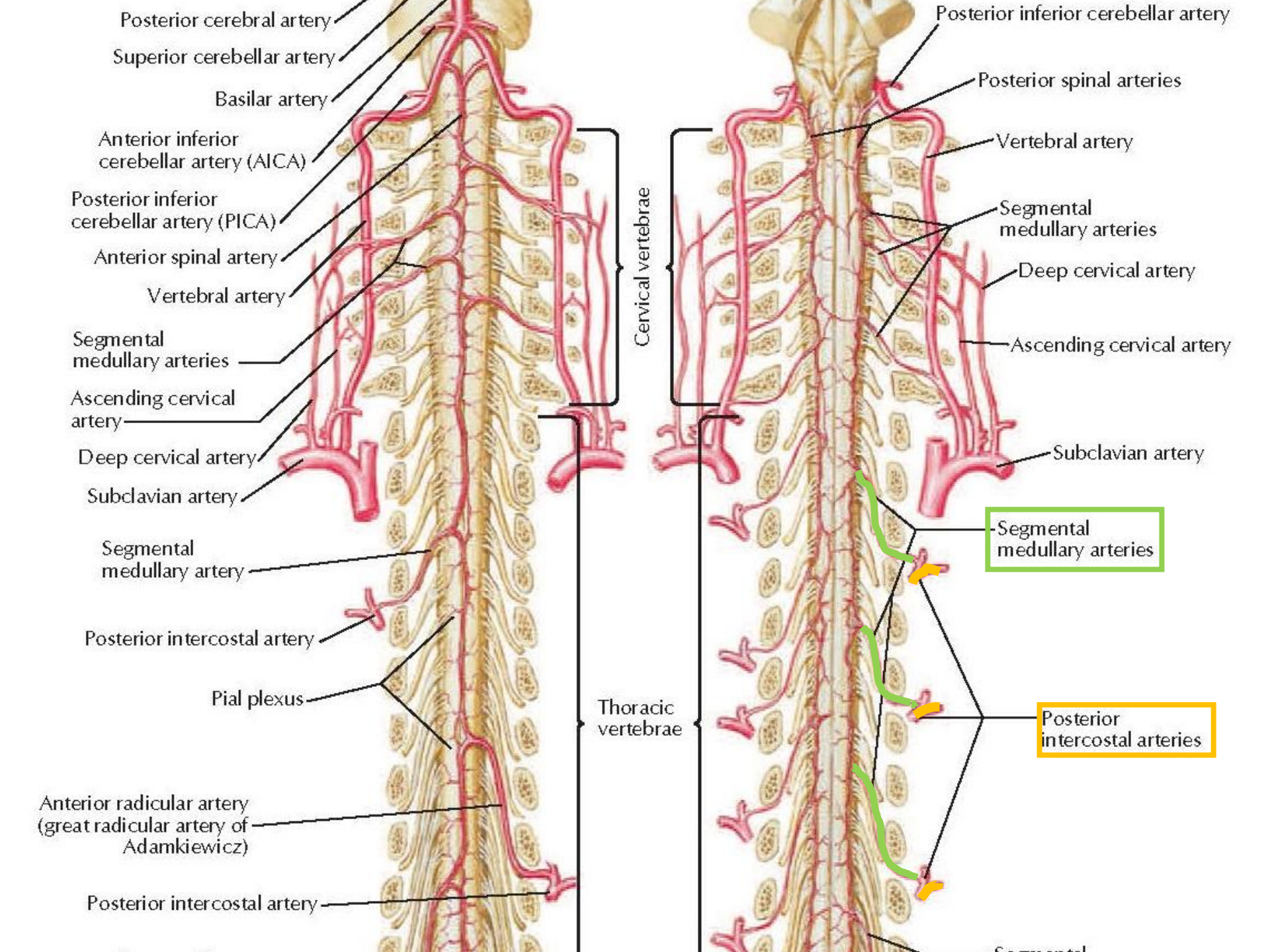
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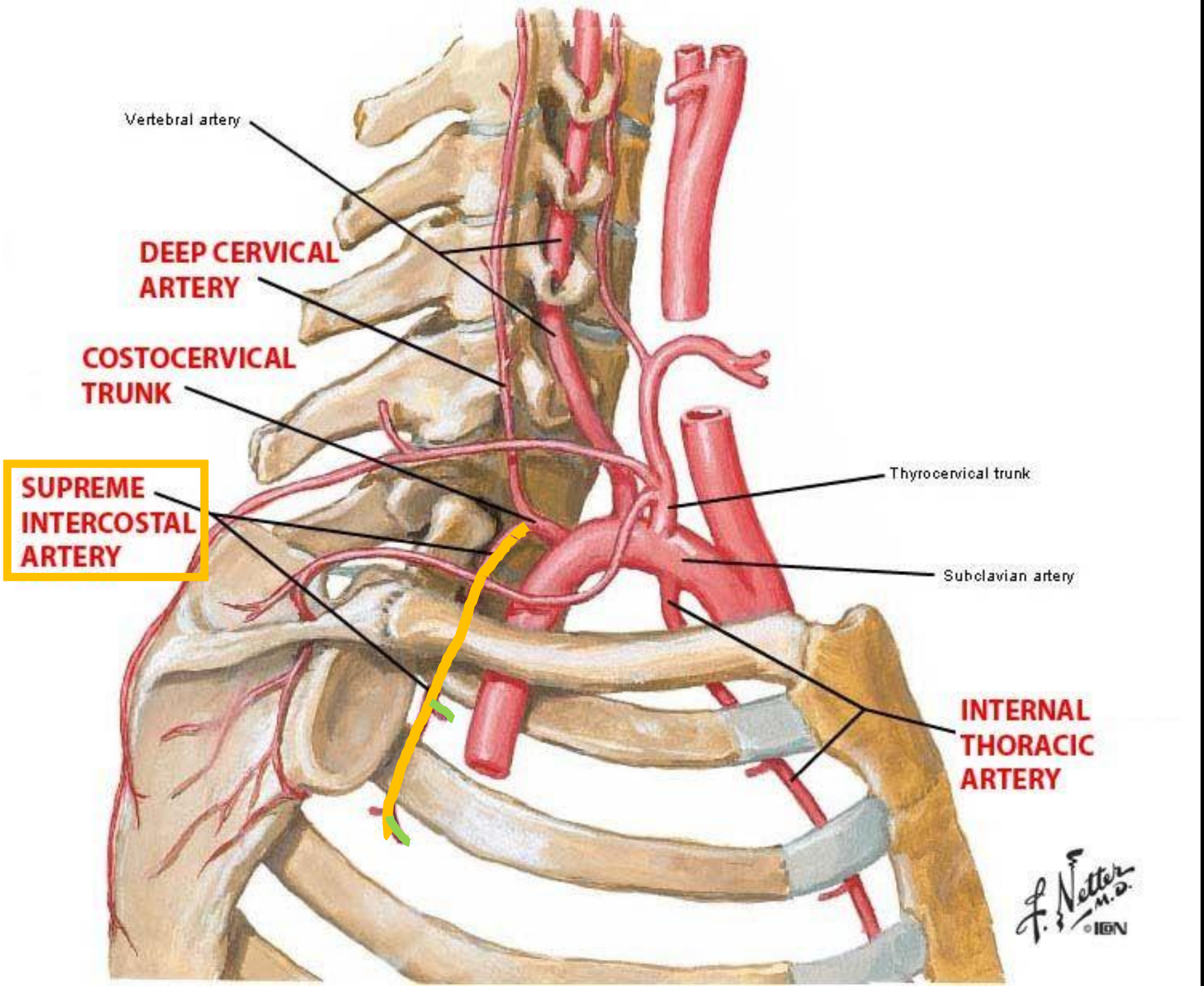
Vertebral artery
DEEP CERVICAL ARTERY
COSTOCERVICAL TRUNK
SUPREME INTERCOSTAL ARTERY
Thyrocervical trunk
Subclavian artery
INTERNAL THORACIC ARTERY
F. Netter M.D.
©IGN

ARTERI

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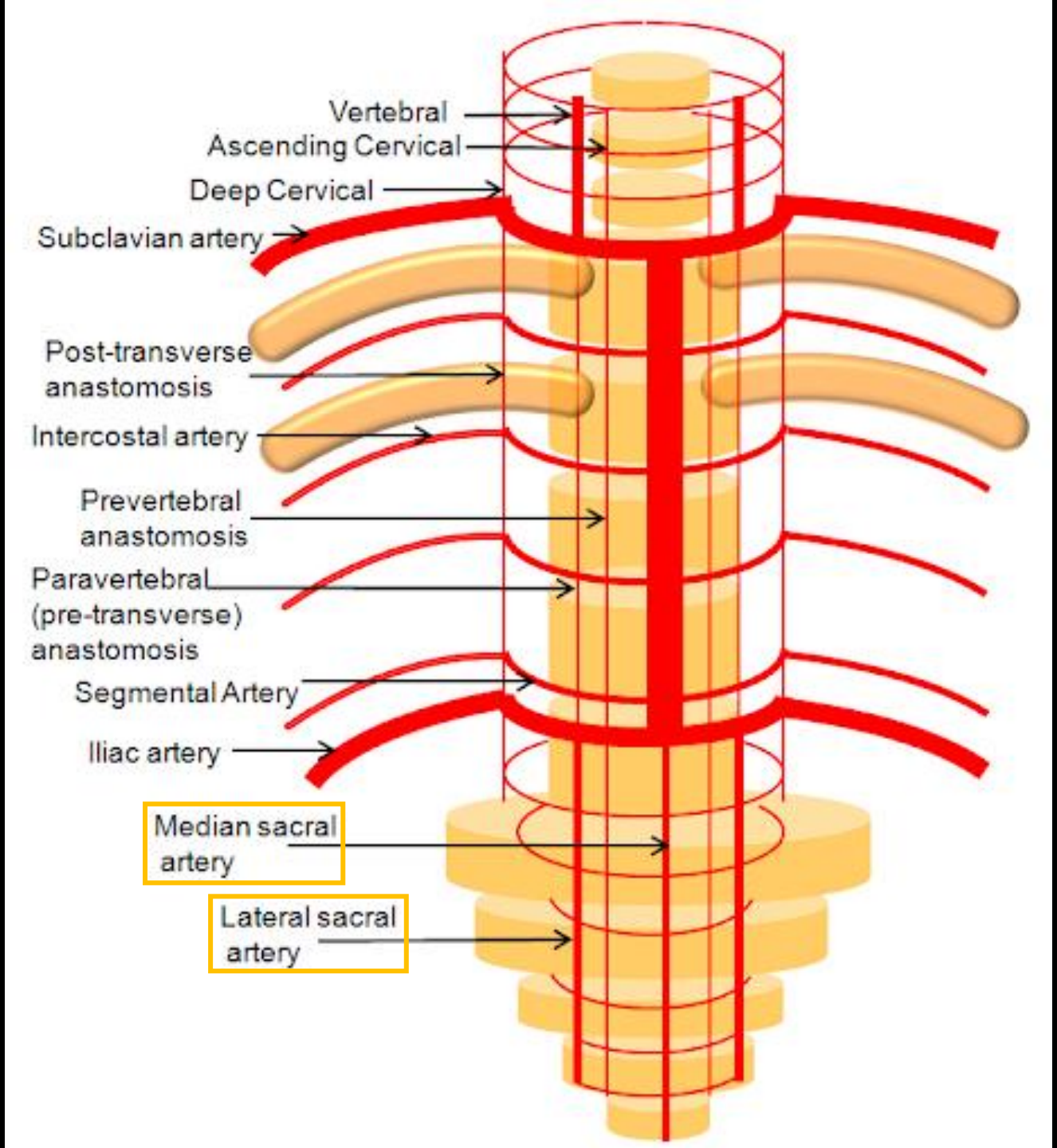
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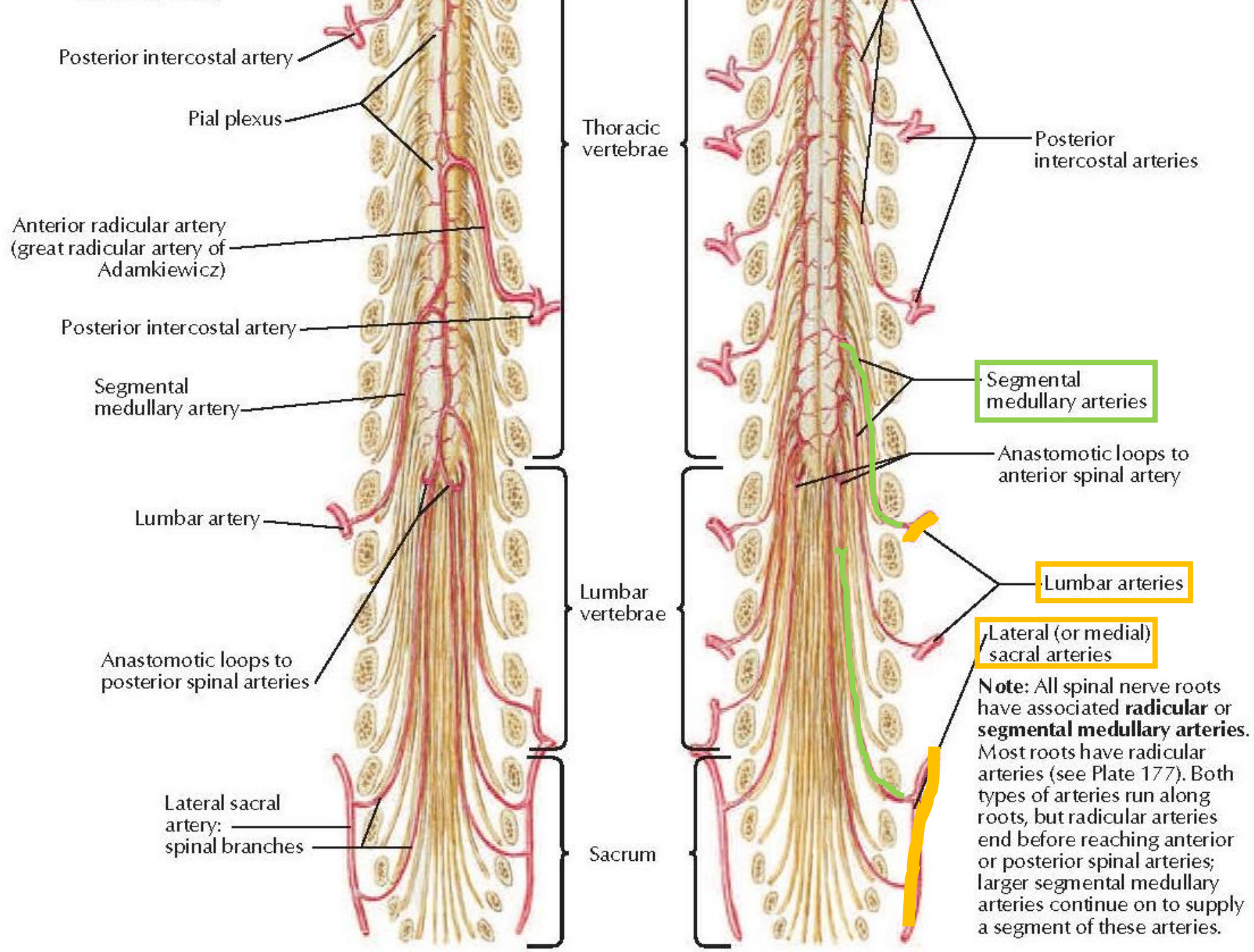
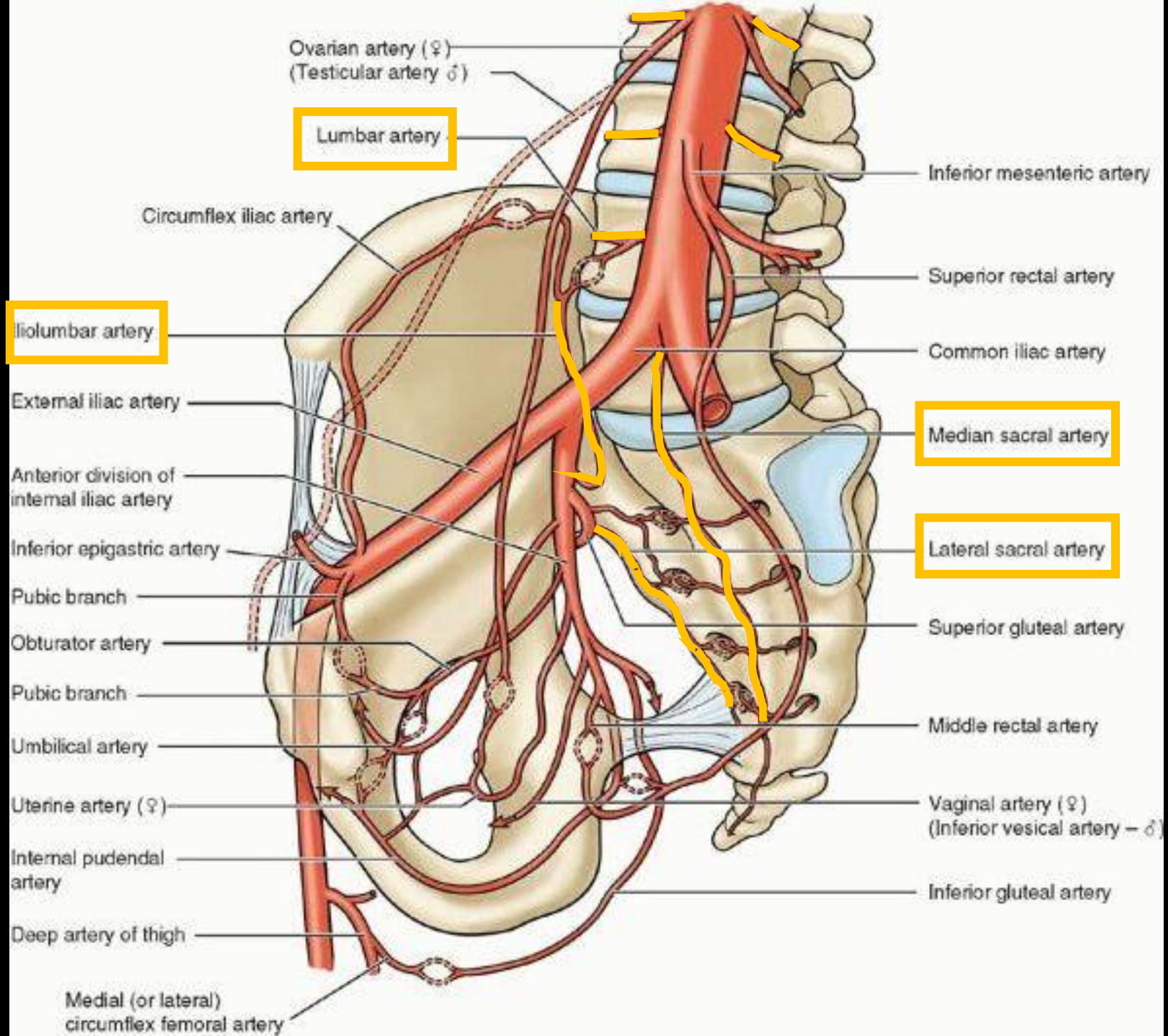


Note: All spinal nerve roots have associated **radicular** or **segmental medullary arteries**. Most roots have radicular arteries (see Plate 177). Both types of arteries run along roots, but radicular arteries end before reaching anterior or posterior spinal arteries; larger segmental medullary arteries continue on to supply a segment of these arteries.

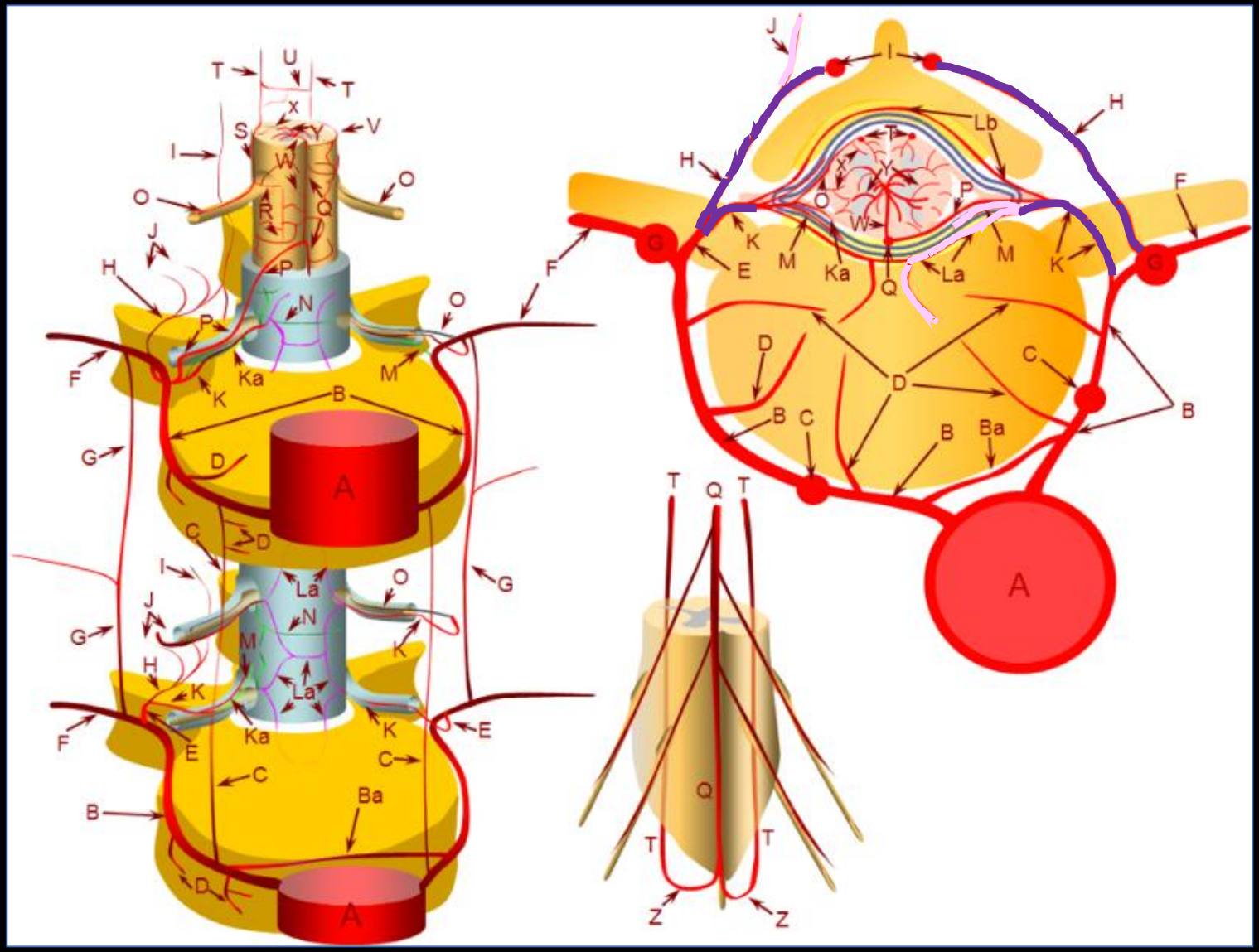

Ovarian artery (♀)
(Testicular artery ♂)
Lumbar artery
Inferior mesenteric artery
Circumflex iliac artery
Superior rectal artery
Iliolumbar artery
Common iliac artery
External iliac artery
Median sacral artery
Anterior division of internal iliac artery
Inferior epigastric artery
Lateral sacral artery
Pubic branch
Superior gluteal artery
Obturator artery
Pubic branch
Middle rectal artery
Umbilical artery
Uterine artery (♀)
Vaginal artery (♀)
(Inferior vesical artery – ♂)
Internal pudendal artery
Inferior gluteal artery
Deep artery of thigh
Medial (or lateral) circumflex femoral artery

ARTERI

- **Arteri segmental** dibagi menjadi tiga kelompok yaitu:
  - **Cabang Ventral**: suplai ke bagian **anterior** kanalis spinalis untuk mensuplai duramater, struktur osseus, musculus dan kutis.
  - **Cabang Dorsal**: suplai ke bagian **posterior** kanalis spinalis untuk mensuplai duramater, struktur osseus, musculus dan kutis.
  - **Cabang Media**: memasuki foramen intervertebralis dan menjadi tiga jenis arteri tergantung dari **struktur yang disuplainya**.

Mandalapu S. 2017, Miyasaka K, et al. 2000, Lasjaunias P, et al. 2001

ARTERI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ARTERI

- **Cabang Media**: memasuki foramen intervertebralis dan menjadi tiga jenis arteri tergantung dari **struktur yang disuplainya**, yakni sebagai berikut:

1. **Arteri radiculomeningeal** atau **arteri radicular**: terdapat pada setiap segmen vertebra dan mensuplai duramater.
2. **Arteri radiculopial**: tidak terdapat di seluruh segmen (berjumlah 10-12) yang mensuplai arteri spinalis posterior.
3. **Arteri radiculomedullaris**: tidak terdapat di seluruh segmen (berjumlah 2-14) yang mensuplai arteri spinalis anterior (*ventral spinal artery*).

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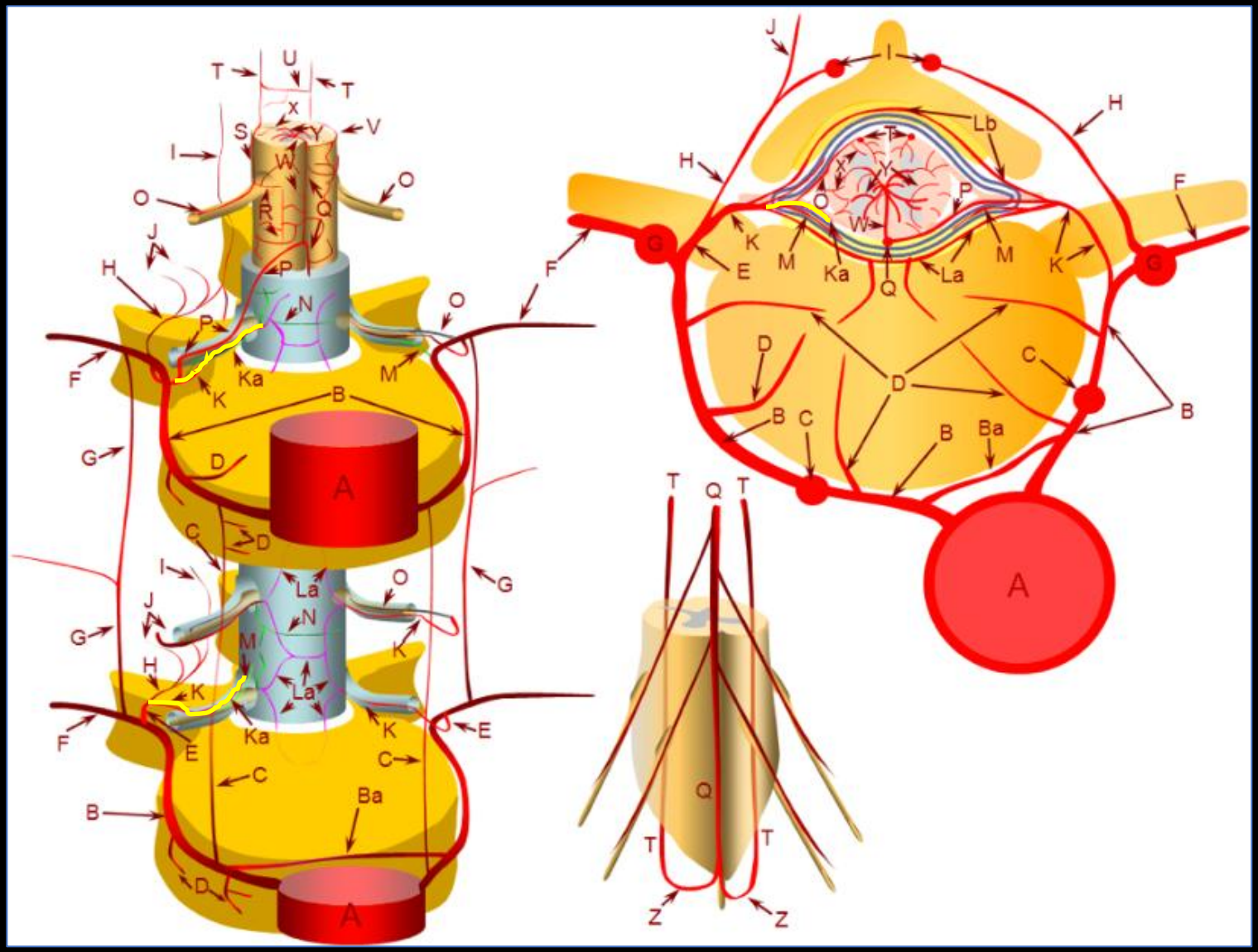
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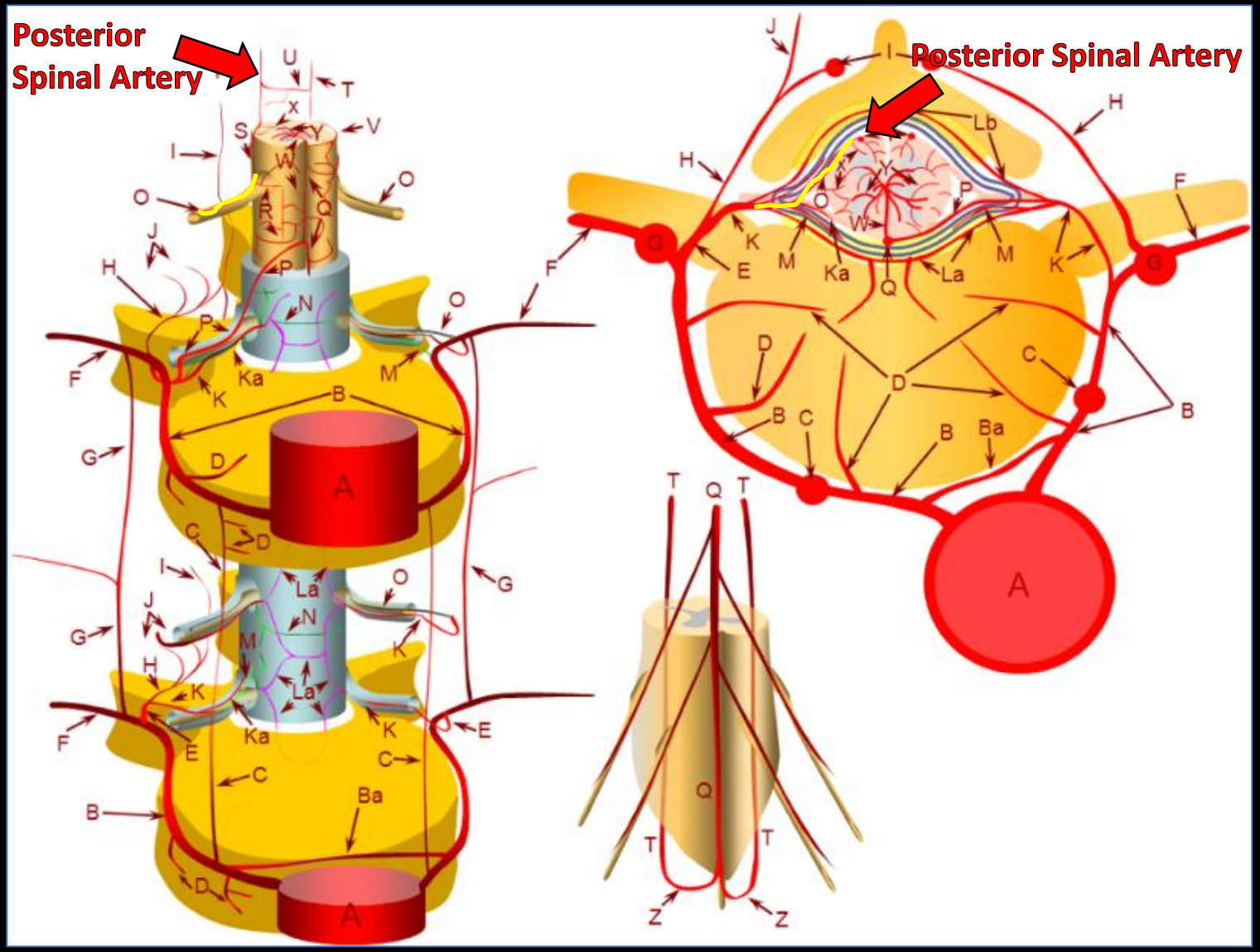

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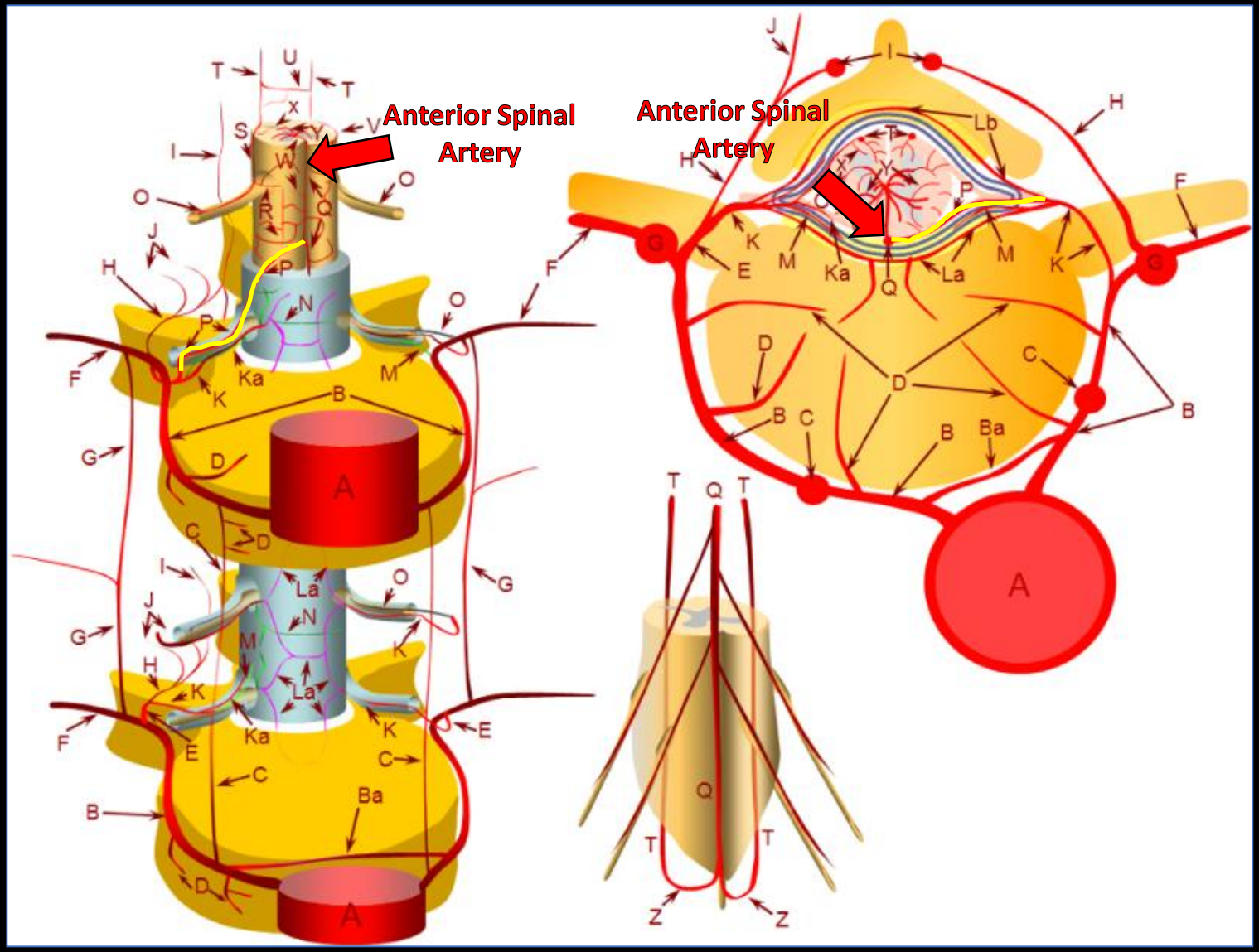
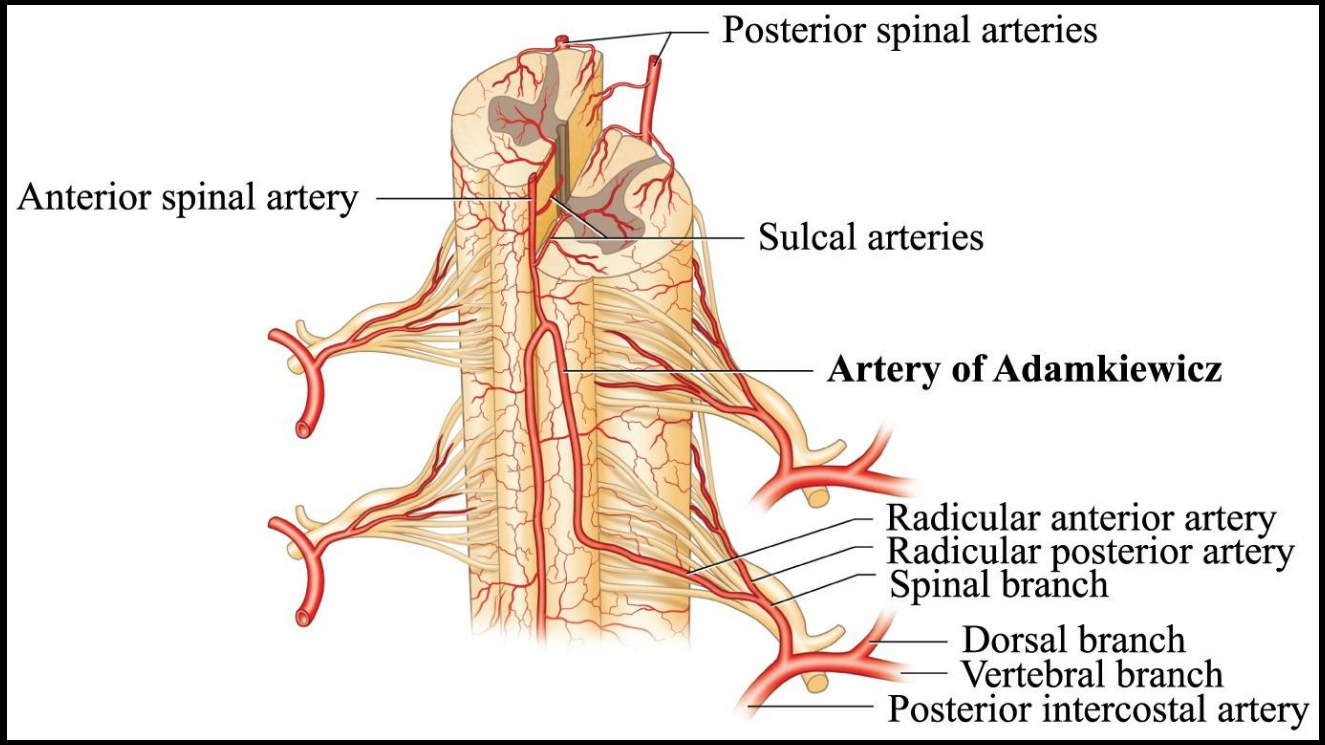


ARTERI

Arteri radiculomedullaris:

Arteri radiculomedullaris yang terbesar disebut juga sebagai arteri radicula magna of Adamkiewicz yang berlokasi pada **T9-T12** pada **75%** **populasi** dan **80%** berasal dari sebelah **kiri**.



ARTERI

Medula spinalis disuplai arteri intrinsik:

1. **Arteri sulcal** atau **sulcocommissural**

   Berasal dari arteri spinalis anterior

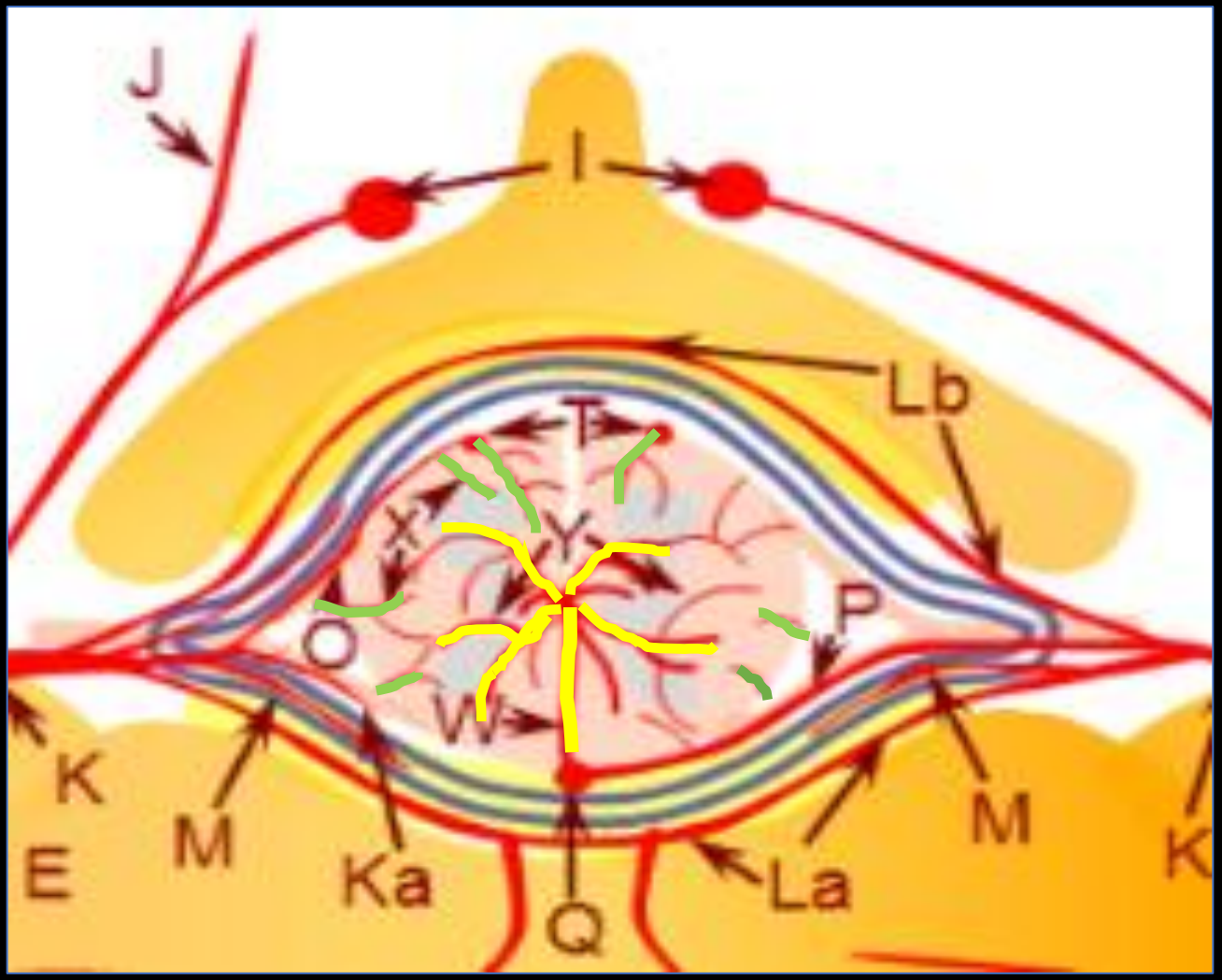
   Sentrifugal.

2. **Arteri radial perforata**

   Berasal dari arteri spinalis posterior dan pleksus pial

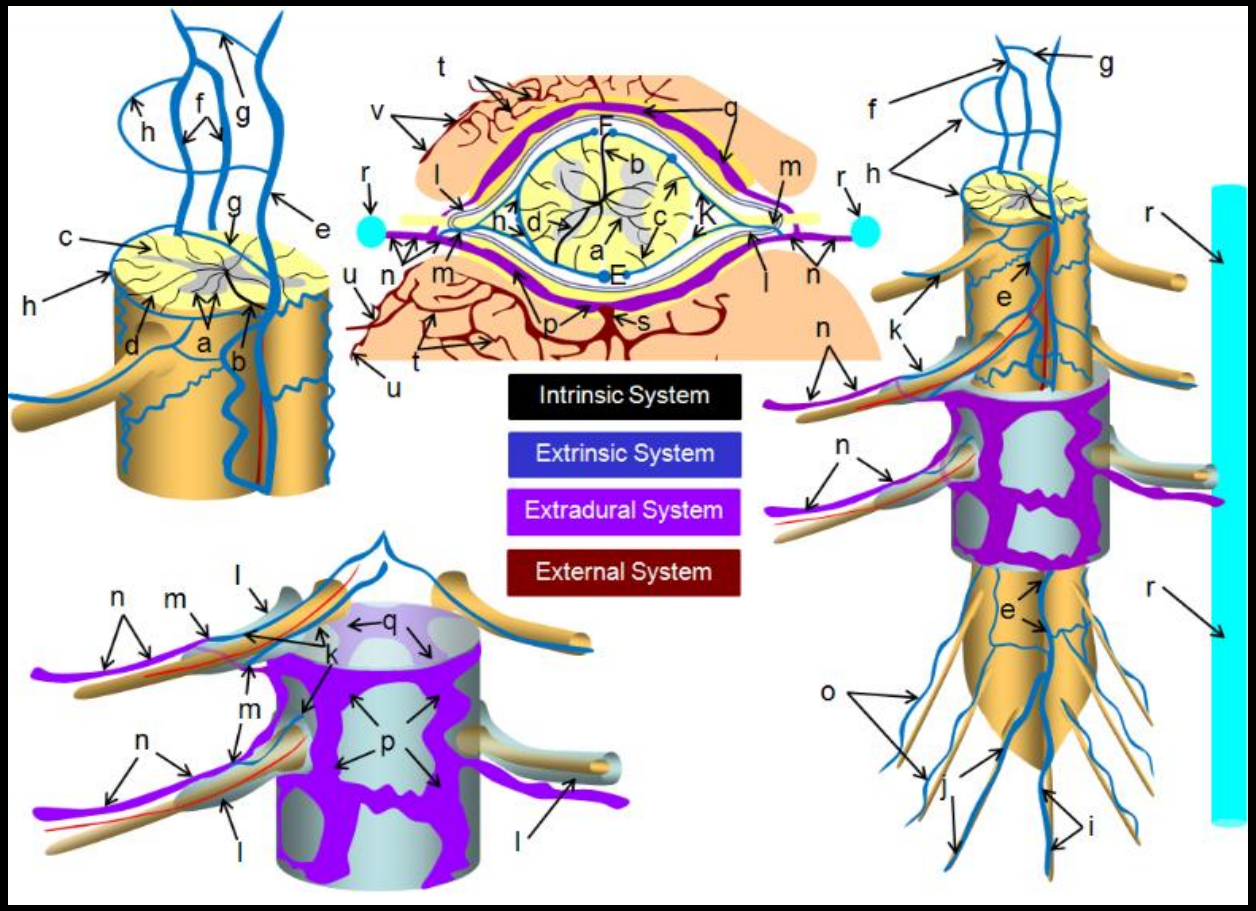
   Sentripetal.

ARTERI

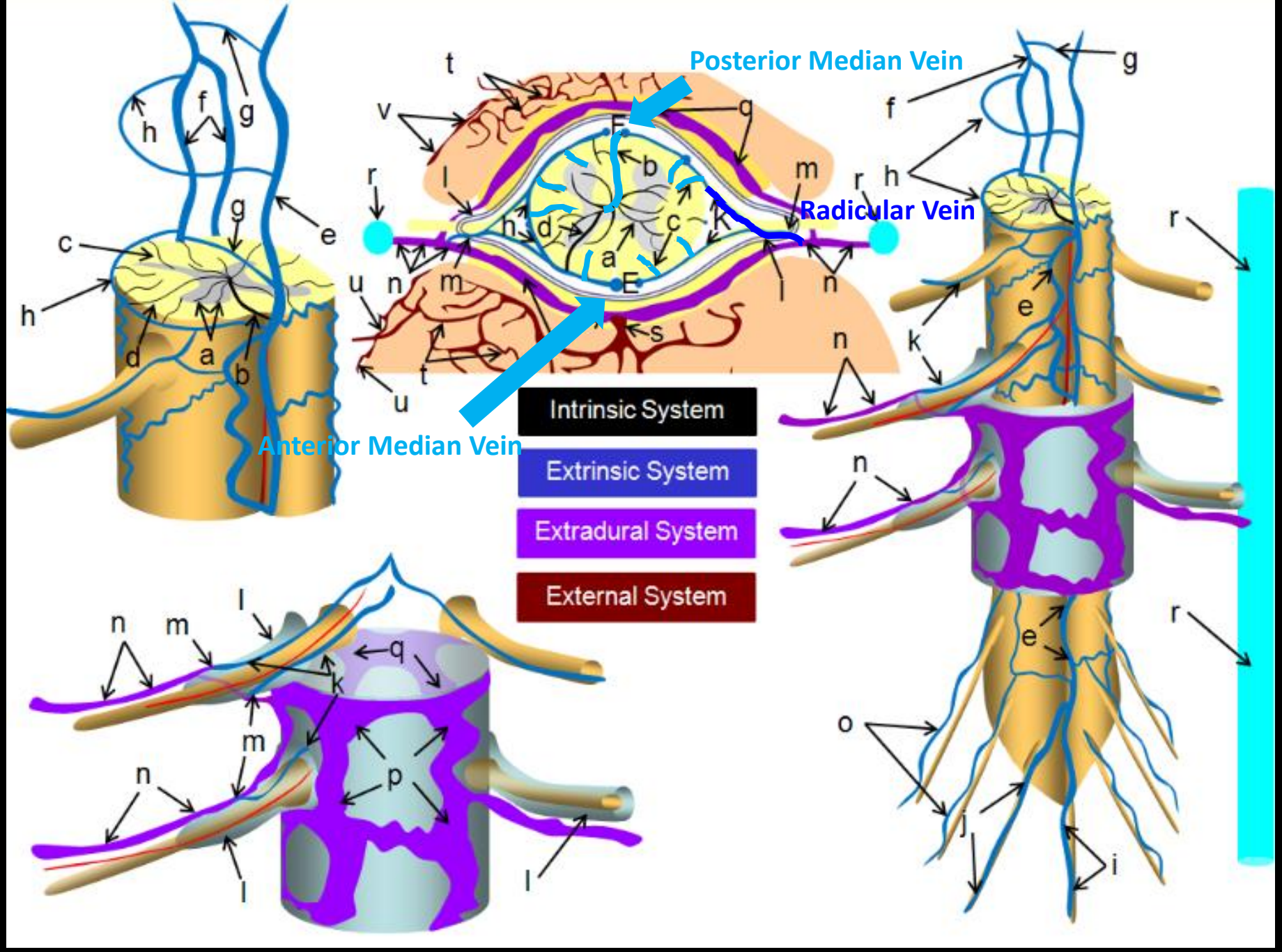


VENA

- Sistem vena berbeda dengan arteri karena vena tidak mengikuti sepenuhnya perjalanan arteri.
- **Vena intrinsik** terdiri:
  - Vena sulcal: drainase bagian sentral sisi ipsilateral medula spinalis sekitar sulcus sentralis.
  - Vena radial: drainase bagian perifer.
- Vena intrinsik akan bermuara ke **vena anterior mediana**, **vena posterior mediana** serta **vena posterolateral kanan dan kiri**.
- Vena-vena tersebut kemudian akan bermuara ke **vena radikular** atau **radikulomedularis** yang melewati foramen intervertebralis menuju **pleksus paravertebra** dan **intervertebra**



Keterangan: a –centripetal network of veins, predominantly draining the gray matter into: b – central (sulcal) veins of the intrinsic system; c – peripheral (radial, a.k.a. marginal) centrifugal veins of the intrinsic system; d – venous anastomosis between the centripetal and centrifugal systems; e – anterior (ventral) median vein; f – posterior (dorsal) median vein; g – transmedullary anastomosis between dorsal and ventral median venous systems; h – extrinsic surface anastomosis between dorsal and ventral median veins; i – vein of filum terminale; j – dominant radicular vein of the cauda equina; k – radicular vein (this is the weak link between the cord venous system and the extradural space); l – nerve root sleeve; m – shallow angle of radicular vein piercing the dura of the nerve root sleeve; n – intervertebral vein; o – radicular veins of the cauda equina; p – anterior epidural (a.k.a. ventral intrinsic) venous plexus; q – posterior epidural (a.k.a. dorsal intrinsic) venous plexus; r – ascending spinal (lumbar) vein; s – basivertebral vein, draining the intravertebral body venous plexus (t); u – anterior extrinsic venous plexus surrounding the surface of the vertebral body; v – posterior extrinsic venous plexus on the surface of the lamina /posterior elements, also participating in drainage of the paraspinal muscles


Posterior Median Vein
Radicular Vein
Anterior Median Vein
Intrinsic System
Extrinsic System
Extradural System
External System

KLASIFIKASI MALFORMASI VASKULAR SPINALIS

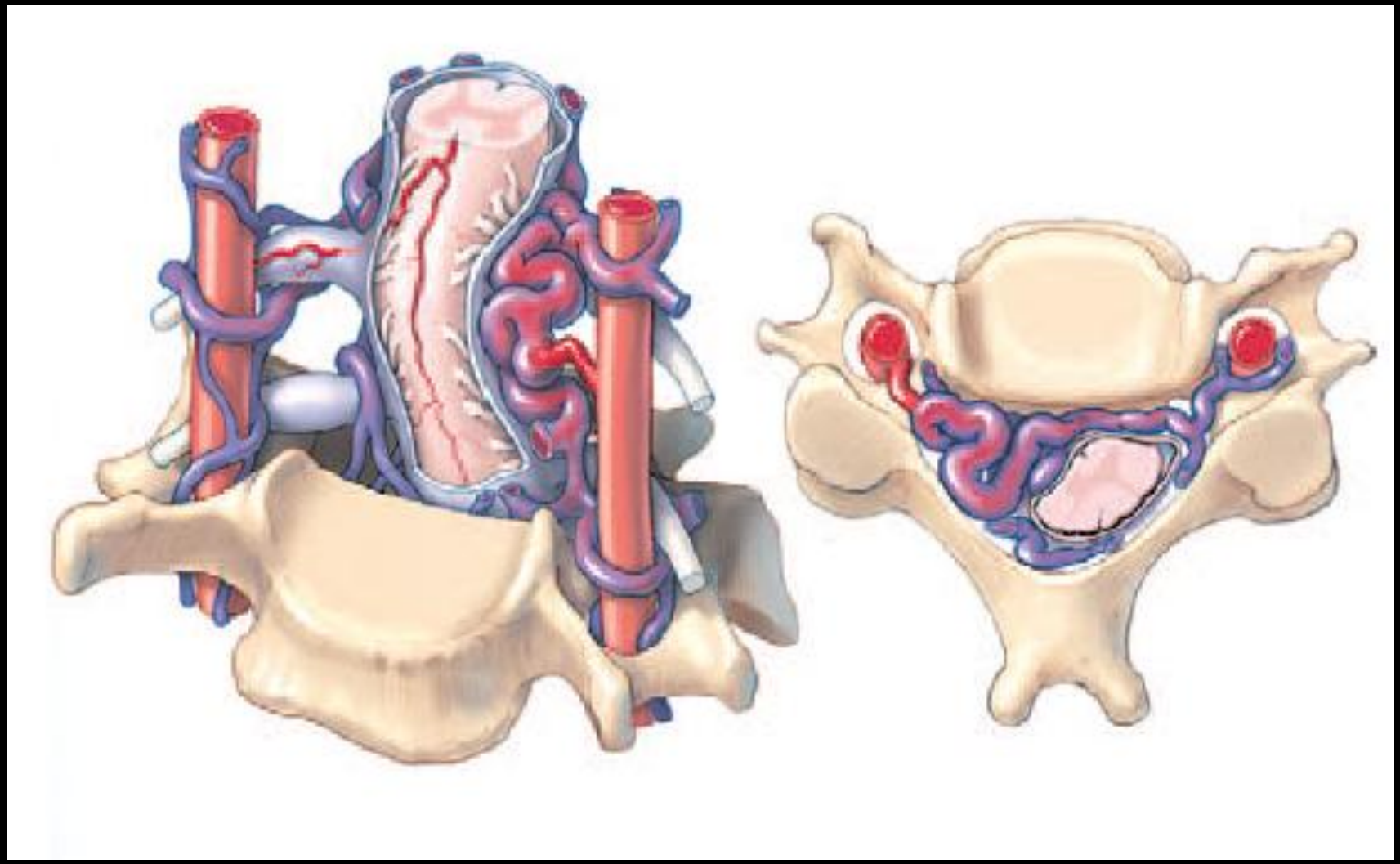
Anson Spletzer:

Tipe	Kelainan
Tipe I	Spinal dural arteriovenous fistula (SDAVF)
Tipe II	Glomus type of intramedullary AVM
Tipe III	Juvenile type of intramedullary AVM
Tipe IV	Perimedullary arteriovenous fistula
IVA	Microfistula with single arterial feeder
IVB	Fistula with multiple feeder
IVC	Macrofistula with multiple feeders and venous sacs

Anson, J.A. and Spetzler, R.F. (1992) Classification of Spinal Arteriovenous Malformations and Implications for Treatment.

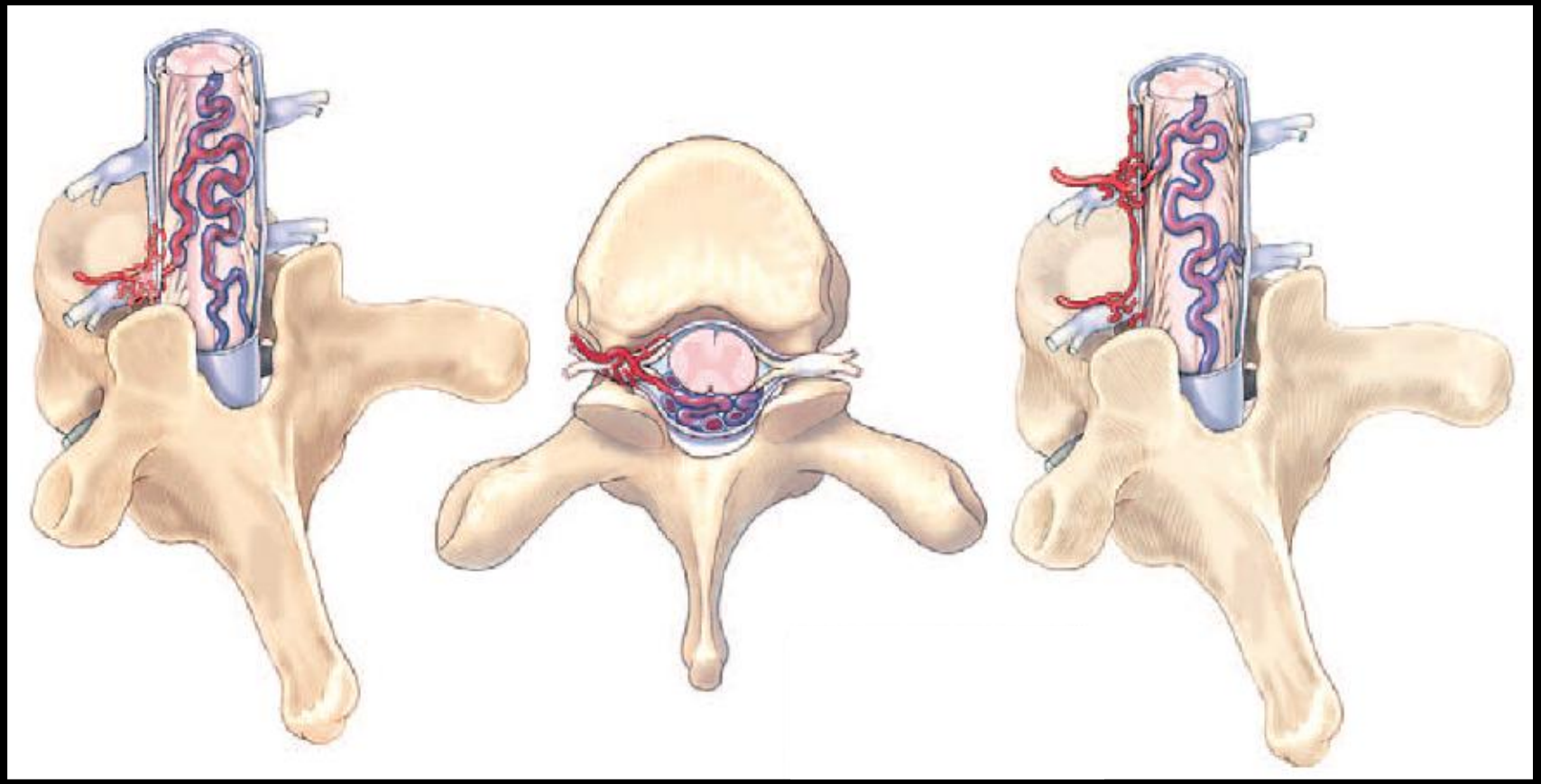
Klasifikasi Modifikasi Robert F. Spletzer			Anson Spletzer
Neoplastic Vascular Lesion	Hemangioblastoma		
	Cavernous malformation		
Spinal Aneurysm			
Arteriovenous Fistula	Extradural		
	Intradural	Ventral	Tipe IV
		Dorsal	Tipe I
Arteriovenous Malformation	Extradural-Intradural		Tipe III
	Intradural	Intramedullary	Tipe II
		Compact	
		Diffuse	
		Conus medullaris	

Extradural Arteriovenous Fistula



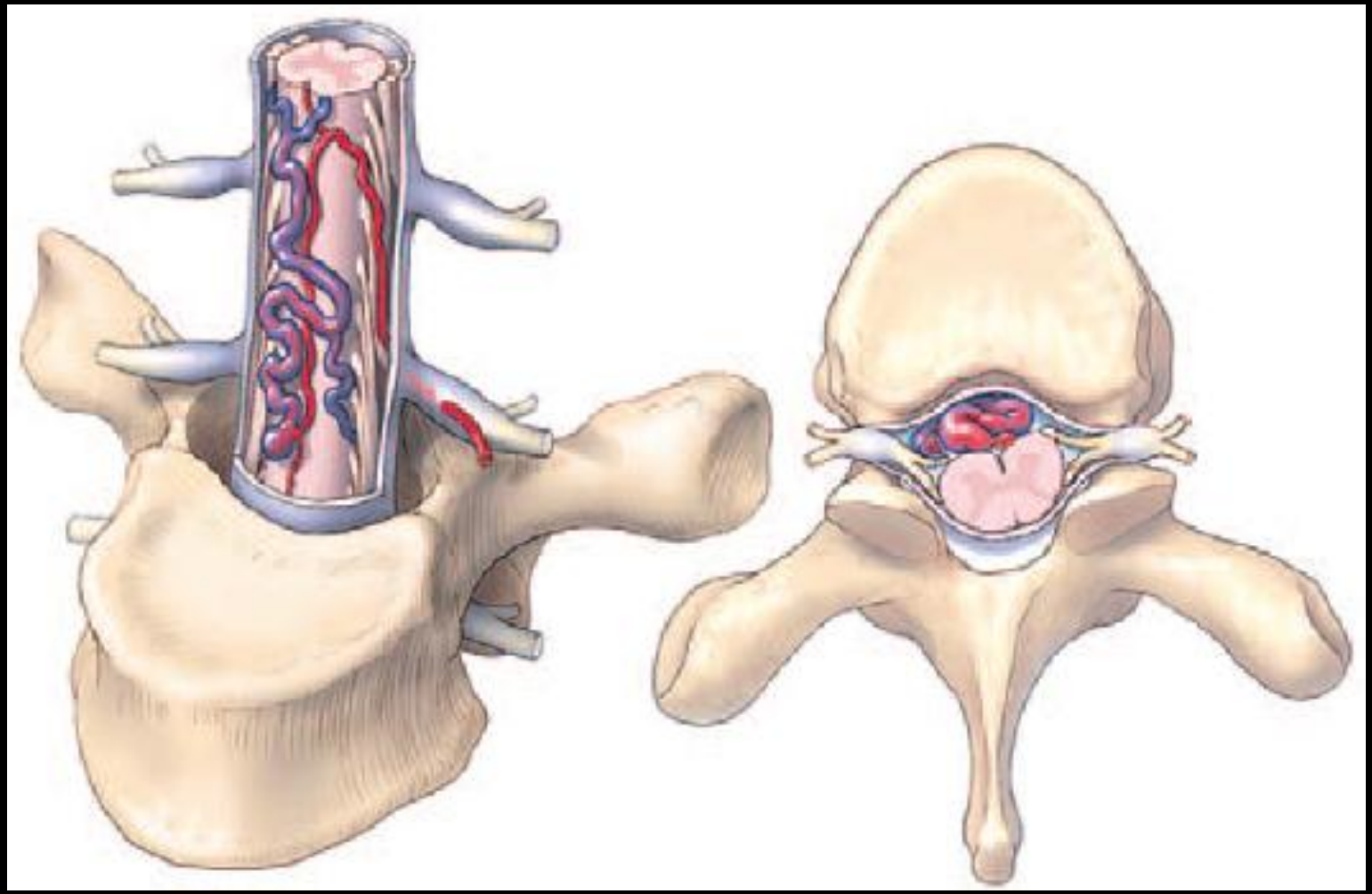
Spetzler RF, Detwiler PW, Riina HA, Porter RW. 2002. Modified Classification of Spinal Cord Vascular Lesion.

Intradural Dorsal Arteriovenous Fistula



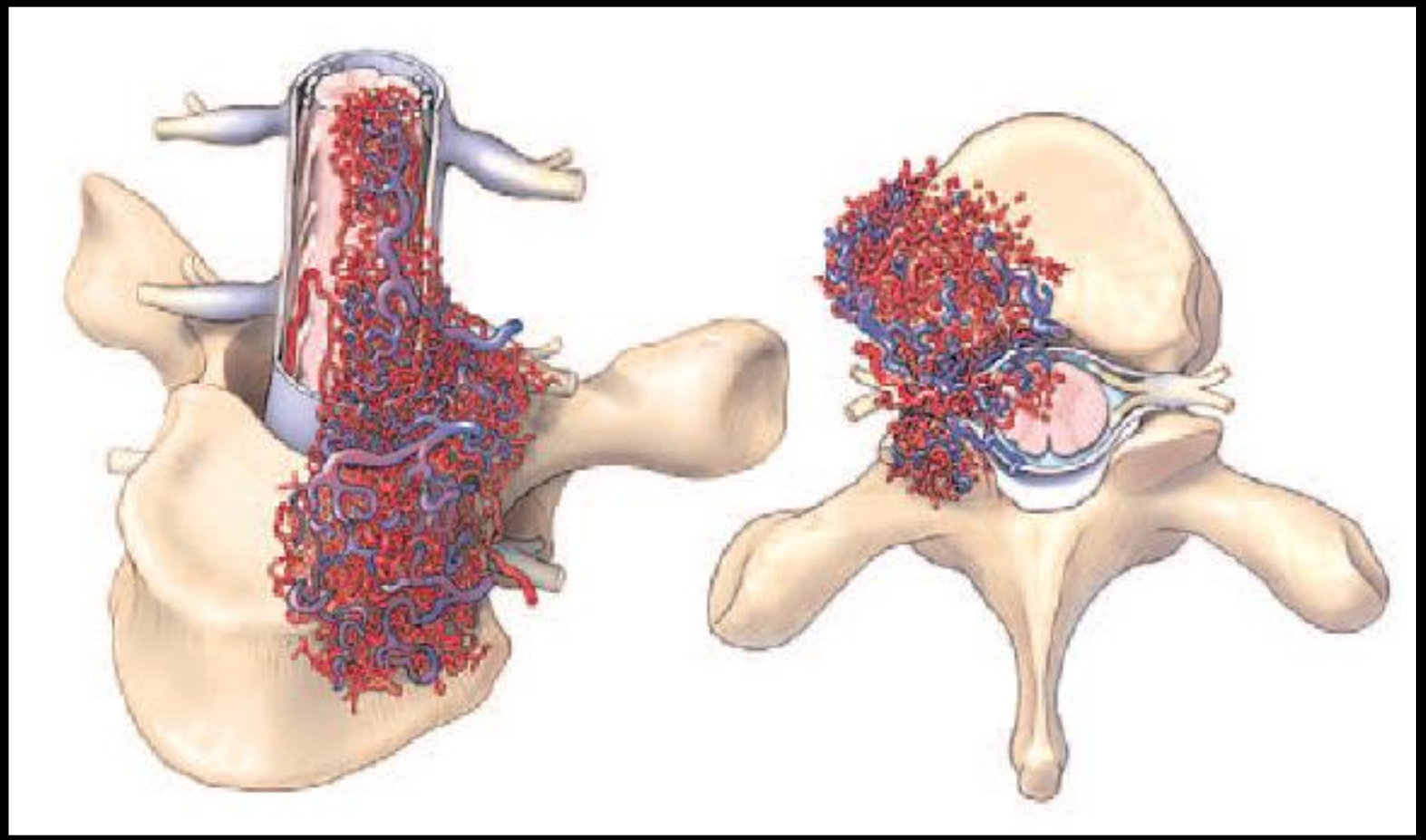
Spetzler RF, Detwiler PW, Riina HA, Porter RW. 2002. Modified Classification of Spinal Cord Vascular Lesion.

Intradural Ventral Arteriovenous Fistula



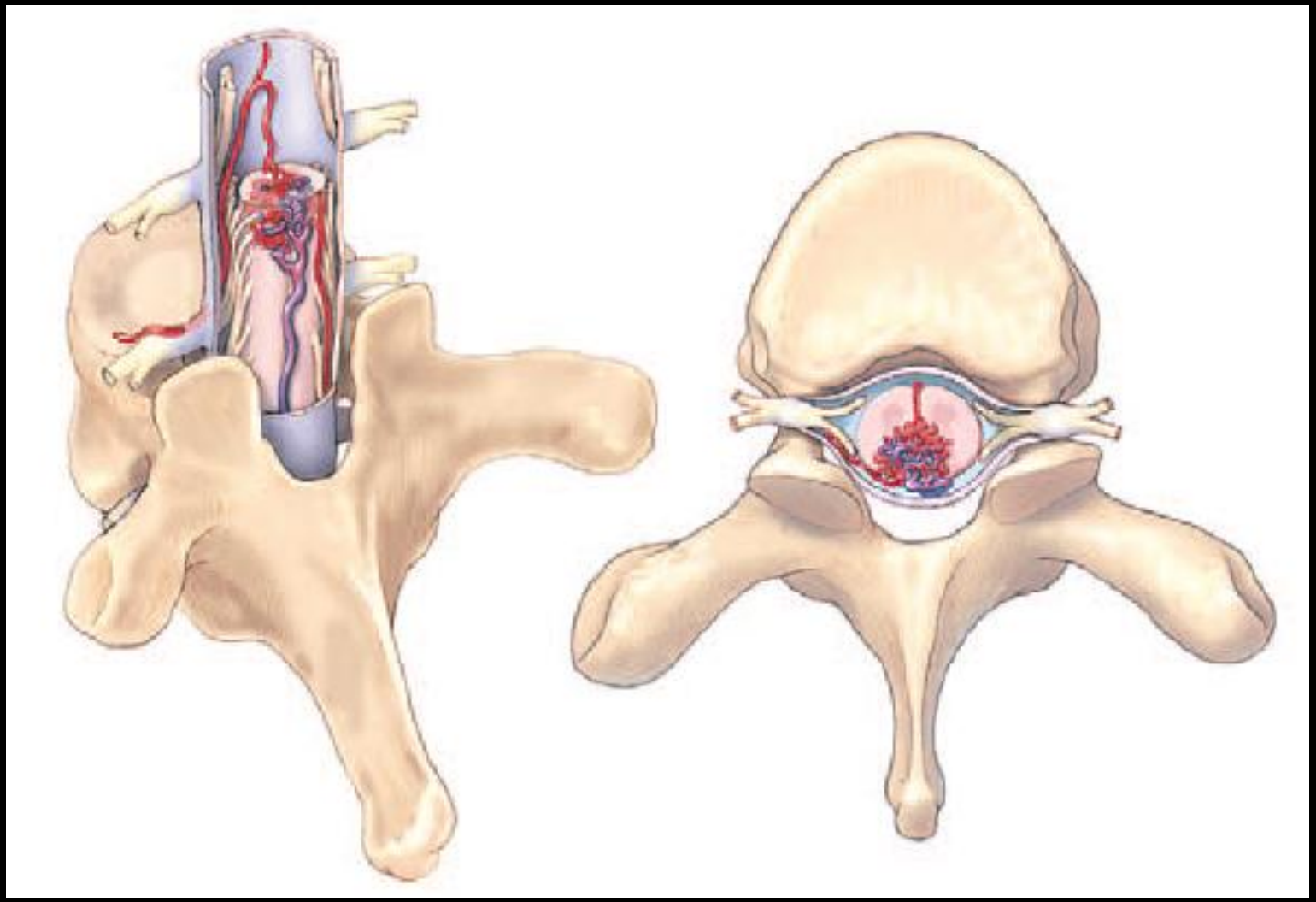
Spetzler RF, Detwiler PW, Riina HA, Porter RW. 2002. Modified Classification of Spinal Cord Vascular Lesion.

Intradural Extradural Arteriovenous Malformation



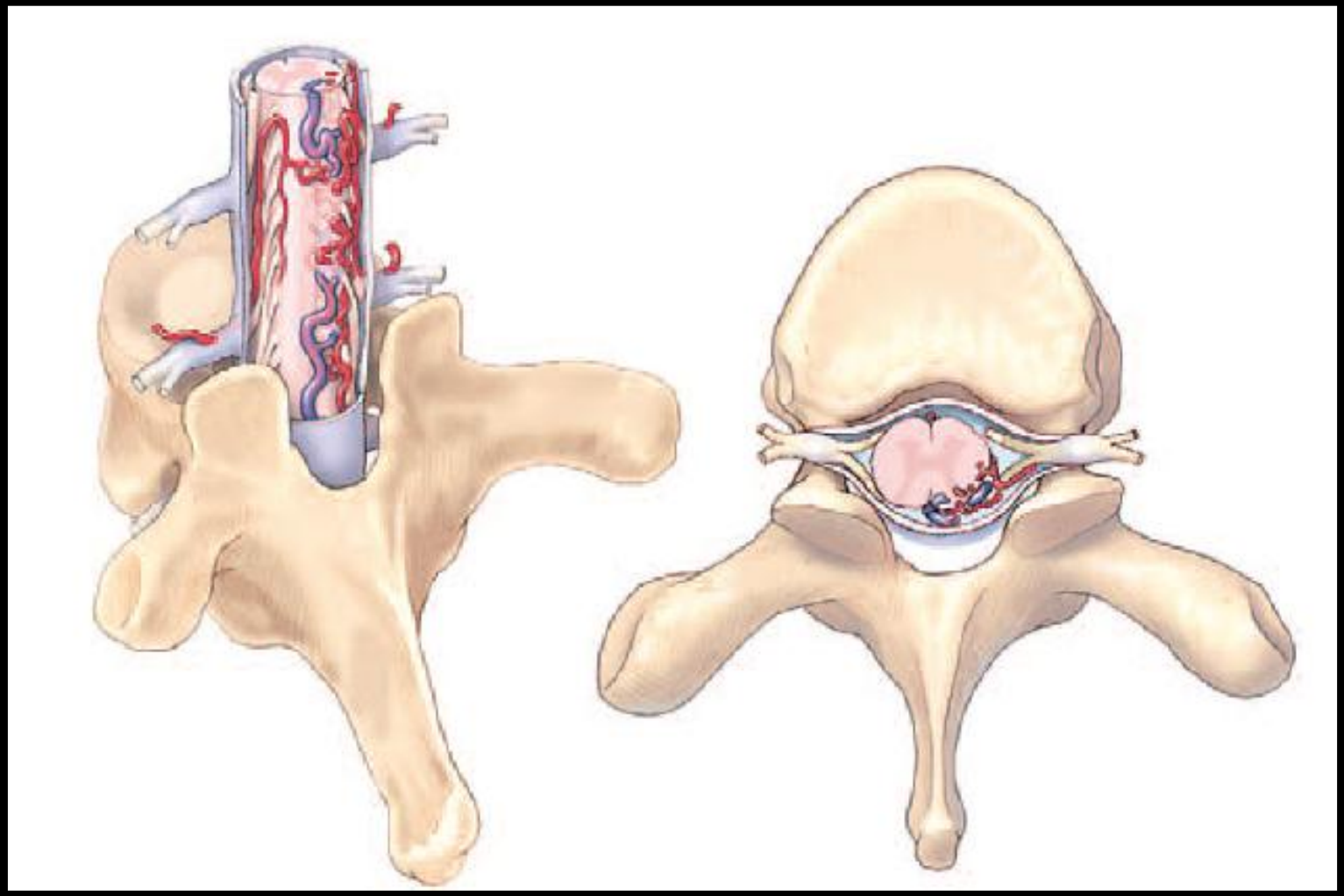
Spetzler RF, Detwiler PW, Riina HA, Porter RW. 2002. Modified Classification of Spinal Cord Vascular Lesion.

Intramedullary Arteriovenous Malformation (Compact)



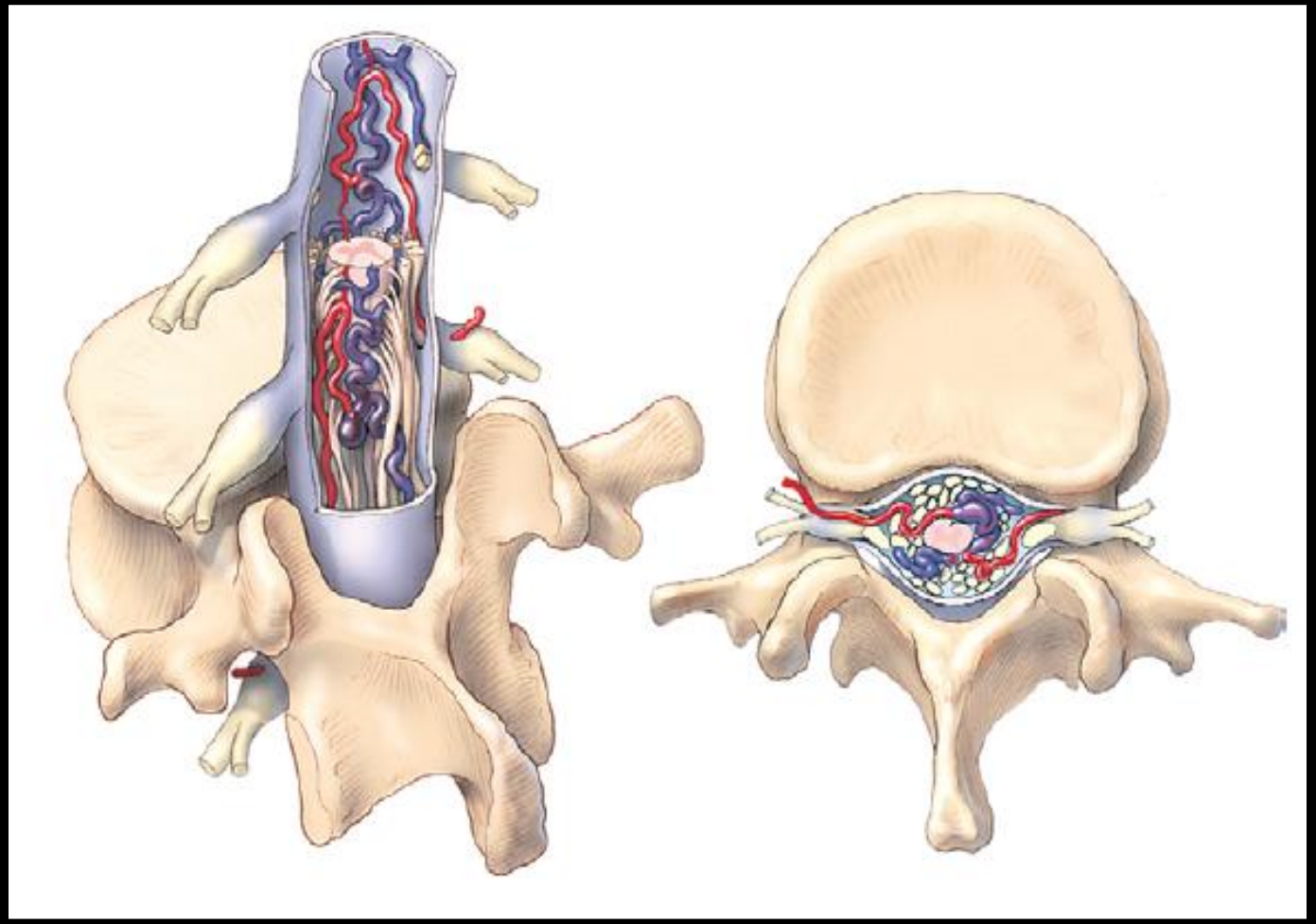
Spetzler RF, Detwiler PW, Riina HA, Porter RW. 2002. Modified Classification of Spinal Cord Vascular Lesion.

Intramedullary Arteriovenous Malformation (Diffuse)

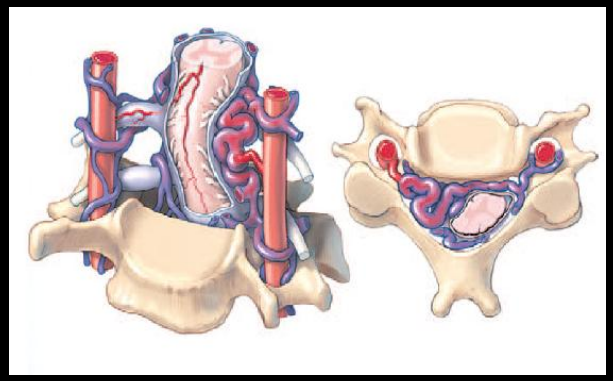


Spetzler RF, Detwiler PW, Riina HA, Porter RW. 2002. Modified Classification of Spinal Cord Vascular Lesion.

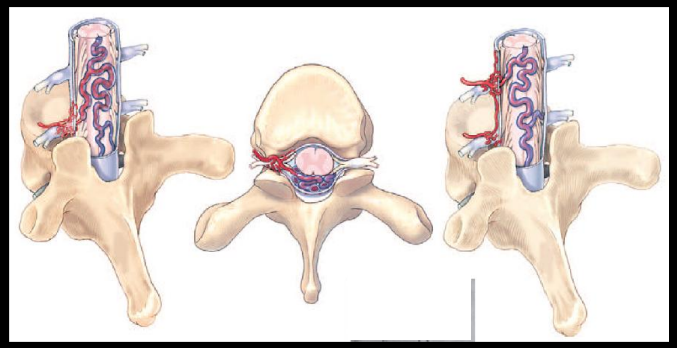
Conus Medullaris Arteriovenous Malformation



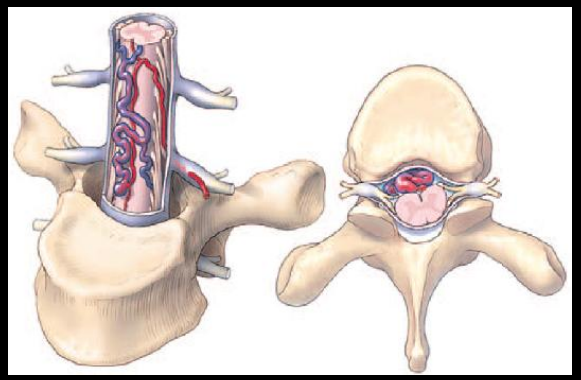
Spetzler RF, Detwiler PW, Riina HA, Porter RW. 2002. Modified Classification of Spinal Cord Vascular Lesion.



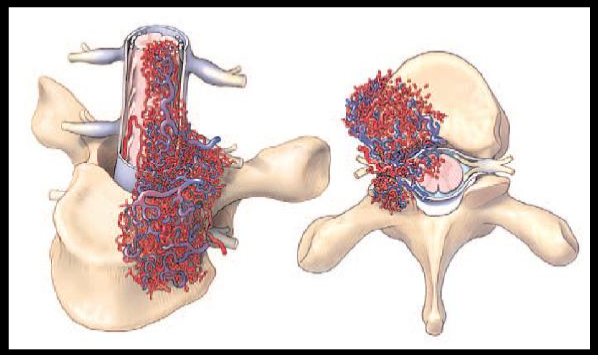
Extradural
Arteriovenous Fistula



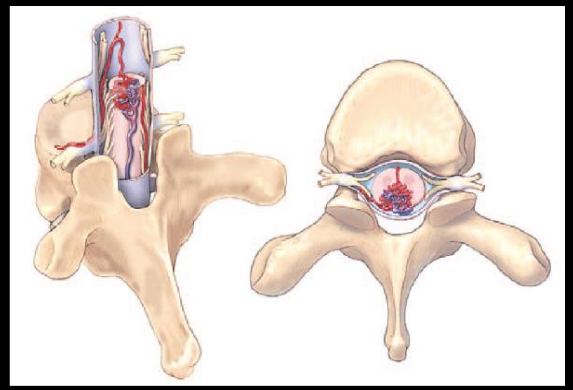
Intradural Dorsal Arteriovenous Fistula



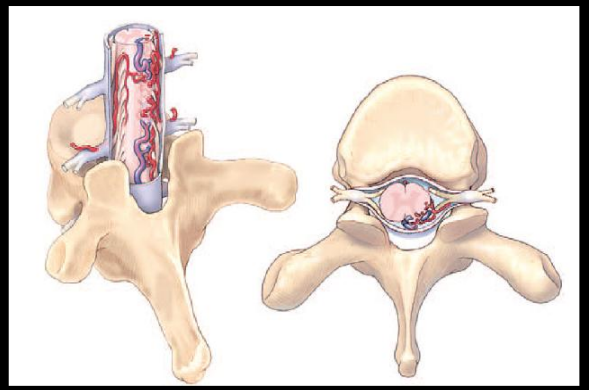
Intradural Ventral
Arteriovenous Fistula



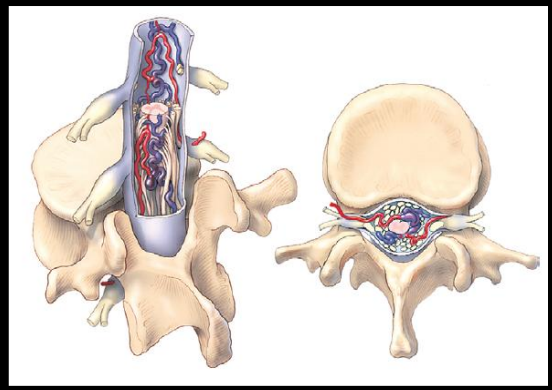
Intradural Extradural Arteriovenous Malformation



Intramedullary Arteriovenous Malformation (Compact)



Intramedullary Arteriovenous
Malformation (Diffuse)



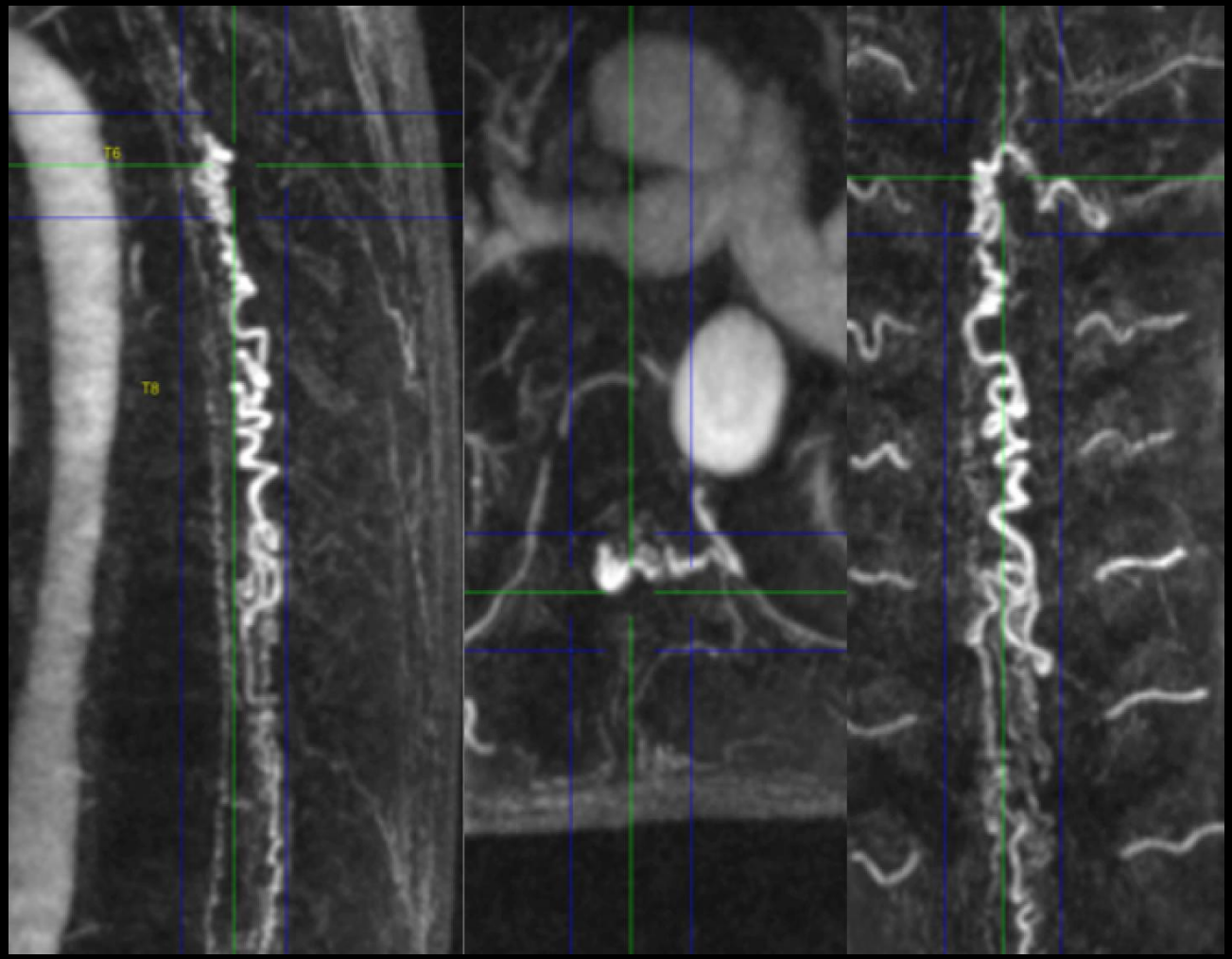
Conus Medullaris
Arteriovenous Malformation

KASUS I
SDAVF dengan MRA teknik CEMRA elliptic centric

- Wanita 42 tahun
- Keluhan: paraplegia yang progresif dalam beberapa bulan.
- T2WI:
  - Lesi hiperintens intramedula setinggi vertebra Th.8-L1 yang melibatkan konus medularis.
  - Lesi flow void tubular berkelok-kelok di posterior medula spinalis.
- MRA:
  - Lesi vaskular di aspek posterior medula spinalis setinggi vertebra Th.6-L1
  - Tanpa gambaran nidus
  - Arterial feeder: arteri segmental dan radikulomeningeal yang melalui foramen intervertebralis Th.6-7 kiri

KASUS I
SDAVF dengan MRA teknik CEMRA elliptic centric

KASUS I
SDAVF dengan MRA teknik CEMRA elliptic centric

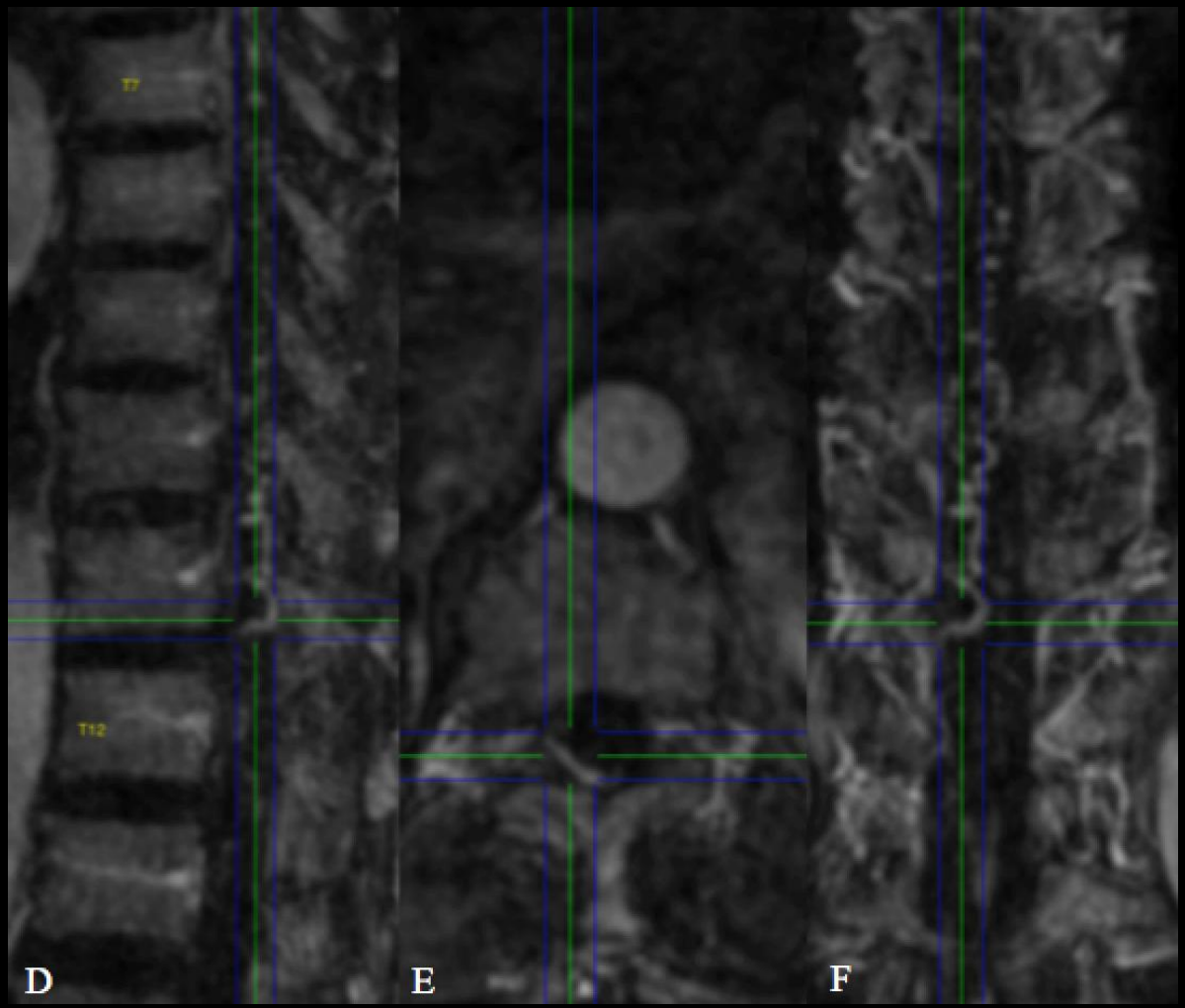


KASUS II
SDAVF dengan MRA teknik TRICKS 1.5T

- Pria 53 tahun
- Keluhan sakit di punggung dan gangguan berjalan.
- T2WI:
  - Lesi hiperintens intramedula setinggi vertebra Th.3-L1 yang melibatkan konus medularis.
  - Lesi flow void tubular berkelok-kelok di daerah posterior medula spinalis.
- MRA:
  - Lesi vaskular di aspek posterior medula spinalis
  - Tanpa gambaran nidus
  - Arterial feeder: arteri segmental dan radikulomeningeal yang melalui foramen intervertebralis Th.11-12 kanan.

KASUS II
SDAVF dengan MRA teknik TRICKS 1.5T

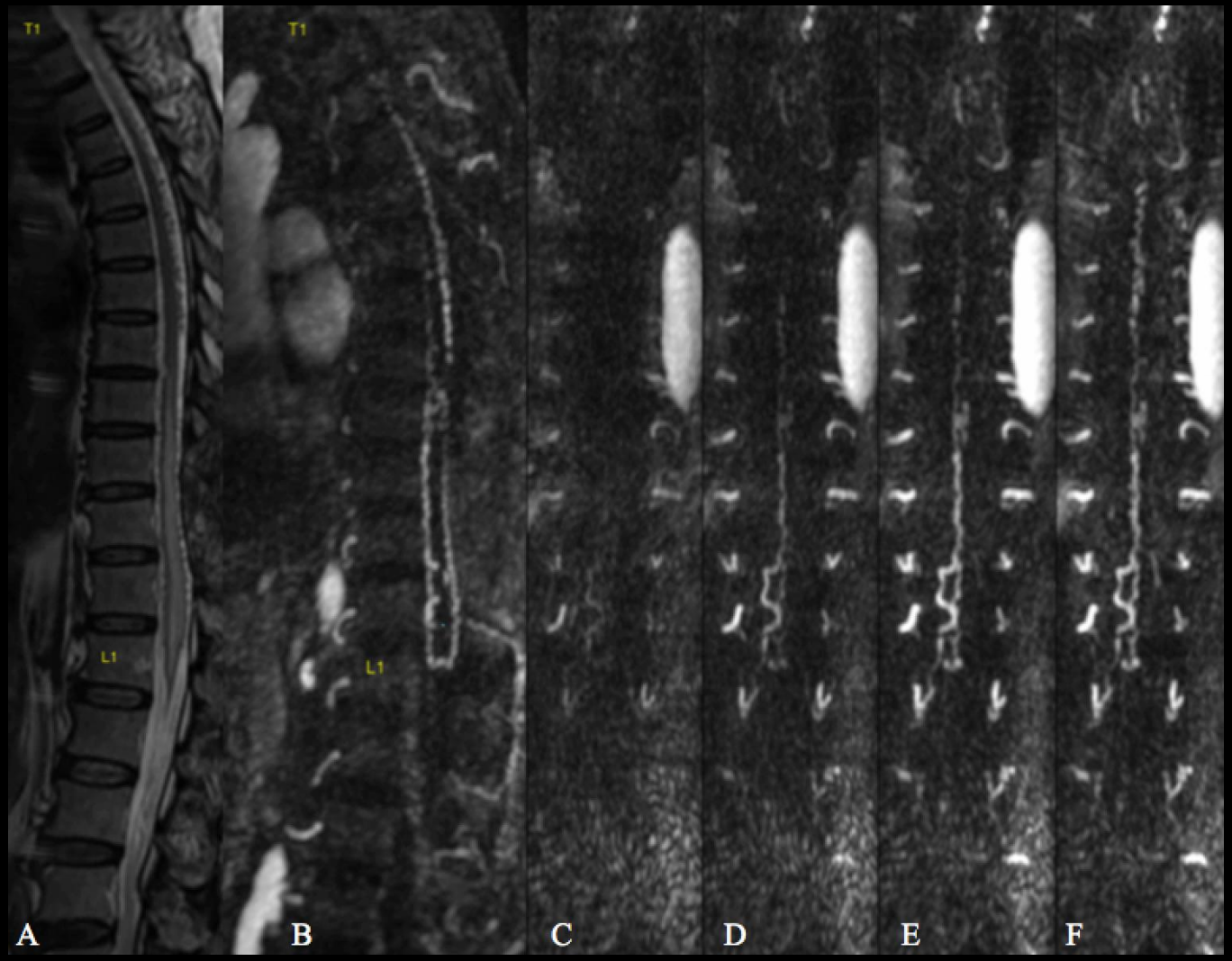
KASUS II
SDAVF dengan MRA teknik TRICKS 1.5T



KASUS III
SDAVF dengan MRA teknik TRICKS 1.5T

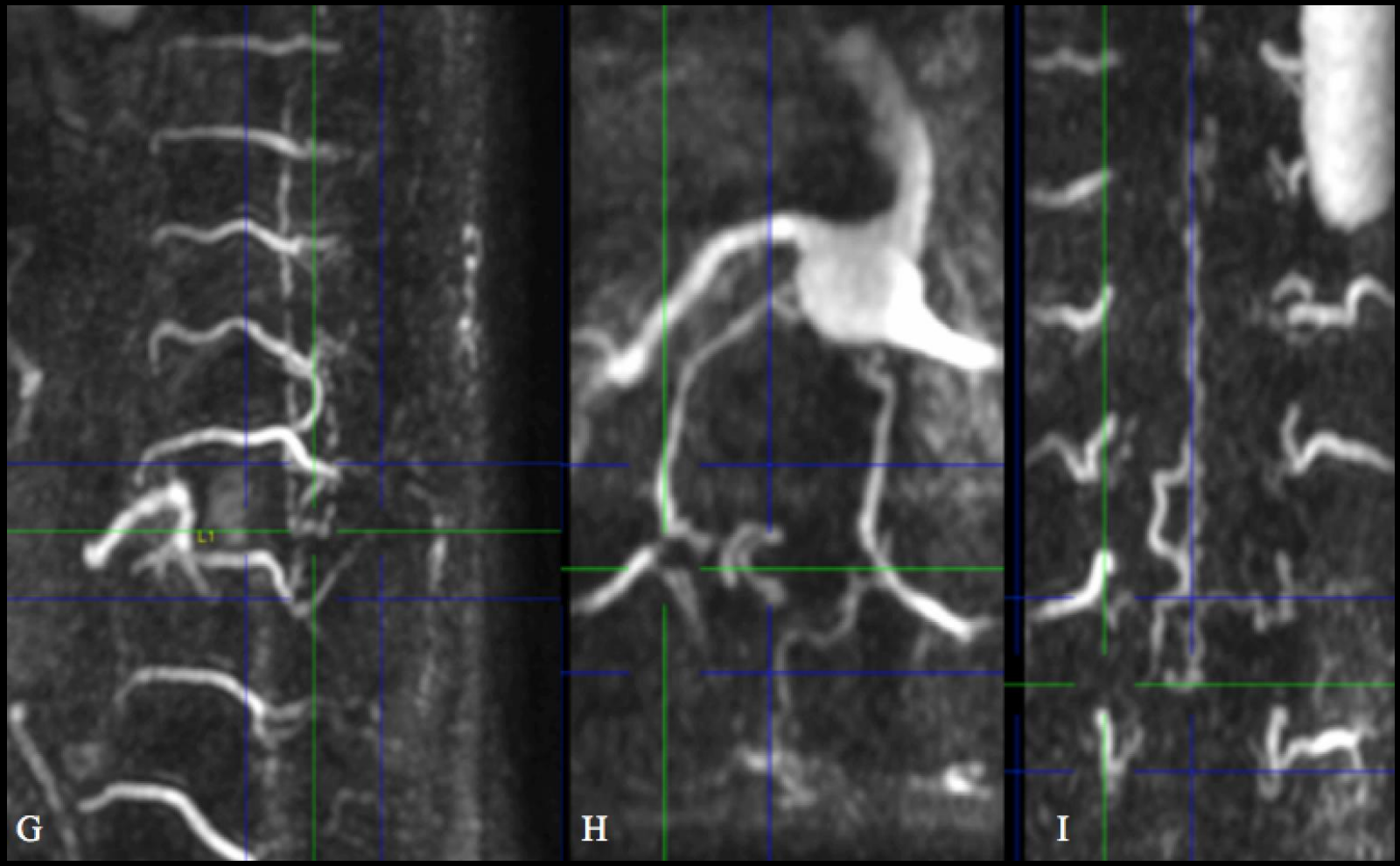
- Pria 64 tahun
- Keluhan kelemahan tungkai.
- T2WI:
  - Lesi hiperintens intramedula setinggi vertebra Th.8-L1 yang melibatkan konus medularis.
  - Lesi flow void tubular berkelok-kelok di daerah posterior medula spinalis.
- MRA:
  - Lesi vaskular di aspek anterior dan posterior medula spinalis
  - Tanpa gambaran nidus
  - Arterial feeder: arteri segmental dan radikulomeningeal yang melalui foramen intervertebralis L1-2 kanan.

KASUS III
SDAVF dengan MRA teknik TRICKS 1.5T



KASUS III

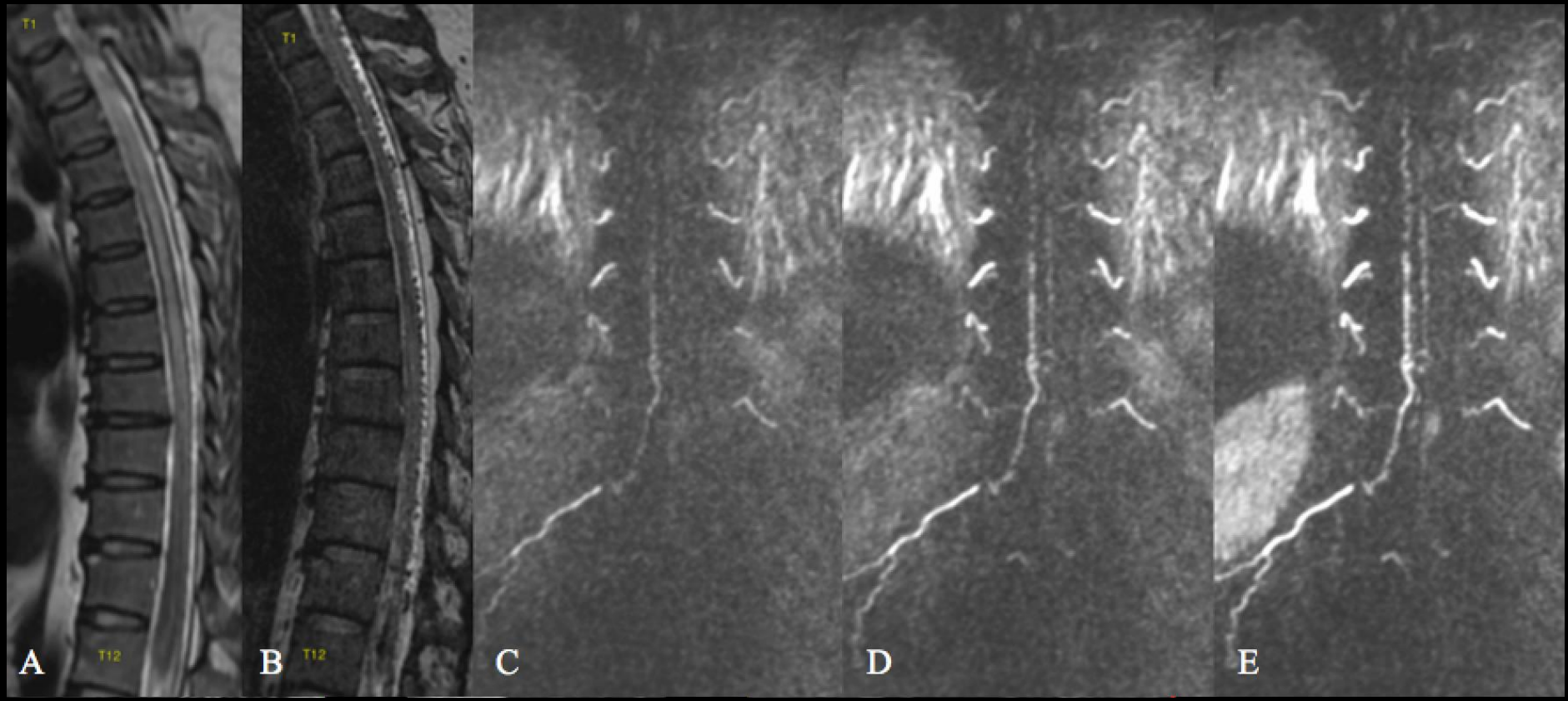
SDAVF dengan MRA teknik TRICKS 1.5T



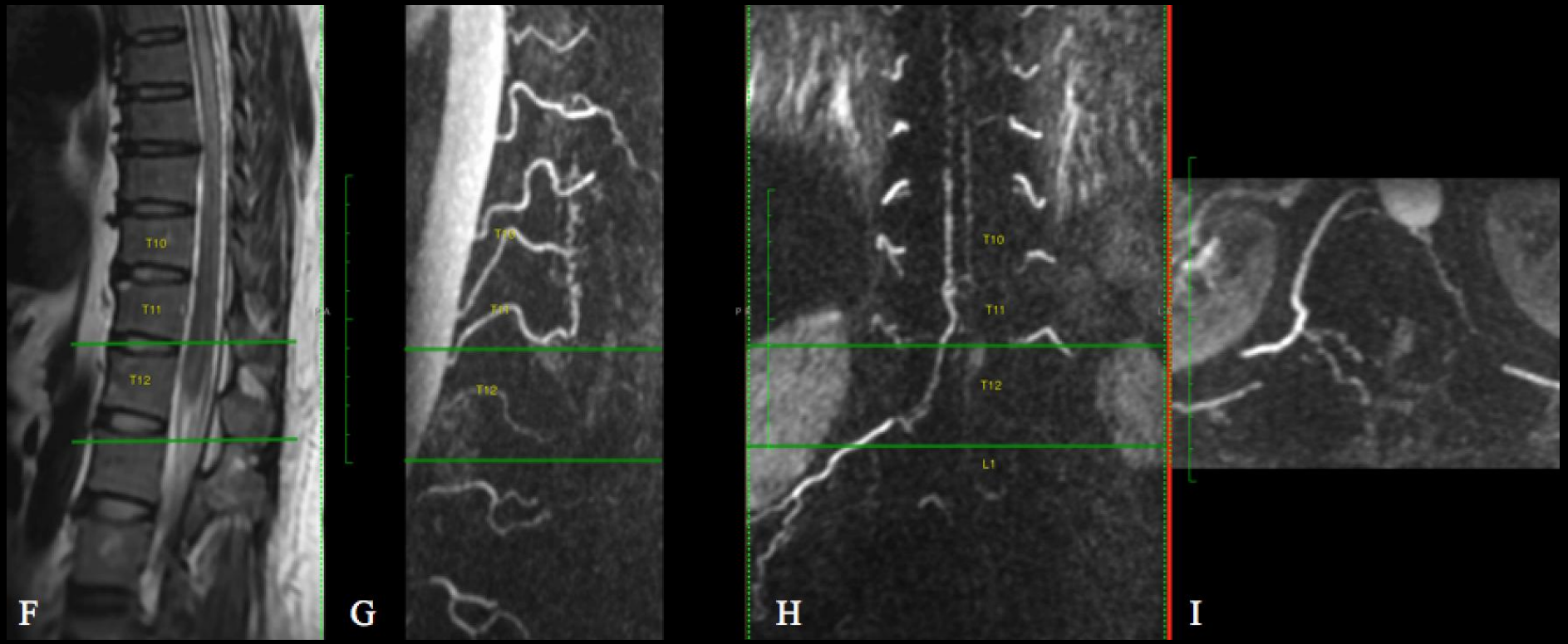
KASUS IV
SDAVF dengan MRA teknik TRICKS 3T

- Pria 43 tahun
- Keluhan kelemahan&baal kedua kaki serta retensio urine&alvi.
- T2WI:
  - Lesi hiperintens intramedula setinggi vertebra Th.1-Th.12 yang melibatkan konus medularis.
  - Lesi flow void tubular berkelok-kelok di daerah posterior medula spinalis.
- MRA:
  - Lesi vaskular di aspek posterior medula spinalis
  - Tanpa gambaran nidus
  - Arterial feeder: arteri segmental dan radikulomeningeal yang melalui foramen intervertebralis Th.12-L1 kanan.

KASUS IV
SDAVF dengan MRA teknik TRICKS 3T



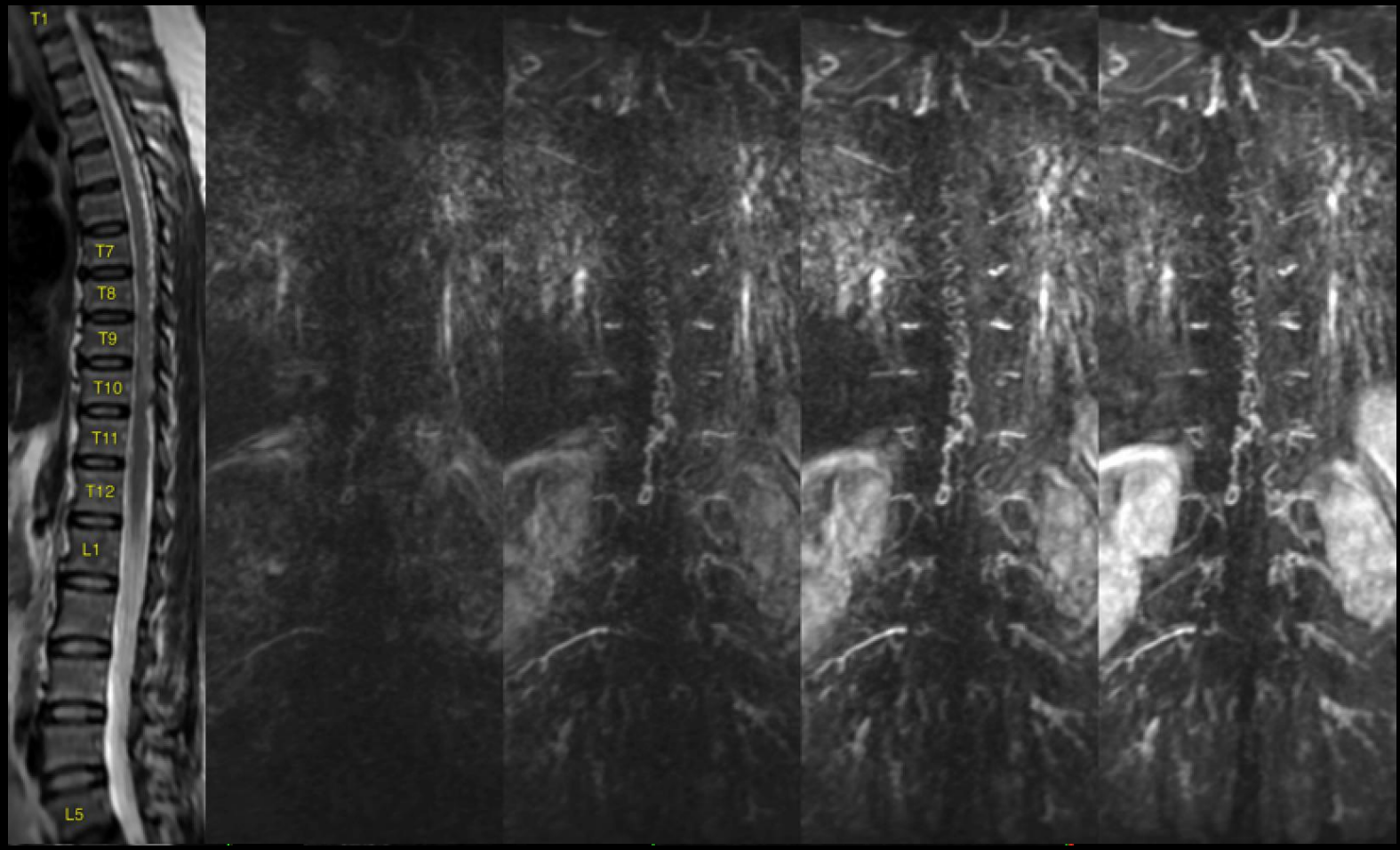
KASUS IV
SDAVF dengan MRA teknik TRICKS 3T



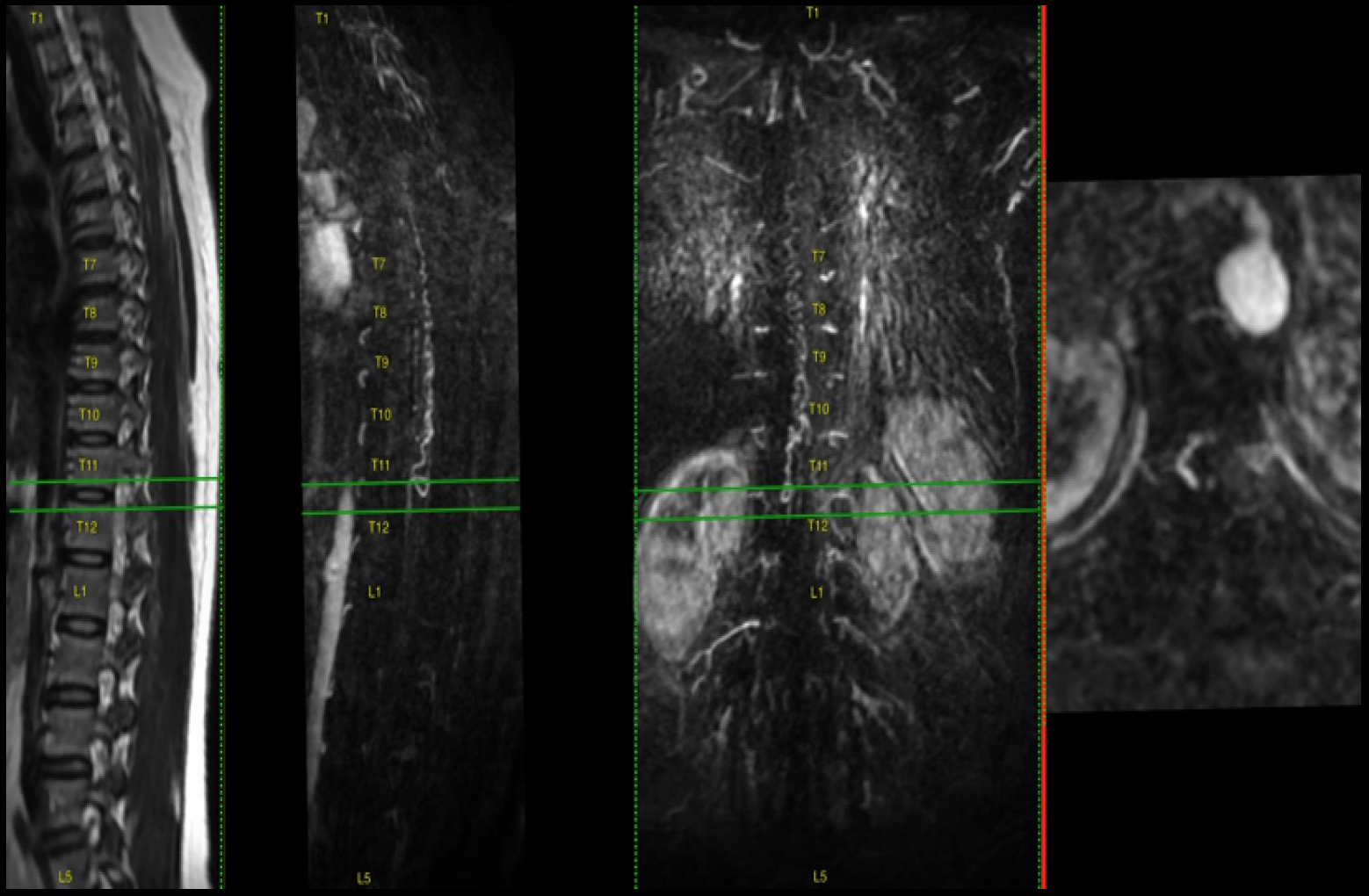
KASUS V
SDAVF dengan MRA teknik TRICKS 3T

- Wanita 48 tahun
- Keluhan nyeri bokong sampai kedua kaki sejak 2 thn.
- T2WI:
  - Lesi hiperintens intramedula setinggi vertebra Th.7-Th.10
  - Lesi flow void tubular berkelok-kelok di daerah posterior medula spinalis.
- MRA:
  - Lesi vaskular di aspek posterior medula spinalis
  - Tanpa gambaran nidus
  - Arterial feeder: arteri segmental dan radikulomeningeal yang melalui foramen intervertebralis Th.11-12 kanan.

KASUS V
SDAVF dengan MRA teknik TRICKS 3T



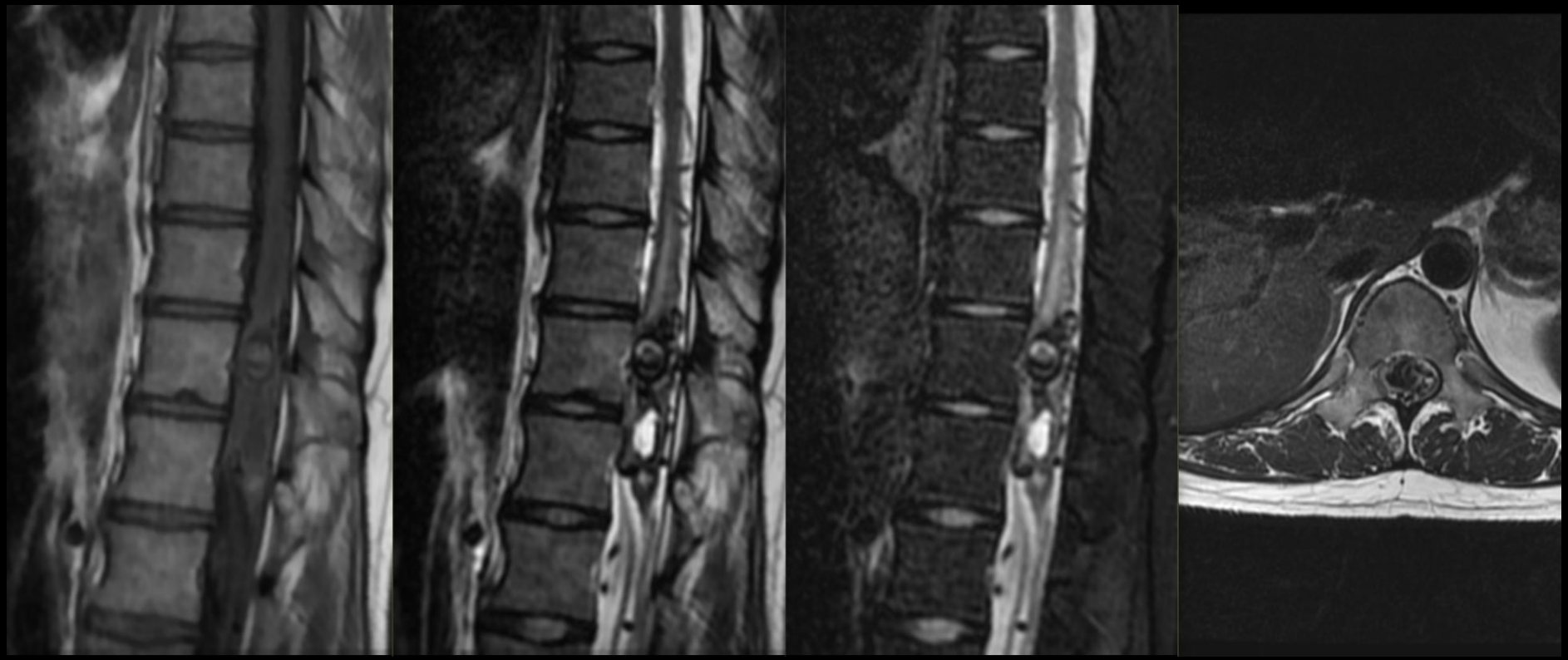
KASUS V
SDAVF dengan MRA teknik TRICKS 3T



KASUS V
SDAVF dengan MRA teknik TRICKS 3T

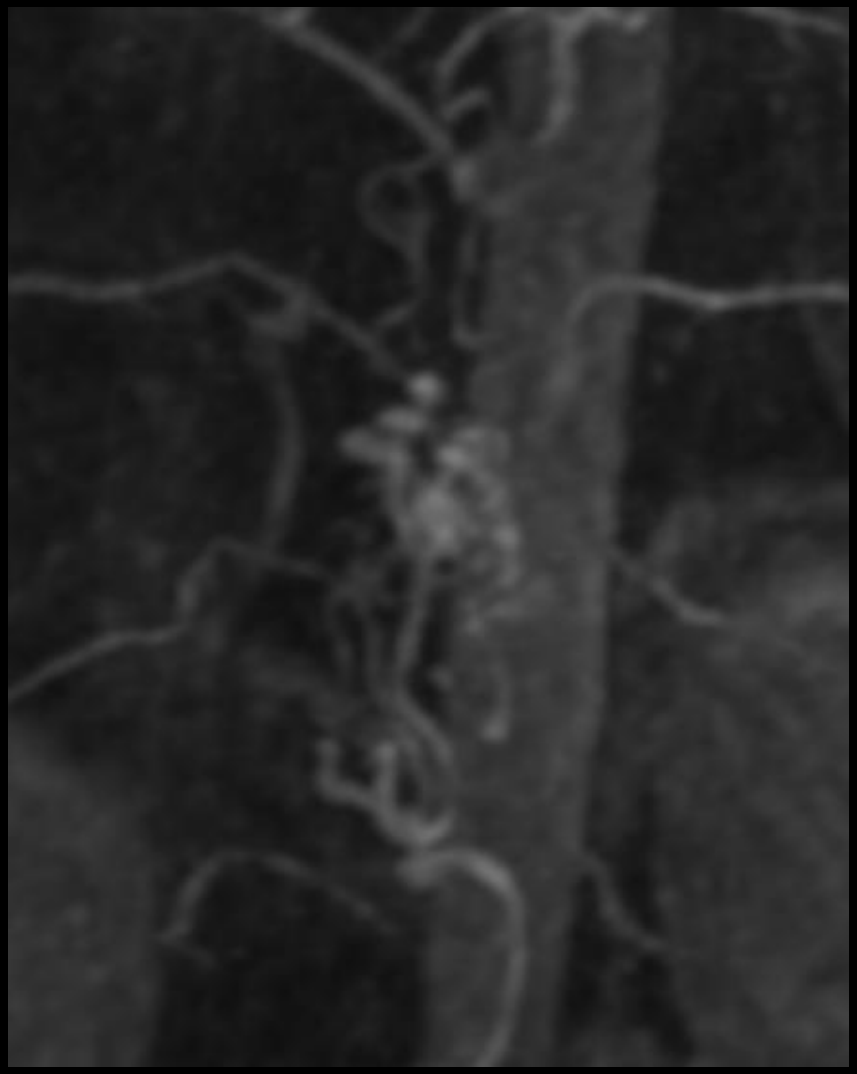
- Wanita 22 tahun
- Conus cauda syndrome, sakit bokong hingga kaki tidak bisa berjalan. Kesulitan BAK.
- T2WI:
  - Lesi flow void tubular berkelok-kelok intra medula spinalis.
  - Lesi hiperintens intramedula di sekitar flow void tubular tersebut
- MRA:
  - Nidus vaskular intra medula spinalis

KASUS V
SDAVF dengan MRA teknik TRICKS 3T

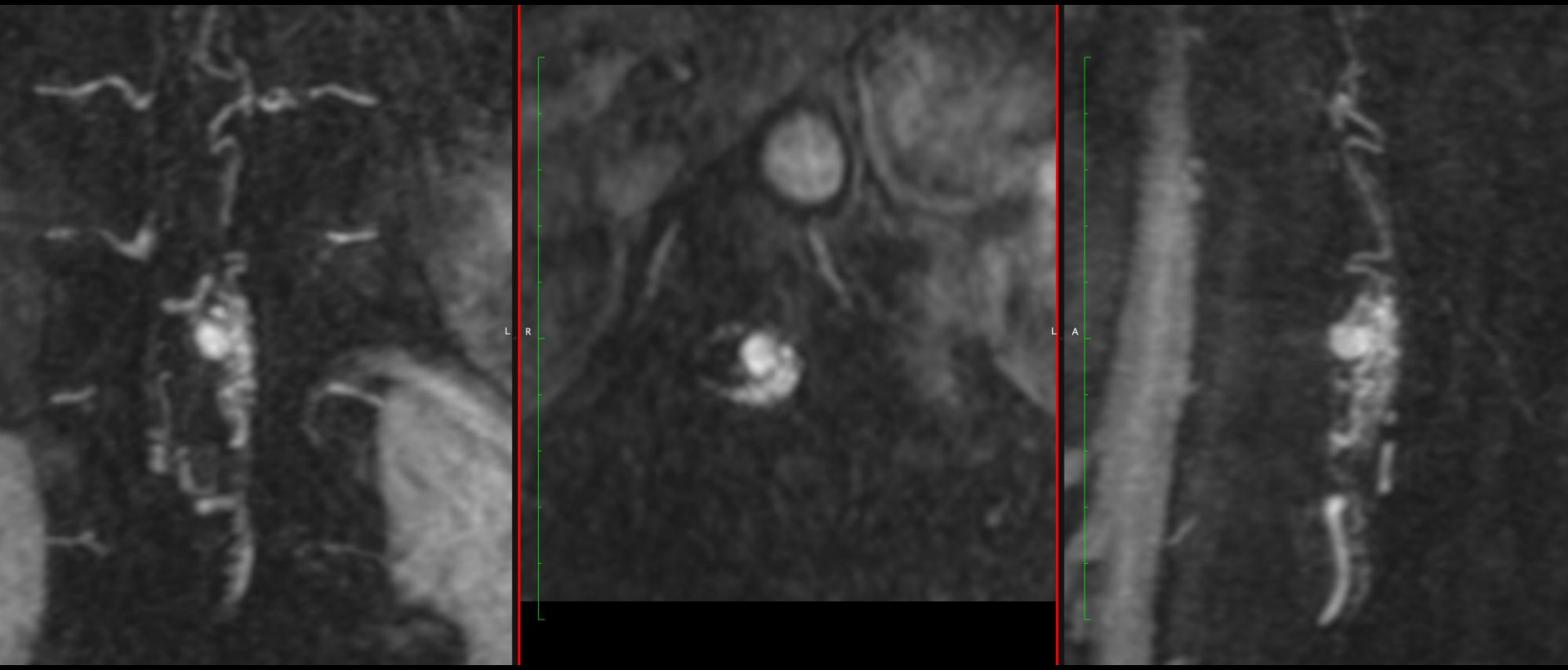


KASUS VI

Intramedullary AVM dengan MRA teknik TRICKS 3T



KASUS VI
Intramedullary AVM dengan MRA teknik TRICKS 3T

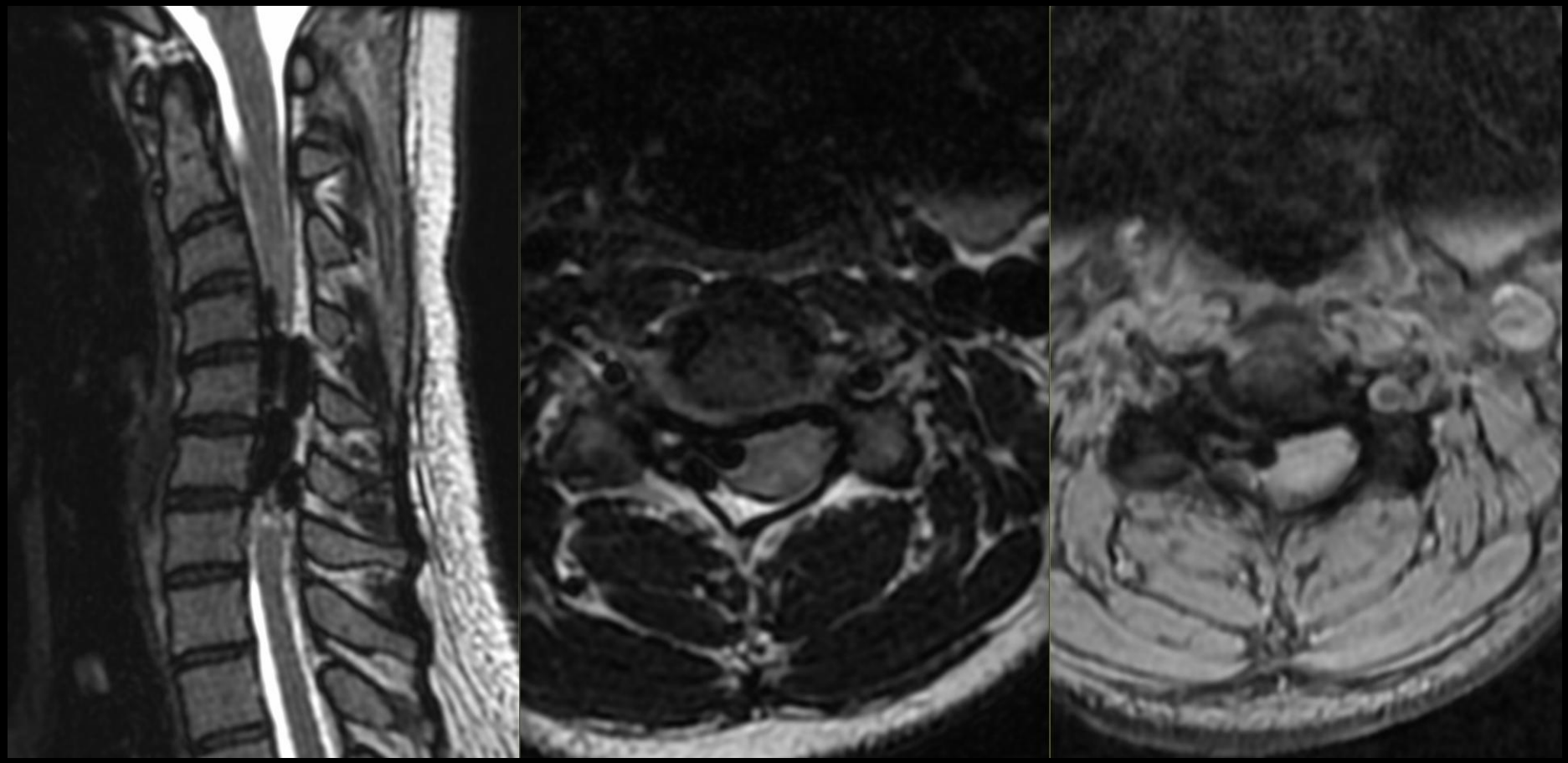


KASUS VII
Spinal extradural/epidural AVF dengan MRA teknik TRICKS 1.5T

- Wanita 21 tahun
- Keluhan: tetraparese kanan > kiri terutama distal. Atrofi otot tangan kanan > kiri. RP Babinsky (+) bilateral
- T2WI:
  - Lesi flow void tubular berkelok-kelok pada aspek lateral kanan kanalis spinalis di epidural space yang mendesak thecal sac dan medulla spinalis ke kiri.
  - Lesi hiperintens intramedula di daerah pendesakan tersebut
- MRA:
  - Arteriovenous fistula epidural dengan pelebaran vena-vena epidural di aspek lateral kanan yang mendesak medulla spinalis berserta thecal sac ke kiri.

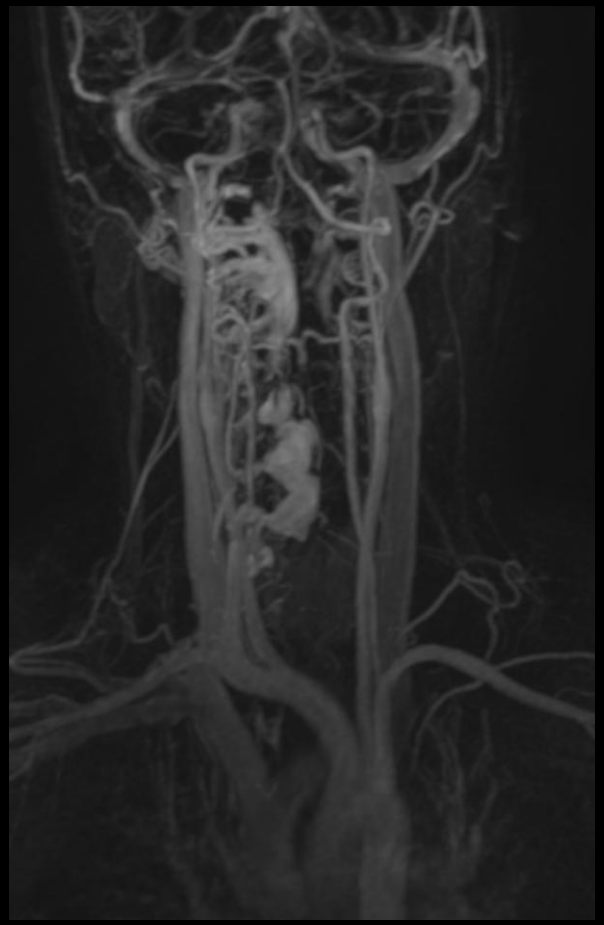
KASUS VII

Spinal extradural/epidural AVF dengan MRA teknik TRICKS 1.5T



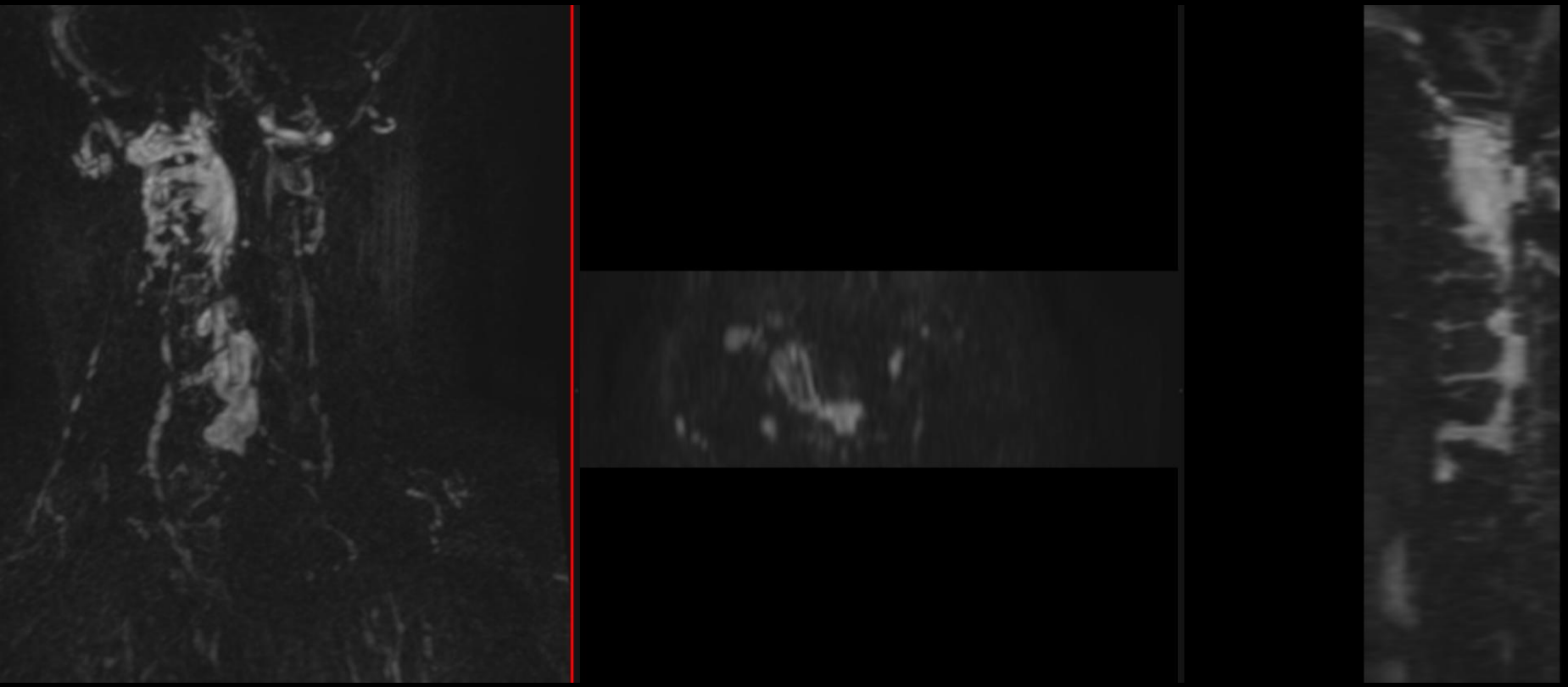
KASUS VII

Spinal extradural/epidural AVF dengan MRA teknik TRICKS 1.5T



KASUS VII

Spinal extradural/epidural AVF dengan MRA teknik TRICKS 1.5T



Summary of outcomes of treatments for spinal vascular malformations

Intramedullary AVM	**Surgery Curative resection if possible Embolisation (curative or palliative)**	**Particles: high recurrence NBCA: better cure rates Onyx: no data**
Perimedullary AVF Type I.	**Surgery (or embolisation) Surgery first-line treatment if AVF accessible**	**NBCA embolisation, but particles may be safer**
Perimedullary AVF Type II	**EVT (or surgery)**	**NBCA, particles or surgery**
Perimedullary AVF Type III	**EVT (surgery if incomplete)**	**Coils, (balloons), NBCA or Onyx**
DAVF	**EVT (surgery if recurrent)**	**NBCA or Onyx**

Summary

Type of Spinal Vascular Lesion	Key Features	Diagnostic Modality and Symptoms	Treatments of Choice
Cavernous Malformation	* Do not involve a shunt * Are typically small * Supplied by thin-walled vessels	* Diagnose: magnetic resonance imaging *Symptoms: onset in 6th decade often with myelopathy	* Conservative management * CO_2 laser guided treatment * Surgical intervention
Intradural Arteriorvenous Malformations	* Congenital lesions with equal male to female ratio * Nidus typically intra-medullary * High flow lesion	* Diagnose: spinal magnetic resonance angiography * Symptoms: subarachnoid hemorrhage with back pain, meningismus, or myelopathy	* Endovascular embolization followed by surgical obliteration * Gamma knife for hard to treat lesions
Perimedullary Arteriovenous Fistulas	* Located in lower lumbar regions * Occur equally between males and females * Presents in 5th decade of life	* Diagnose: contrast-enhanced magnetic resonance angiography * Symptoms: slower progressive myelopathy or subarachnoid hemorrhage	*Onxy or coil presurgical embolization * Selective balloon occlusion * Surgical interruption
Dural Arteriovenous Fistulas	* Acquired lesions * Low flow shunt * Coronal venous plexus dialation	* Diagnose: contrast-enhanced magnetic resonance angiography * Symptoms: ischemic injury to spinal cord with progressive myelopathy	* Endovascular embolization priot to surgical intervention *Onyx embolization has been shown to be superior to other methods * Surgical interruption

Thank You..


PERKUMPULAN SUBSPESIALIS NEURORADIOLOGI - KEPALA LEHER INDONESIA
INDONESIAN NEURORADIOLOGY - HEAD & NECK SOCIETY