

# Echo-endoscopie : Particularités et indications

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DU Radiologie

2020



# Un compromis

<b>MHz</b>	<b>Penetration (cm)</b>	<b>Resolution (mm)</b>
<b>20</b>	<b>1</b>	<b>0.2</b>
<b>10</b>	<b>2</b>	<b>0.5</b>
<b>7.5</b>	<b>5</b>	<b>1</b>
<b>5</b>	<b>10</b>	<b>2</b>
<b>3.5</b>	<b>20</b>	<b>5</b>

# Modalités pratiques

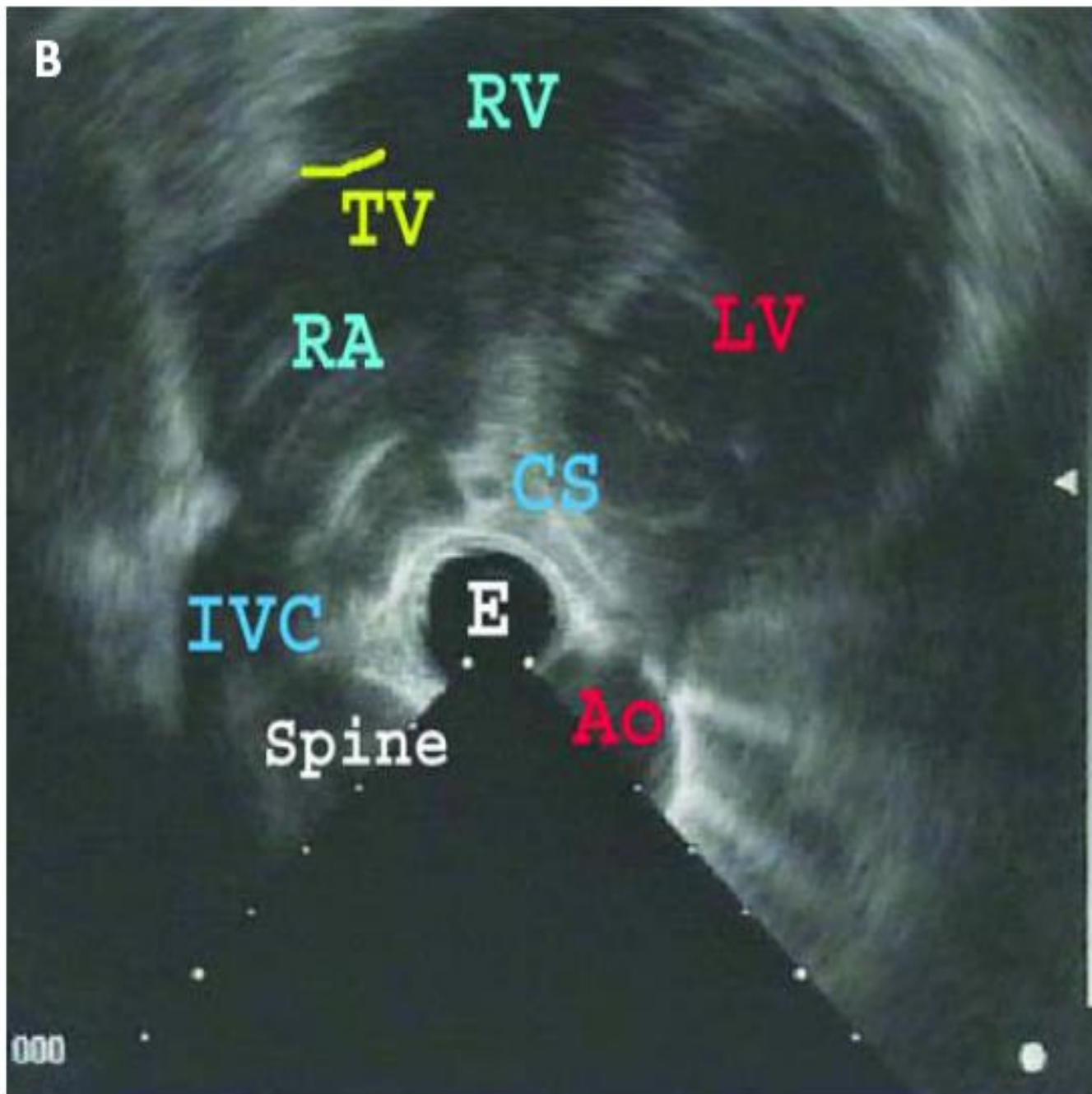
- ❖ Endoscope souple de 11-13 mm de diamètre
- ❖ Console:
  - Doppler
  - Echographie de contraste
  - Elastographie
- ❖ A jeun
- ❖ Anesthésie fréquemment nécessaire
  - Biliopancréatique++
  - Œsophage +
  - Rectum, sans sédation

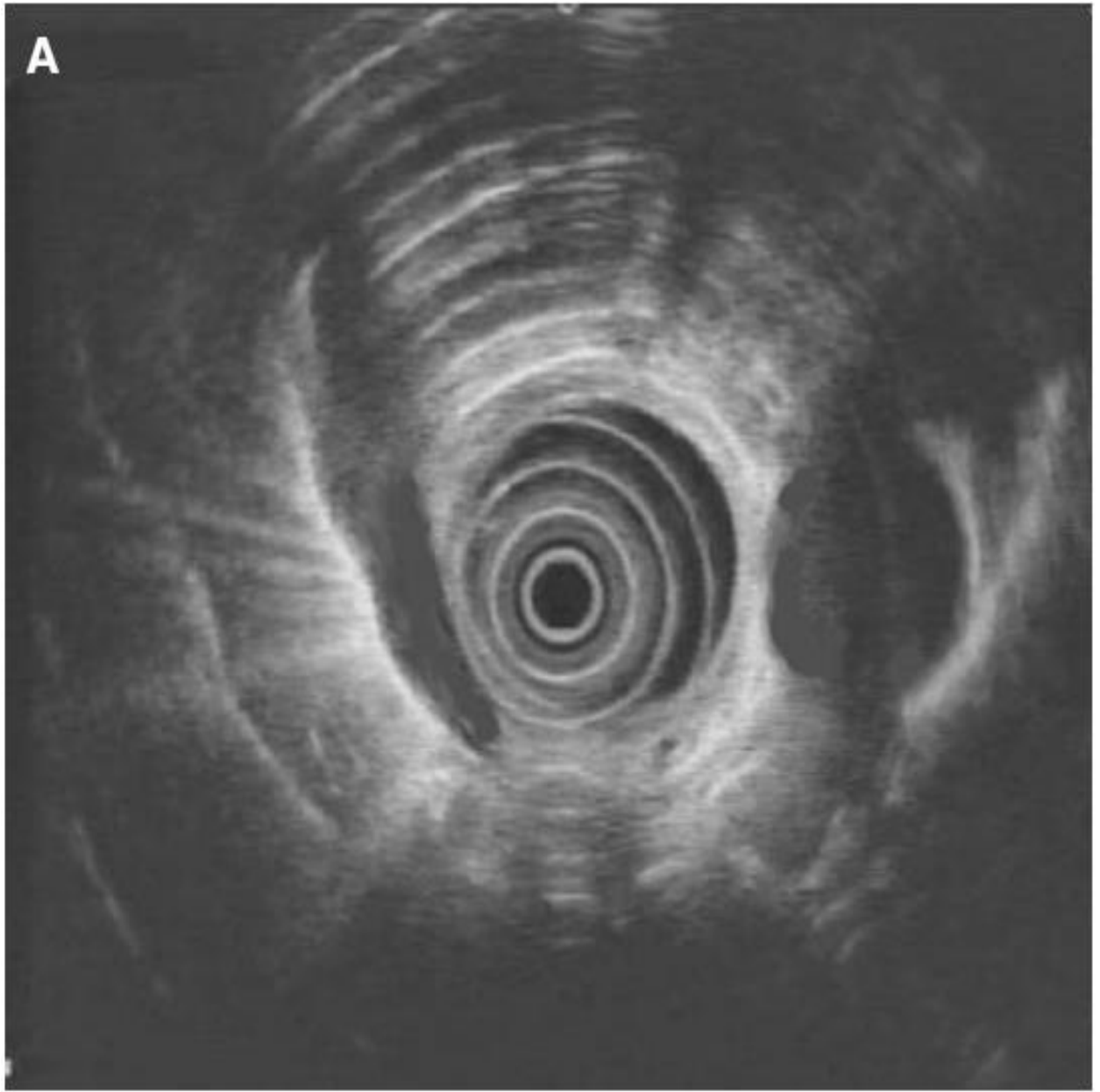
# Les appareils

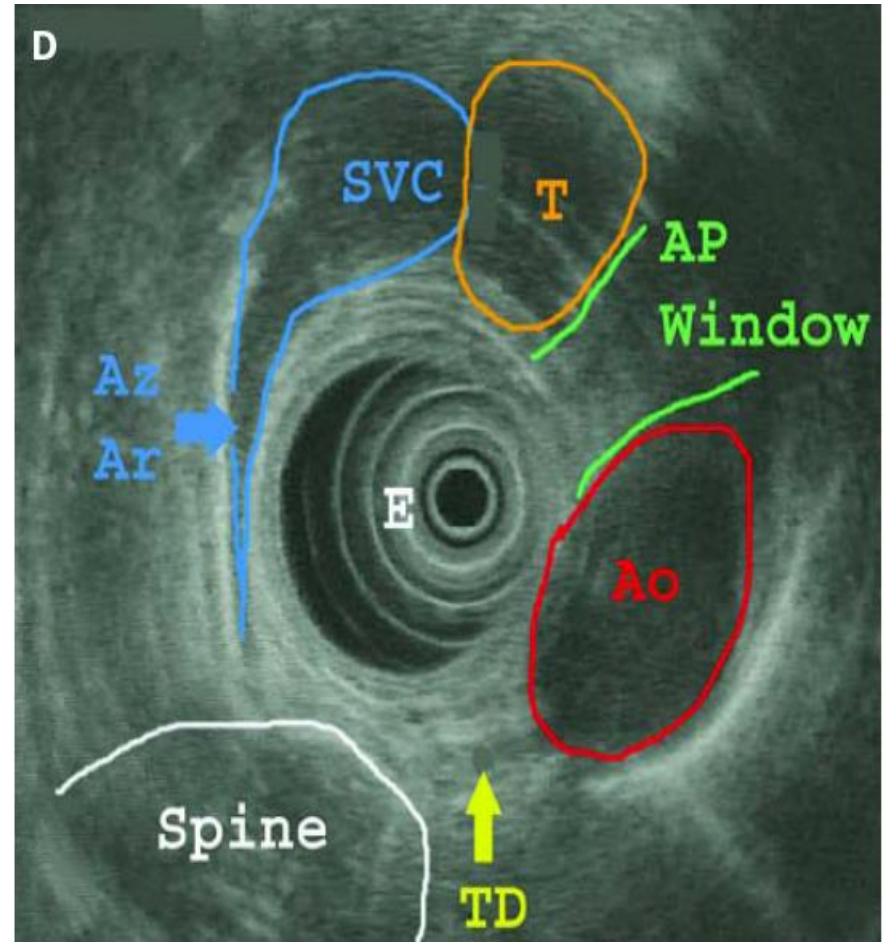
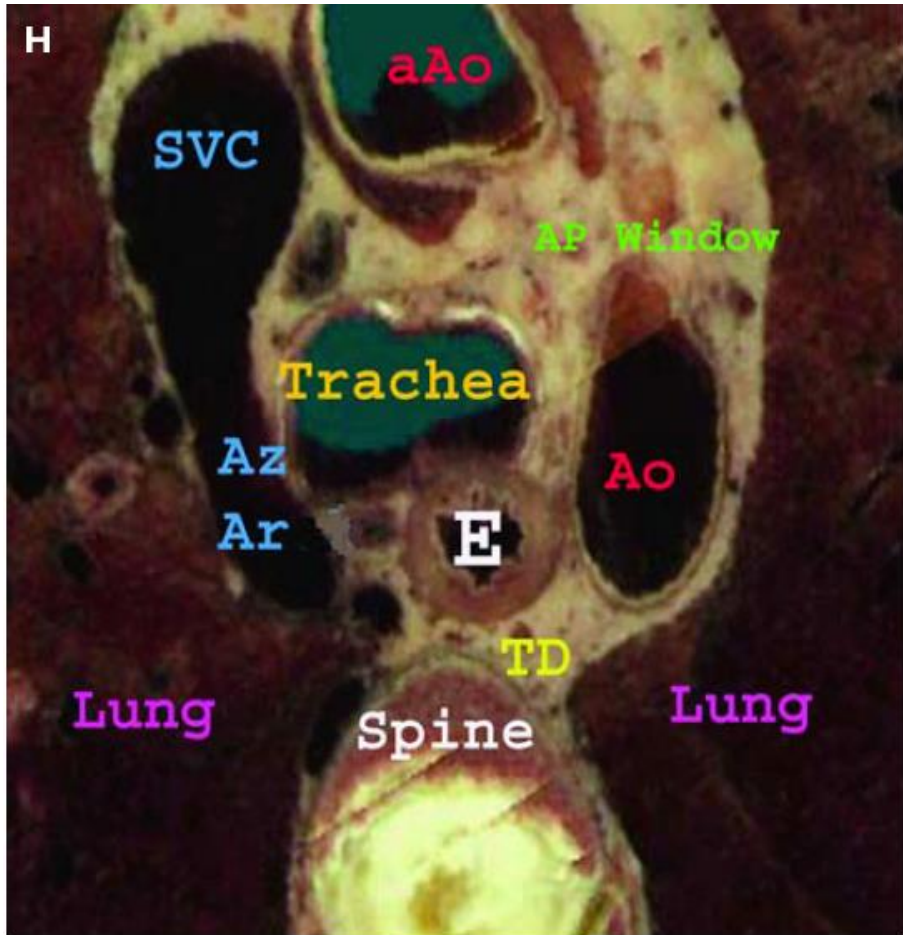


# Anatomie du médiastin

- Peu de contraintes spécifiques
- Structures aériques = barrage aux ultrasons
- Appareil radial : cf TDM
- Appareil linéaire : cf reconstructions TDM
- Zones accessibles :
  - Tout le médiastin inférieur autour de l'œsophage
  - Le médiastin postérieur









B

Pleural  
Reflection

T

Balloon Air

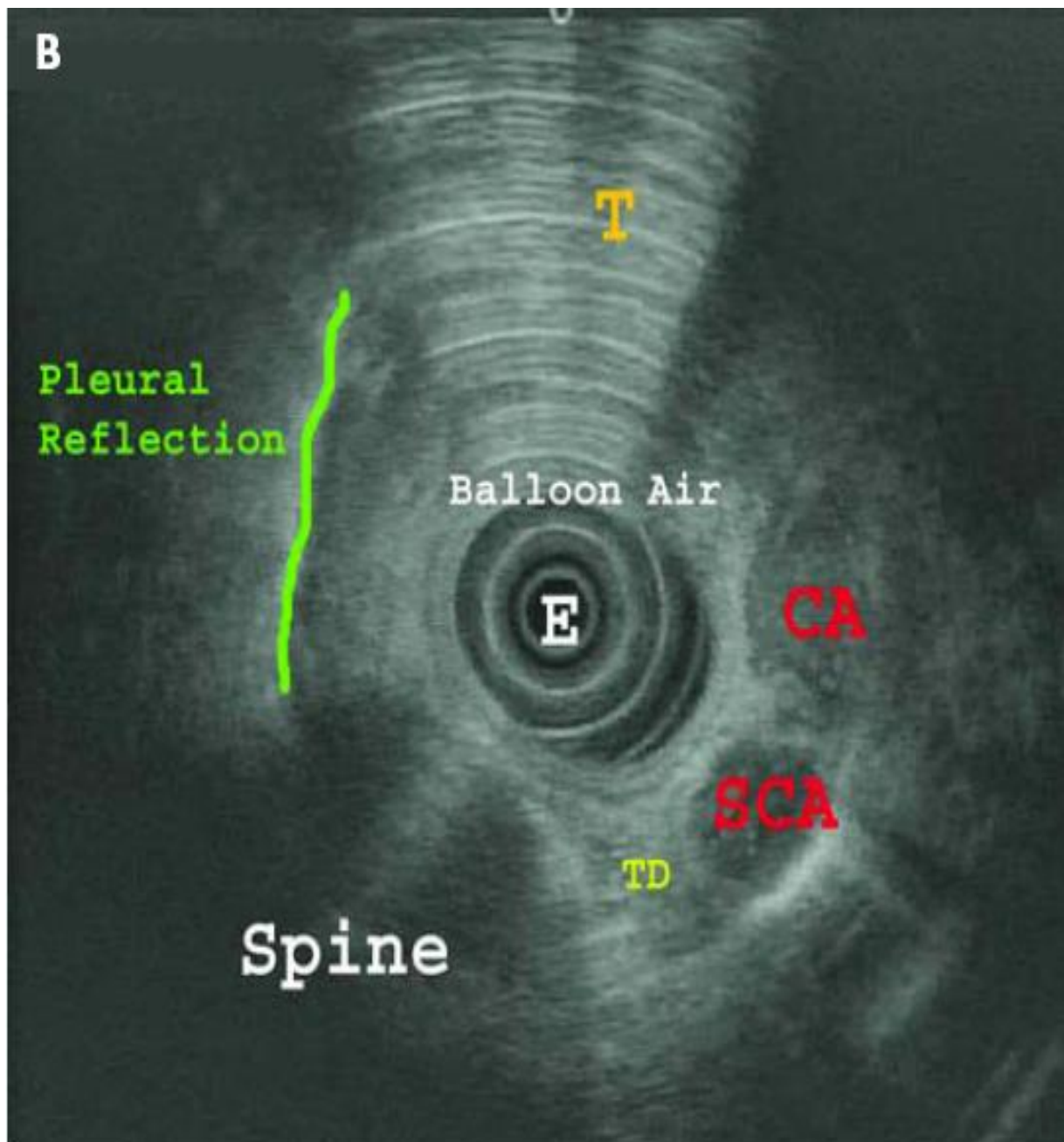
E

CA

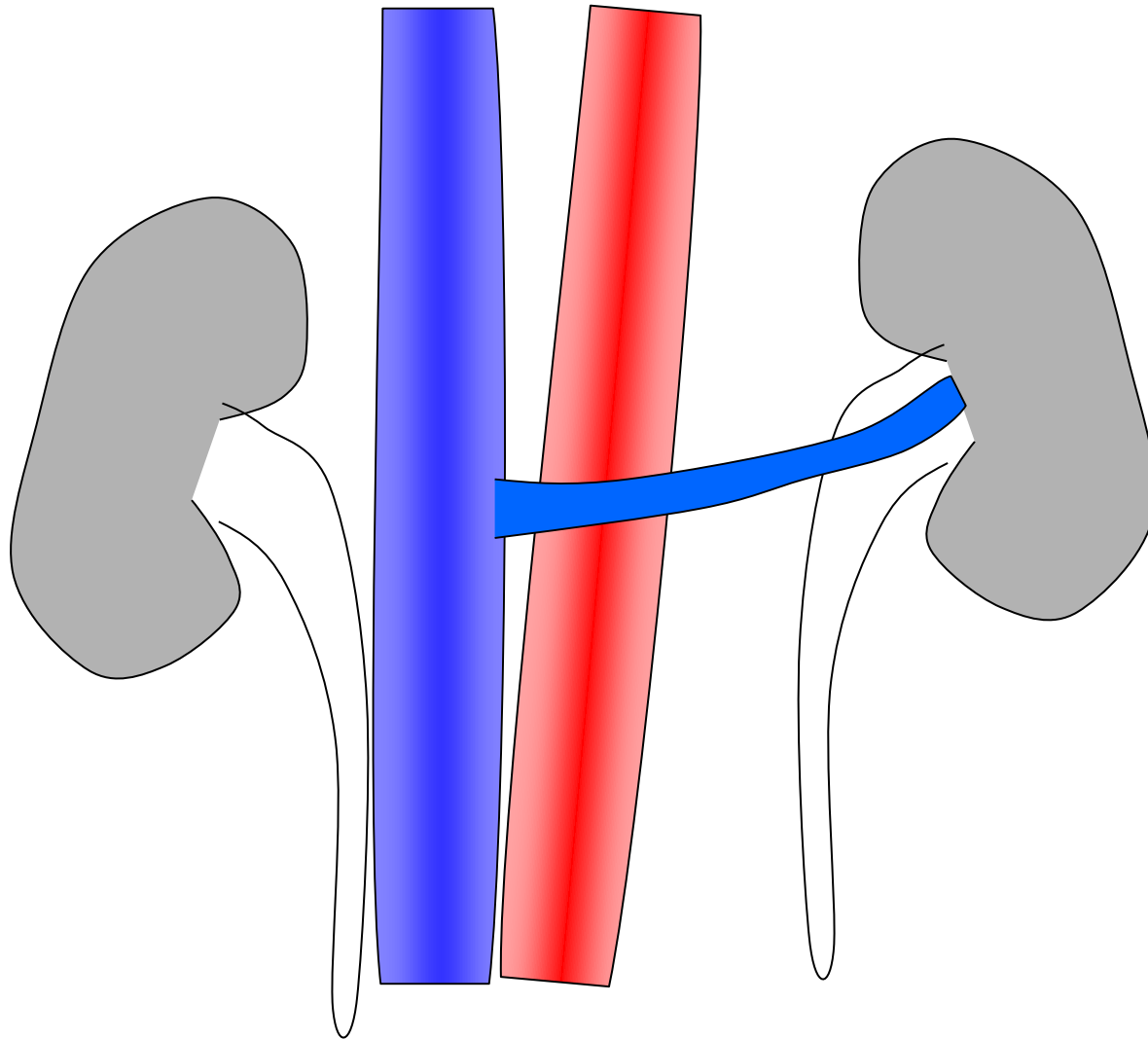
SCA

TD

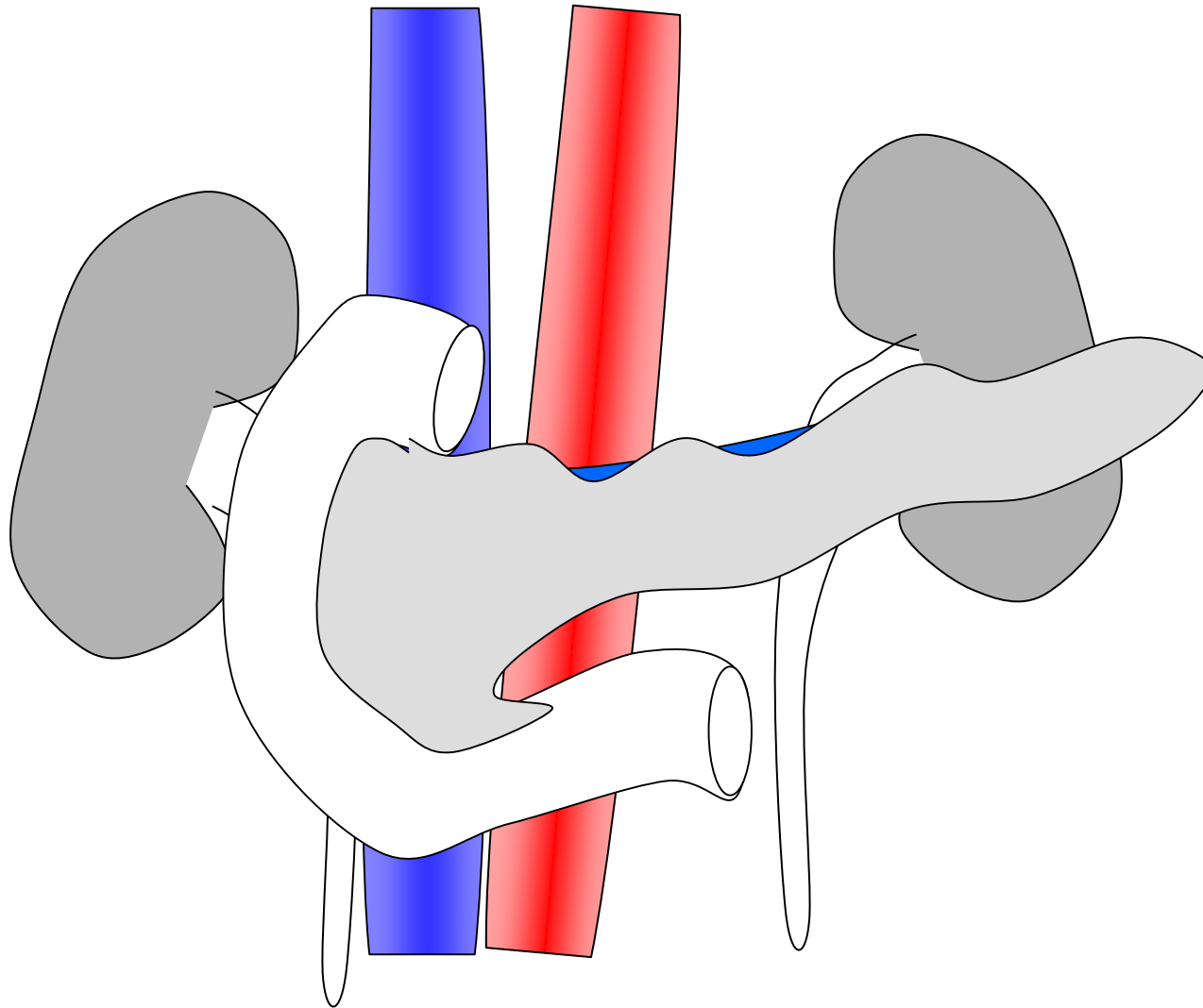
Spine



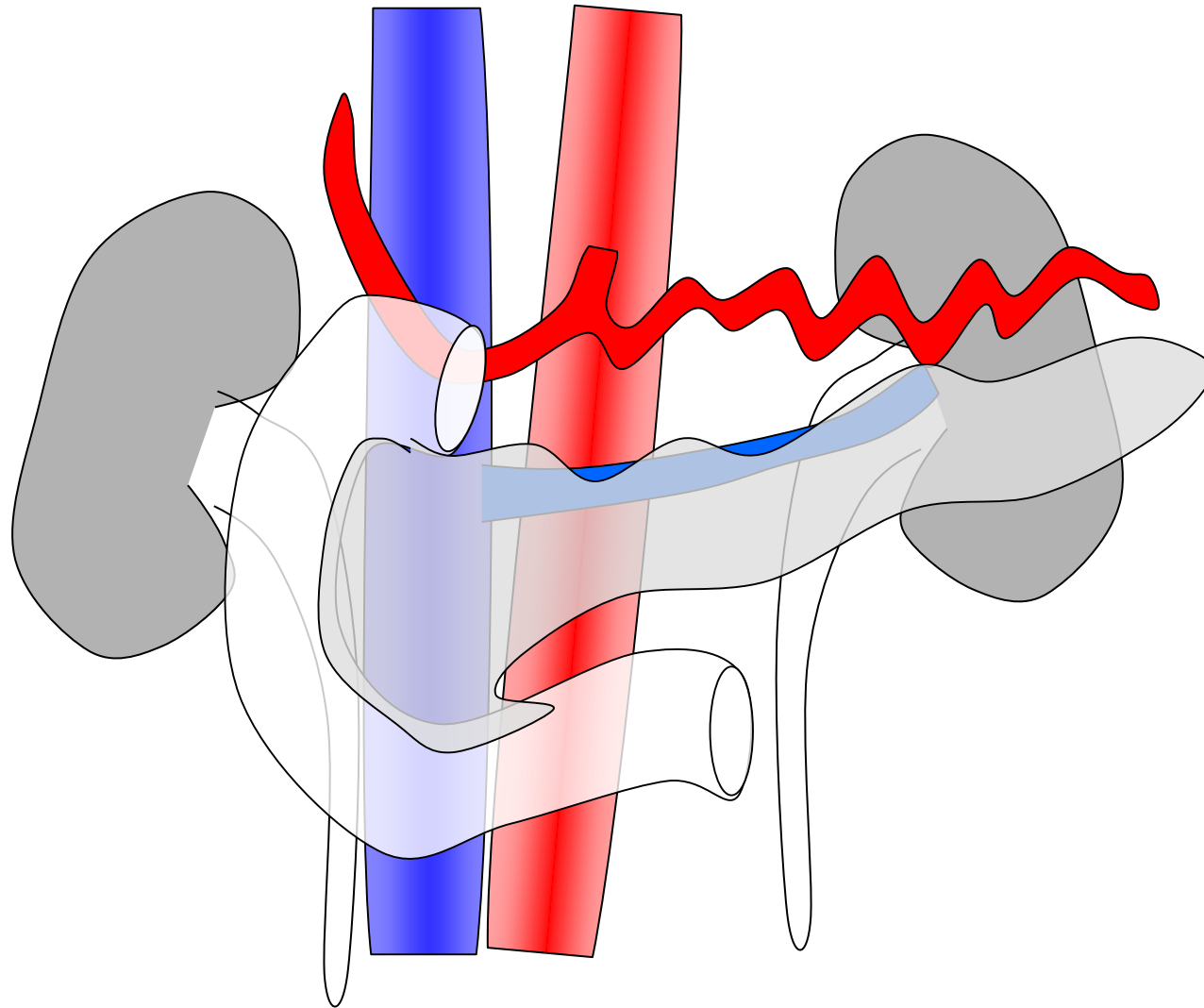
# Anatomie biliopancréatique



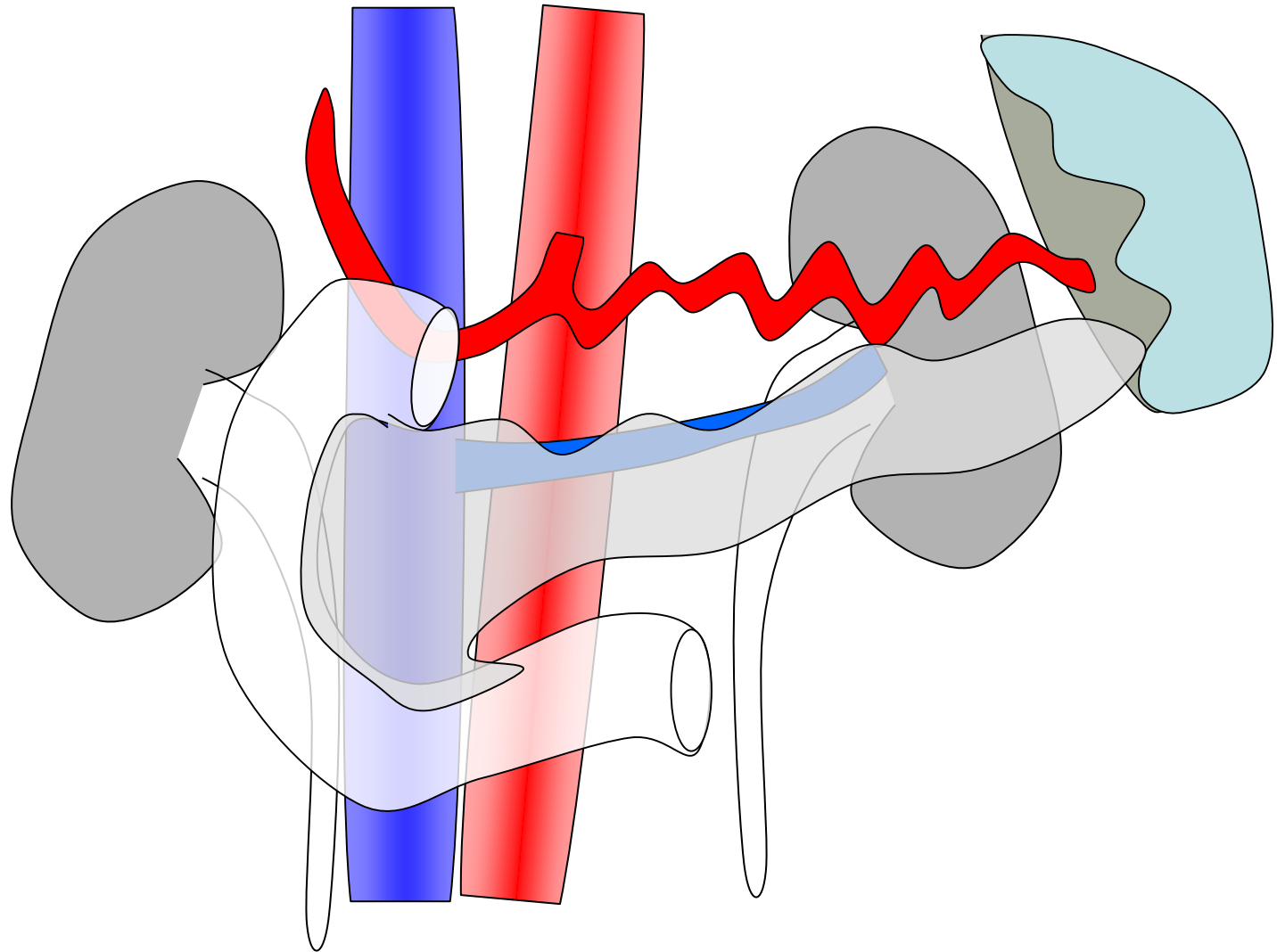
# Duodeno-pancreas



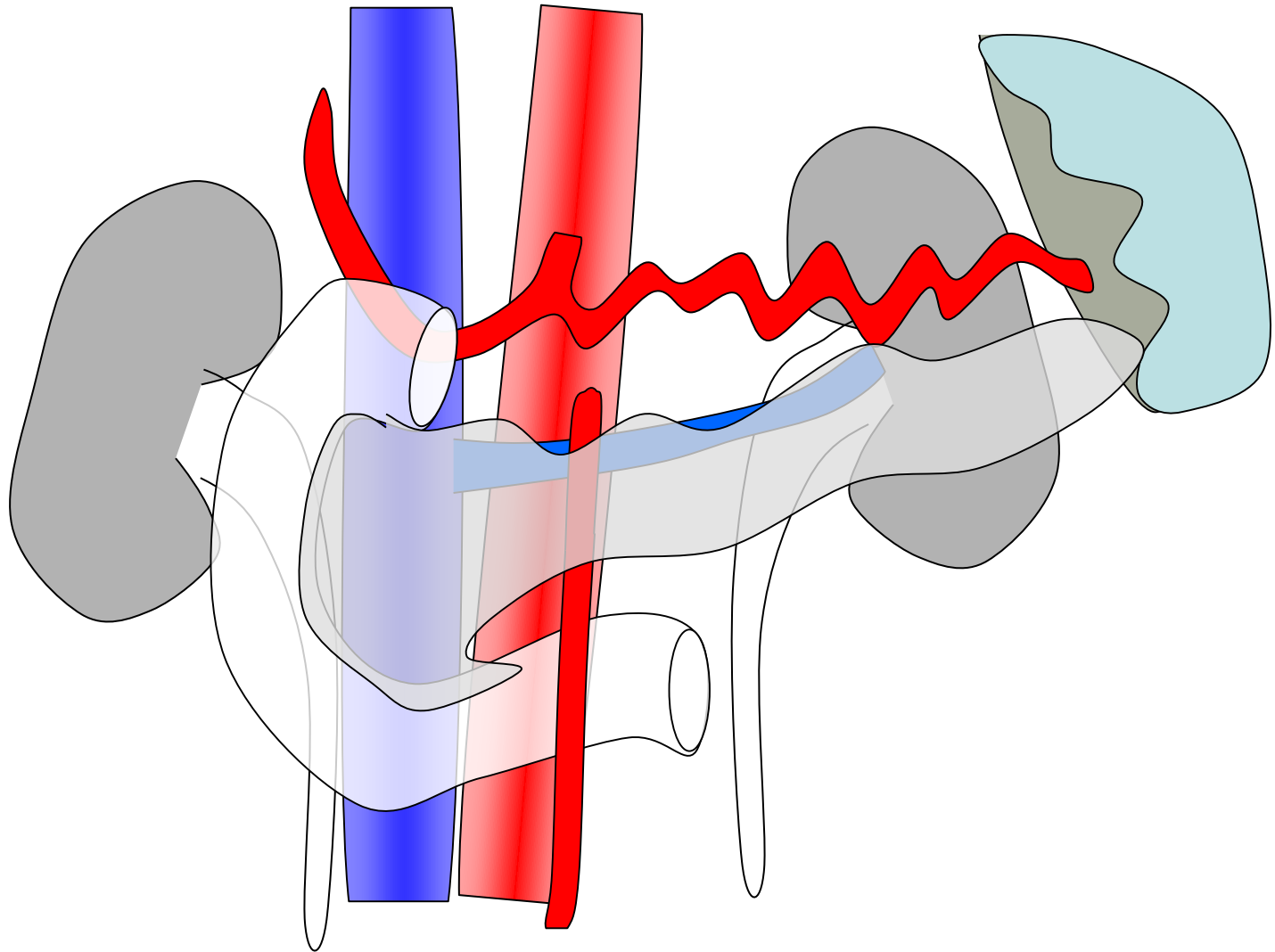
# Tronc coeliaque et branches



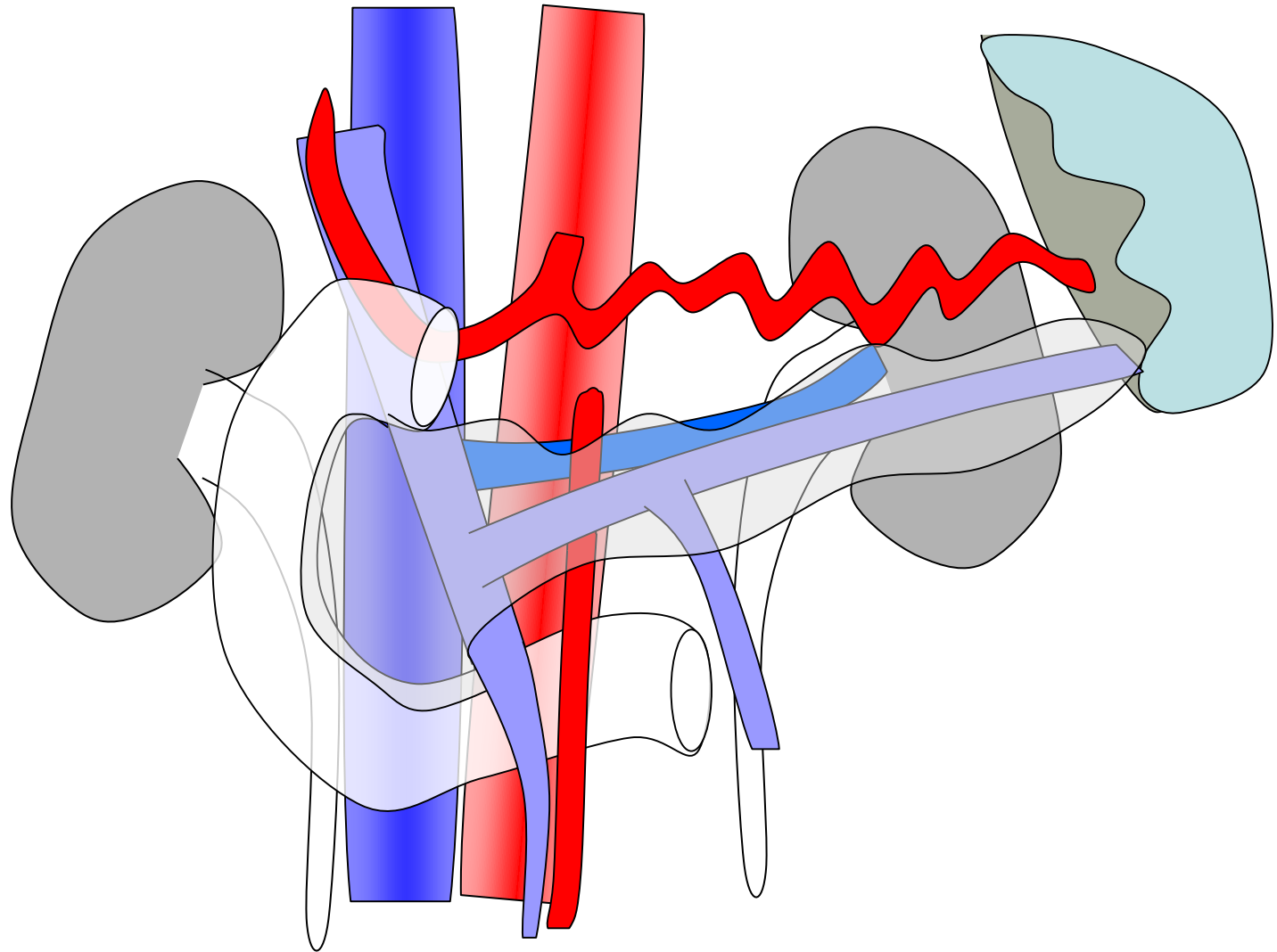
# Tronc coeliaque et branches



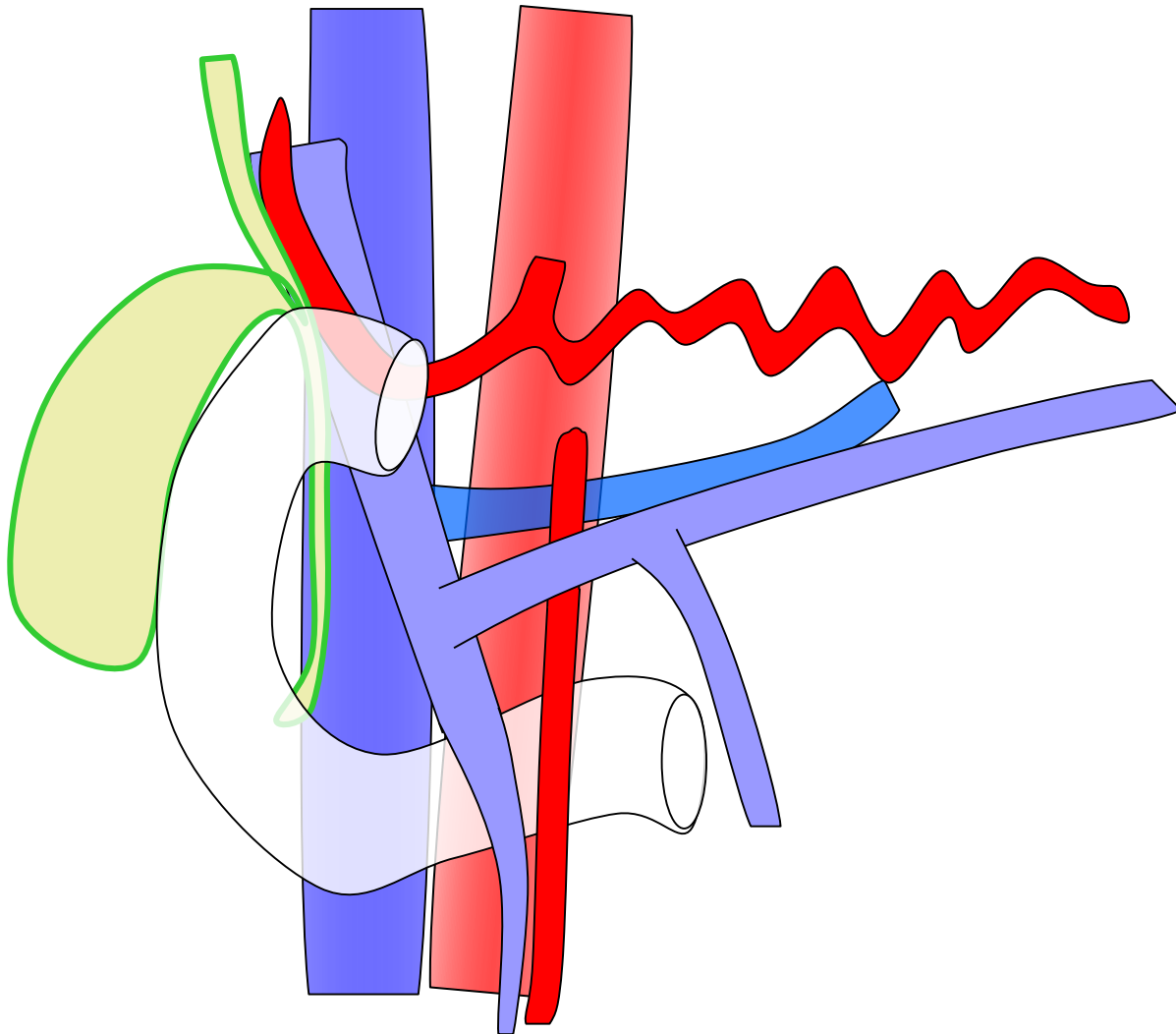
# Artère mésentérique supérieure



# Systeme veineux splanchnique

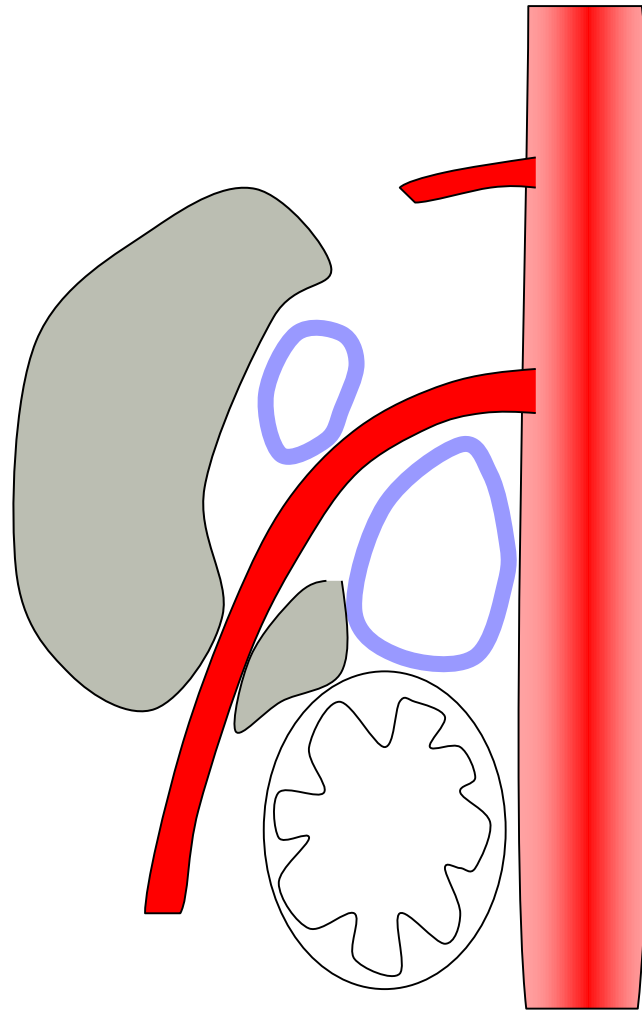


# Voies biliaires

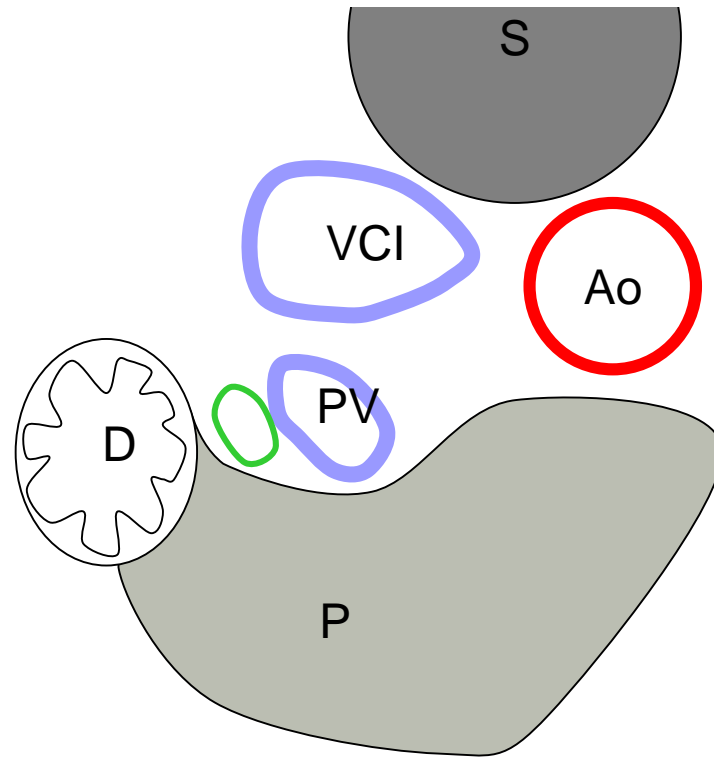




# Vue latérale gauche

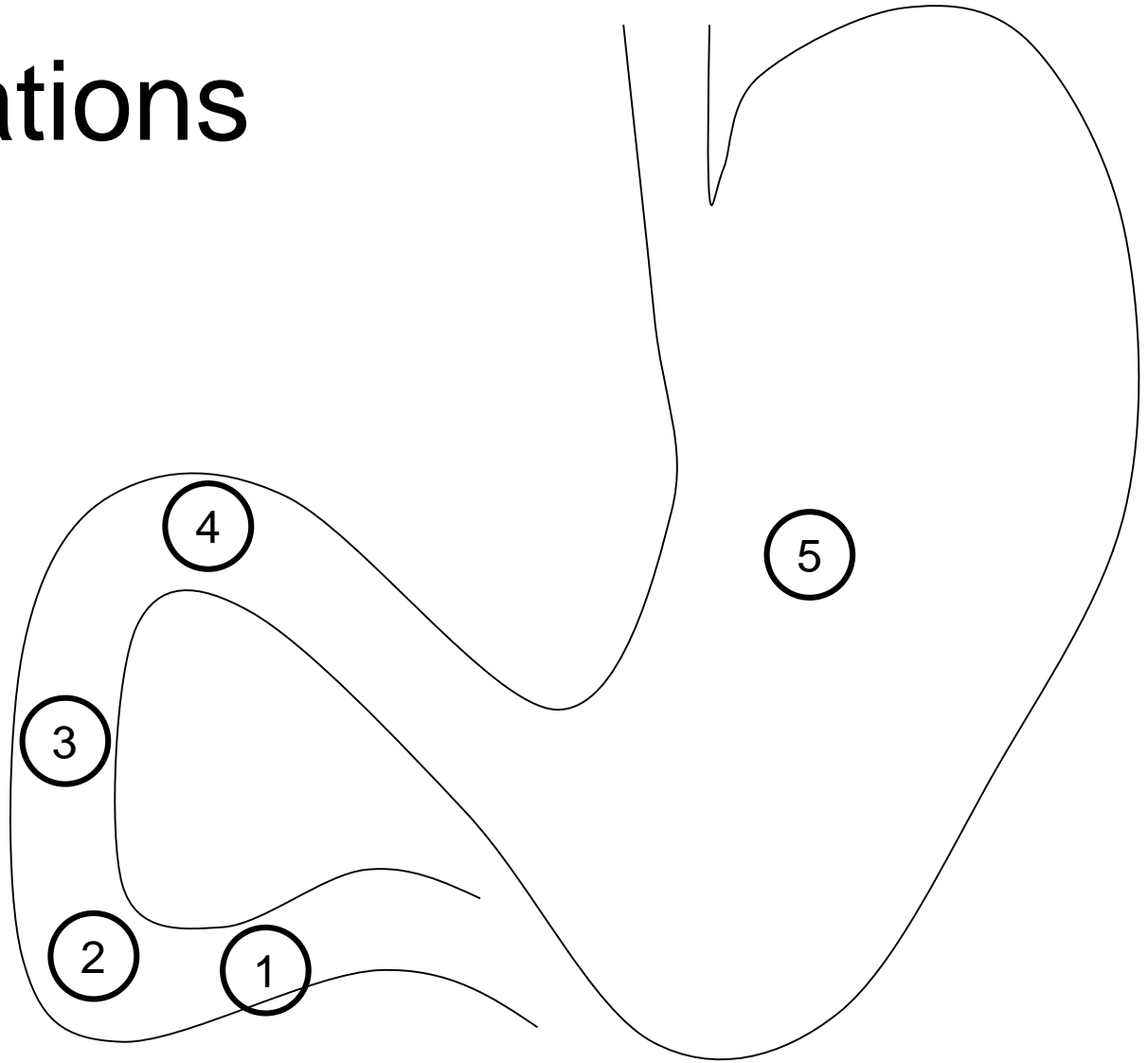


# Second duodenum

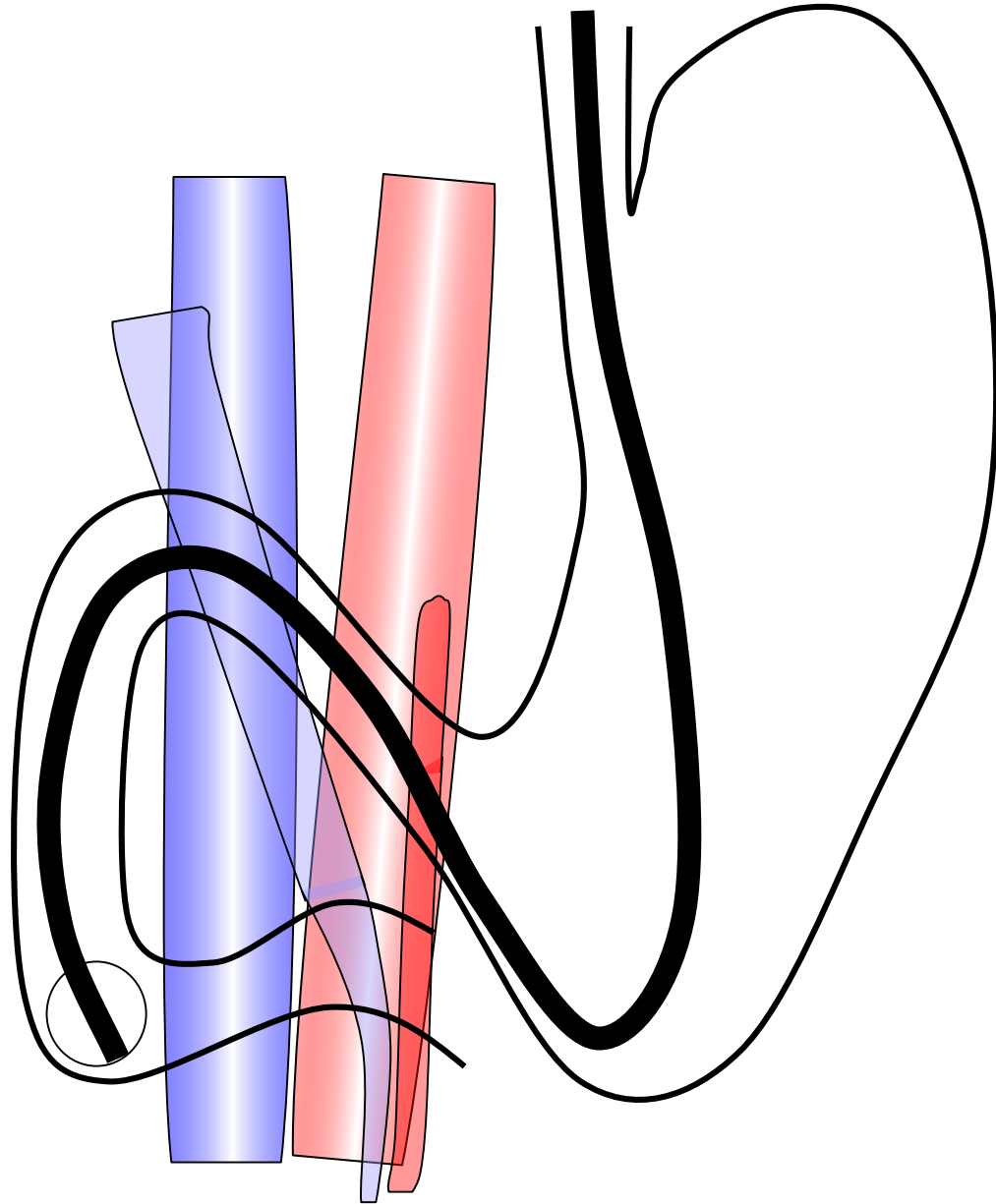


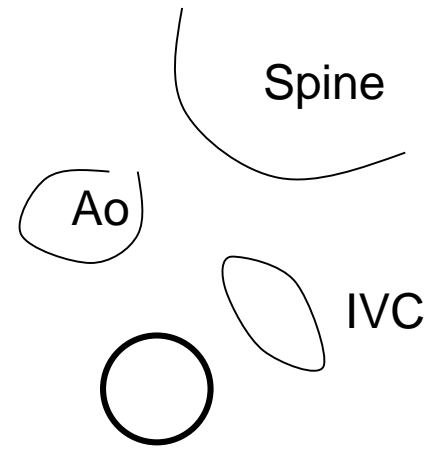
# Réalisation pratique

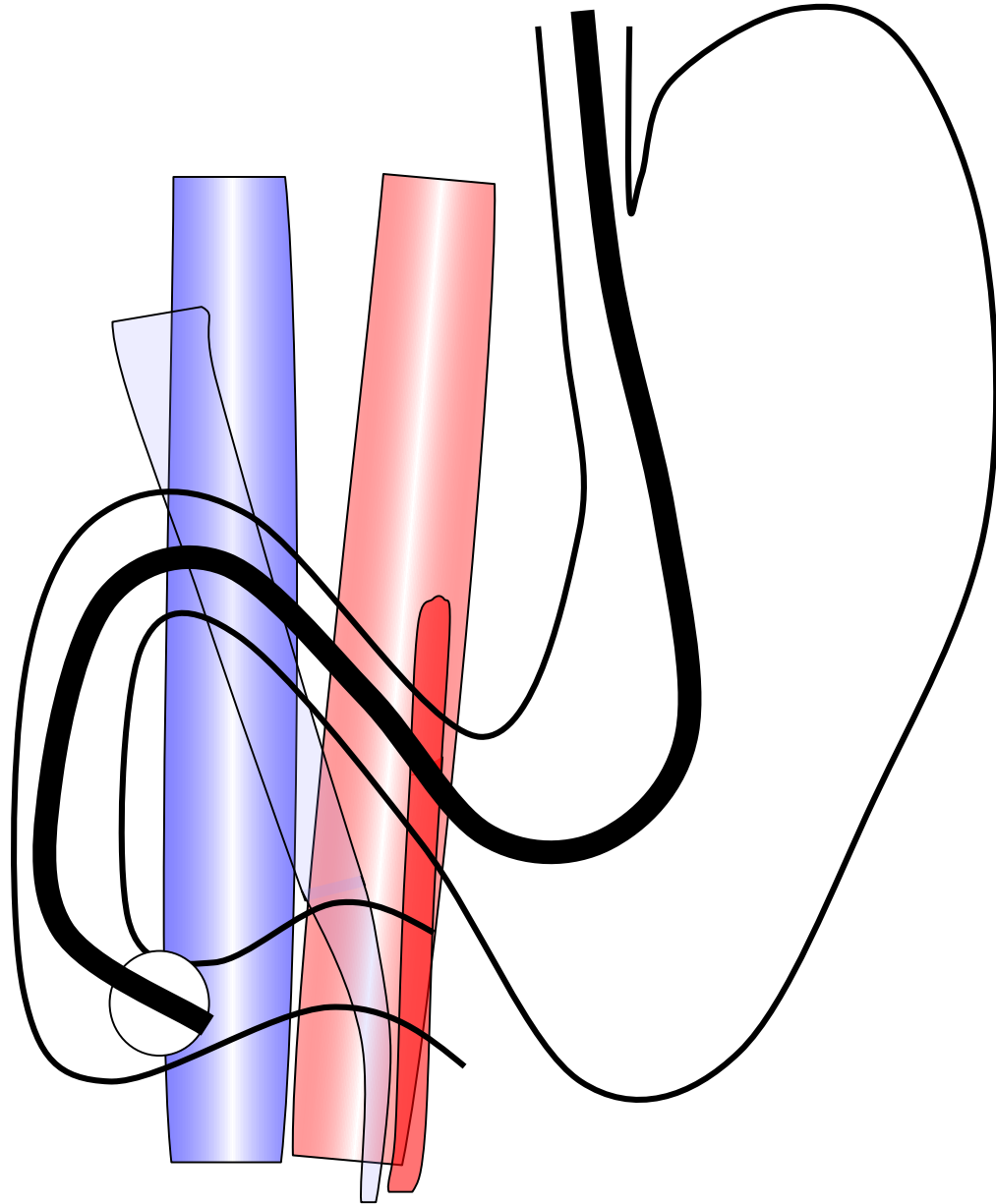
# Stations



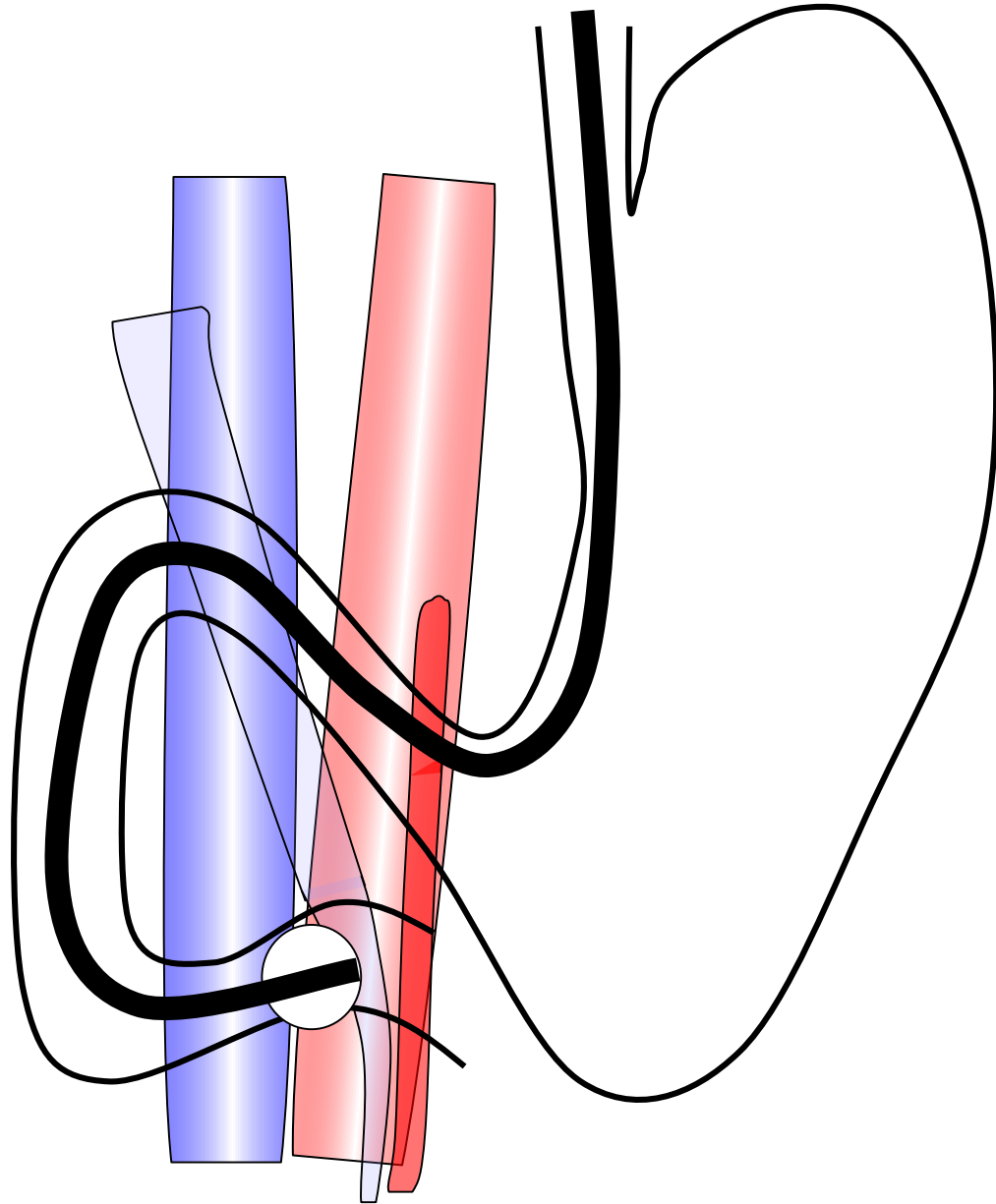
En radial

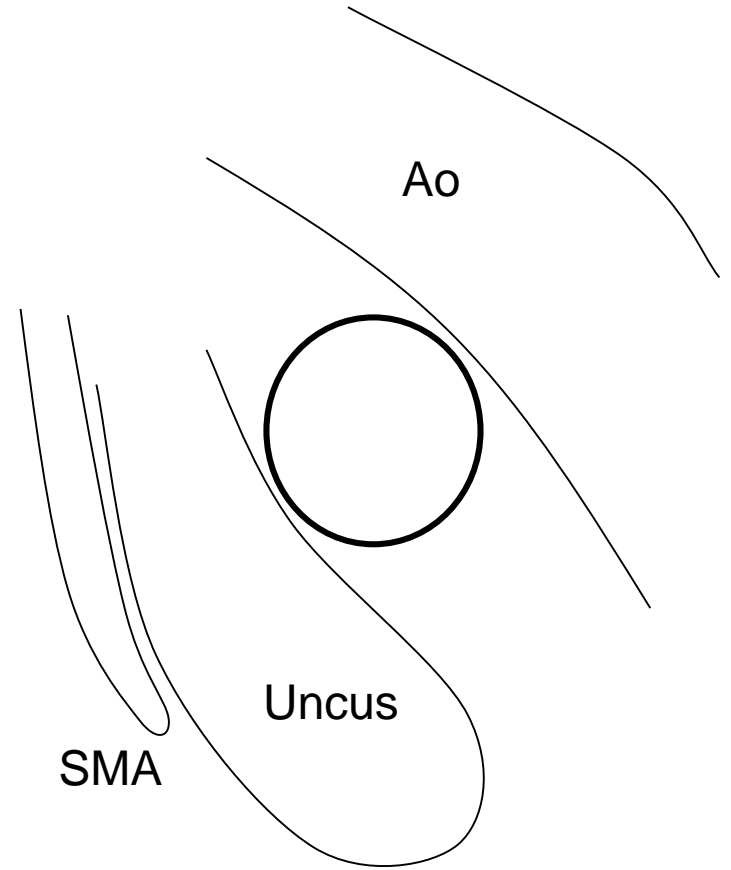




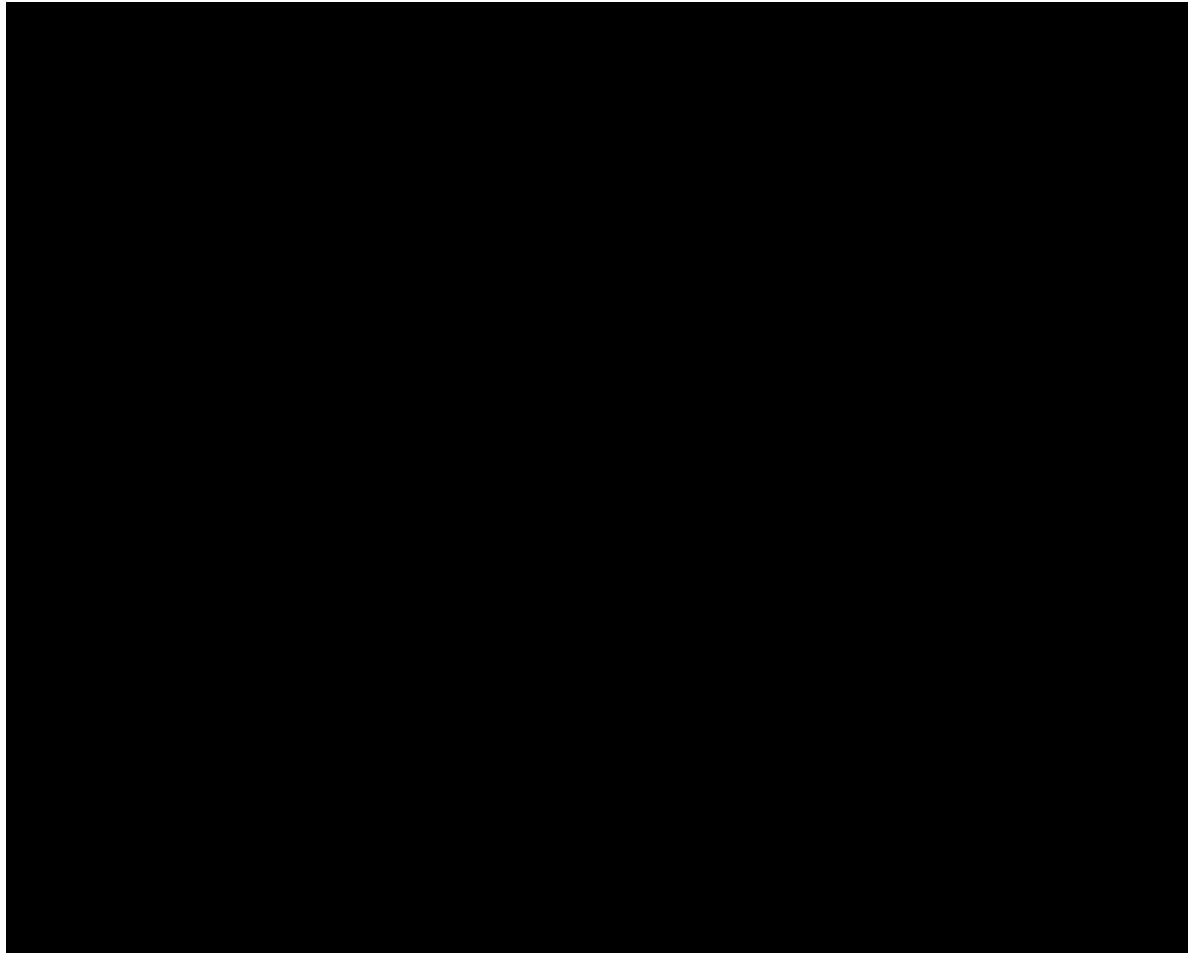


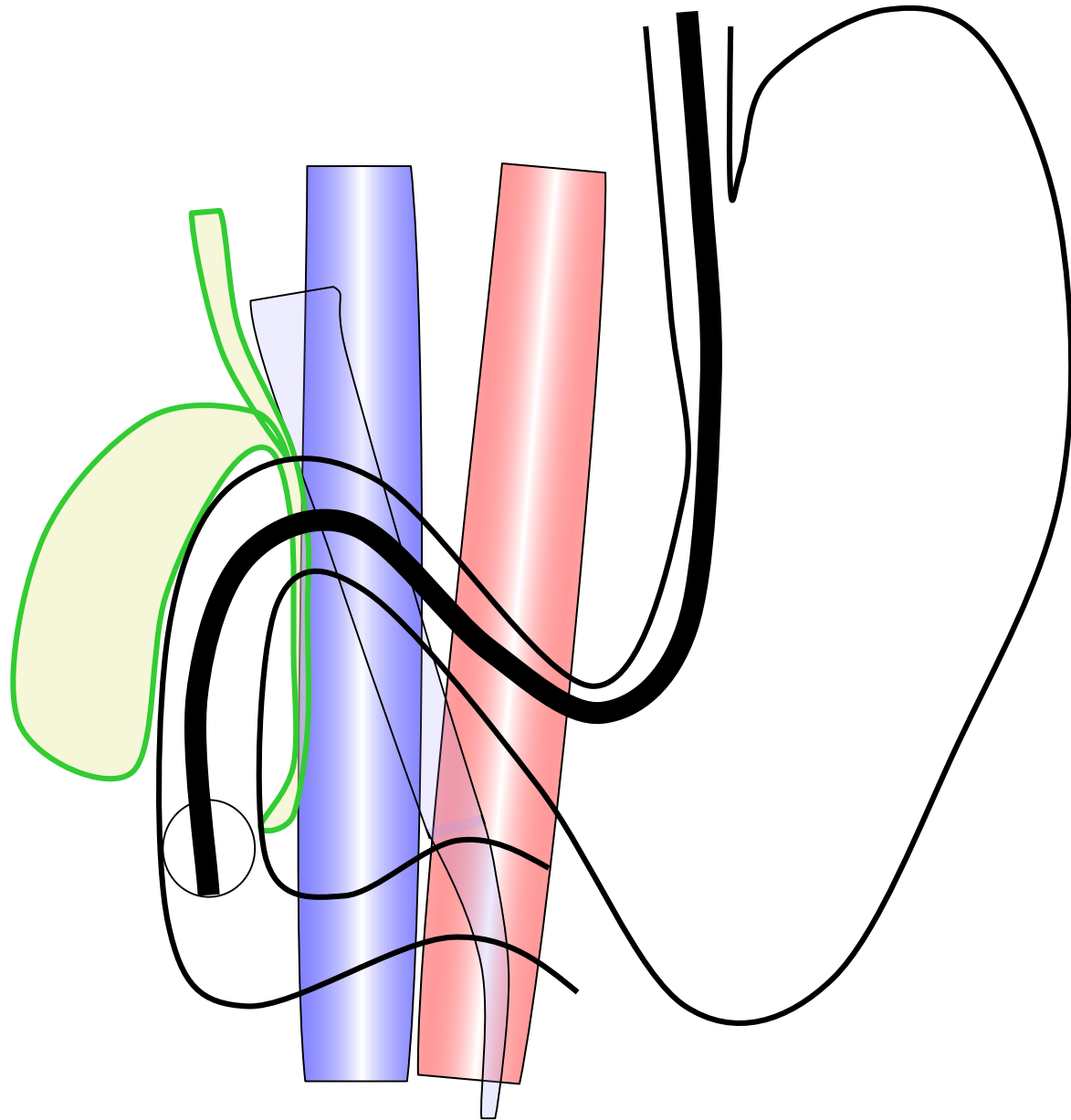






# Uncinate process





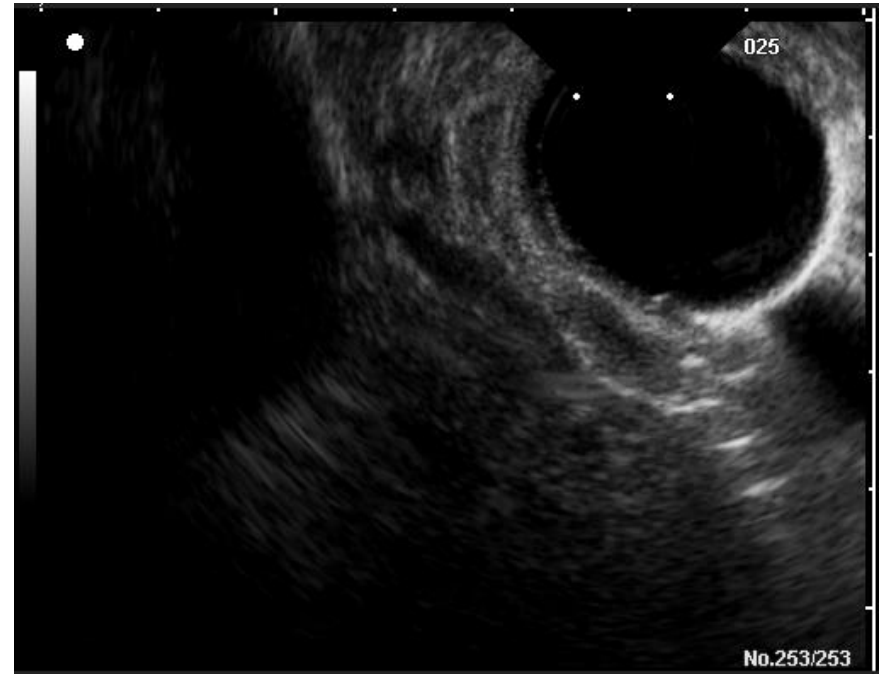


# Papilla



Pancreatic duct

Biliary duct

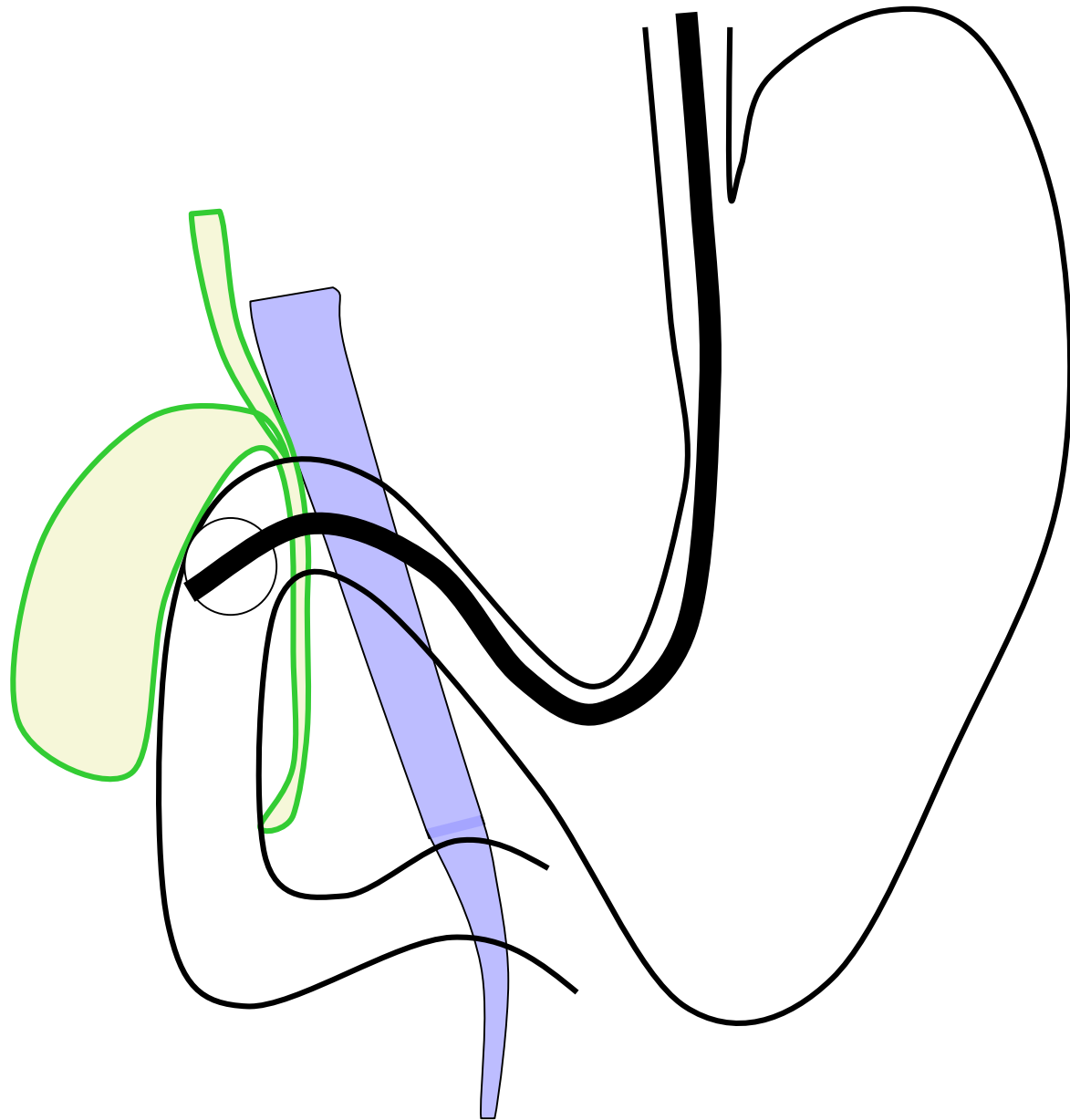


HITACHI GB-5 DYN-75 P-2/2/1/A  
PTR-H IN-20 LIS-6 50mm 7.5H

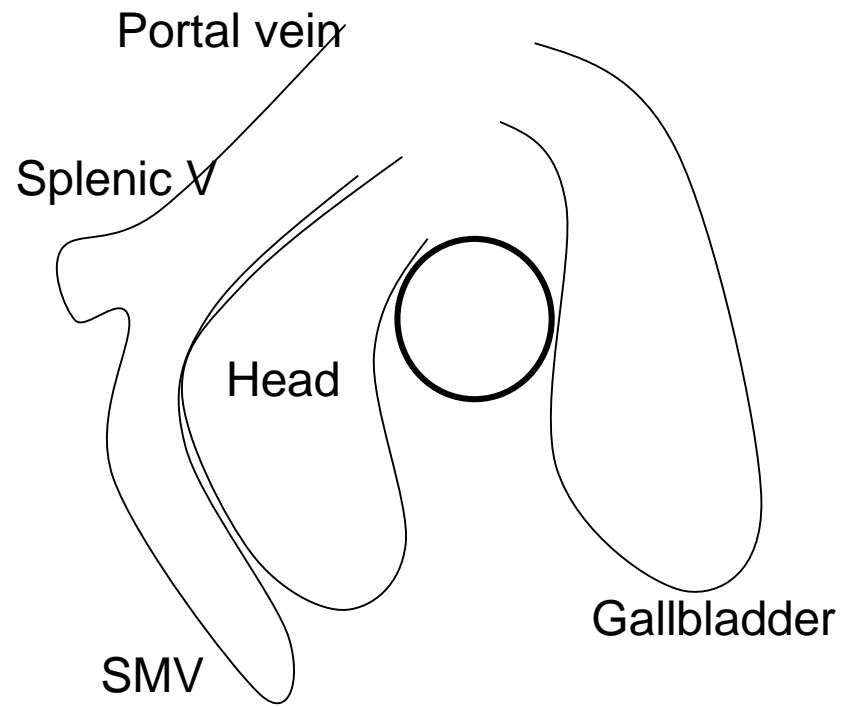
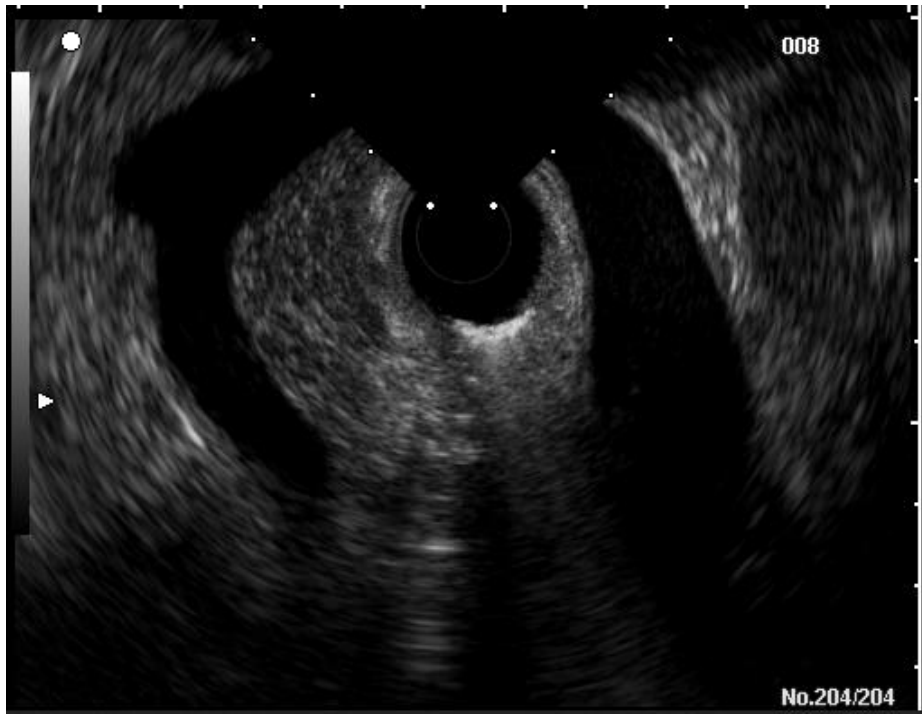


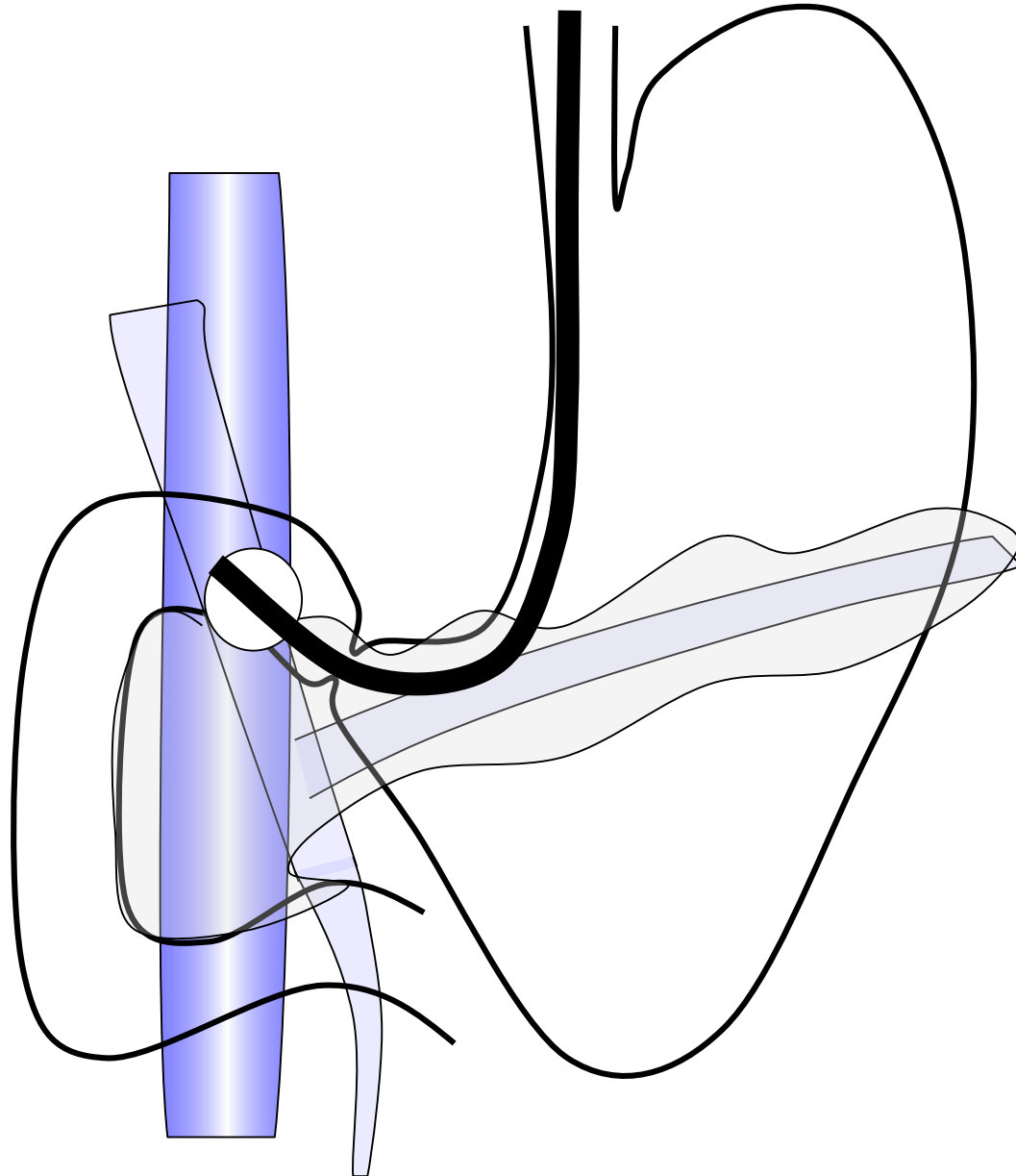
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27-HA1-02 F1  
10:48:05

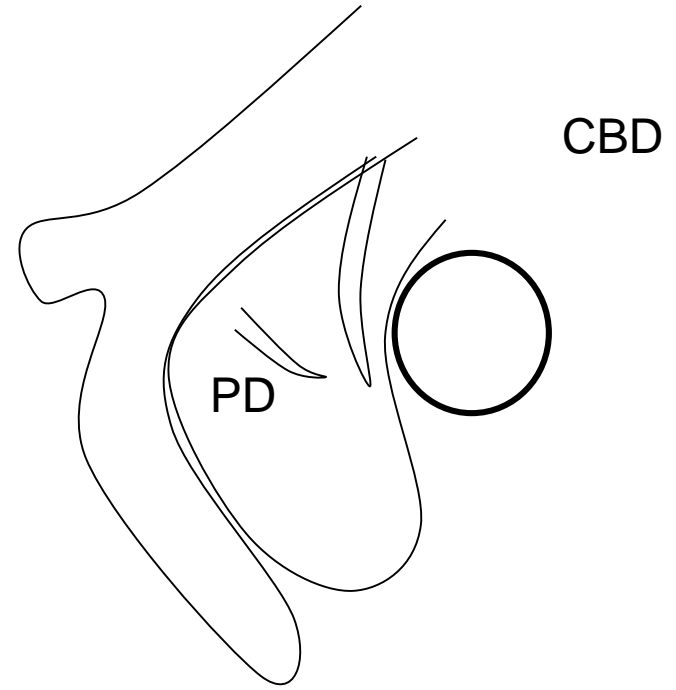
ENDOSCOPIE CHU NORD

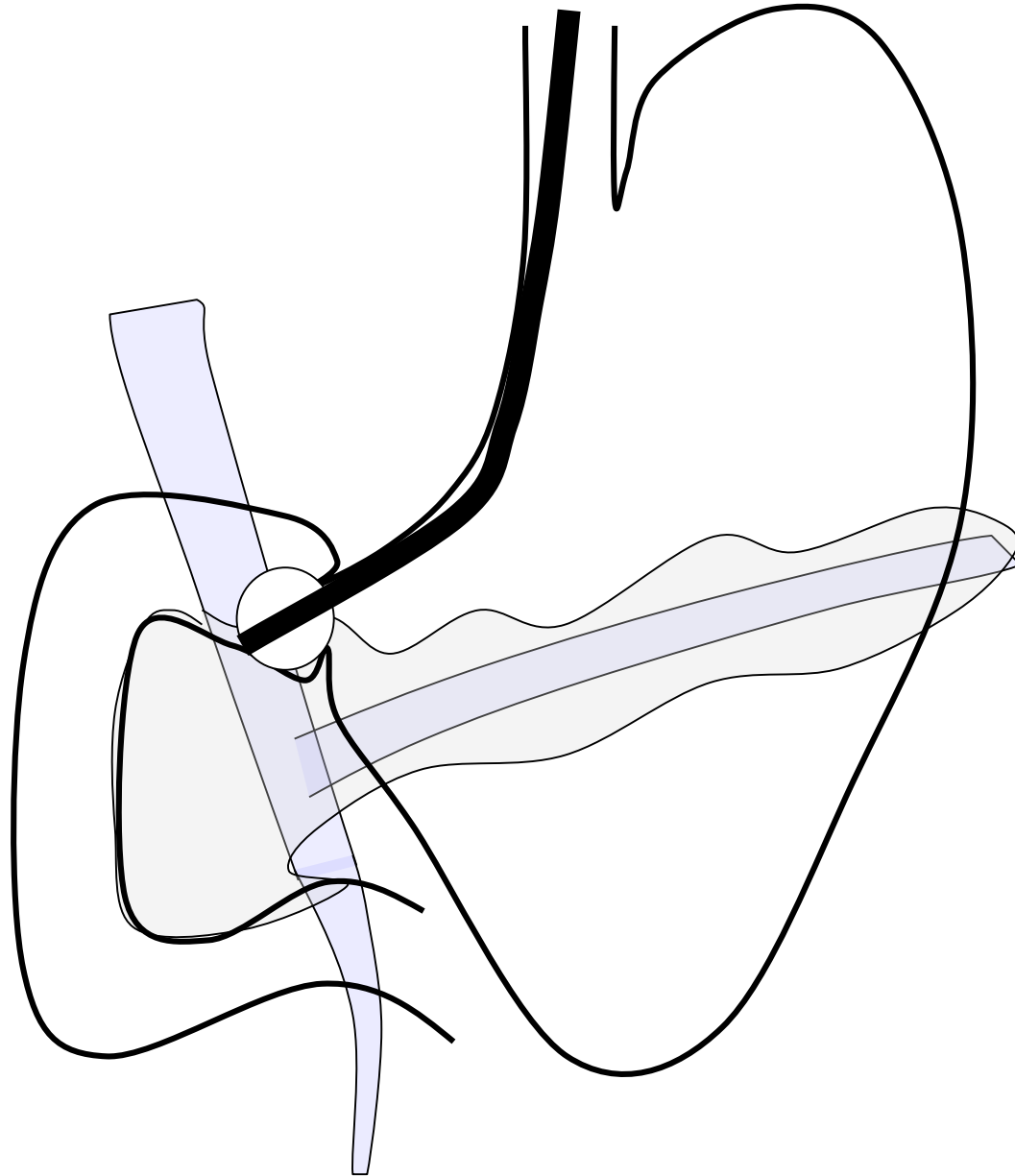


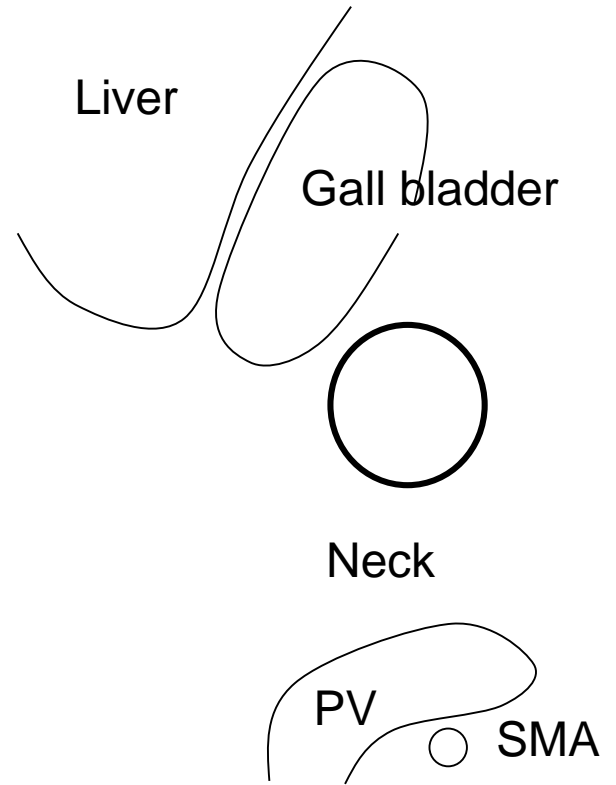


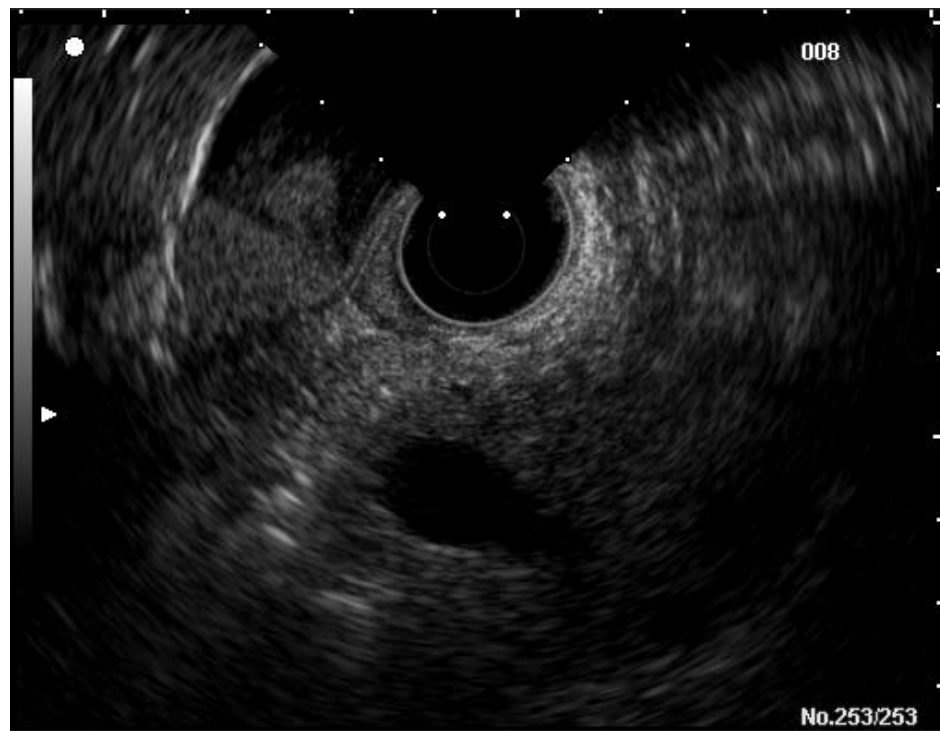


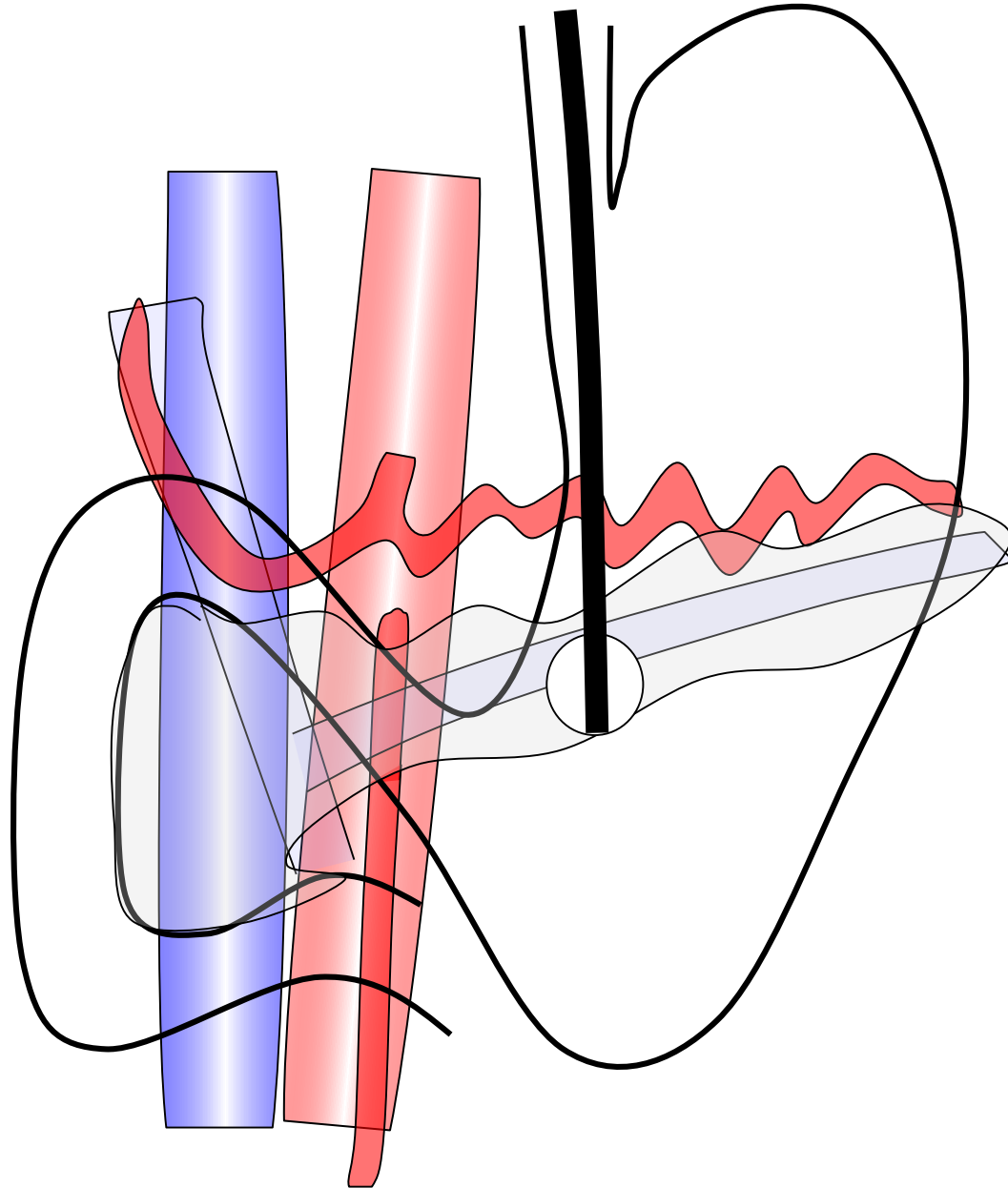


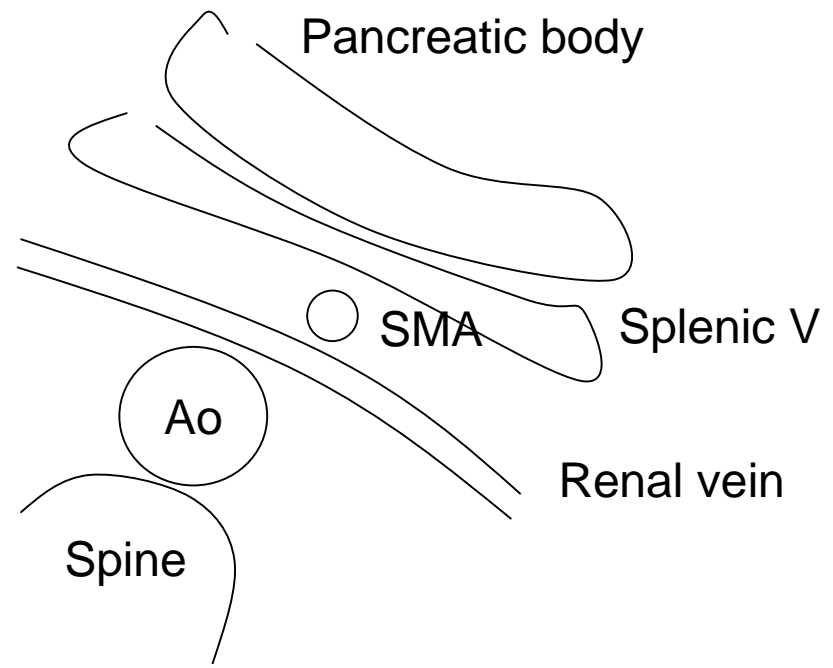




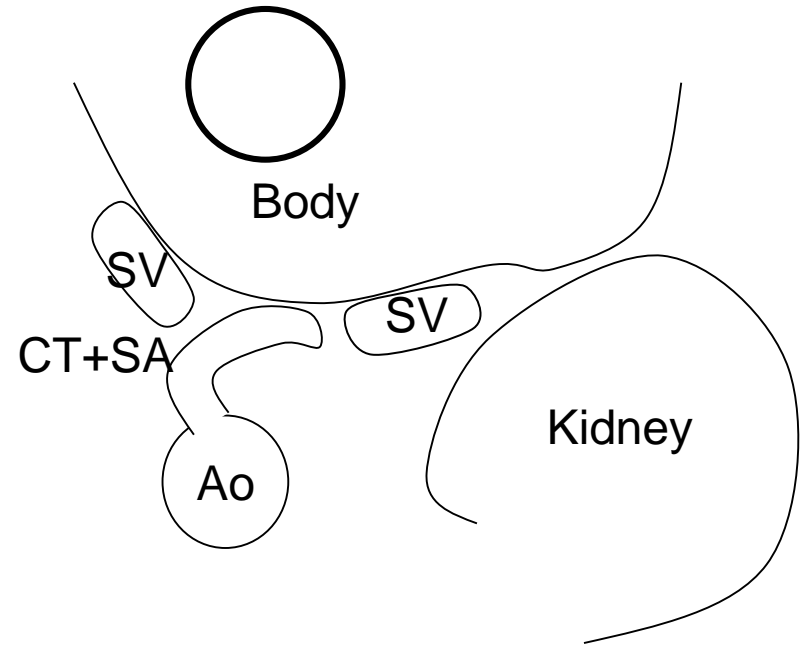


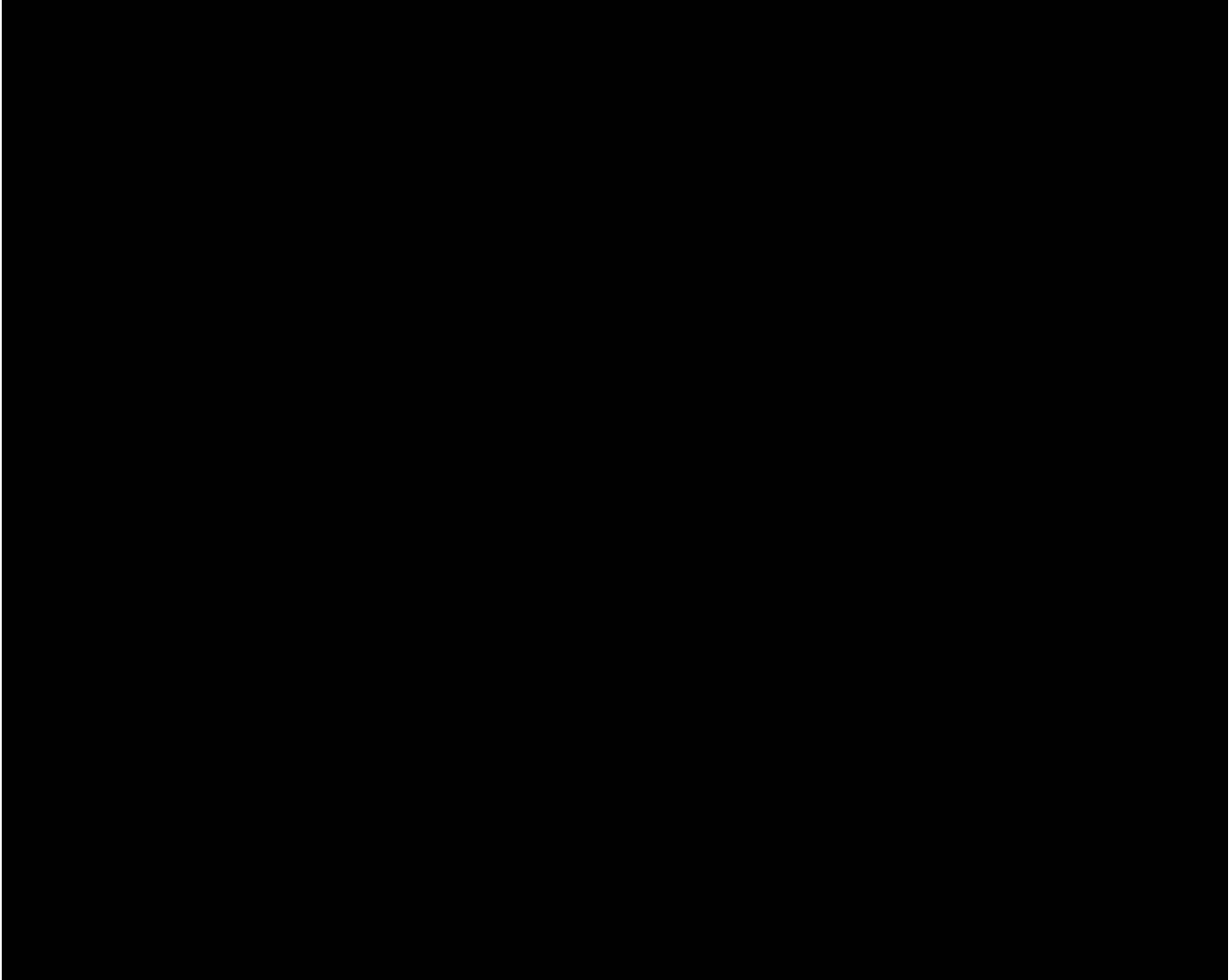






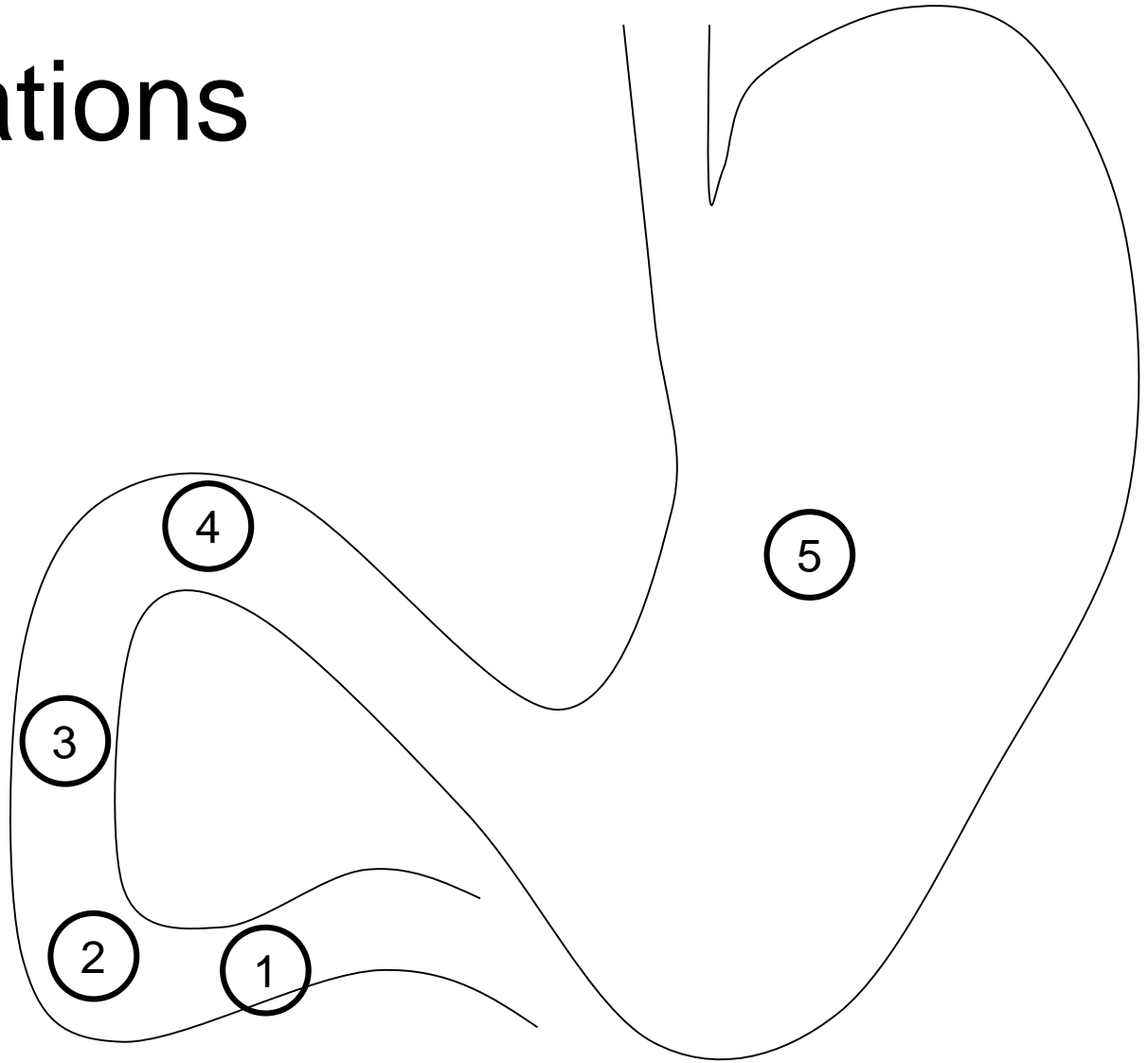


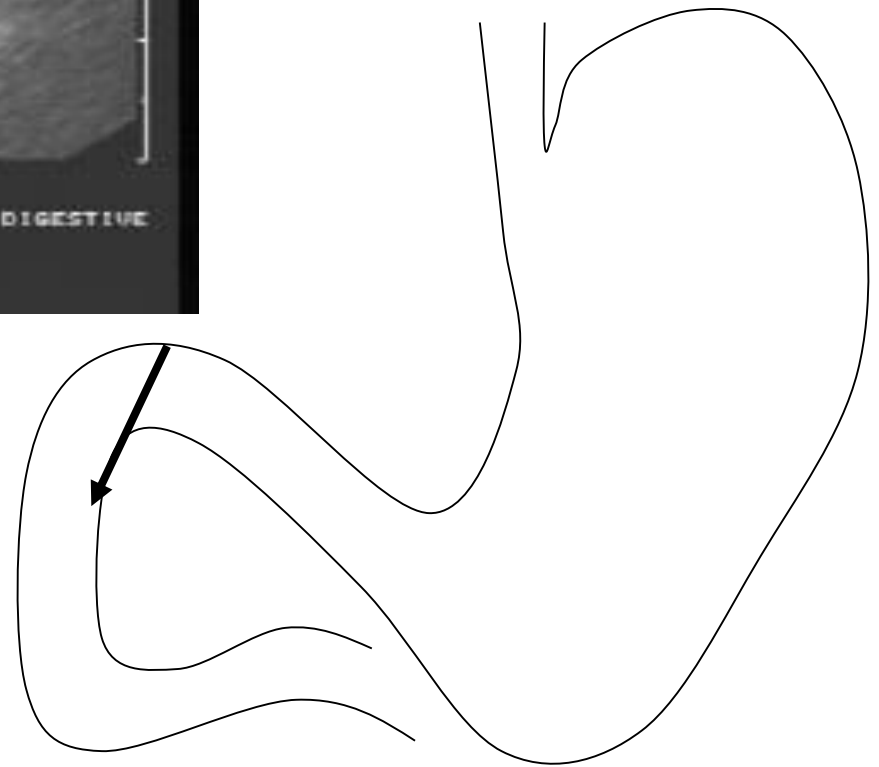


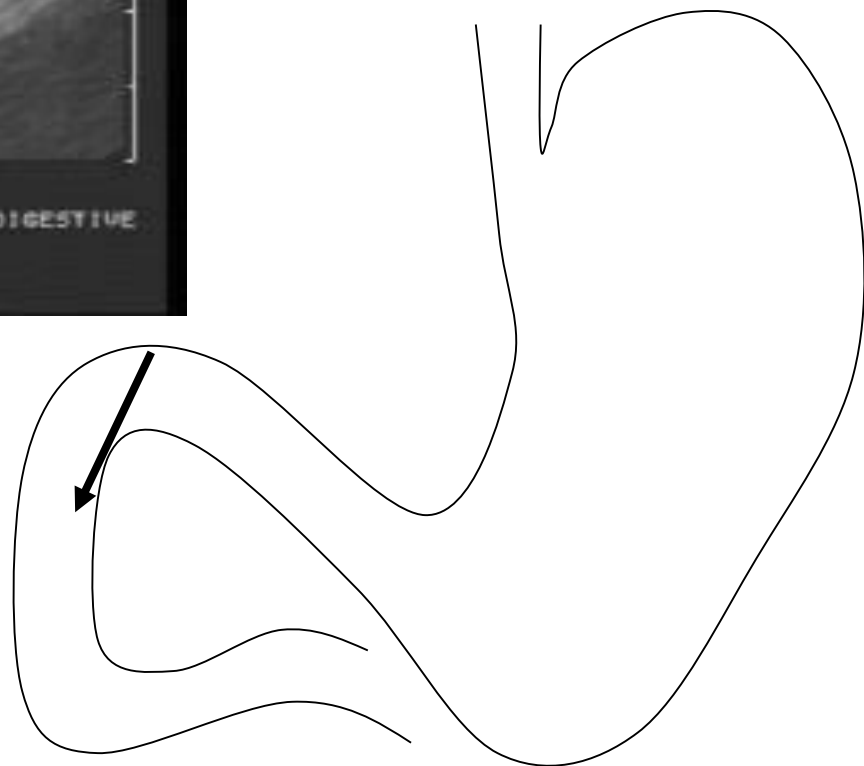
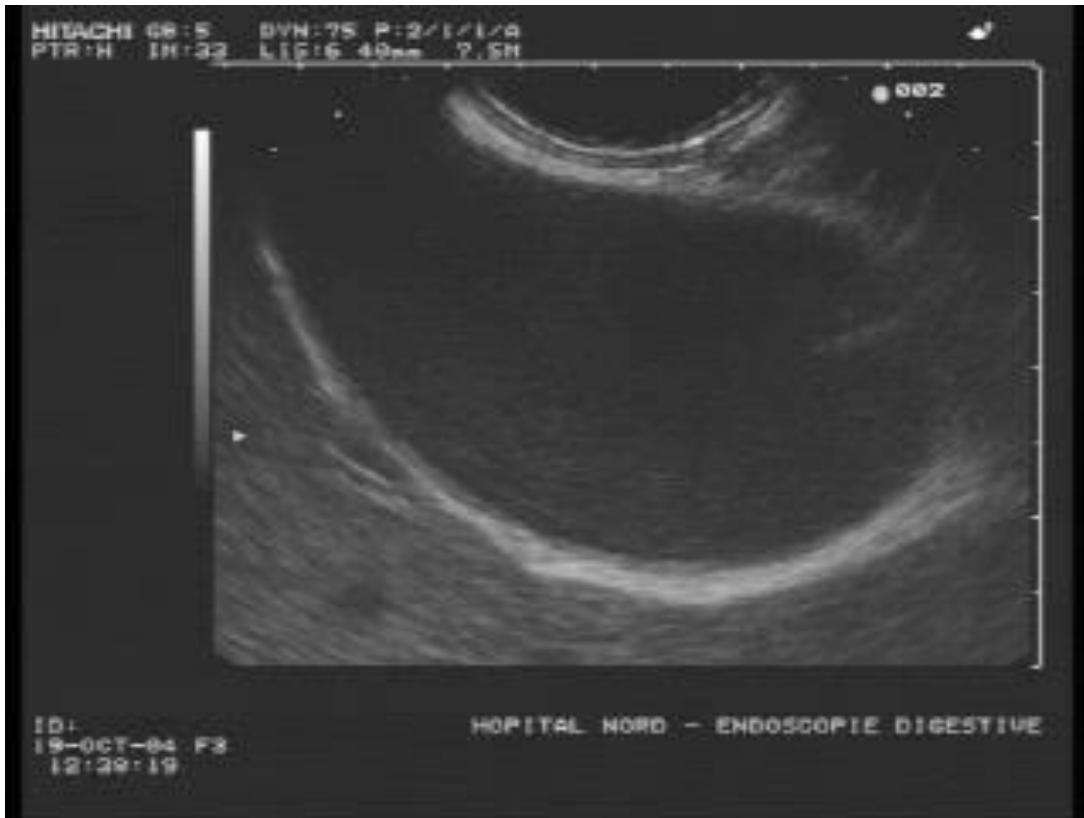


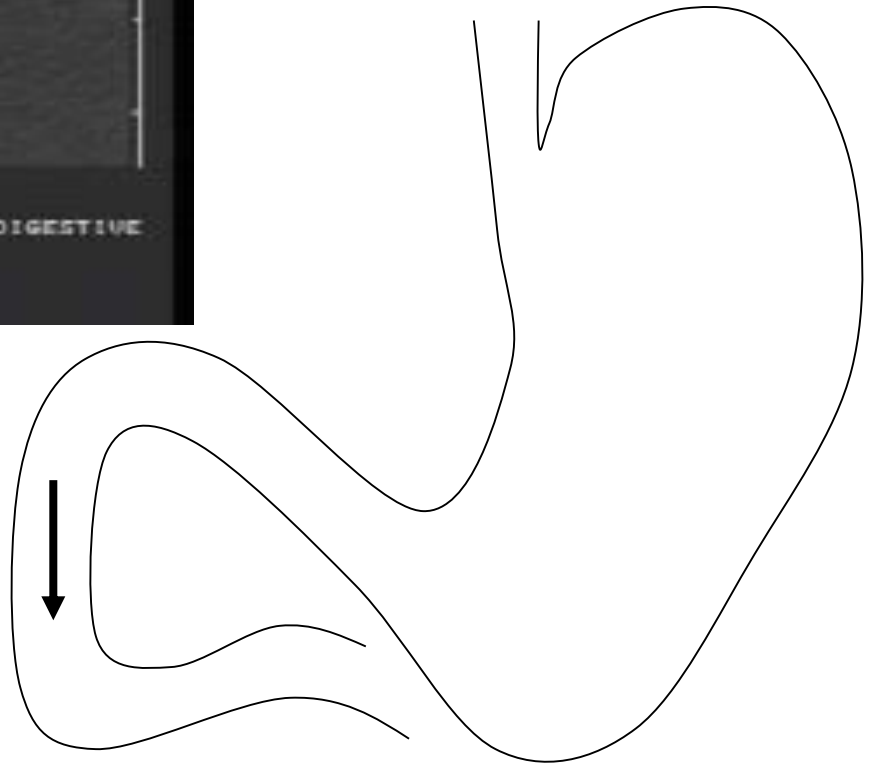
- En linéaire

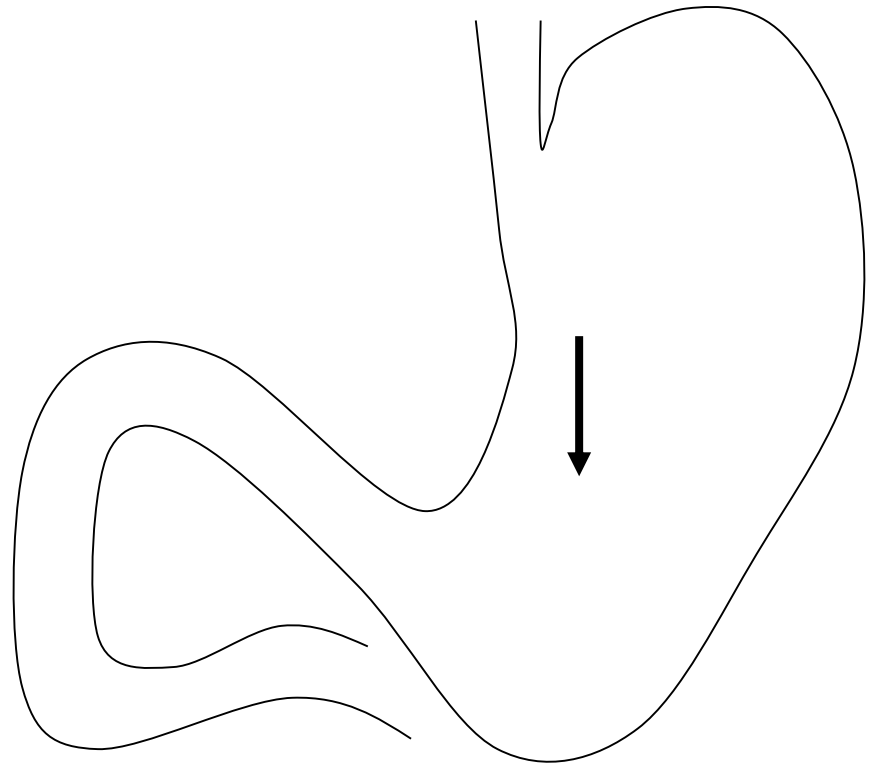
# Stations



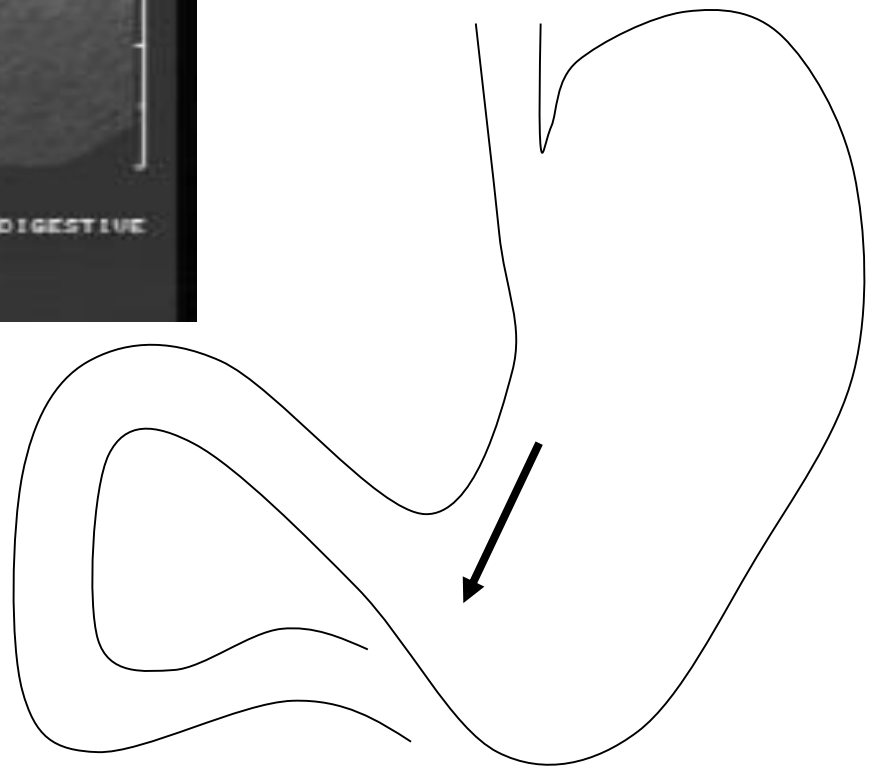












# Indications cliniques

# Les indications reconnues

- ❖ Bilan d'extension des cancers des organes creux
  - Œsophage
  - Rectum
  - Estomac, plus récent
- ❖ Exploration des cholestases
- ❖ Bilan des tumeurs des VB et pancréas
- ❖ Lésions kystiques du pancréas
- ❖ Tumeurs endocrines
- ❖ Troubles fonctionnels anorectaux

# Indications interventionnelles

- ❖ Ponction à l'aiguille fine
- ❖ Neurolyse coeliaque
- ❖ Drainage pseudokystes et collections
- ❖ Stents biliodigestifs (trans gastrique trans duodéal)
- ❖ Injections intratumorales (fiduciels, molécules)
- ❖ Dérivations gastro-digestives (expérimental)

# Cholestases

- ❖ Zones visualisées
  - Vésicule biliaire
  - Voies biliaires sous hilaires
  - Papille
  - Pancréas
- ❖ Diagnostic étiologique ~ 96 %
- ❖ Limites : Lésions sus-hilaires

# Diagnostic de lithiase

- ❖ 95% concordance avec la CPRE

  - *Amouyal et al., Palazzo et al, Prat et al., Burtin et al.*

- ❖ Moins invasive que la CPRE

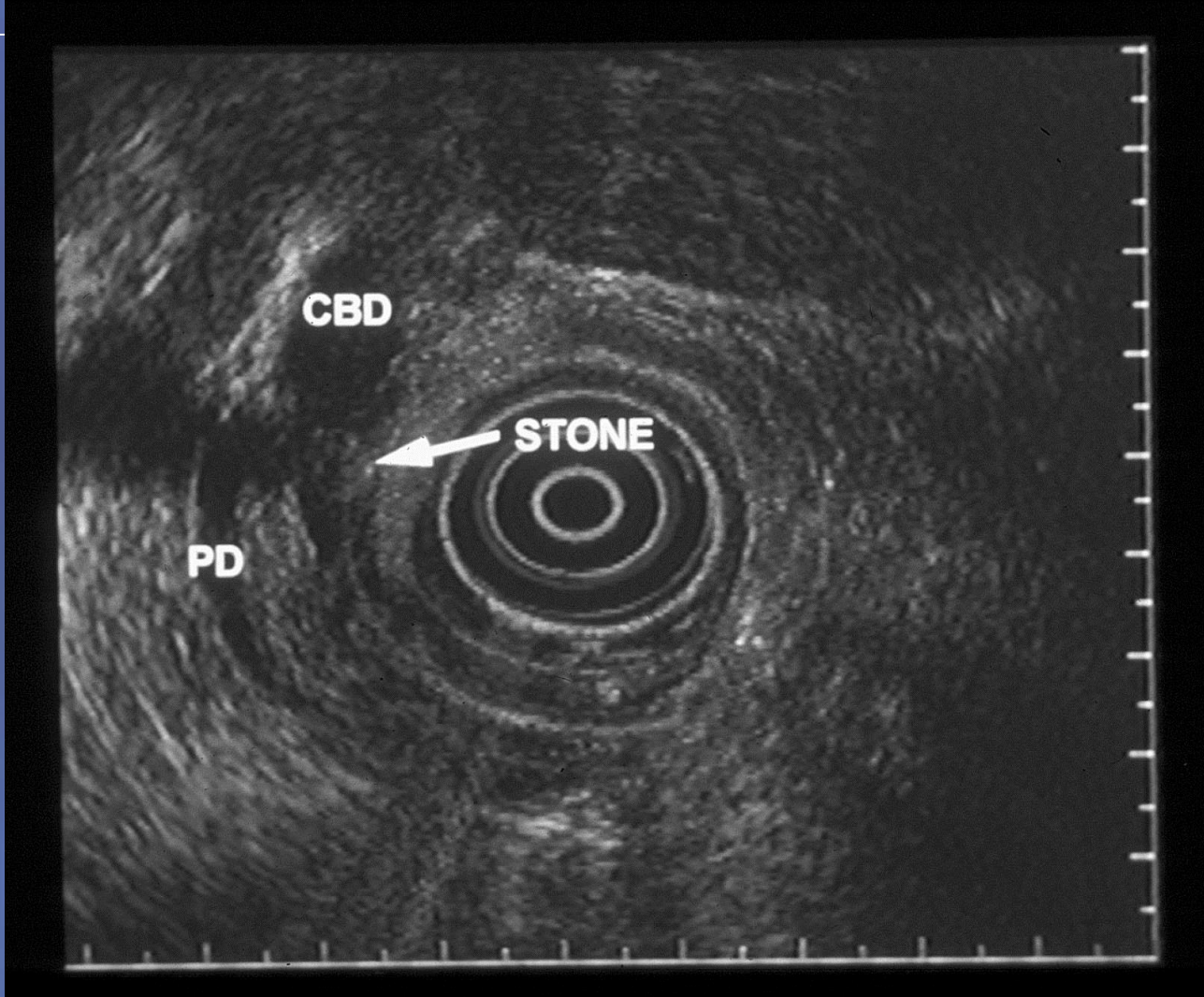
- ❖ Superposable à la MRI (papille, petit calculs)

  - *Aubé et al, 2003,*

- ❖ Combinée à la CPRE ++

  - Traitement immédiat

  - Cout efficace en cas de P moyenne de LVBP *Prat et al, Canto et al.*



# Stratégies avant cholecystectomie

	Asymptomatique	Pancreatite Cholestase	Angiocholite
P lithiase	3 %	30 %	80 %
Action	stop	EUS puis ERCP	ERCP Pas d'EUS



# Détection tumeur

## ❖ Borbath 2005

**Table 2.** Respective sensitivities and specificities of EUS, PET and MRI for tumor detection

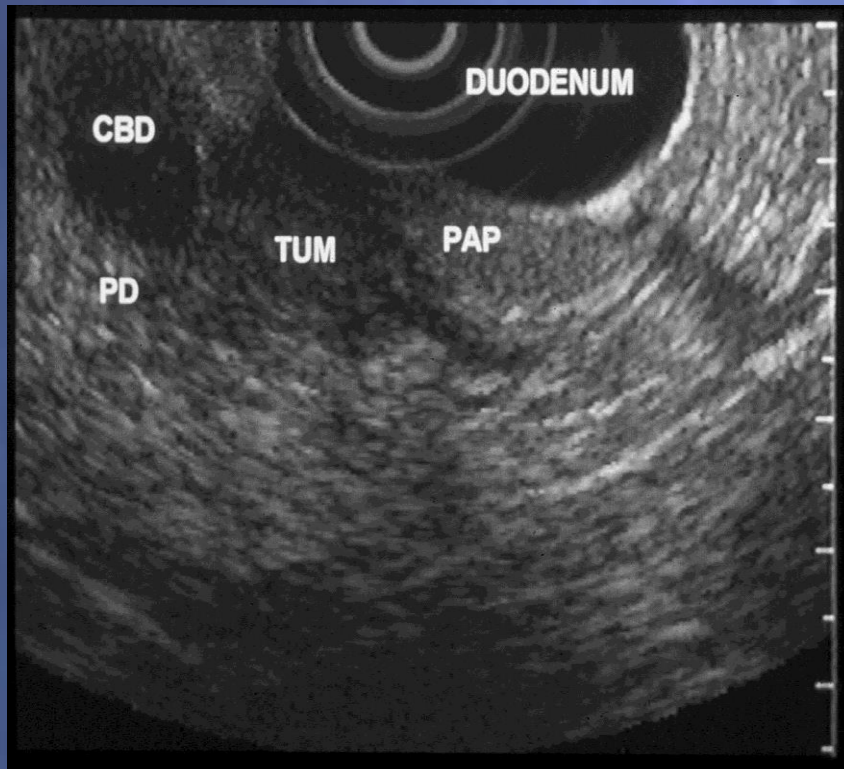
	EUS	PET	MRI
Sensitivity, %	98 (47/48)	87.5 (42/48)	87.5 (42/48)
Tumors <25 mm, %	100 (12/12) <sup>a</sup>	83 (10/12)	50 (6/12)
Tumors >25 mm, %	97 (35/36)	89 (32/36)	100 (36/36) <sup>a</sup>
Specificity, %	82 (9/11)	54.5 (6/11) 66.6 (6/9) <sup>b</sup>	91 (10/11)

## Diagnostic cancer du pancréas (%)

	<b>EUS</b>	<b>US</b>	<b>CT</b>	<b>ANGIO</b>
<b>All cancers (No=333)</b>	<b>94</b>	<b>69</b>	<b>74</b>	<b>91</b>
<b>Tumors &lt; 3 cm</b>	<b>100</b>	<b>59</b>	<b>53</b>	<b>85</b>

*Palazzo et al. 1998*

# Papillary and pancreatic tumors



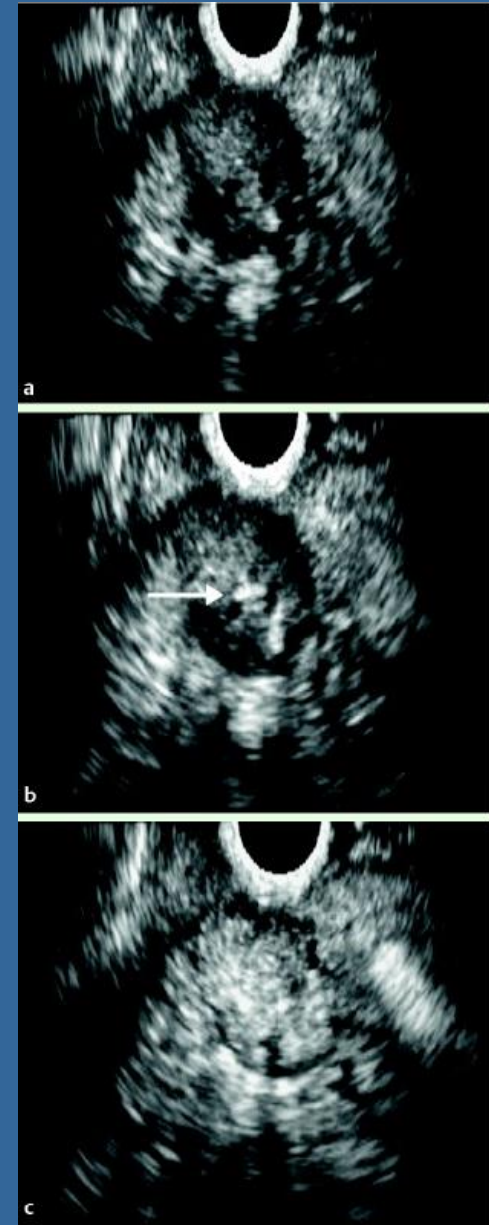
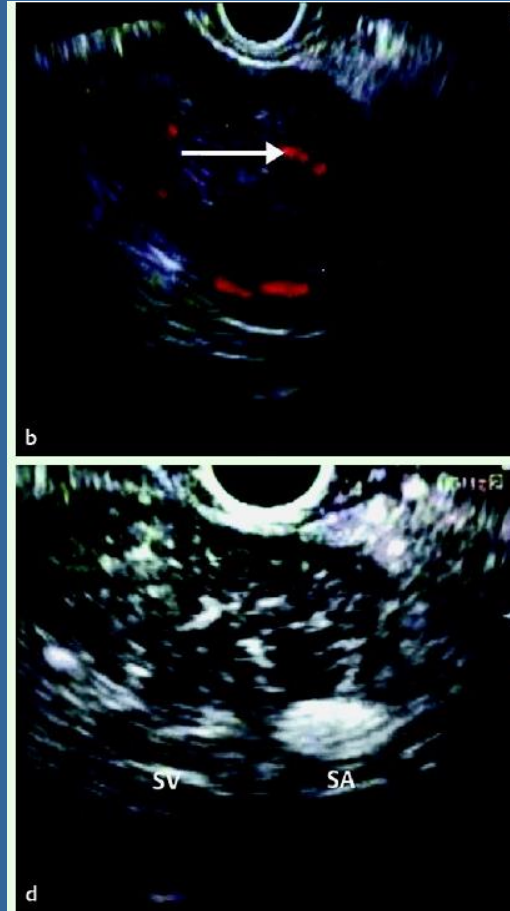
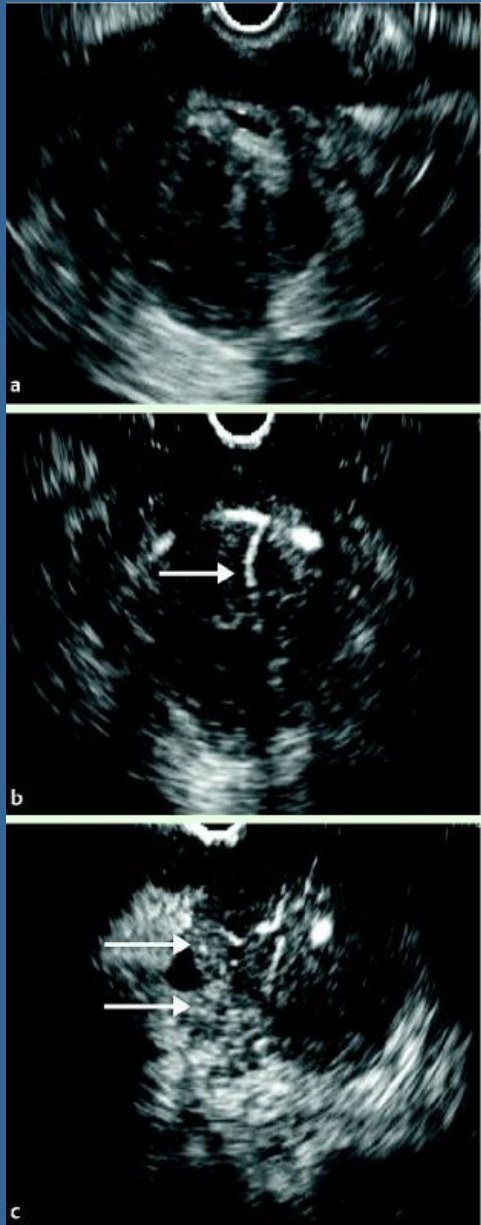
# Les techniques EUS pour améliorer le diagnostic ?

- ❖ 3D ?
- ❖ Echoendoscopie de contraste ?
- ❖ Elastographie ?
- ❖ Endomicroscopie ?
- ❖ Ponction cytologique

# Echoendoscopie de contraste

- ❖ Evaluation de la vascularisation en dynamique
- ❖ Marqueur de flux sanguin : microbulles
- ❖ Aspects observés :
  - Hypovasculaire (cancer)
  - Isovasculaire
  - Hypervasculaire avec washout rapide (TNE)
  - Avasculaire (kystes)

# Contrast EUS

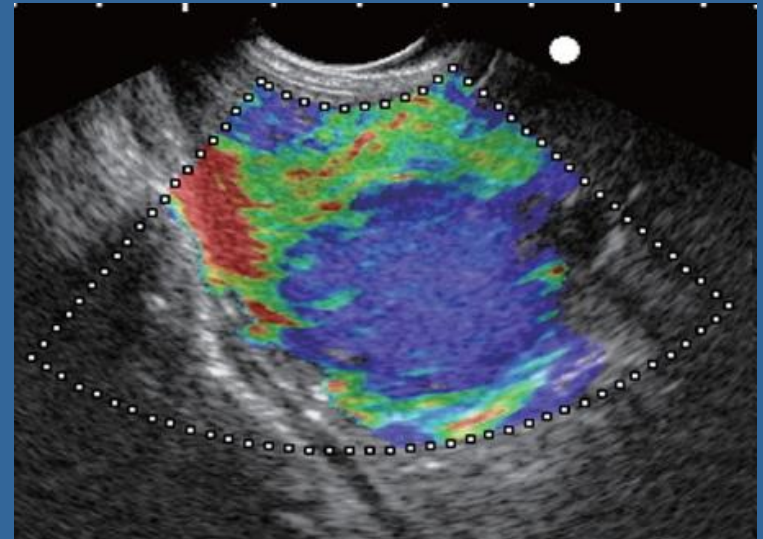
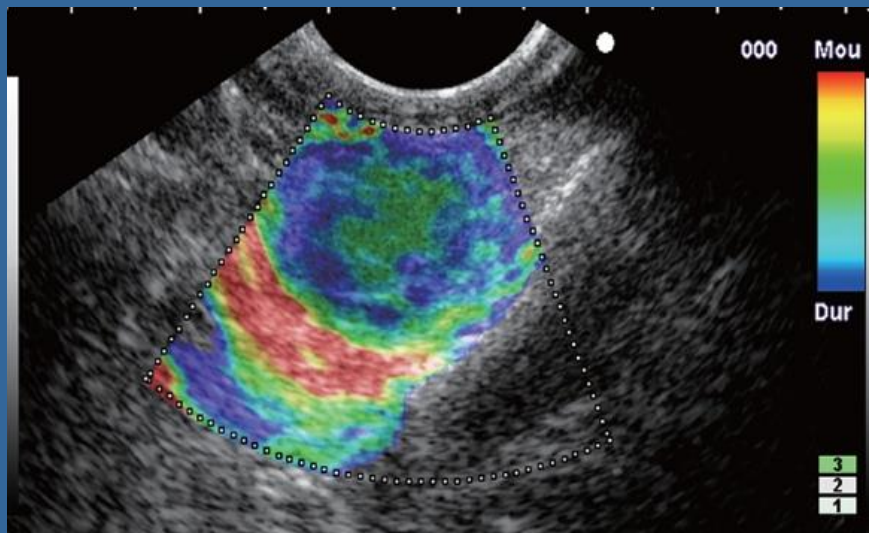
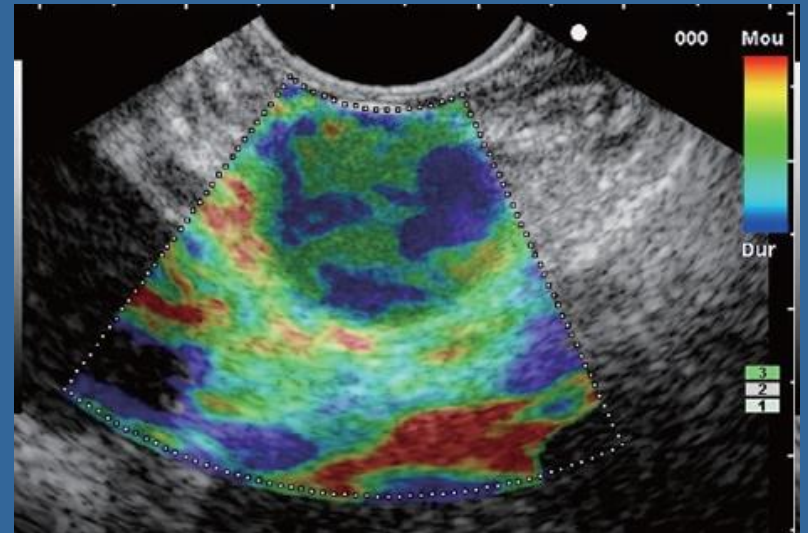
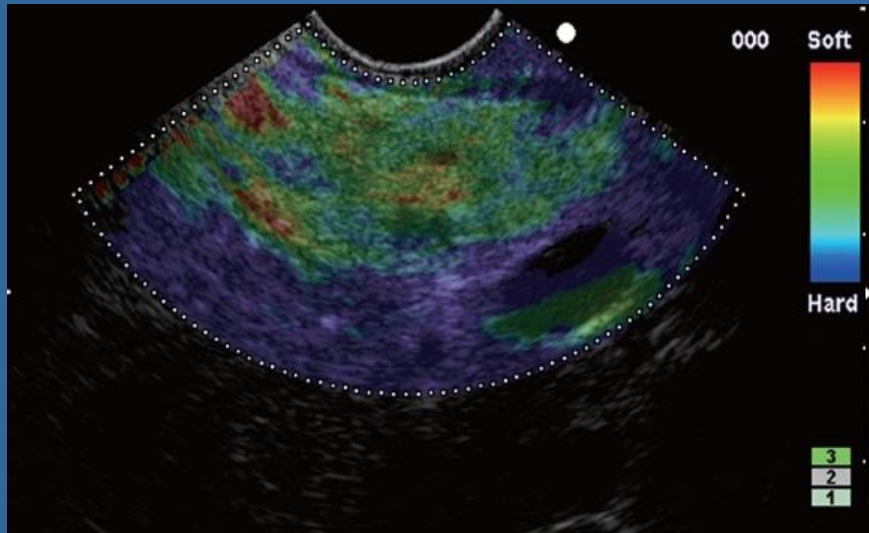


ADK

AIP

NET

# Elastographie



# Bilan d'extension tumorale



# Cancer du pancréas

- ❖ T 82%
- ❖ N 65-75%
- ❖ N2 ?
- ❖ Extension vasculaire ++

# Cancer du pancréas : 2 facteurs pronostiques majeurs

## ❖ Marge rétropéritonéale

→ AMS, VMS, Confluent MP

## ❖ Atteinte ganglionnaire N3

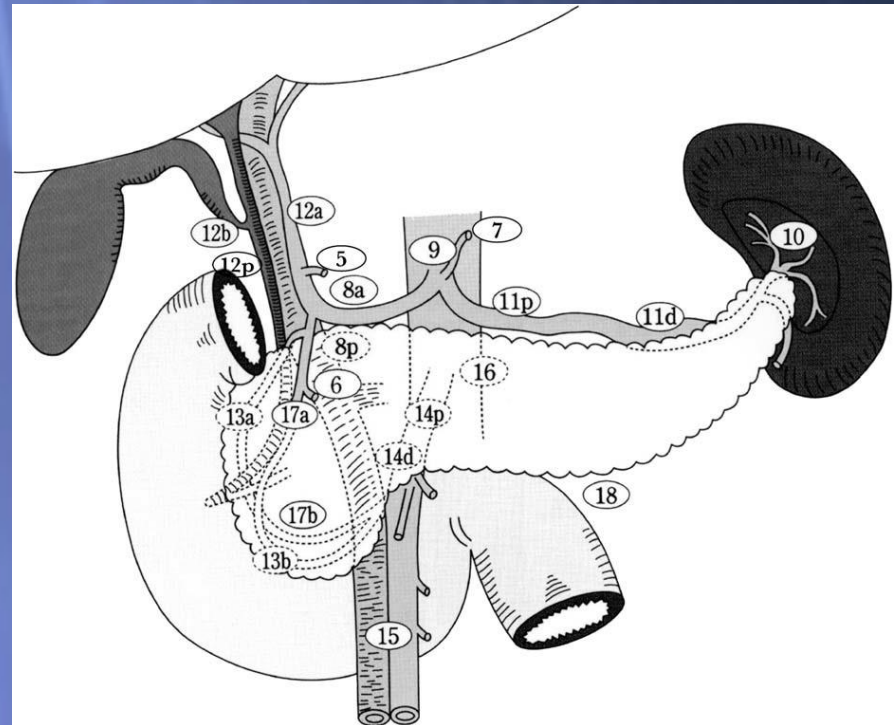
→ Péripancréatique : 50%

→ Sus claviculaire gauche : 2%

→ Mediastinal postérieur: 5%

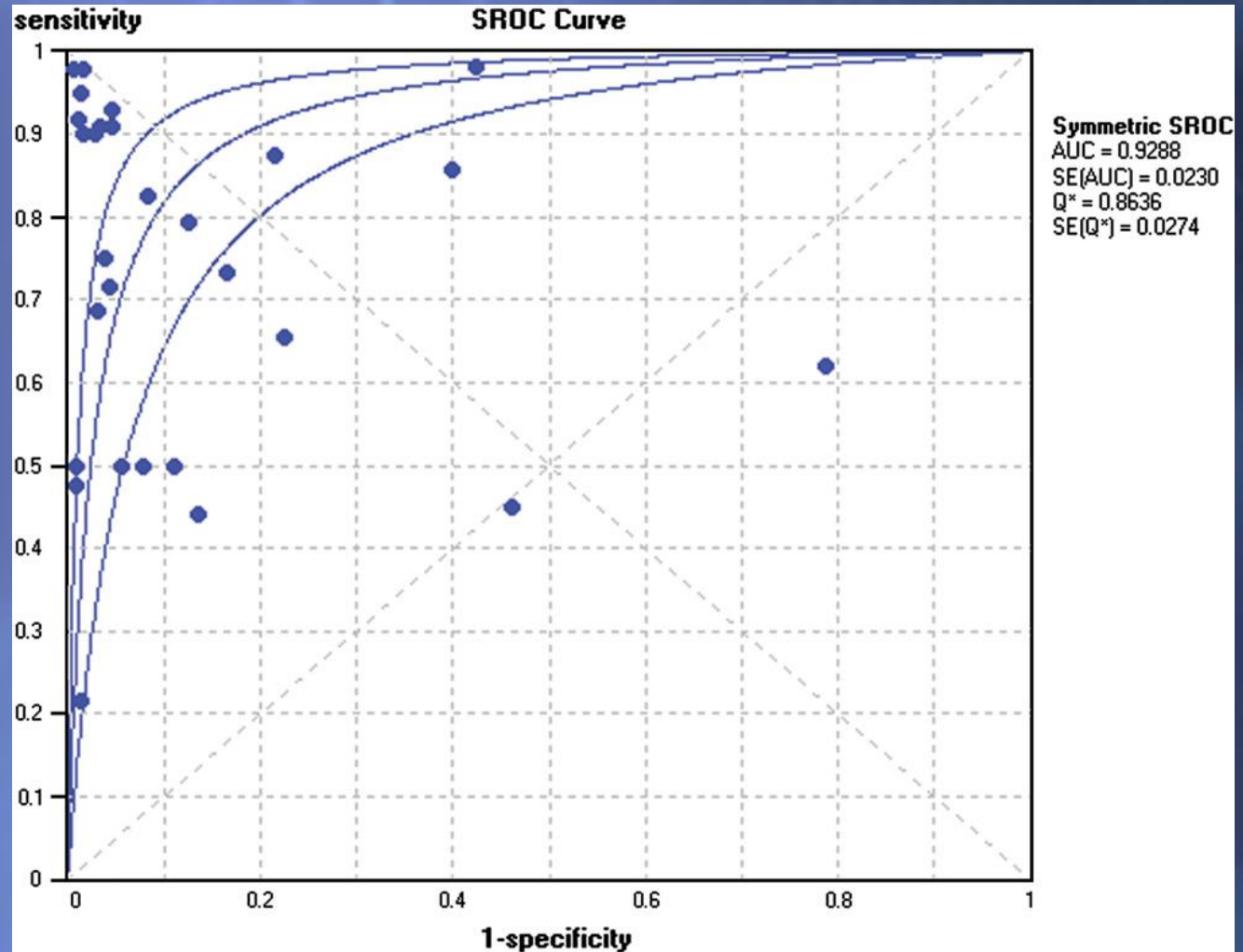
→ Coeliaque : 15%

→ Lombo-aortique : 20%



# Metaanalyse : cancer du pancréas invasion vasculaire

*Puli  
GIE  
2007*



# Diagnostic et bilan d'extension

## Hunt 2002

Detection		Accuracy for resectability		Sensitivity for vascular invasion	
EUS	CT	EUS	CT	EUS	CT
27/27	25/27	20/22	19/22	6/7	7/7
33/34	26/34	25/30	23/30	13/16	9/16
		30/31	25/31	16/16	10/16
29/31	16/31	16/16	13/16	6/6	3/6
97%	73%	91%	83%	91%	64%
<0.001		0.02		<0.001	

# Cancer du pancreas : extension vasculaire

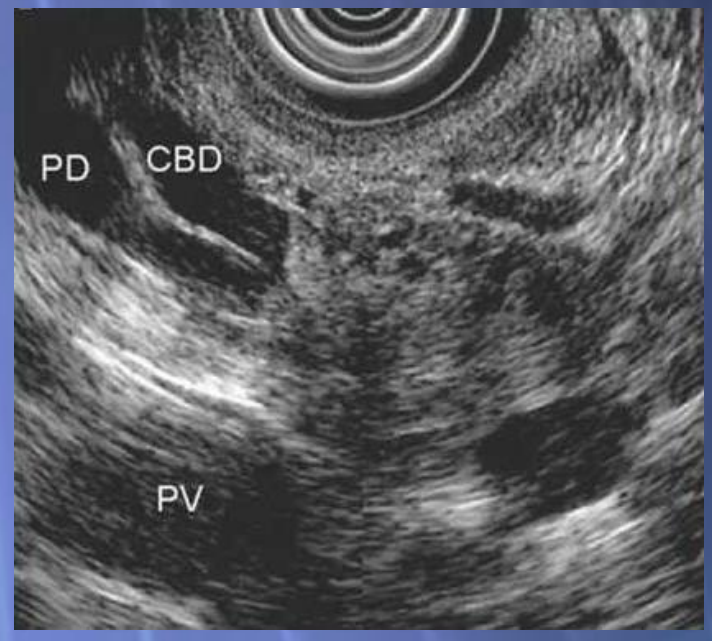
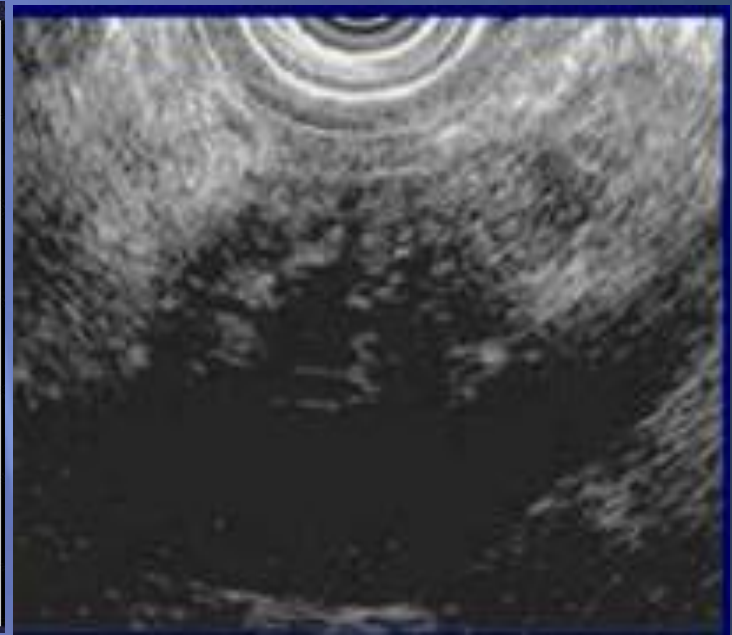
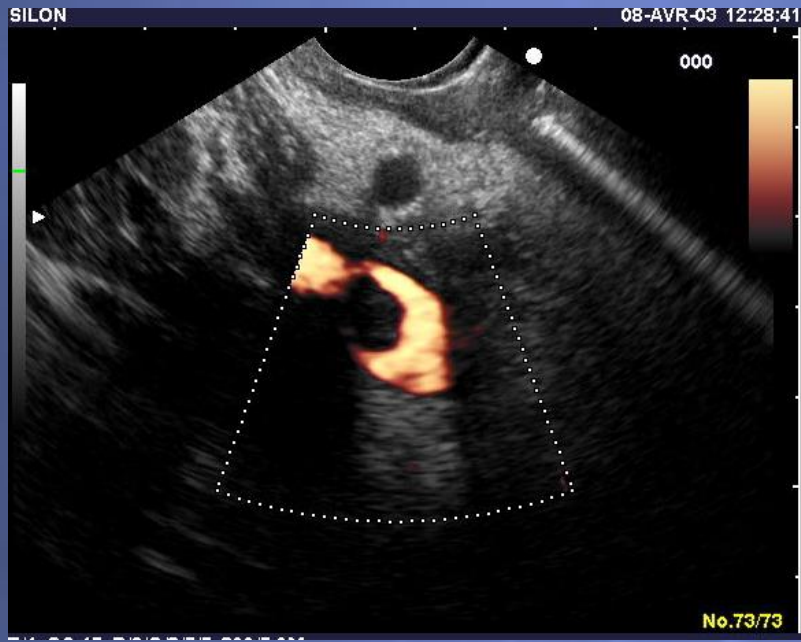
## ❖ Critères habituels d'envahissement vasculaire

- Bourgeon intravasculaire
- Vaisseau absent
- Extension  $> 180^\circ$
- Disparition d'interface
- Hypertension portale (cavernome)

# Tumeurs borderline

- ❖ Atteinte du confluent ou de la VMS
  - < 2 cm de hauteur
  - < 180°
- ❖ Thrombose VMS courte
- ❖ Atteinte AMS < 180°
- ❖ Atteinte AH réparable < 180°
  
- ❖ *Intérêt d'un traitement néo-adjuvant ?*

*Gigot et , CFE, 2012*



# Ganglions lombo-aortiques

## ❖ Murakami 2010

	Présents	Absents
S 2 ans	12%	49%
S 5 ans	0%	23%
Mediane	12 mo	15 mo

## ❖ Donc : ponctionner les ganglions N2 ou N3



❖ Soriano et al, 2004

→ EES            Stade

Ganglions ++

→ TDM            Extension locorégionale

Extension vasculaire

❖ Cout efficacité : Faire TDM, puis EES si résécabilité potentielle

# Oesophagus 7<sup>th</sup> edition

## TNM definitions: AJCC = UICC

Tis Carcinoma in situ /High-grade dysplasia

T1 lamina propria or submucosa  
T1a lamina propria or muscularis mucosae  
T1b submucosa

T2 muscularis propria

T3 adventitia

T4 adjacent structures  
T4a pleura, pericardium, diaphragm, or adjacent peritoneum  
T4b other adjacent structures, e.g. aorta, vertebral body, trachea

N0 No regional lymph node metastasis

N1 1 to 2 regional lymph nodes

N2 3 to 6

N3 >6  
[N1 was site dependent]

M - Distant Metastasis

M1 Distant metastasis  
[M1a,b were site dependent]

Changes from 6<sup>th</sup> edition

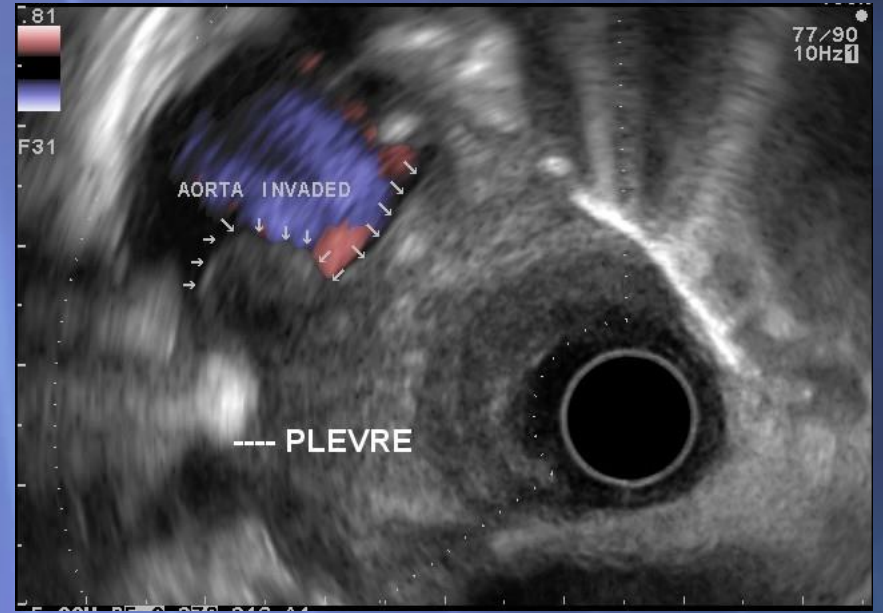
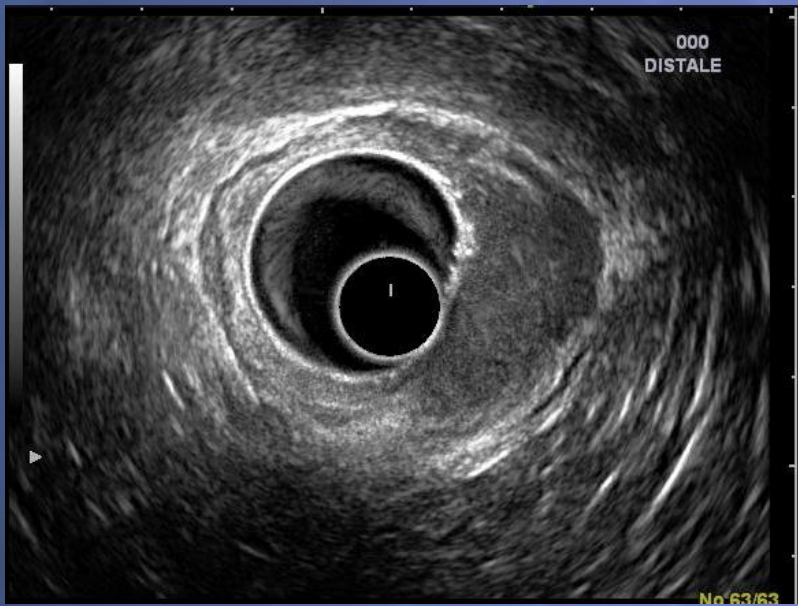
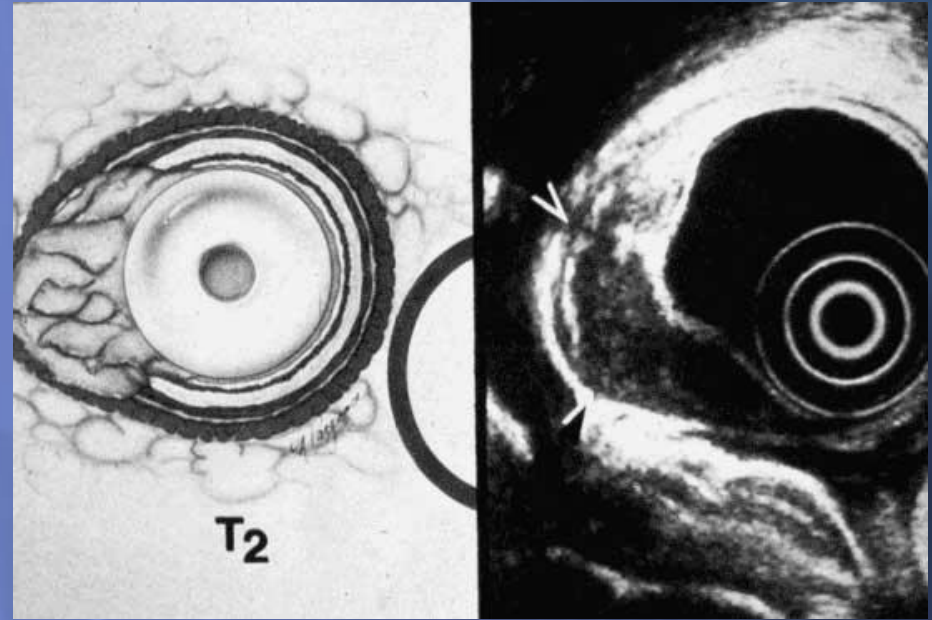
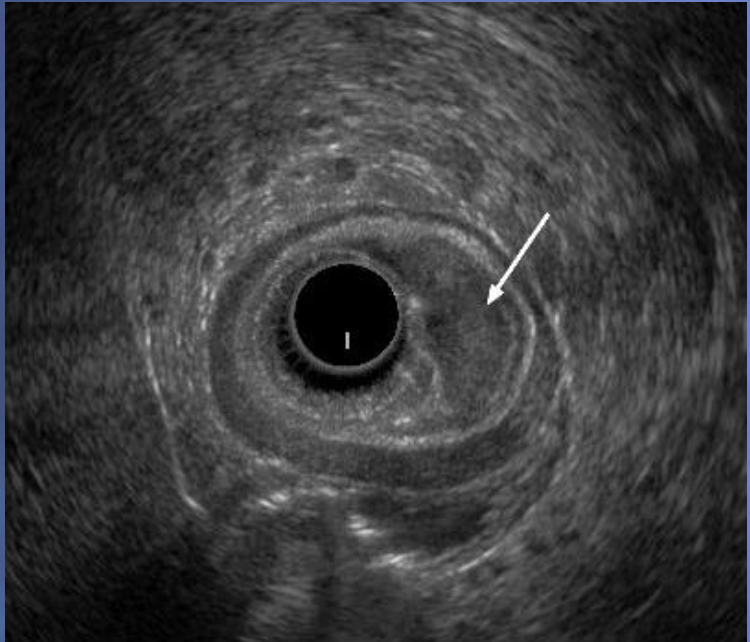
# Stomach 7<sup>th</sup> edition

- T1 Lamina propria, submucosa
  - T1a Lamina propria
  - T1b Submucosa
- T2 Muscularis propria
- T3 Subserosa (*was T2b*)
- T4a Perforates serosa (*was T3*)
- T4b Adjacent structures
  
- N1 1 to 2 nodes
- N2 3 to 6 nodes (*was N1*)
- N3a 7 - 15 nodes (*was N2*)
- N3b 16 or more (*was N3*)

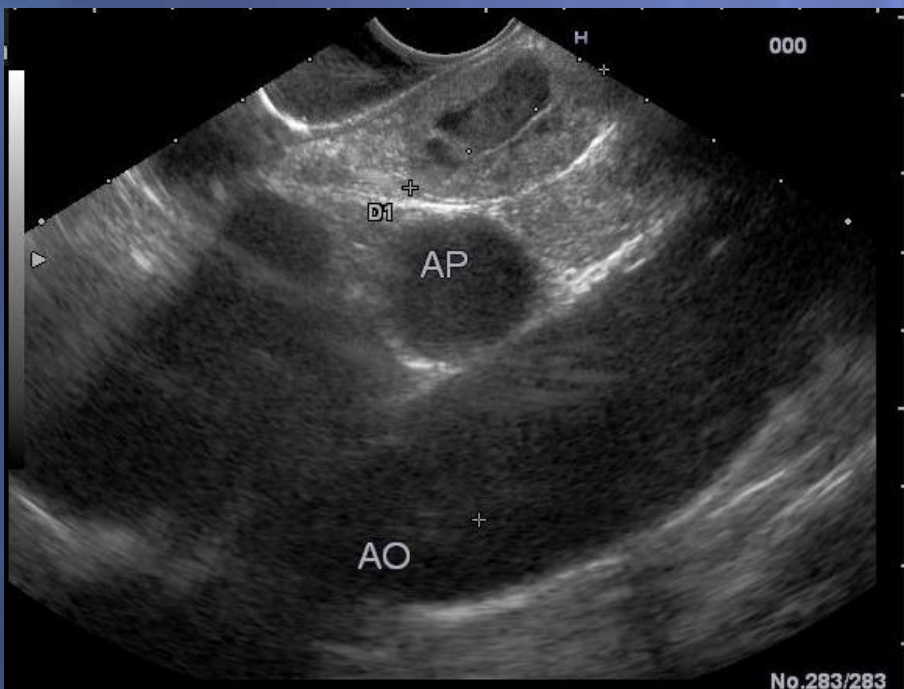
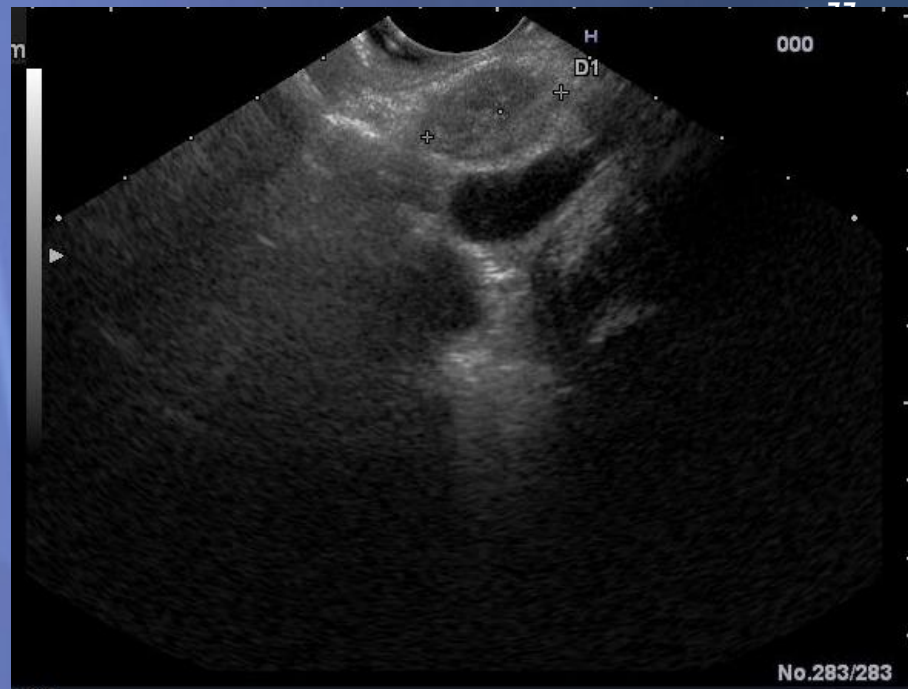
Changes from 6<sup>th</sup> edition

Stage IA	T1	N0
Stage IB	T2	N0
	T1	N1
Stage IIA	T3	N0
	T2	N1
	T1	N2
Stage IIB	T4a	N0
	T3	N1
	T2	N2
	T1	N3
Stage IIIA	T4a	N1
	T3	N2
	T2	N3
Stages IIIB, IIIC, IV...		

Stages: most changed



# GANGLIONS



# Ganglions

	Mediastinaux	Coeliaques
Se	79 %	83 %
Sp	63 %	98 %
Kappa	0.50	0.73

- ❖ *Catalano et al. Gastrointest endosc 1999;50:352-6*
- ❖ *Burtin et al. Gastrointest Endosc 1996;43:20-4*

# Metaanalyse : cancer de l'oesophage

*Puli World J Gastroenterol 2008*

	<b>Pooled sensitivity (%)</b>	<b>Pooled specificity (%)</b>	<b>Pooled LR+</b>	<b>Pooled LR-</b>	<b>Pooled DOR</b>
T1	81.6 (77.8-84.9)	99.4 (99.0-99.7)	44.4 (15.5-127.4)	0.2 (0.2-0.4)	221.5 (118.5-413.9)
T2	81.4 (77.5-84.8)	96.3 (95.4-97.1)	16.6 (9.3-29.7)	0.2 (0.2-0.3)	90.7 (48.3-170.5)
T3	91.4 (89.5-93.0)	94.4 (93.1-95.5)	12.5 (7.7-20.3)	0.1 (0.1-0.2)	145.2 (90.3-233.4)
T4	92.4 (89.2-95.0)	97.4 (96.6-98.0)	25.4 (13.7-47.0)	0.1 (0.1-0.2)	250.0 (145.2-430.5)

# Metaanalyse : ganglions et cancer de l'oesophage

*British J cancer 2008*

<b>Disease</b>	<b>Investigation</b>	<b>Pooled sensitivity (95% CI)</b>	<b>Pooled specificity (95% CI)</b>
Regional lymph node metastases	EUS	0.80 (0.75–0.84)	0.70 (0.65–0.75)
Regional lymph node metastases	CT	0.50 (0.41–0.60)	0.83 (0.77–0.89)
Regional lymph node metastases	FDG-PET	0.57 (0.43–0.70)	0.85 (0.76–0.95)
Celiac lymph node metastases	EUS	0.85 (0.72–0.99)	0.96 (0.92–1.00)
Abdominal lymph node metastases	CT	0.42 (0.29–0.54)	0.93 (0.86–1.00)
Distant metastases	CT	0.52 (0.33–0.71)	0.91 (0.86–0.96)
Distant metastases	FDG-PET	0.71 (0.62–0.79)	0.93 (0.89–0.97)



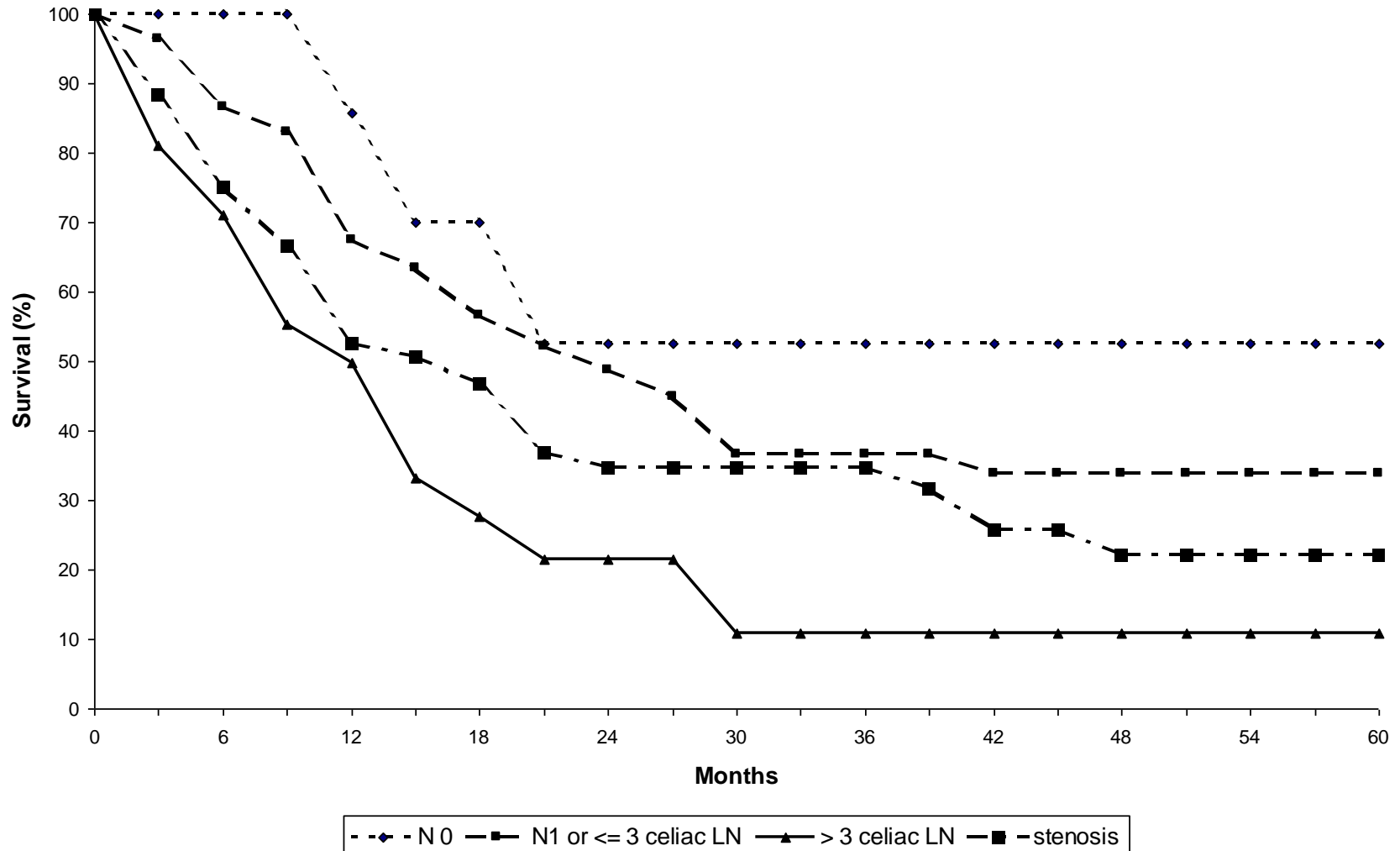
# Ganglions : pronostic

- ❖ Peu d'études multivariées
- ❖ Stade T : ne prédit pas le pronostic
- ❖ Stade N : prédicteur du pronostic
  - > 3 gg médiastin
  - > 3 gg coeliaques
- ❖ Ponction à l'aiguille fine ?
  - Sièges inattendus
  - Associés à une petite tumeur

*Giovannini et al. Endoscopy 1999; 31:536-40*

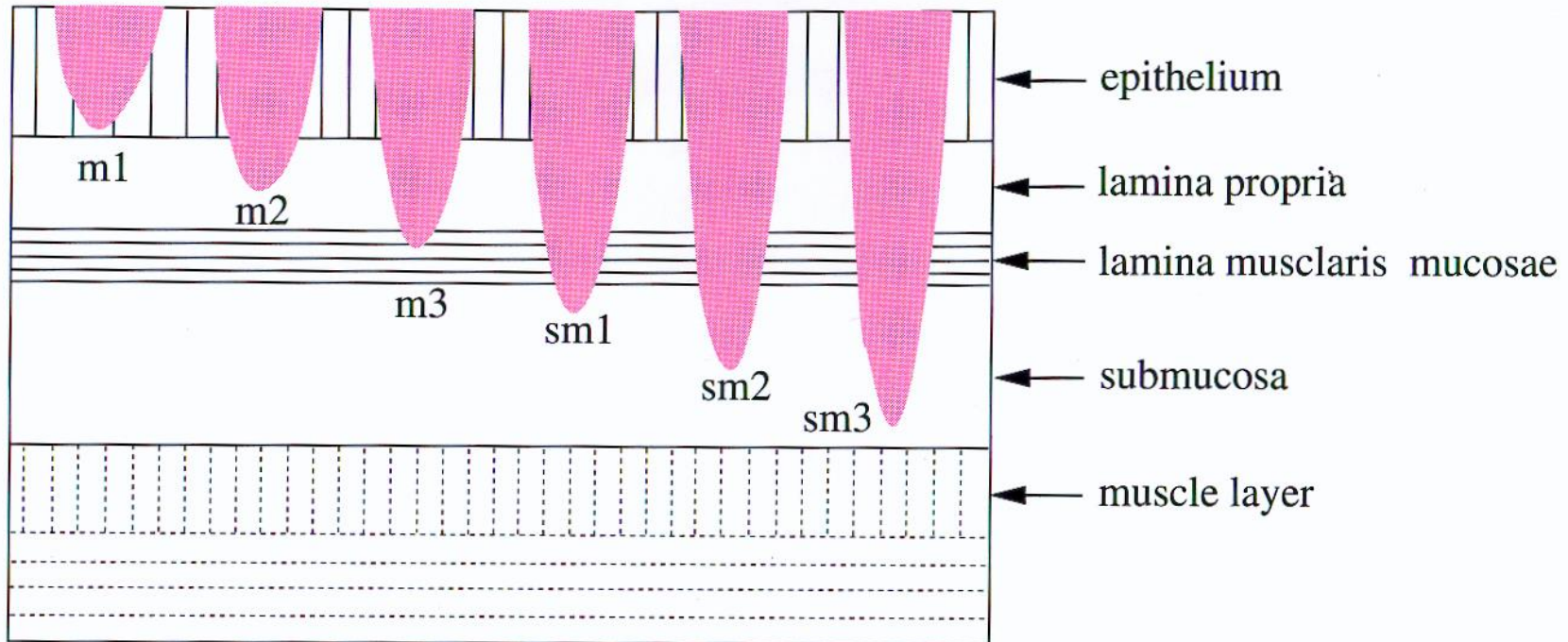
*Burtin et al. In press*

# Survies cancer œsophage avancé



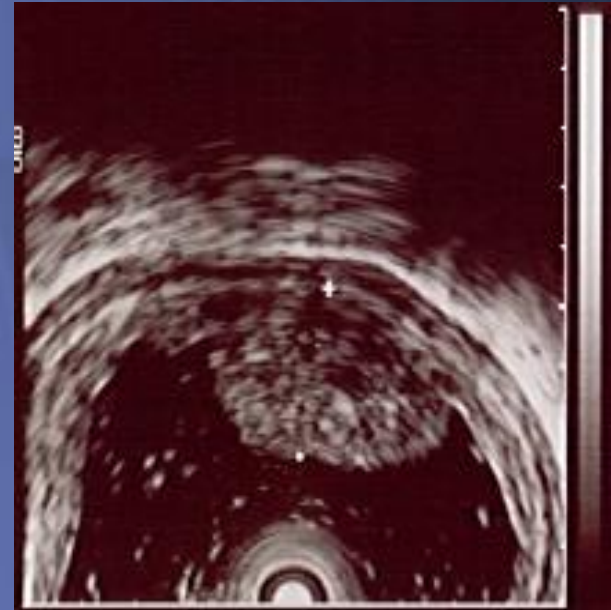
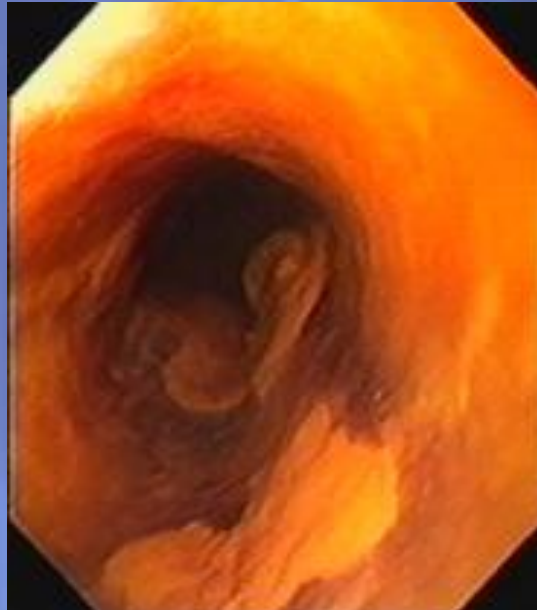
# Tumeurs superficielles

0 %   0 %   2 %   10 %   30 %   60 %   Lymphatic extent

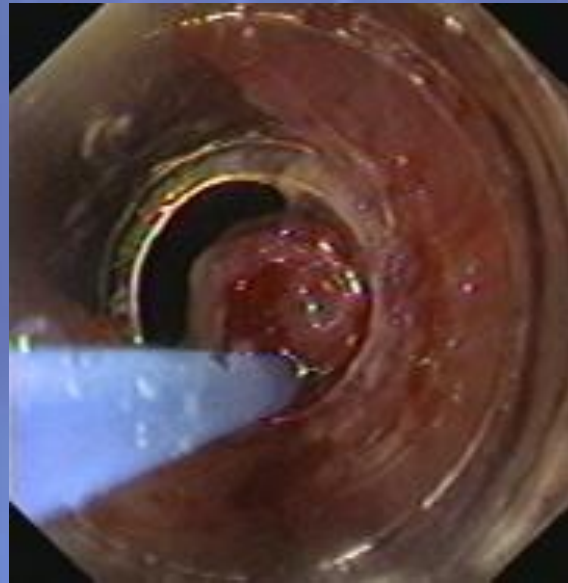


**Fig. 1-3** Classification of depth of invasion of superficial esophageal cancer (Japanese Society of Esophageal Diseases, 1992).

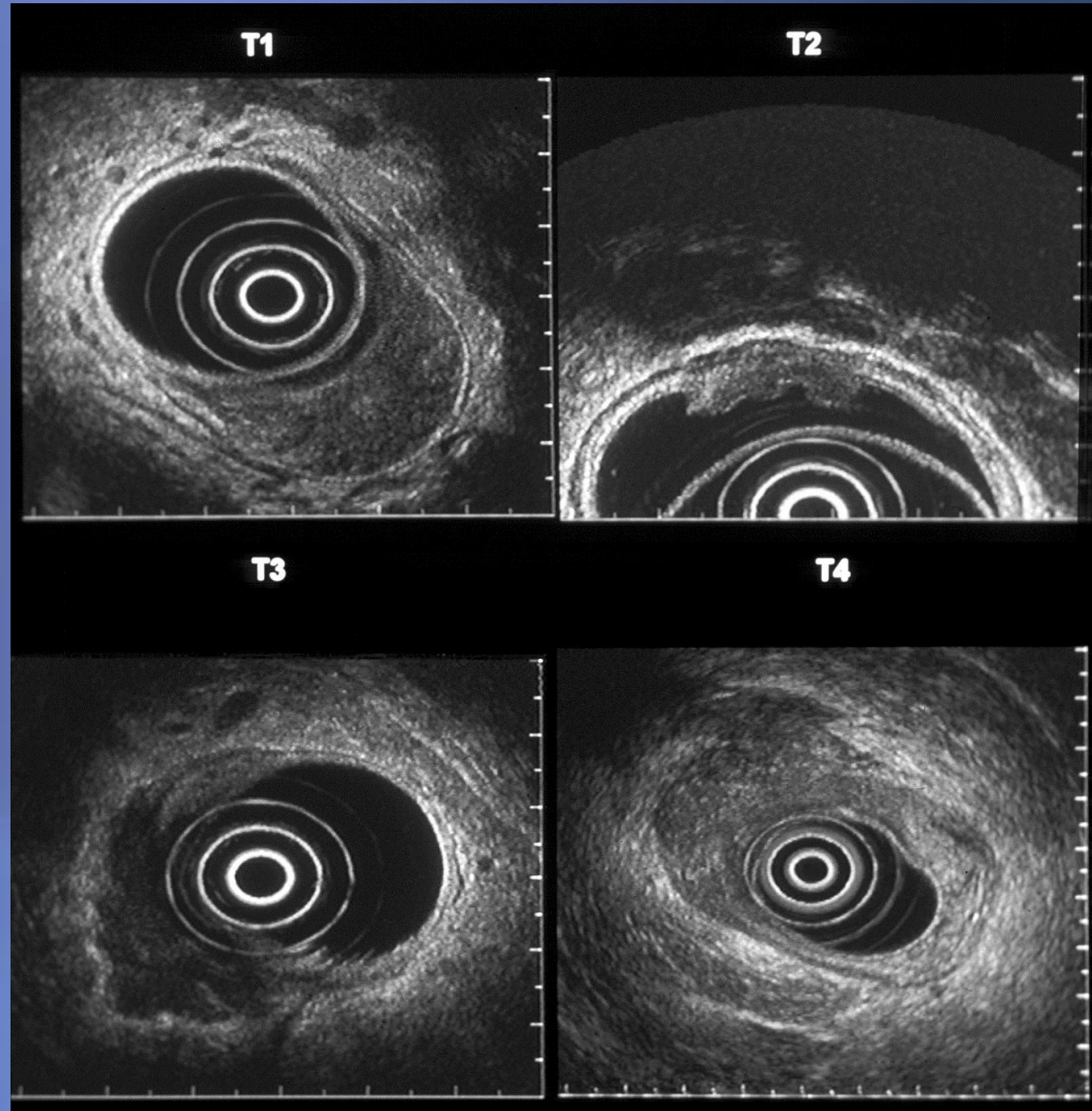
# Mucosectomie endoscopique



# Résection muqueuse endoscopique



# Tumeurs rectales



## Colon - Rectum – 7<sup>th</sup> edition

**T4** Tumour directly invades other organs or structures and/or perforates visceral peritoneum

T4a perforates visceral peritoneum

T4b directly invades other organ or structures

**M1** Distant metastasis

M1a one organ

M1b > one organ or peritoneum

Basic categories unchanged

Subdivisions expanded

**N1** Metastasis in 1 to 3 regional lymph nodes

N1a 1 node

N1b 2 – 3 nodes

N1c satellites in subserosa, *without* regional nodes\*

**N2** Metastasis in 4 or more regional lymph nodes

N2a 4 – 6 nodes

N2b 7 or more nodes

Basic categories unchanged

Subdivisions expanded

Changes from 6<sup>th</sup> edition

# Tumeurs du rectum

- ❖ Radiothérapie préopératoire efficace

*Lancet 2001;20:1291-304*

- ❖ Meilleurs résultats pour les tumeurs T3 ou N1

- ❖ Cf cancer de l'oesophage

*Gastroenterol Clin Biol 1995*

- ❖ Cout-efficacité: CT-scan + EUS

*Am J Gastroenterol 2002;97:874-82*



# Carcinoids (NET) – 7<sup>th</sup> edition

## Gastrointestinal

### Appendix

T1  $\leq$  2 cm

T2 > 2 – 4 cm; cecum

T3 > 4 cm; ileum

T4 Perforates peritoneum; other organs, structures

### Small Intestine

T1 Lam propria/ submucosa and  $\leq$  1 cm

T2 Muscularis propria or > 1 cm

T3 Jejunal, ileal: subserosa.

Ampullary, duodenal: pancreas or retroperitoneum`

T4 Perforates serosa; adjacent structures

### Stomach

Tis < 0.5 mm confined to mucosa

T1 Lam propria or submucosa &  $\leq$  1cm

T2 Muscularis propria or > 1 cm

T3 Subserosa

T4 Perforates serosa; adjacent structures

### Large Intestine

T1 Lamina propria or submucosa or  $\leq$  2cm

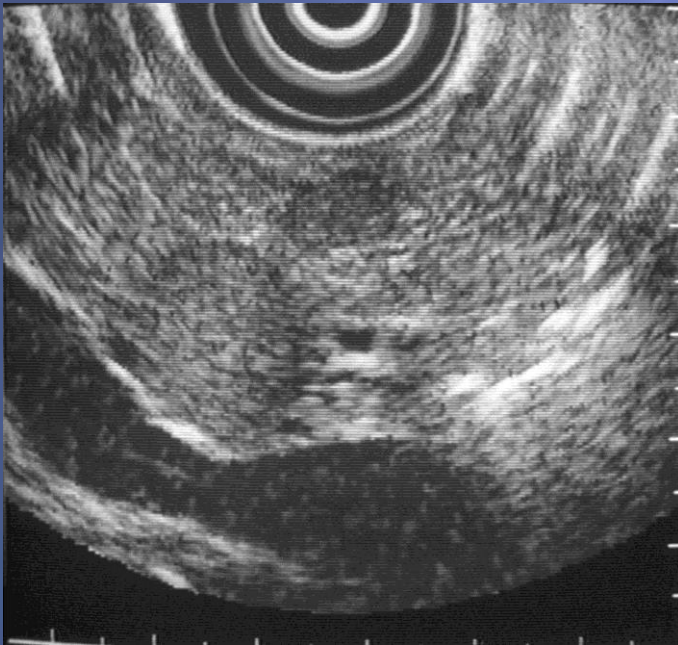
T1a  $\leq$  1 cm; T1b 1 to 2 cm

T2 Muscularis propria or > 2 cm

T3 Subserosa, or pericorectal tissues

T4 Perforates serosa; adjacent structures

# Tumeurs neuroendocrines



# Endocrine tumors : EES vs SRS

	<b>Gastrinome</b>	<b>Insulinome</b>
<b>EUS seule</b>	<b>79%</b>	<b>93%</b>
<b>octréoscan</b>	<b>86%</b>	<b>14%</b>
<b>EES + octréoscan</b>	<b>100%</b>	<b>-</b>

*Zimmer et coll. Gut 1996;39:562-568*

# Gastrinome

- ❖ 22 pts opérés
- ❖ Faux négatifs:  
5 duodenum / 10

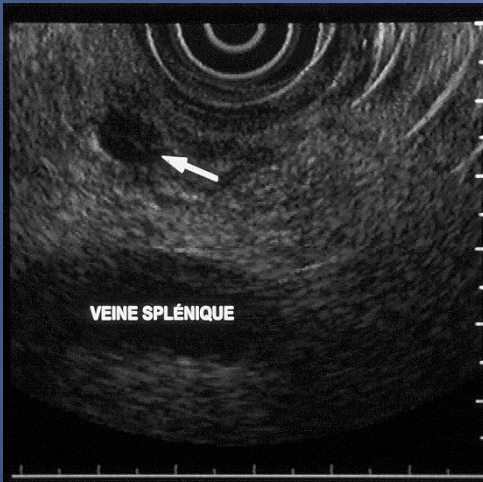
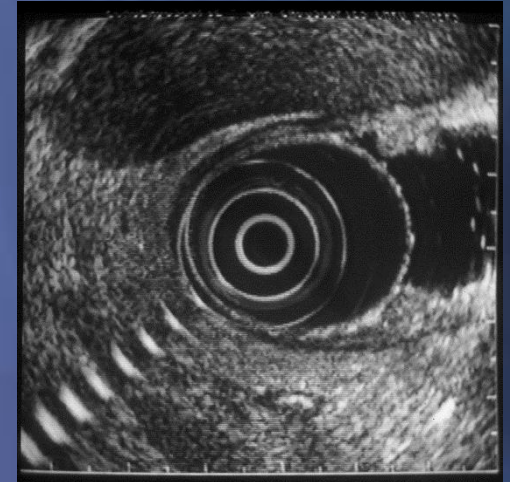
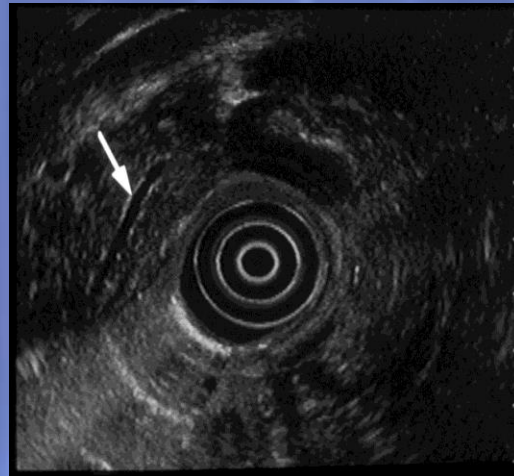
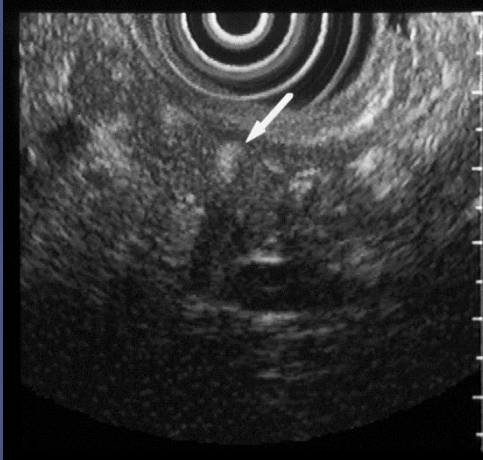
Ruszniewski et coll. *Surgery* 1995;117:629-635  
Cadiot et coll. *Gastroenterology* 1996;111:845-854

	<b>PD (%)</b>
<b>EUS seule</b>	<b>41</b>
<b>EUS + TI</b>	<b>59</b>
<b>octréoscan</b>	<b>50</b>
<b>EUS + octréo</b>	<b>90</b>

# Pancréatite chronique

- ❖ Bonne concordance interobservateurs
- ❖ Diagnostic précoce, avant TDM et CPRE
- ❖ Non indiqué à un stade avancé
- ❖ Sauf pour le bilan des calculs obstructifs

# Pancréatite chronique



# Tumeurs kystiques

## ❖ Cystadénome séreux

→ Aspects typiques connus

- Calcifications
- Microkystes

→ Pas de risque de malignité

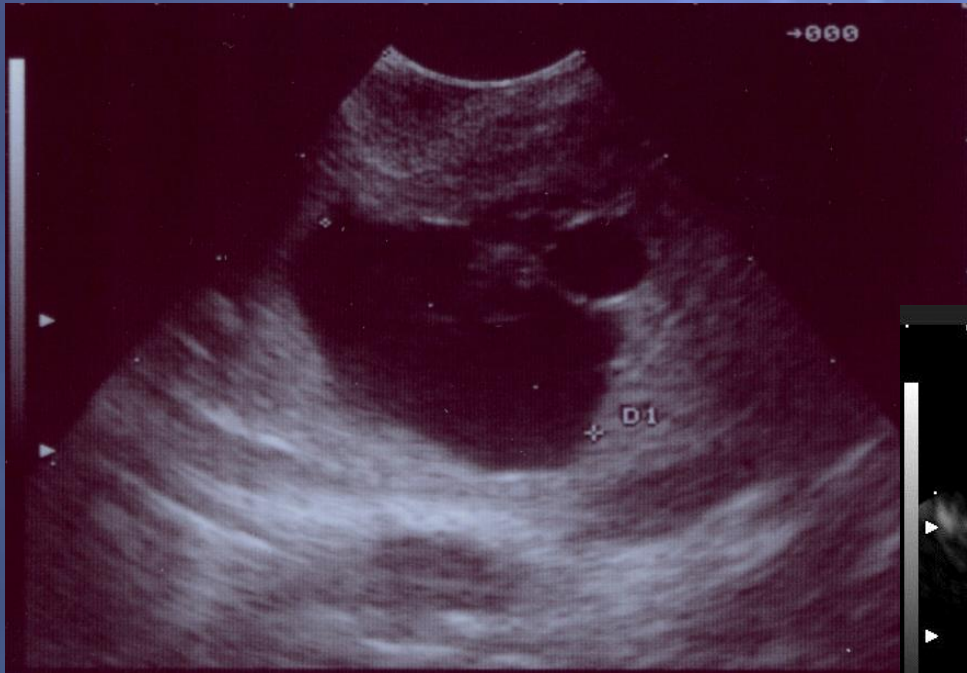
## ❖ Autres lésions kystiques

→ Fréquemment aspécifiques

→ Risque de malignité

→ PAF+++

# Tumeurs kystiques





# Analyse liquide

	<b>Pseudokyste</b>	<b>CA séreux</b>	<b>Autres *</b>
<b>Amylase</b>	> 5000 U/L	var	var
<b>CEA</b>	var	< 5 ng/mL	> 400 ng/mL
<b>CA 19.9</b>	var	< 150 U/mL	> 50,000 U/mL
<b>CA 72.4</b>	bas		> 40 U/mL

❖ \* Spécificité > 90 %

# Marqueurs intra kystiques

Marqueur	Diagnostic	VPP	VPN
Amylase > 5 000 U/L	Pseudokyste	85%	88%
CA 19.9 > 50 000 U/mL	TKM	67%	90%
CEA > 400 ng/mL	TKM	100%	85%
CEA < 5 ng/mL	CS	54%	100%
CA 72.4 > 40 U/mL	TKM	95%	85%
Mucines M1 >1 200 U/mL	TKM	100%	79%

# TIPMP

## ❖ Deux formes

→ Canal principal : dégénérescence 50% - Chirurgie

→ Canaux secondaires : dégénérescence 15% - Surveillance

## ❖ Ponction peu contributive au stade non dégénéré

## ❖ Aspects morphologiques évocateurs

→ IRM

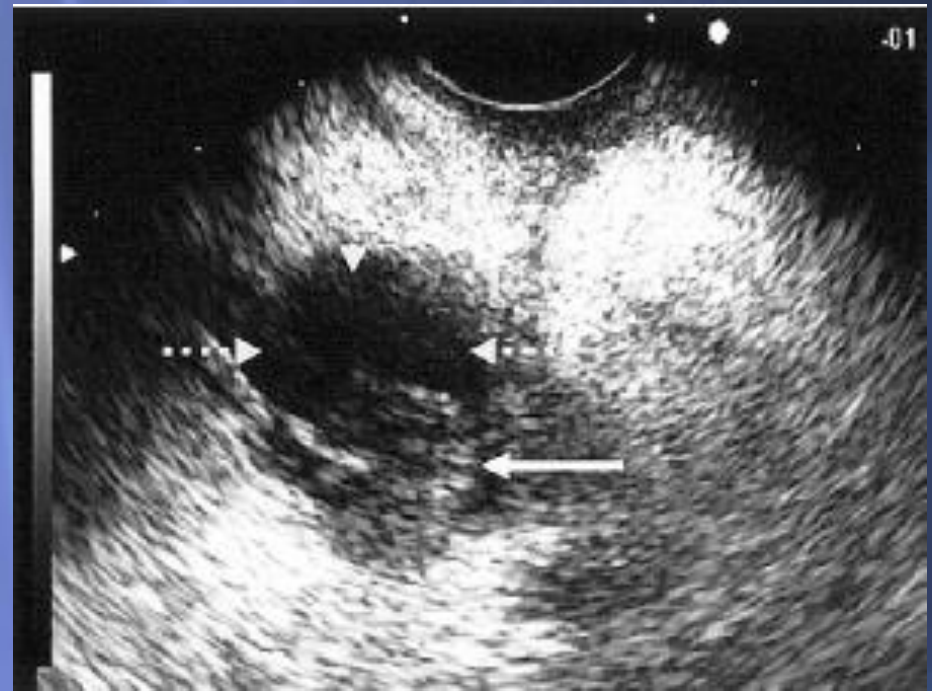
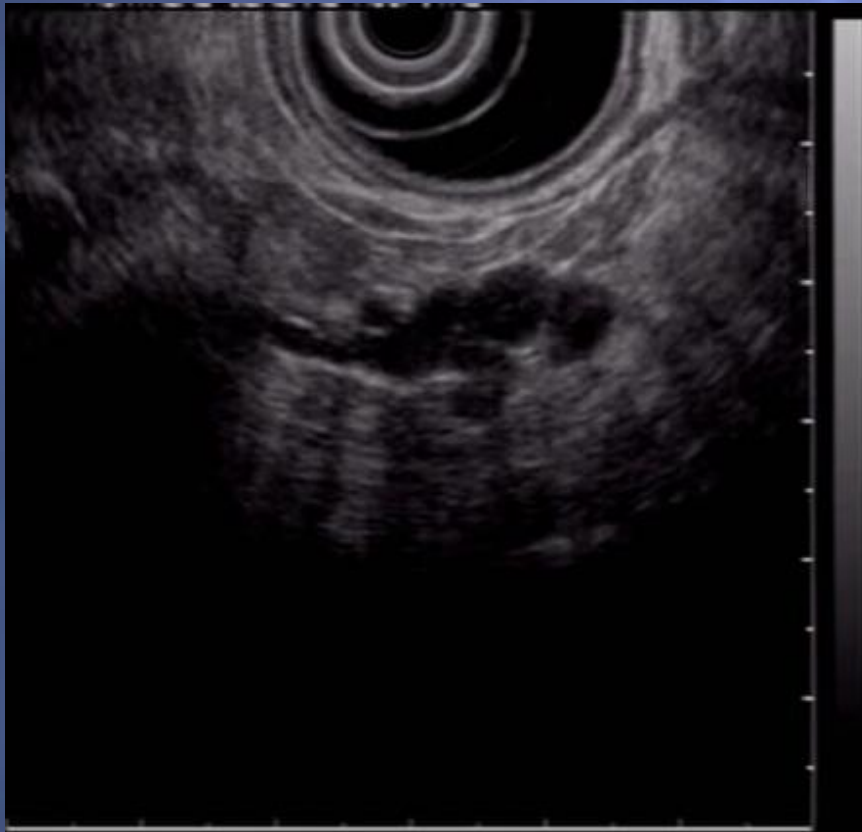
→ Echoendoscopie

## ❖ Ponction cytologique si

→ Progression de diamètre

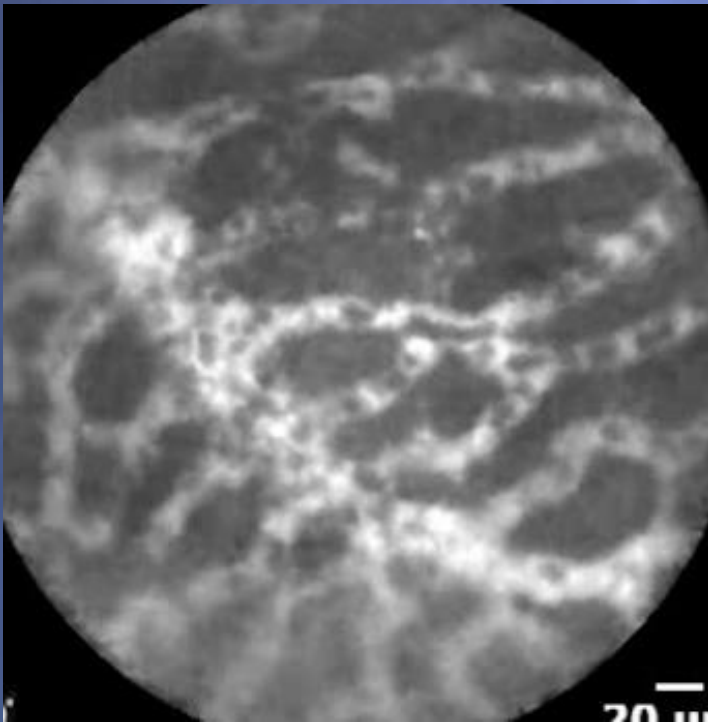
→ Apparition de zones tissulaires (végétations, épaissement pariétal)

# TIPMPs

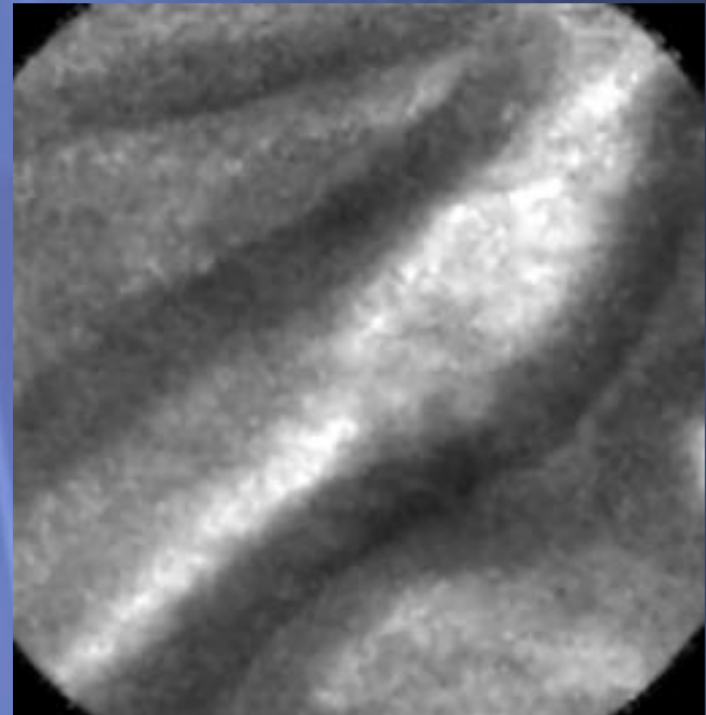


# Endomicroscopy

Cystadénome séreux



TIPMP



*Sensibilité : 70 %, Spécificité 100%.*

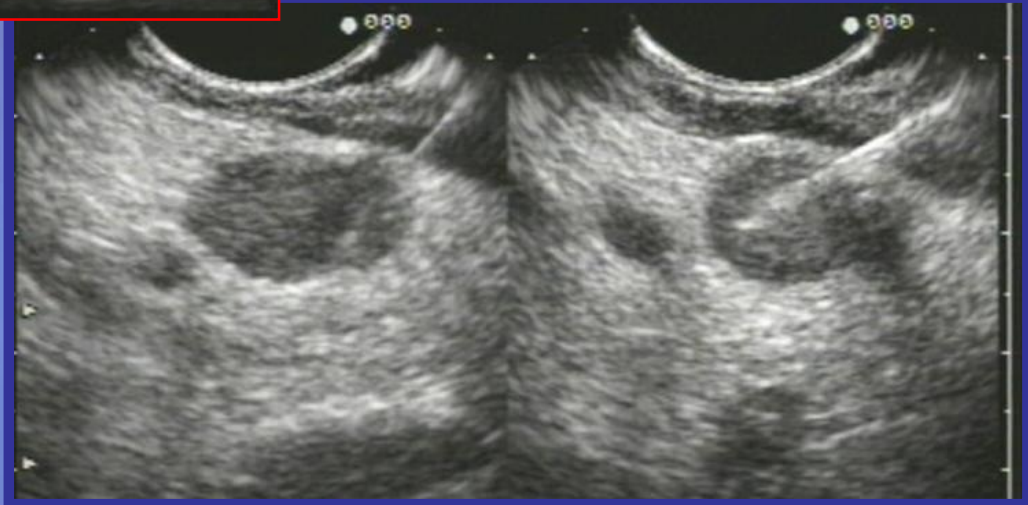
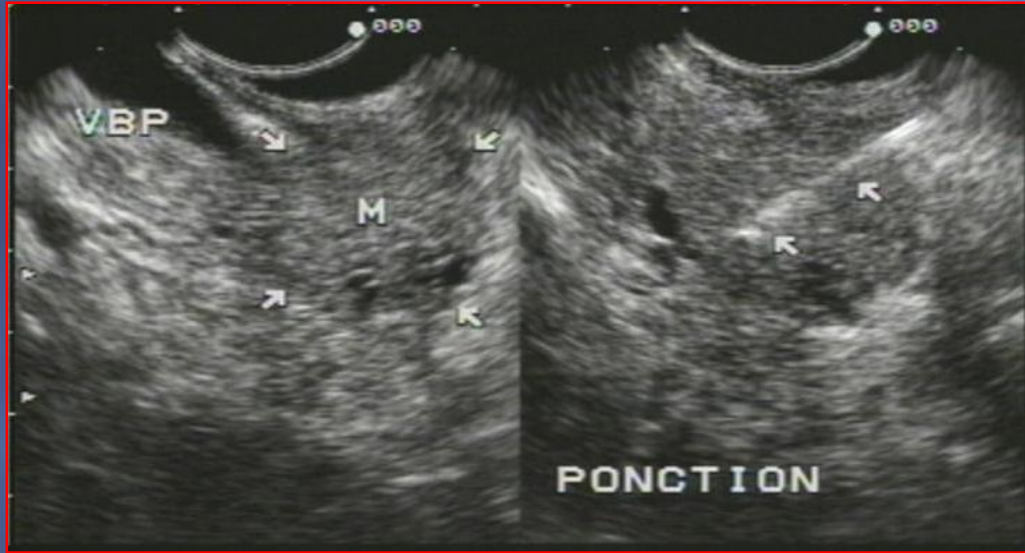
# Minisondes

- ❖ *Nombreuses études ; résultats prometteurs*
- ❖ *Place à valider*
  
- ❖ Esophage : avant résection muqueuse endoscopique
- ❖ Canaux biliaires : bilan tumeurs intra hépatiques
- ❖ Papille : avant papillectomie

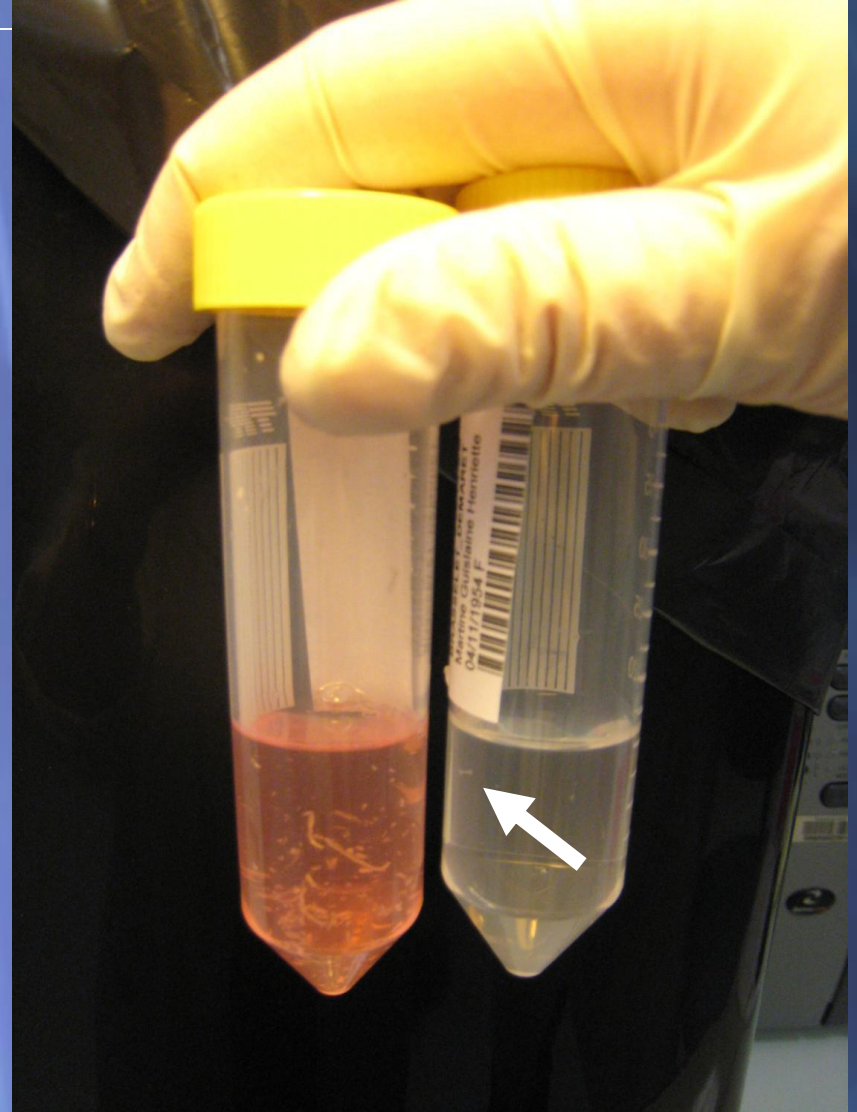
# EE interventionnelle

- ❖ Ponction aiguille fine
- ❖ Neurolyse coeliaque
- ❖ Kystogastrostomie
- ❖ Drainage biliaire transgastrique
- ❖ injections intratumorales

# FNA







# Pancreas — résultats FNA

*Volmar GIE 2005,*  
1000 cas

	EUS	US	CT	EUS <2cm	US <2cm
PPV	99%	100%	100%	97%	100%
NPV	73%	49%	47%	88%	50%
Acc	87%	82%	82%	92%	83%

## En cas de ponction négative...

*Tessier, Am J Surgery 2006*

Predictive factors for finding neoplasia in patients with suspected pancreas malignancy

Factors	Sensitivity (%)	Specificity (%)
Wt loss >20 lb or bili >3 mg/dL or CA 19-9 >37 U/mL	90.5	40.0
Wt loss >20 lb & bili >3 mg/dL & CA 19-9 >37 U/mL	45.4	100
Wt loss >20 lb & bili >3 mg/dL & CA 19-9 >37 U/mL & biliary stricture	66.7	100
Wt loss >20 lb & bili >3 mg/dL & CA 19-9 >37 U/mL & mass on CAT/EUS	83.3	100

bili = bilirubin; CAT = computerized axial tomography; EUS = endoscopic ultrasound; NPV = negative value; Wt = weight.

# PAF lésions médiastinales

- ❖ Précision > 90 %
- ❖ 3 passages dans la lésion
- ❖ Prise en charge modifiée dans 80 %
- ❖ Ponctionner tous les ganglions ?

→ *Catalano et al. Am J Gastroenterol 2002;97:2559-65*

→ *Chlieng et al. Cancer 2002;96:232-9*

→ *Erickson et al. Gastrointest Endosc 2000;51:184-90*

→ *Wallace et al. Gastrointest Endosc 2001;54:441-5*

# Complications des ponctions cytologiques

Wang GIE 2011

❖ 107/10941 patients (51 studies)

**TABLE 1. EUS-FNA-related complications in 10,941 patients (51 studies)**

EUS-FNA related complications	No.	%
Chest or abdominal pain	37	34.6
Acute pancreatitis	36	33.6
Mild-moderate	33	
Severe	3	
Bleeding	14	13.1
Fever	12	11.2
Infection	5	4.7
Perforation	2	1.9
Bile leakage	1	0.9
<b>Total</b>	<b>107</b>	<b>100</b>

EUS-FNA, EUS-guided FNA.

**TABLE 3. Rates of EUS-FNA complications relative to organs sampled, as determined in retrospective and prospective studies**

	Retrospective studies	Prospective studies	P value
Pancreas	0.59%	2.64%*	.0000
Pancreatic mass	0.35%	2.44%*	.0000
Pancreatic cyst	2.33%	5.07%†	.0363
Mediastinal	0.26%	0.43%	.6491
Liver	2.29%	2.44%	.9337
Abdominal mass	0%	0.36%	.0825
Ascites	3.33%	4.0%	.4256
<b>Total</b>	<b>0.64%</b>	<b>1.72%*</b>	<b>.0000</b>

EUS-FNA, EUS-guided FNA.

\*P < .001 compared with retrospective studies.

†P < .05 compared with retrospective studies.

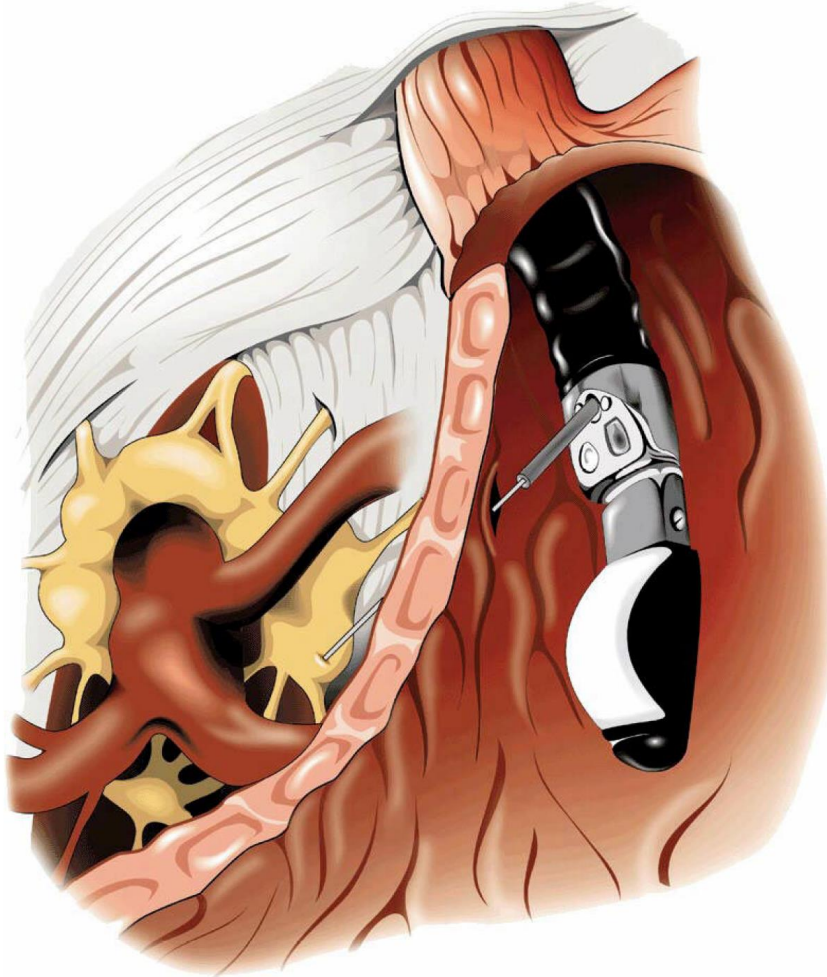
# Indications PAF

- ❖ Masses médiastinales et ganglions
- ❖ Tumeurs pancréatiques (pleines, kystiques)
- ❖ Tumeurs extrinsèques
- ❖ GIST (?)
- ❖ Ganglions péirectaux ?
- ❖ Lésions hépatiques gauches (*Gastrointest Endosc, 2002*)

# Les indications reconnues

- ❖ Bilan d'extension des cancers des organes creux
  - Œsophage
  - Rectum
  - Estomac, plus récent
- ❖ Exploration des cholestases
- ❖ Bilan des tumeurs des VB et pancréas
- ❖ Lésions kystiques du pancréas
- ❖ Tumeurs endocrines
- ❖ Troubles fonctionnels anorectaux
- ❖ La ponction à l'aiguille fine
- ❖ Drainage des pseudokystes

# Neurolyse coeliaque



**Figure 1.** The celiac plexus.



# Neurolyse coeliaque

## ❖ Une méta analyse récente

Cochrane Database Syst Rev. 2011

- 6 études, CT Vs EUS, 358 pts
- Hétérogénéité
- Contrôle de la douleur : limité
- Consommation d'opioïdes : diminuée,  $p < 10^{-5}$

# Remerciements

- ❖ Laurent Palazzo
- ❖ Marc Barthet
- ❖ Manoop Bhutani

*Pour la mise à disposition de plusieurs figures*