THE UNIVERSITY OF TEXAS
MD Anderson Cancer Center
Making Cancer History®

GIST 201: Why Pathology & Your Pathologist Matter

GSI Patient Summit Saturday 13 September 2014

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GIST Pathology: Lecture Overview

1. **What happens to my tumor in pathology?**
2. **What information is in my pathology report?**
3. **Why is this information there?**
4. **What is the evidence that the information is useful?**

What happens to my tumor in pathology?

Tumor is examined by a pathologist.

Tumor sample is received from the OR and logged into computer.

Tumor is sampled and placed in plastic cassettes for further processing.

Tumor is also given to cytogenetics, tumor bank, molecular diagnosis and electron microscopy when appropriate.

The tissue blocks are fixed in formalin and then loaded on a tissue processor overnight.

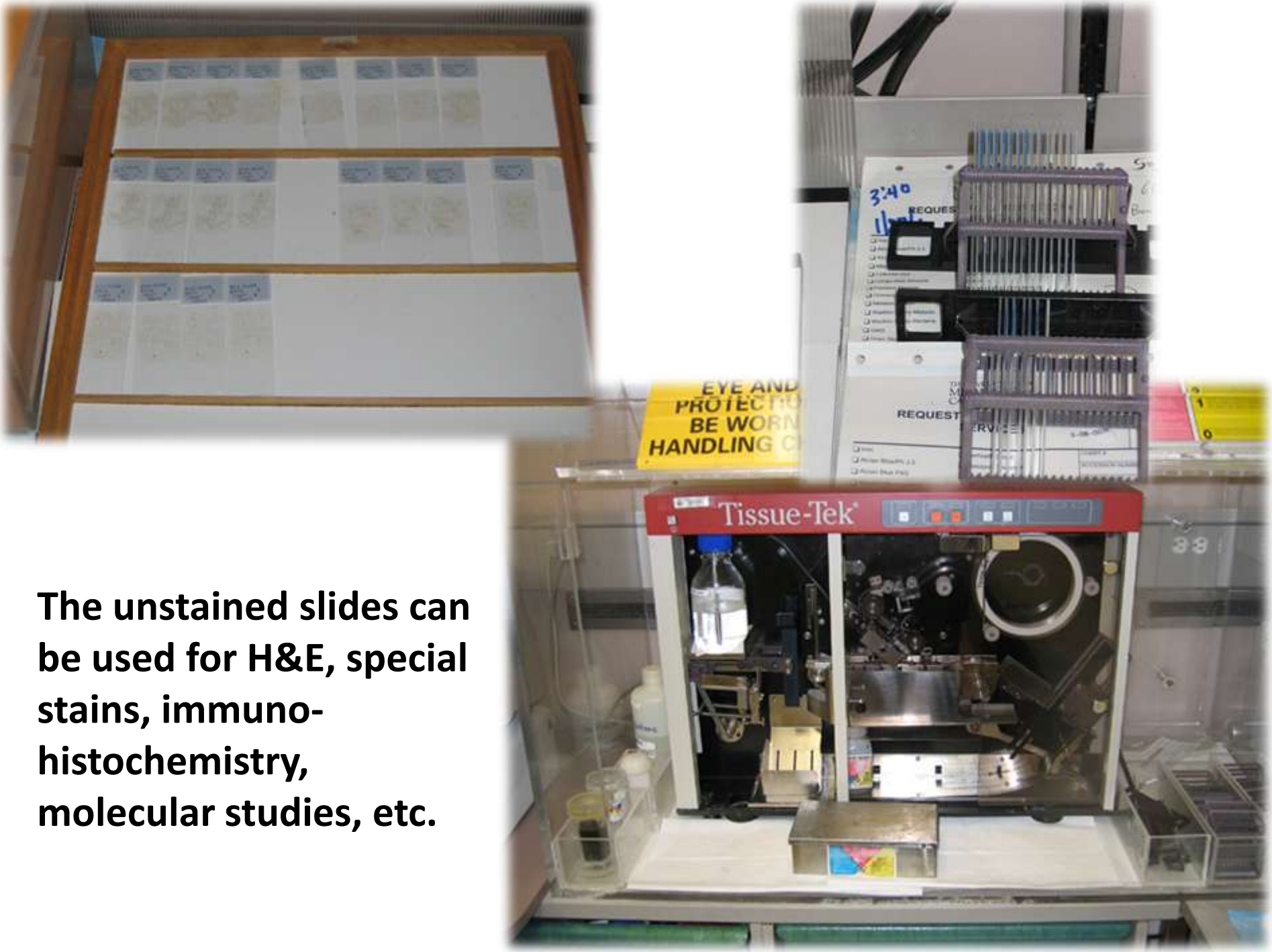
Tissue processing is done overnight and utilizes graded treatments of formalin, ethanol, xylene and paraffin.

Blocks are retrieved from the tissue processor.

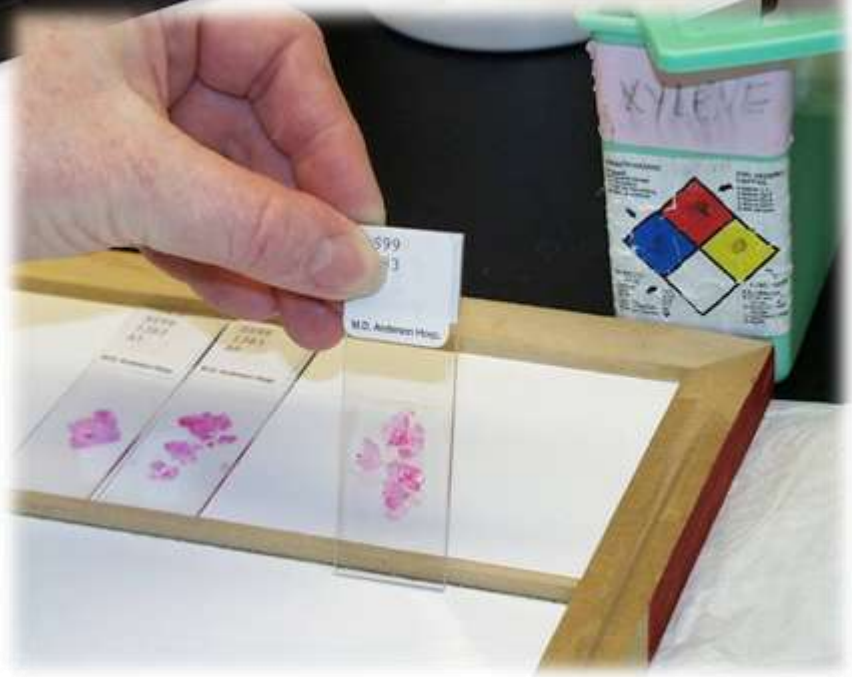
The tissue fragments are embedded in a paraffin mold and cooled – resulting in a tissue block.

The paraffin-embedded blocks are loaded and cut using a microtome.

Tissue paraffin ribbons are placed in a warm waterbath and then picked up on glass slides.



The unstained slides can be used for H&E, special stains, immuno-histochemistry, molecular studies, etc.



Most slides are H&E (hemotoxlin & eosin) stained, given coverslips, organized and delivered to the proper pathologist.

Additional unstained slides can be cut at a later time.

After final diagnosis, both slides and the paraffin blocks from which they are cut are cataloged and stored for future use.

What information is in my pathology report?

Protocol for the Examination of Specimens From Patients With Gastrointestinal Stromal Tumor (GIST)

Based on AJCC/UICC TNM, 7th edition
Protocol web posting date: June 2012

Procedures
- Biopsy
- Resection

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Surgical Pathology Cancer Case Summary

Protocol web posting date: June 2012

GASTROINTESTINAL STROMAL TUMOR (GIST): Resection

Select a single response unless otherwise indicated.

Procedure
___ Excisional biopsy
___ Resection
Specify type (eg, partial gastrectomy): _____
___ Metastasectomy
___ Other (specify): _____
___ Not specified

Tumor Site
Specify (if known): _____
___ Not specified

Tumor Size
Greatest dimension: ___ cm
+ Additional dimensions: ___ x ___ cm
___ Cannot be determined (see "Comment")

Tumor Focality
___ Unifocal
___ Multifocal
Specify number of tumors: _____
Specify size of tumors: _____

GIST Subtype
___ Spindle cell
___ Epithelioid
___ Mixed
___ Other (specify): _____

Mitotic Rate

Specify: ___ /50 HPF

Note: The required total count of mitoses is per 5 mm² on the glass slide section. With the use of older model microscopes, 50 HPF is equivalent to 5 mm². Most modern microscopes with wider 40X lenses/fields require only 20 HPF to embrace 5 mm². If necessary please measure field of view to accurately determine actual number of fields required to be counted on individual microscopes to count 5 mm².

+ Necrosis

+ ___ Not identified
+ ___ Present
    + Extent: ___%
+ ___ Cannot be determined

Histologic Grade (Note B)
___ GX: Grade cannot be assessed
___ G1: Low grade; mitotic rate ≤5/50 HPF
___ G2: High grade; mitotic rate >5/50 HPF

Risk Assessment (Note C)
___ None
___ Very low risk
___ Low risk
___ Intermediate risk
___ High risk
___ Overtly malignant/metastatic
___ Cannot be determined

Margins
___ Cannot be assessed
___ Negative for GIST
Distance of tumor from closest margin: ___ mm *or* ___ cm
___ Margin(s) positive for GIST
Specify margin(s): _____

Pathologic Staging (pTNM) (Note G)

TNM Descriptors (required only if applicable) (select all that apply)
___ m (multiple)
___ r (recurrent)
___ y (posttreatment)

Primary Tumor (pT)
___ pTX: Primary tumor cannot be assessed
___ pT0: No evidence for primary tumor
___ pT1: Tumor 2 cm or less
___ pT2: Tumor more than 2 cm but not more than 5 cm
___ pT3: Tumor more than 5 cm but not more than 10 cm
___ pT4: Tumor more than 10 cm in greatest dimension

Regional Lymph Nodes (pN) (Note D)
___ Not applicable
___ pN0: No regional lymph node metastasis
___ pN1: Regional lymph node metastasis

Distant Metastasis (pM) (Note D)
___ Not applicable
___ pM1: Distant metastasis
+ Specify site(s), if known: _____

+ Additional Pathologic Findings
+ Specify: _____

Ancillary Studies (select all that apply) (Note E)

Immunohistochemical Studies
___ KIT (CD117)
    ___ Positive
    ___ Negative
___ Others (specify): _____
___ Not performed

Molecular Genetic Studies (eg, *KIT* or *PDGFRA* mutational analysis)
___ Submitted for analysis; results pending
___ Performed, see separate report: _____
___ Performed
    Specify method(s) and results: _____
___ Not performed

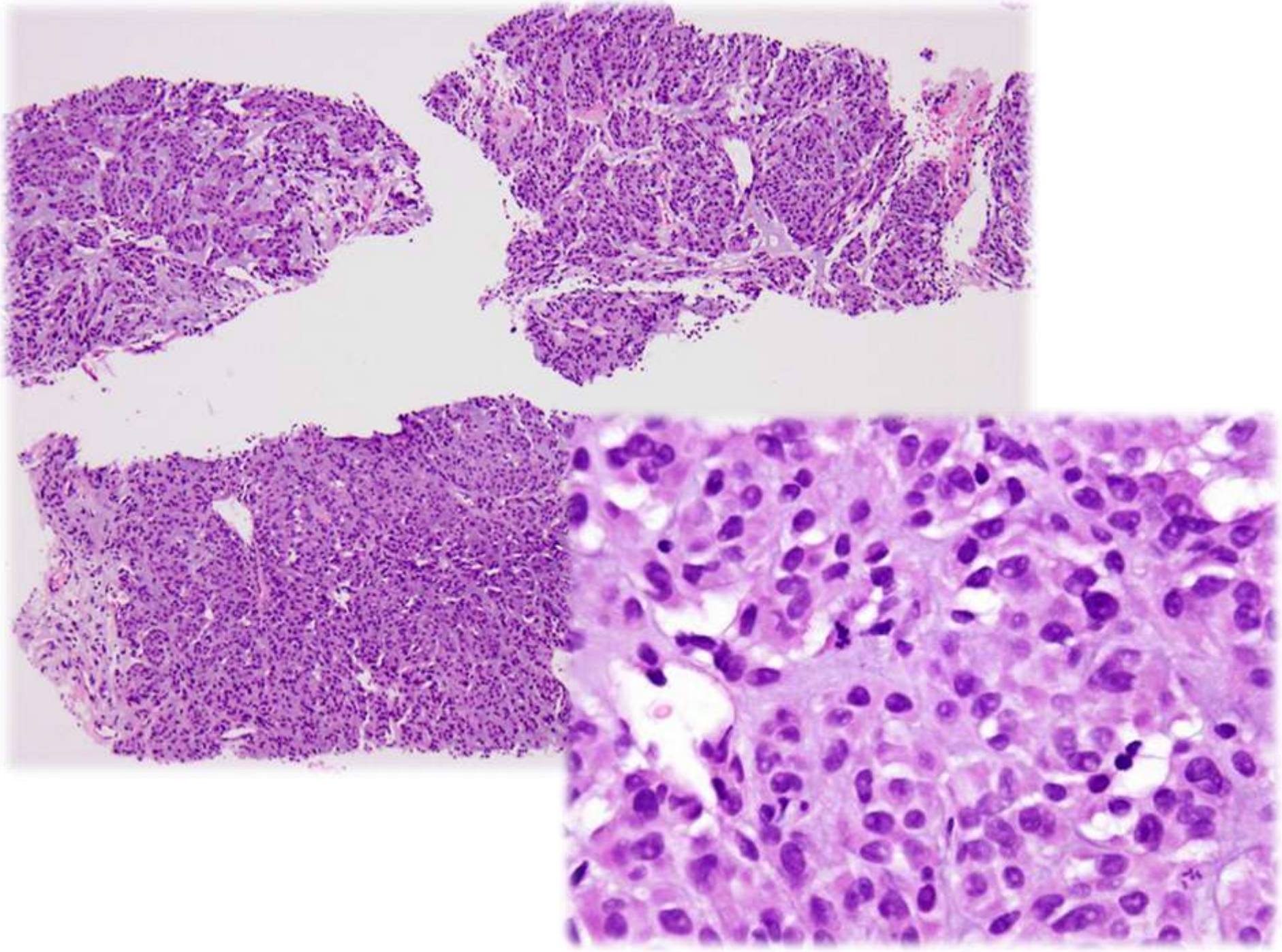
Preresection Treatment (select all that apply)
___ No therapy
___ Previous biopsy or surgery
    Specify: _____
___ Systemic therapy performed
    Specify type: _____
___ Therapy performed, type not specified
___ Unknown

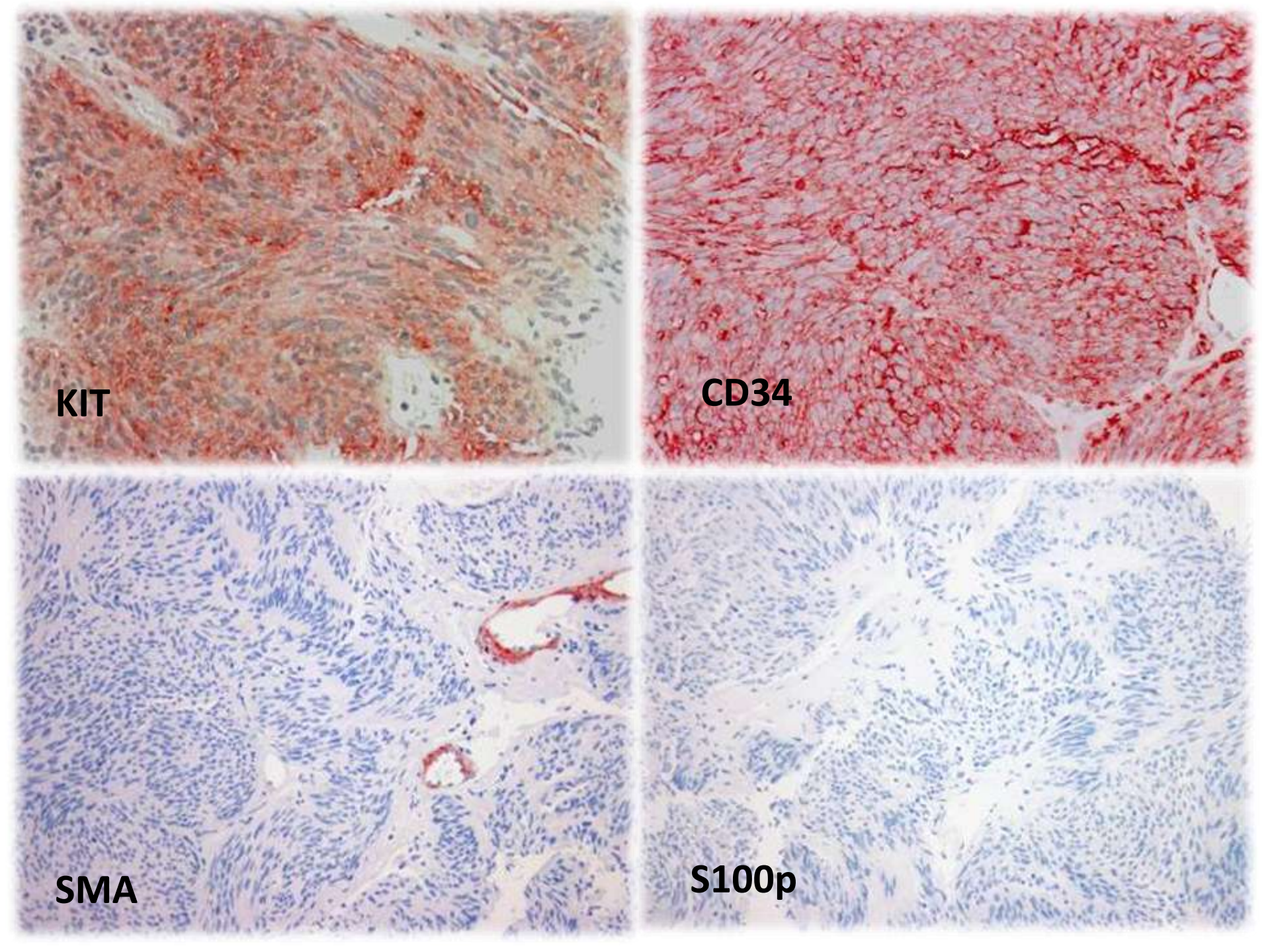
+ Treatment Effect (Note F)
+ Specify percentage of viable tumor: ___%

+ Comment(s)

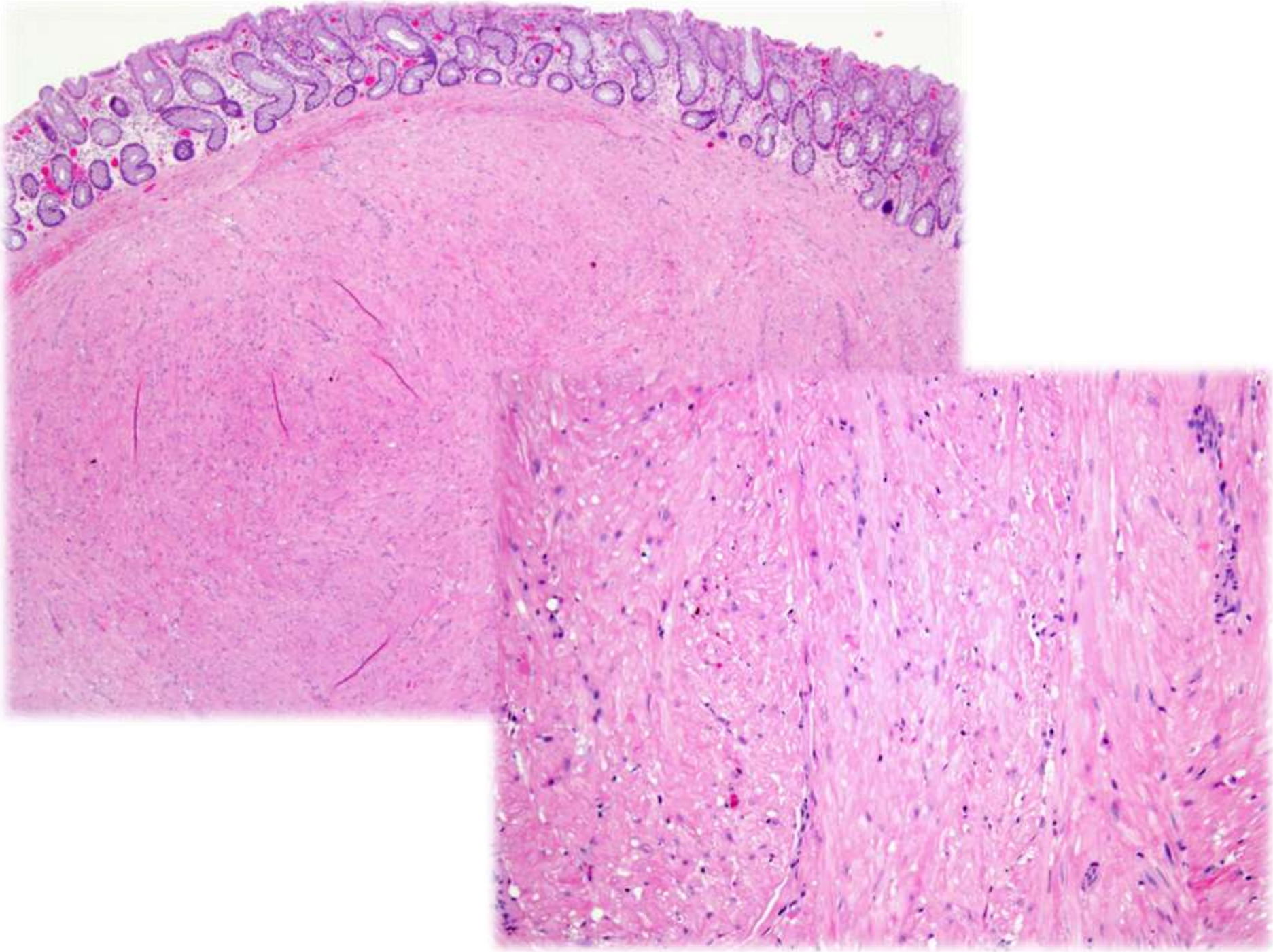
Getting the diagnosis right

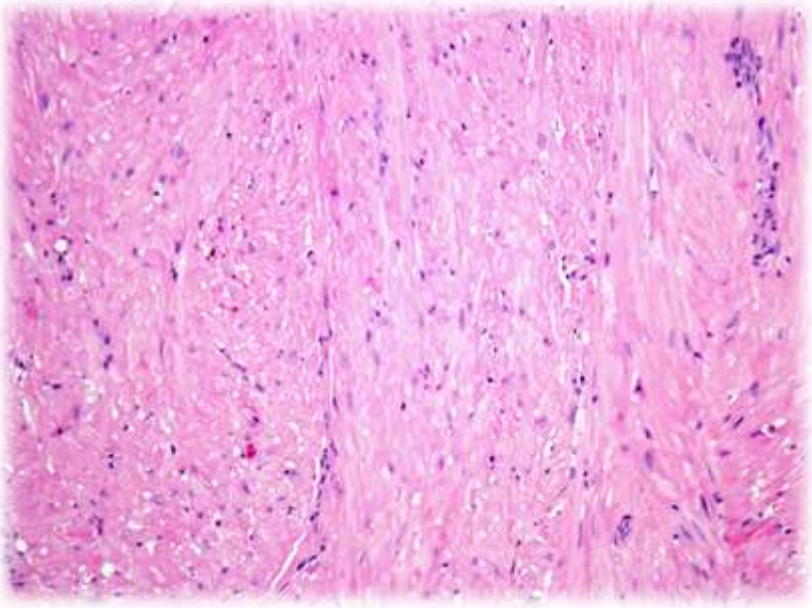
Case 1

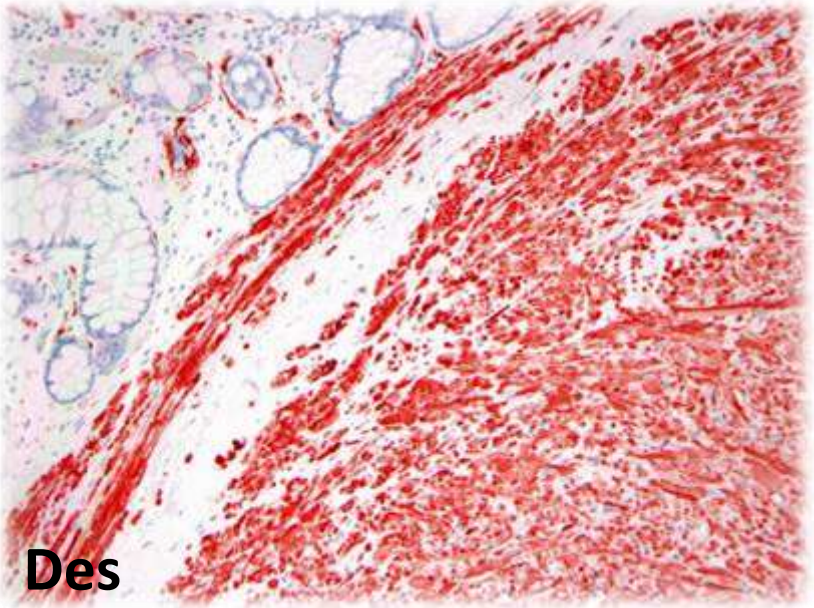


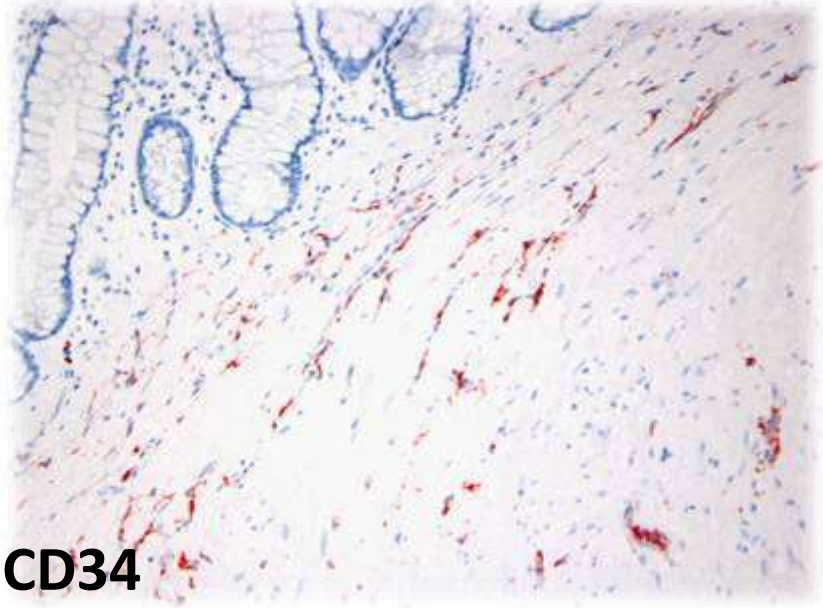

KIT
CD34
SMA
S100p

Case 2



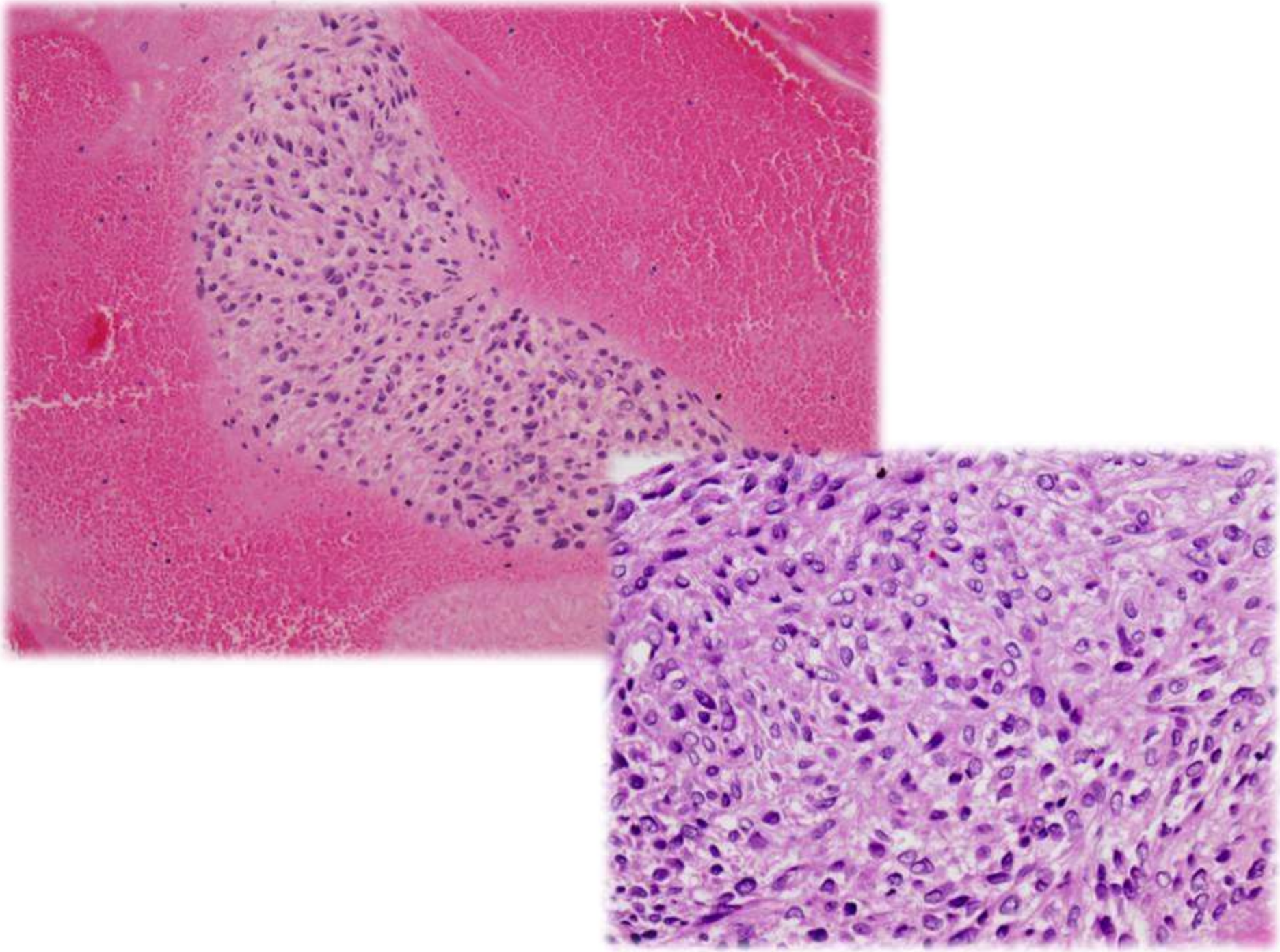


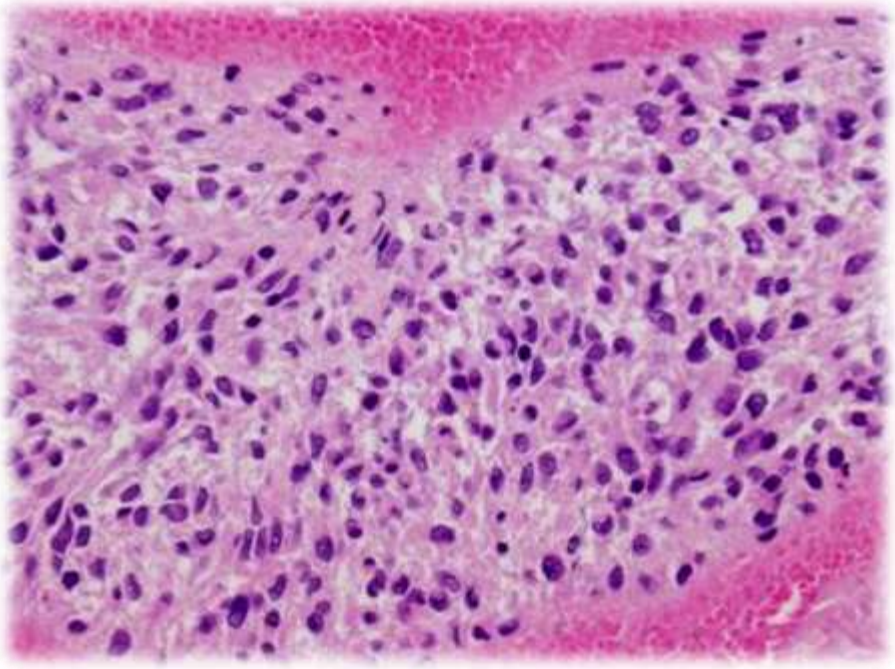

Des


CD34


KIT

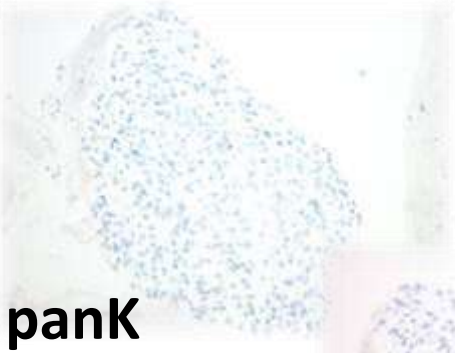
Case 3

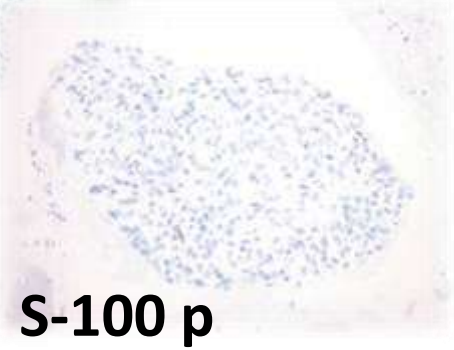




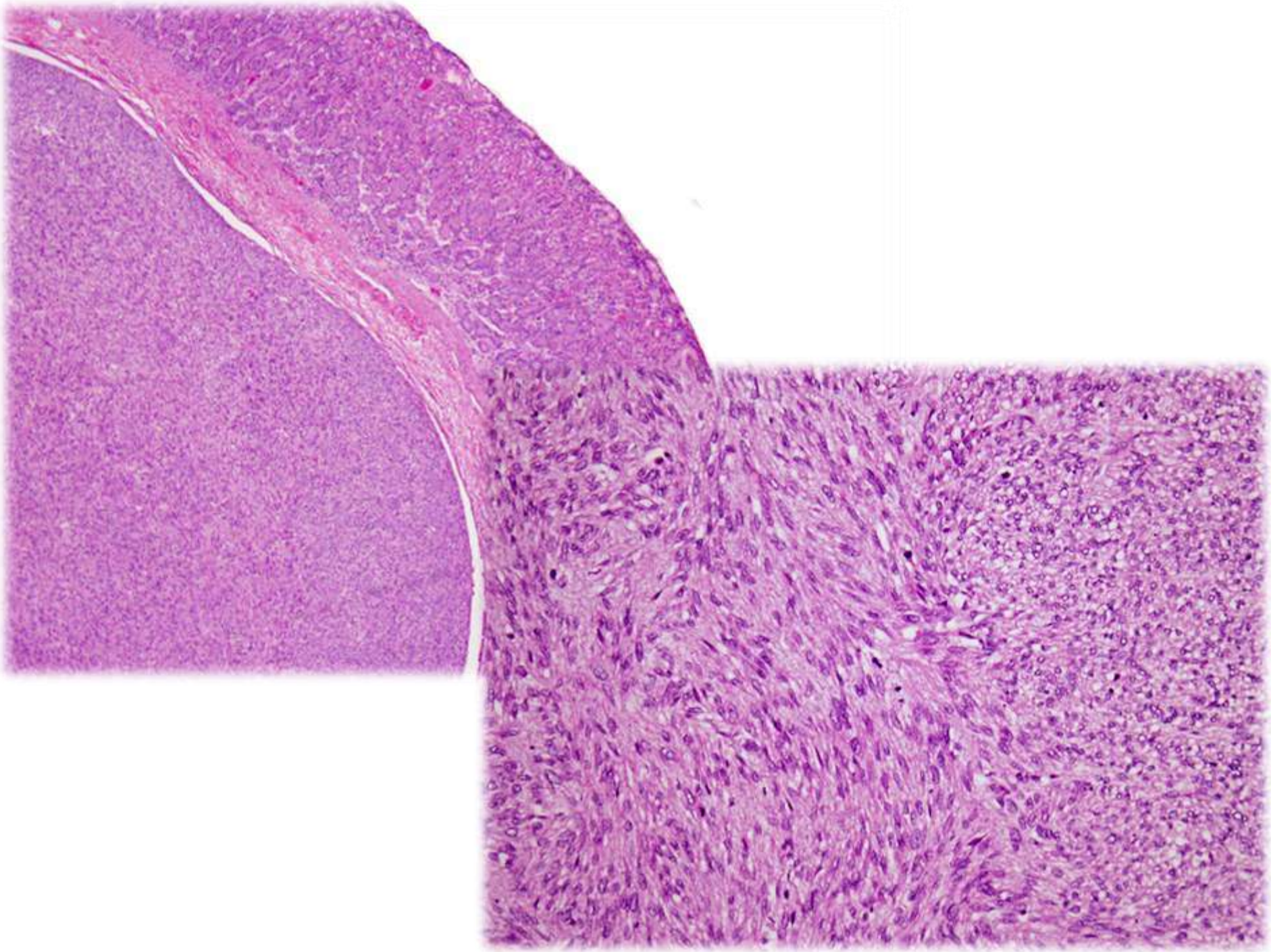

SMA

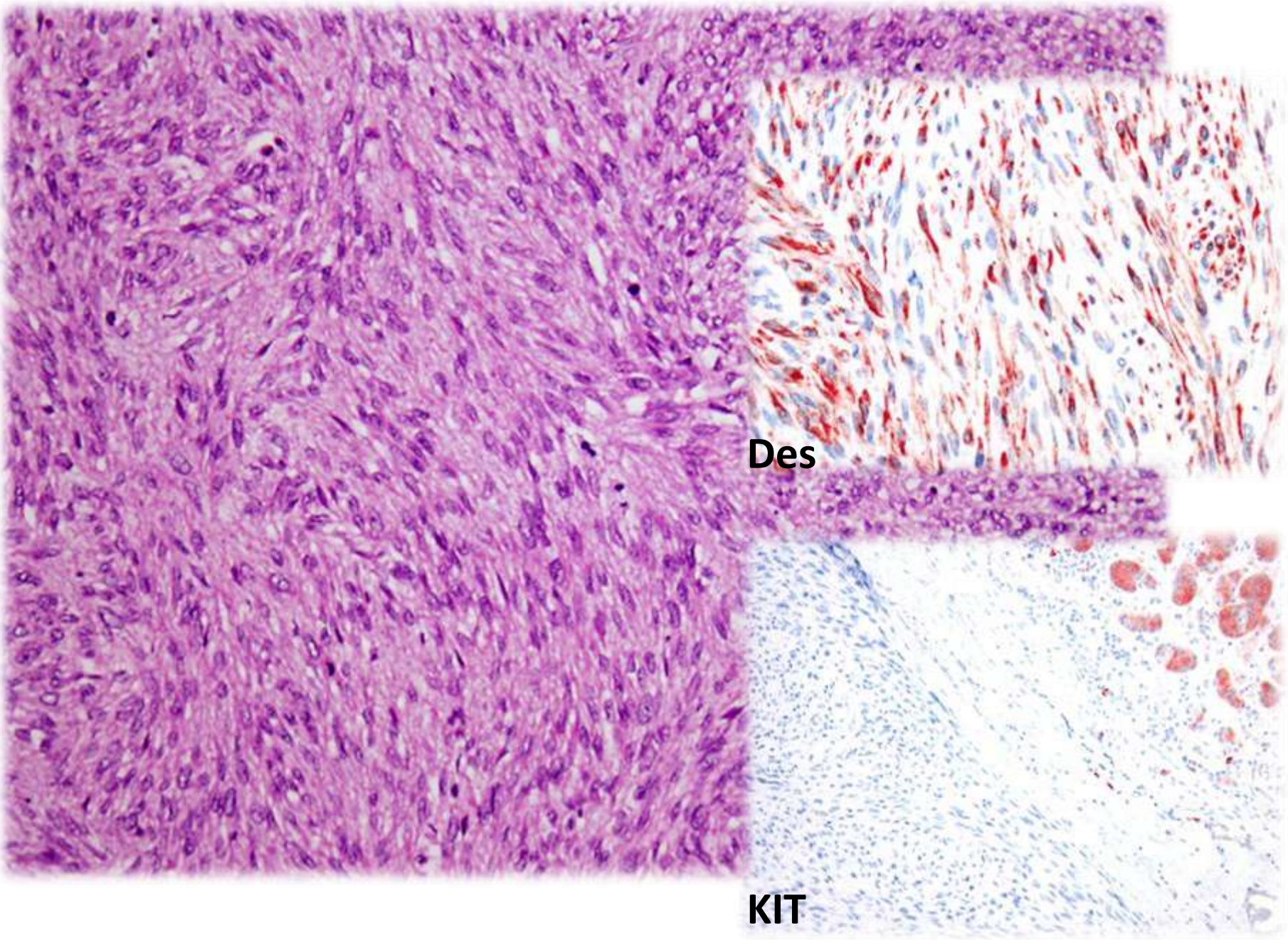

Des

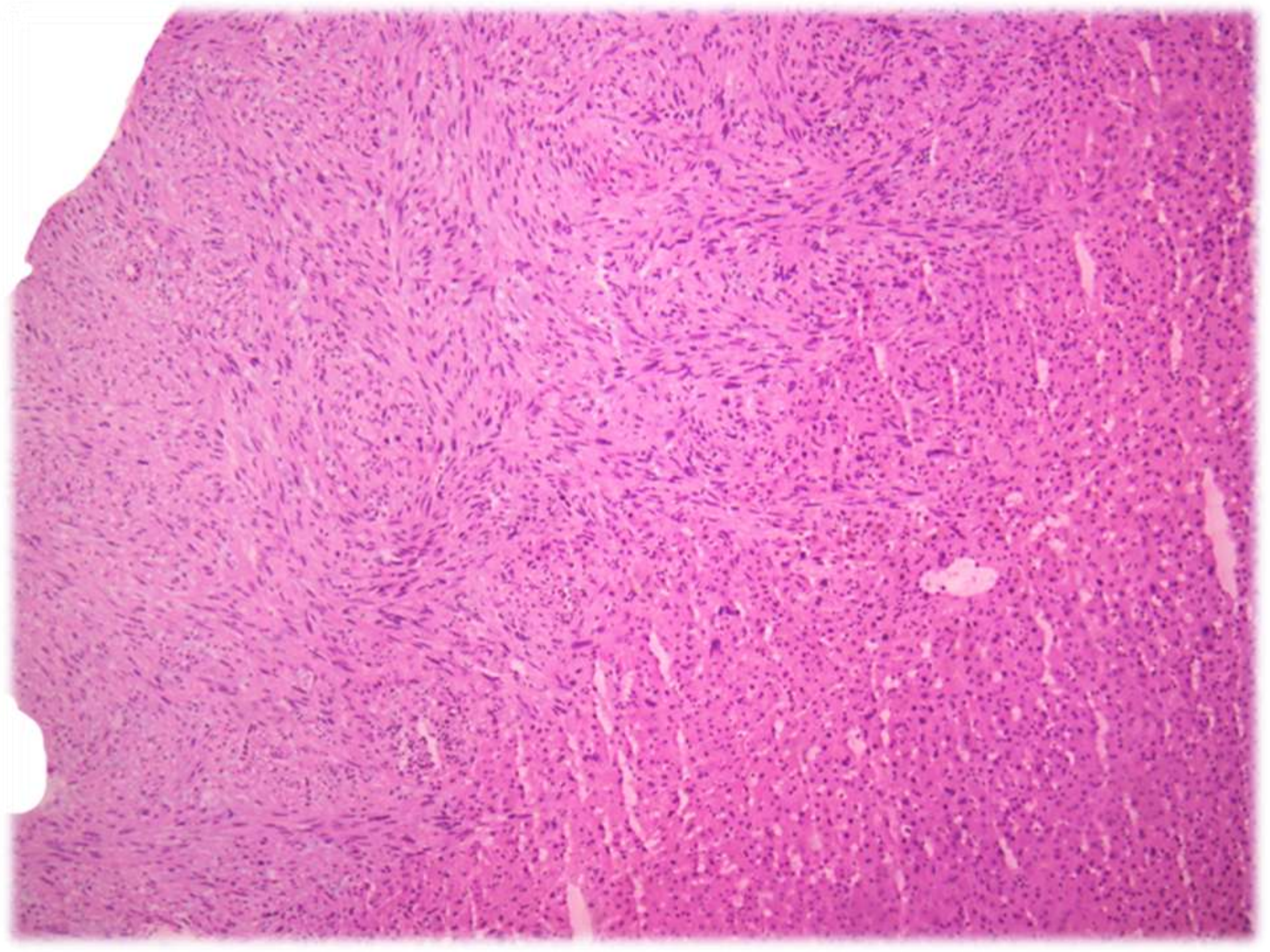

panK


S-100 p

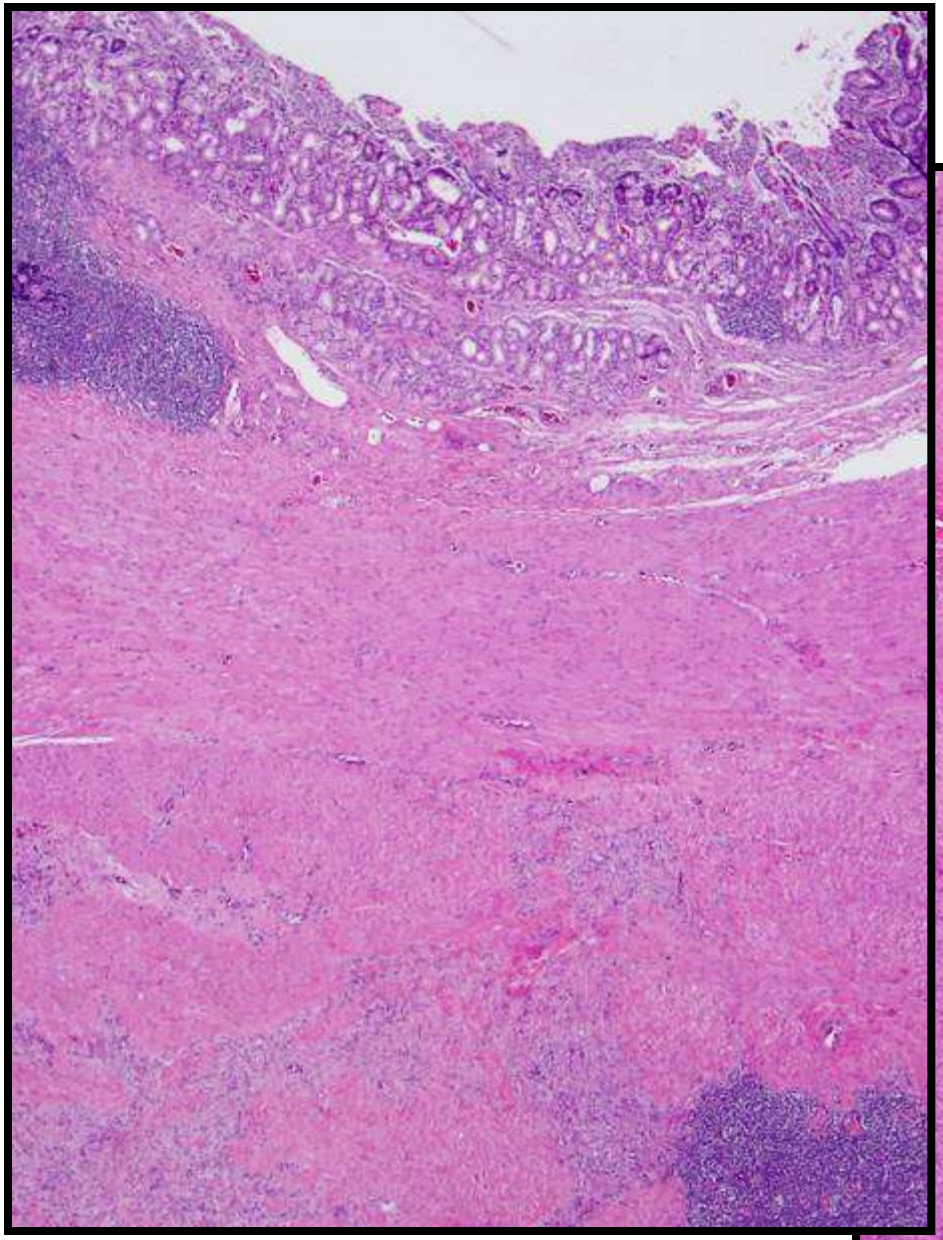

KIT

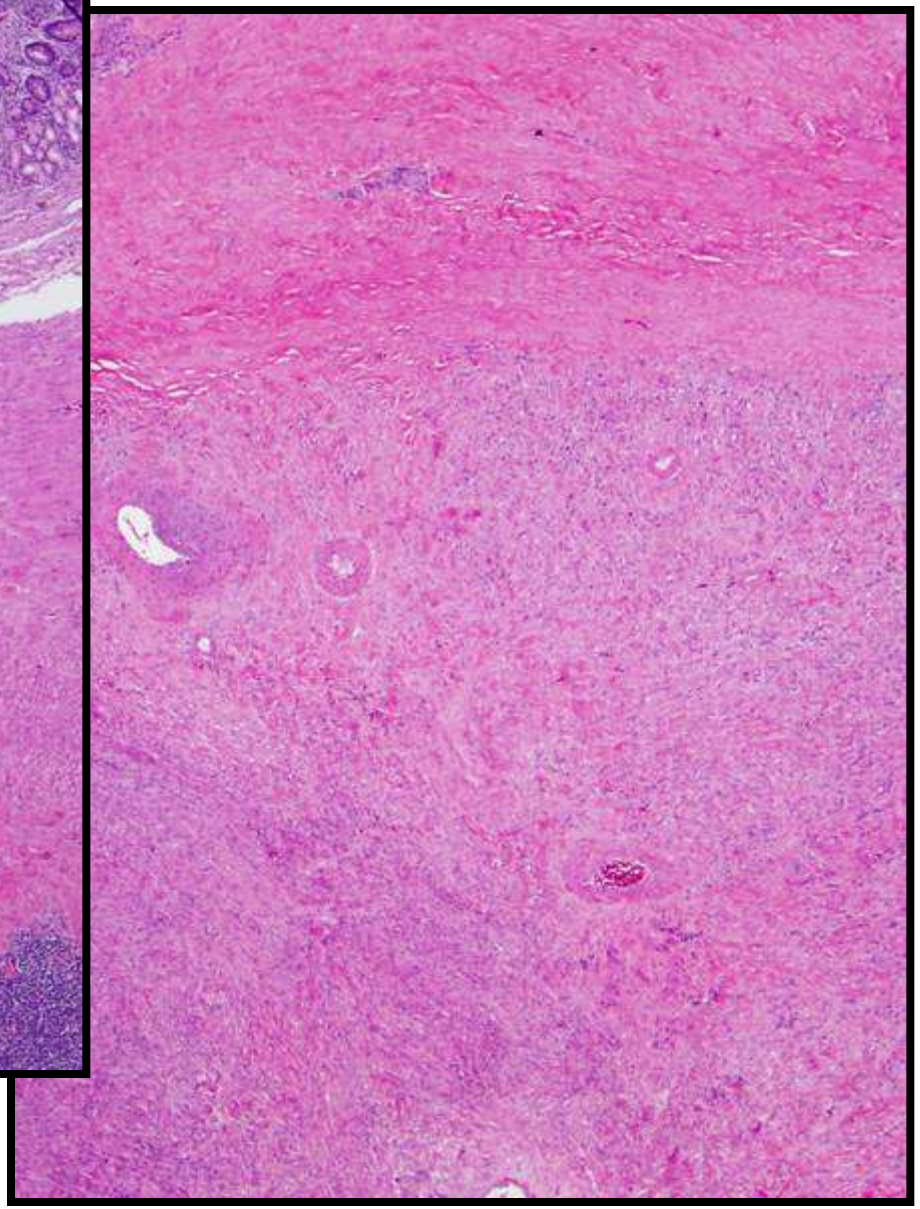


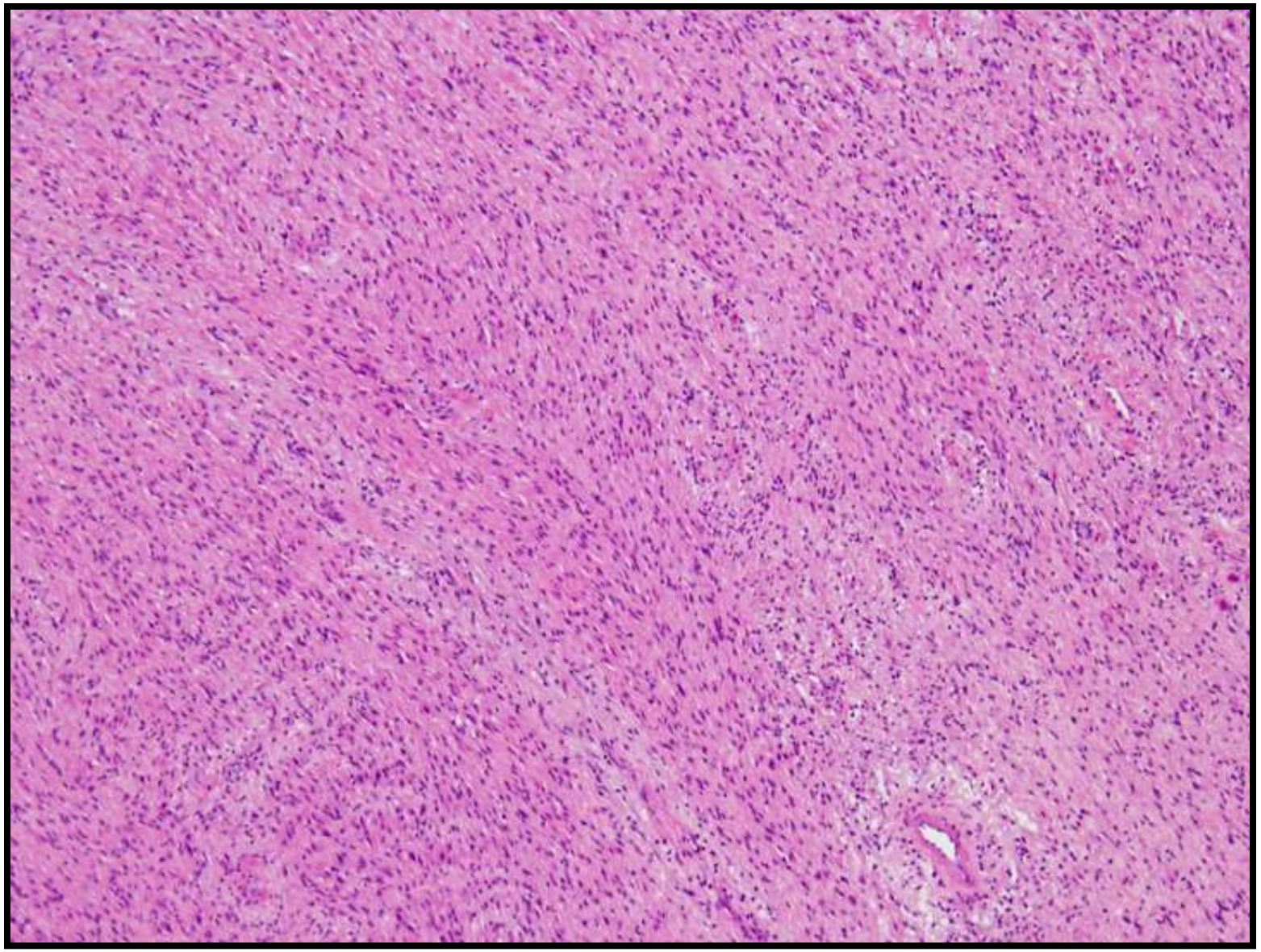

Des
KIT

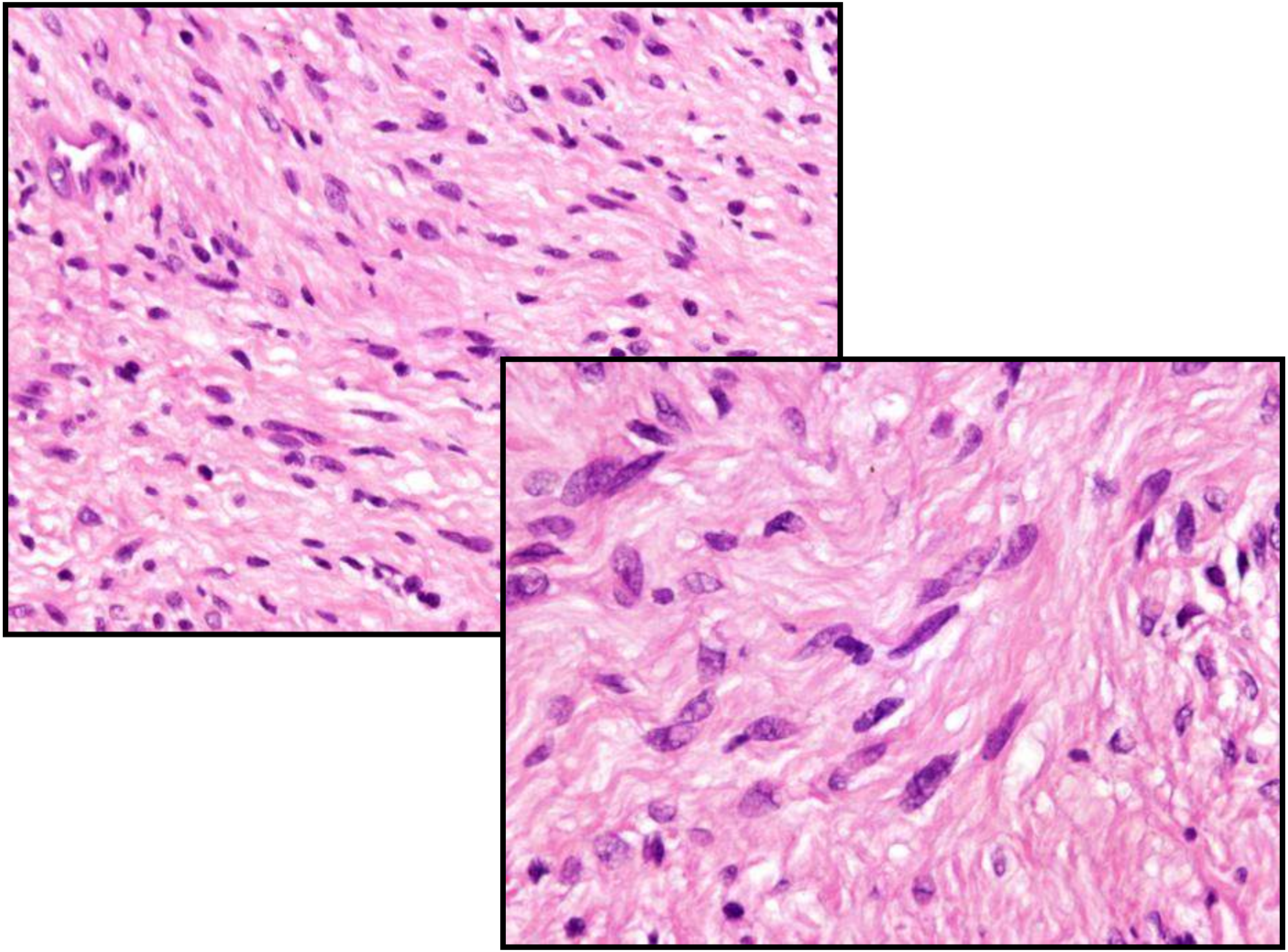


Case 4

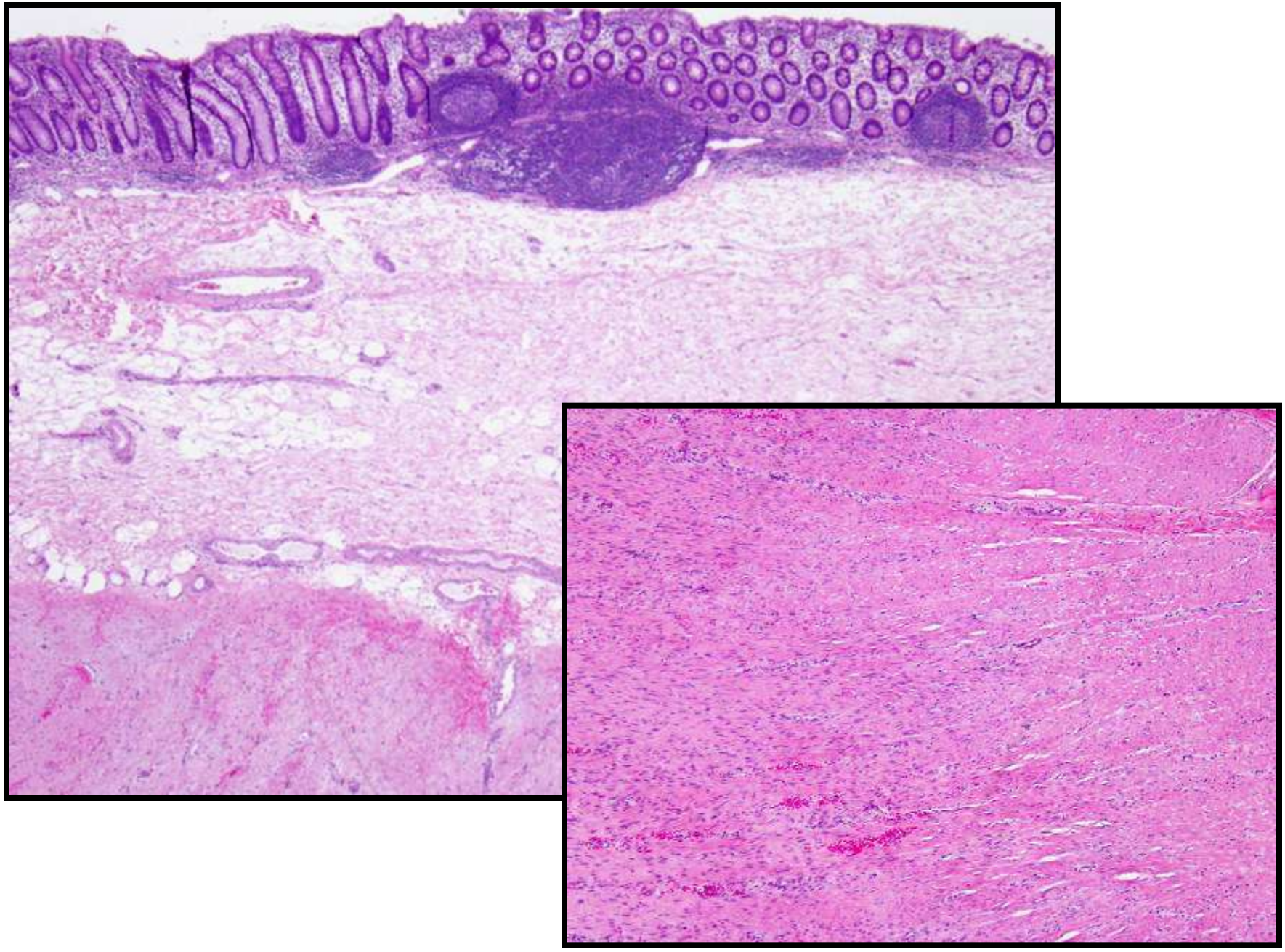


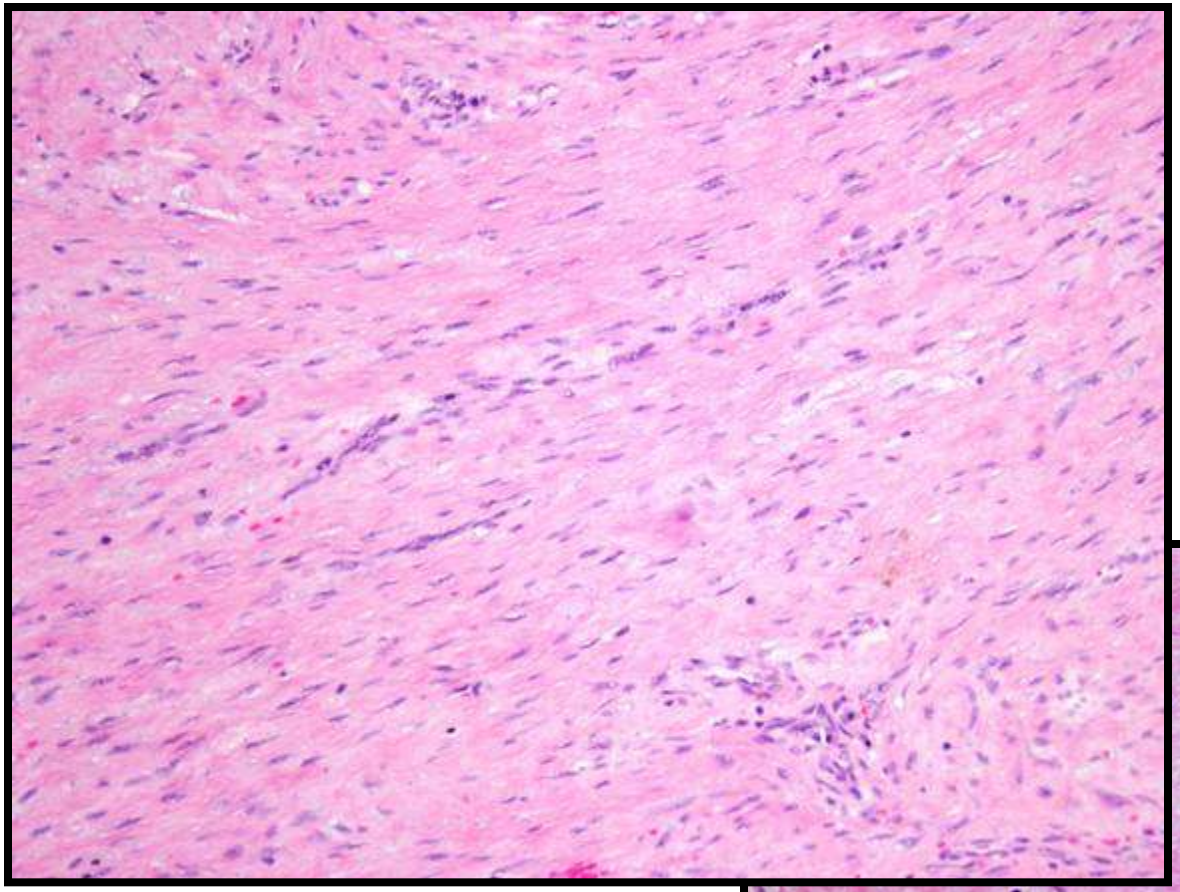


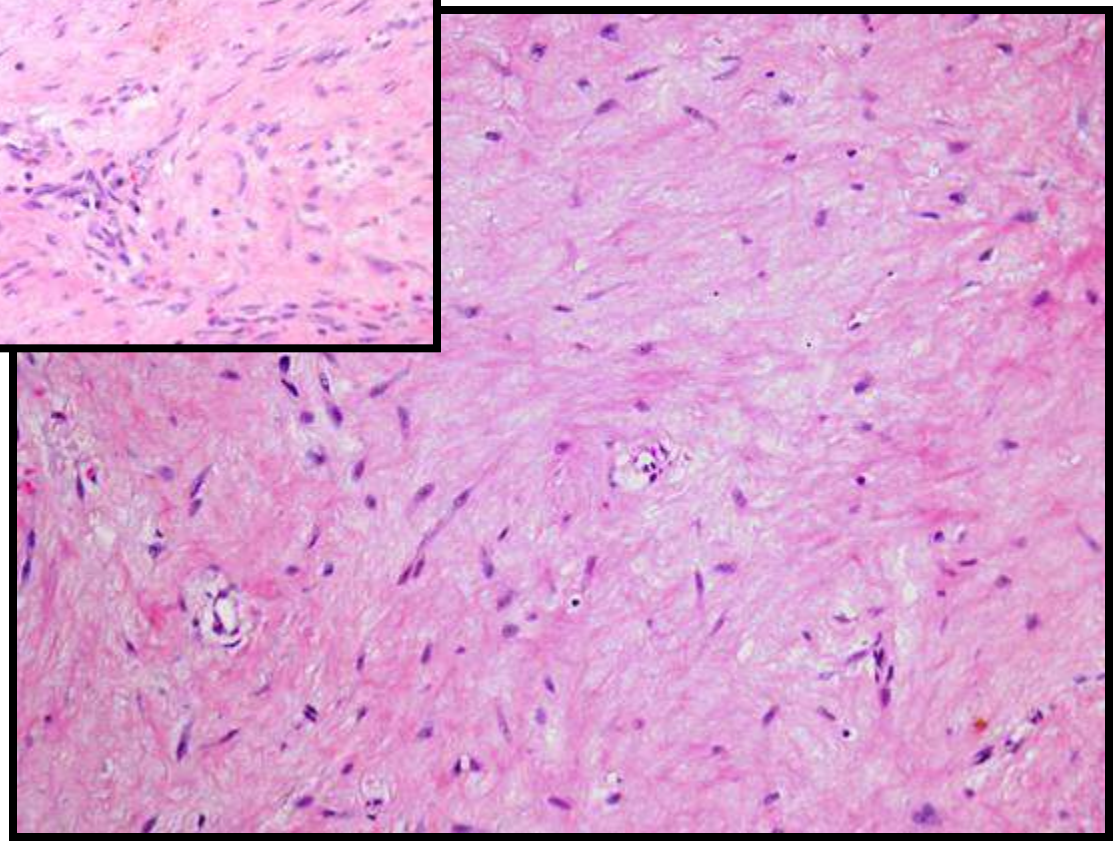


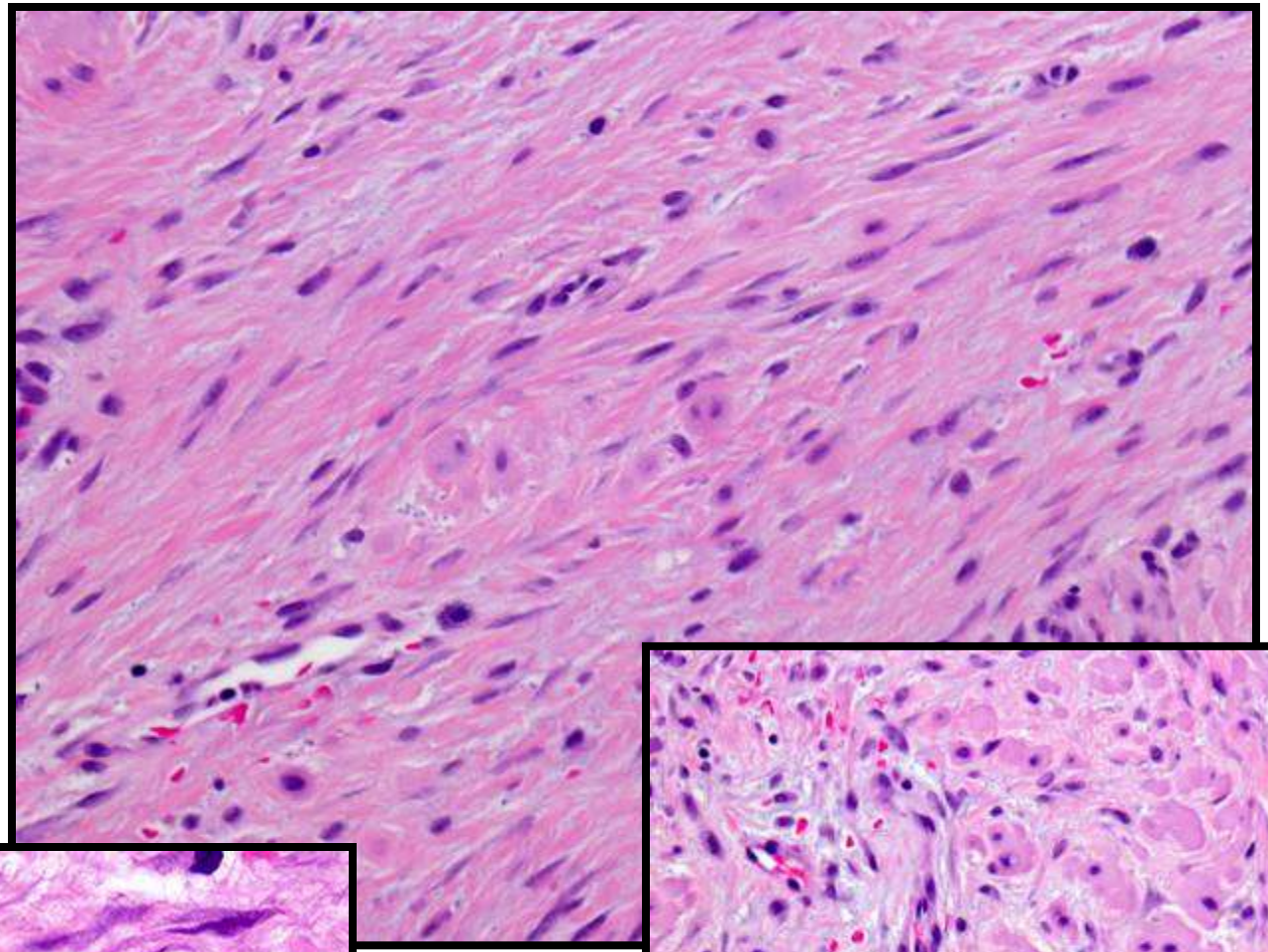


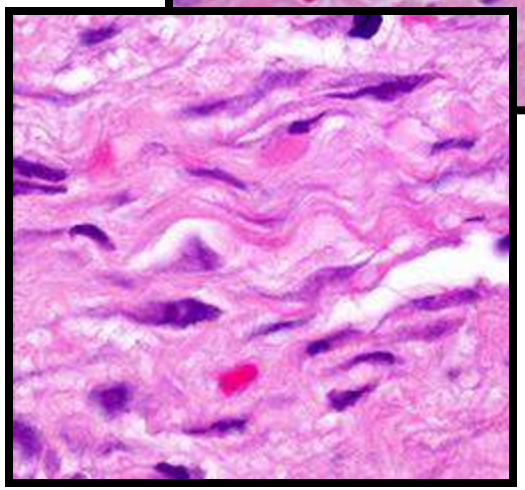
Case 5

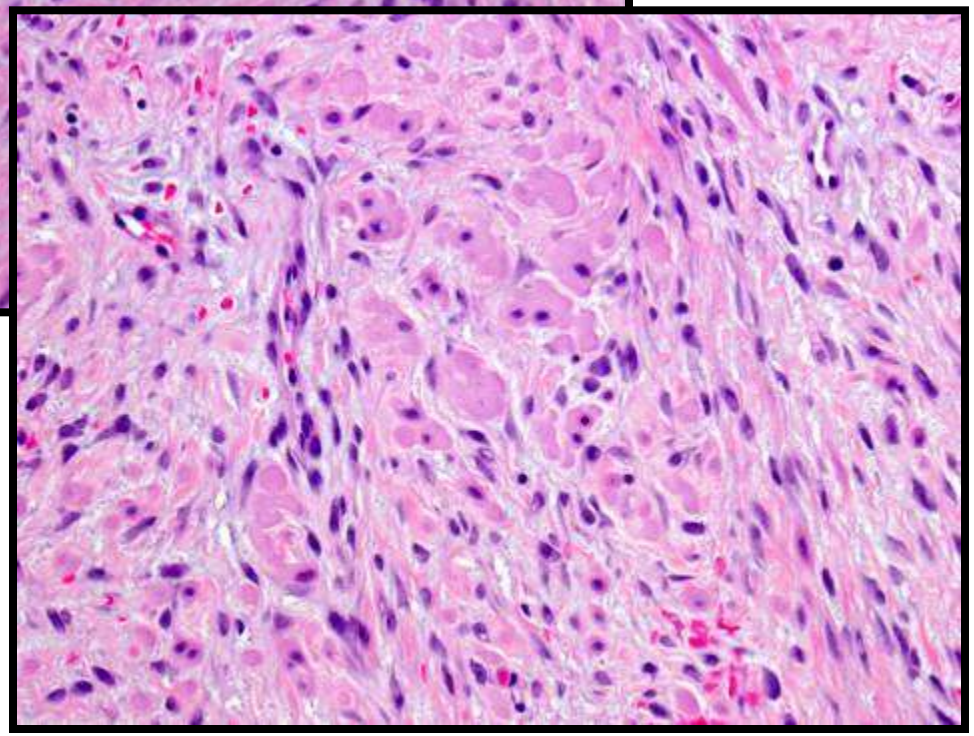


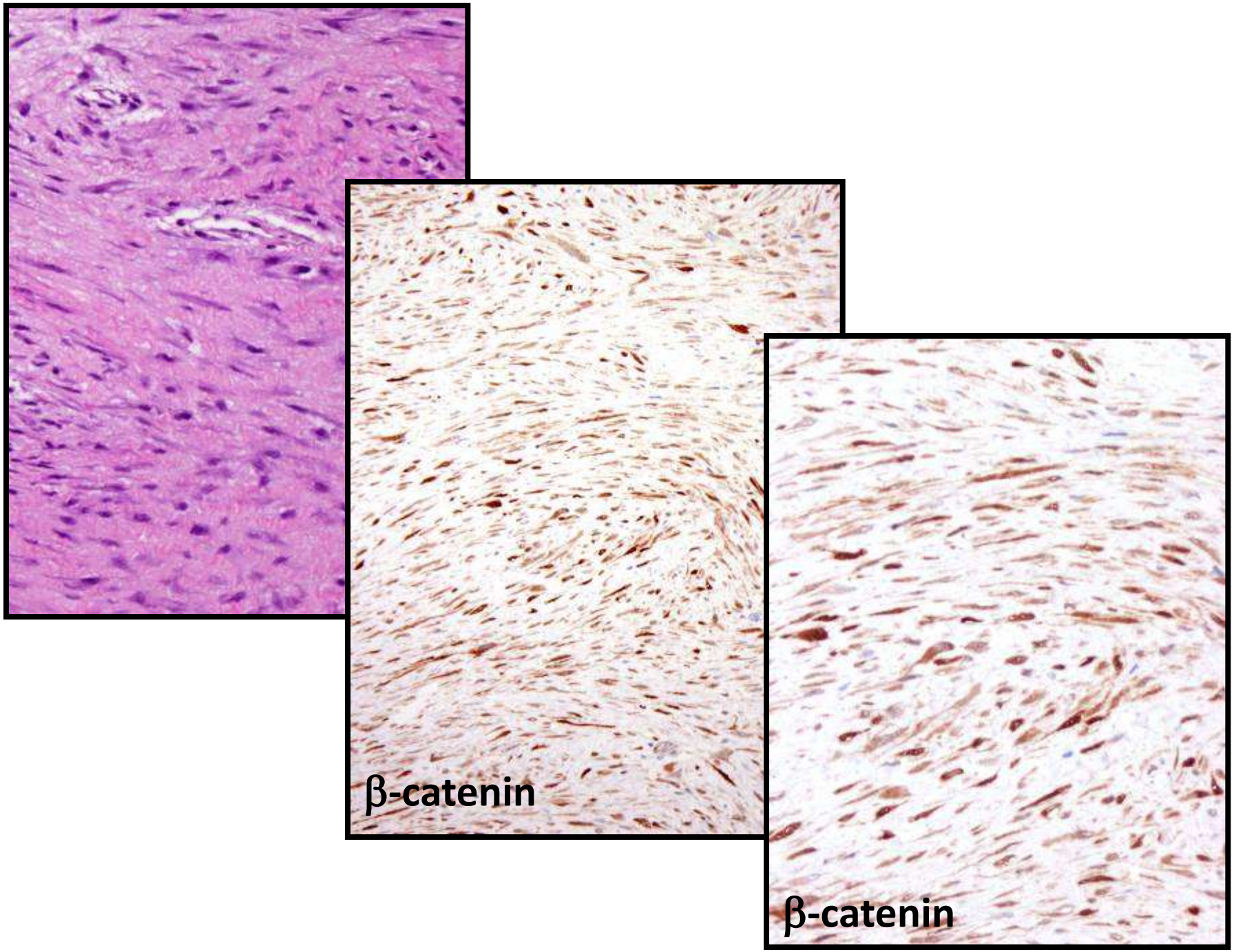


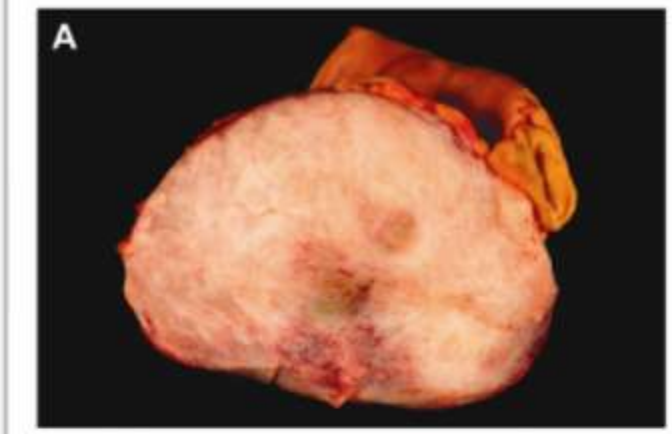


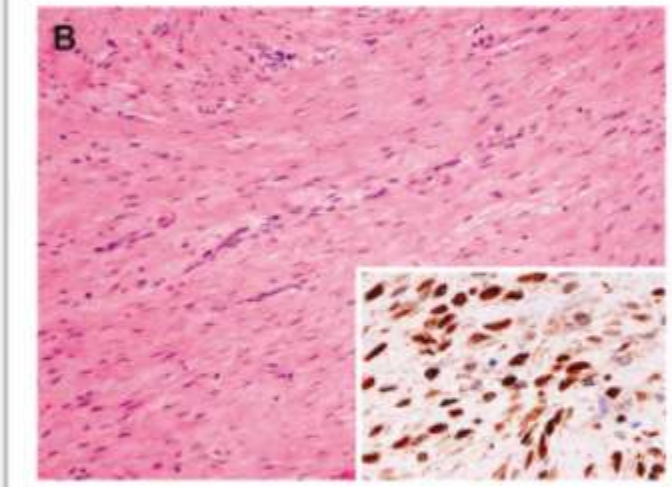


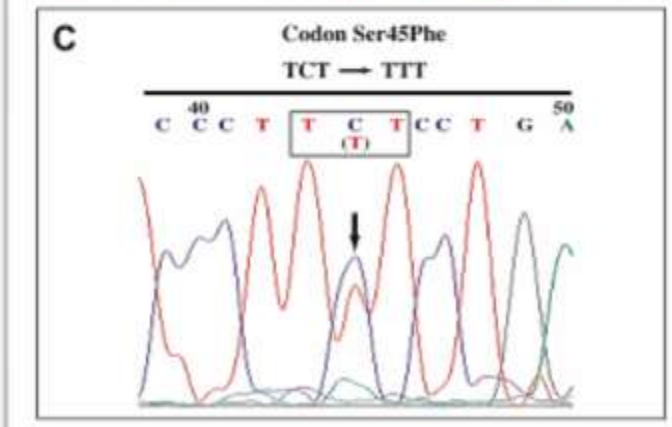





β-catenin
β-catenin


A


B

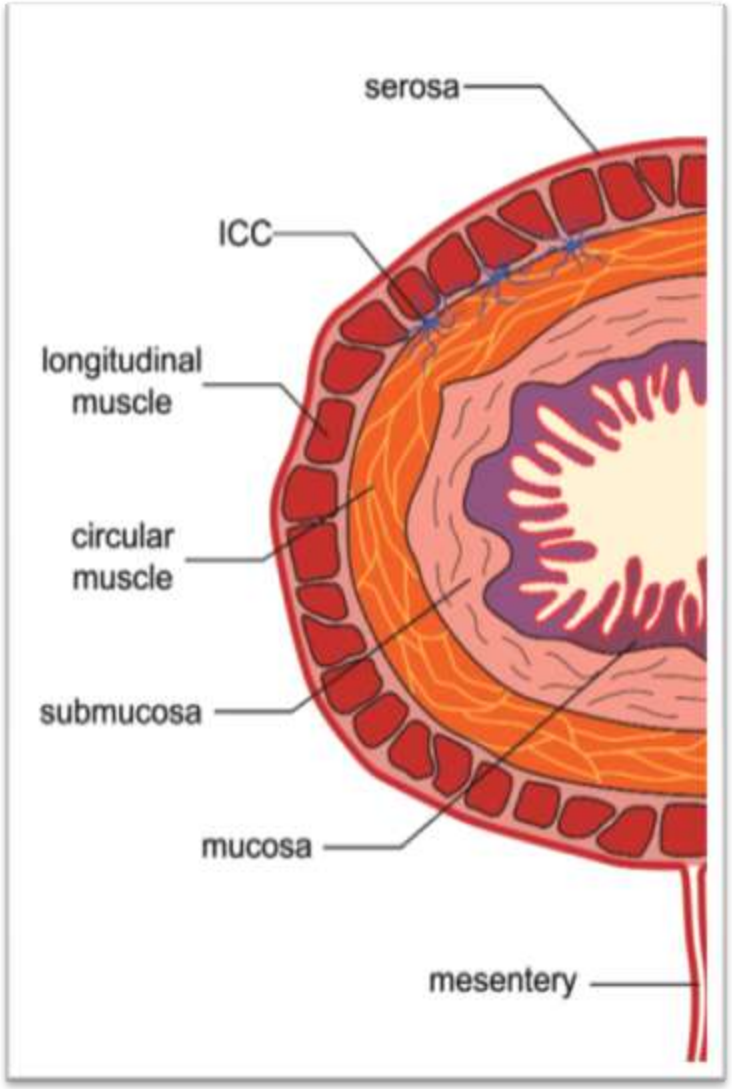

C
Codon Ser45Phe
TCT → TTT
40
C C C T T C T C C T G 50
A
(T)

Immunohistochemical Scheme

DIAGNOSIS	KIT	CD34	Ker	SMA	DES	S-100
GIST	+	+(70%)	-	+(40%)	-	-
Carcinoma	-	-	+	+(sar)	-	-
Melanoma	+/-	-	-	-	-	+
Leiomyoma	-	+/-	+/-	+	+	-
Leiomyosarcoma	-	+/-	+/-	+	+/-	-
Schwannoma	-	-	-	-	-	+
Fibromatosis	-	-	-	-	-	+/-

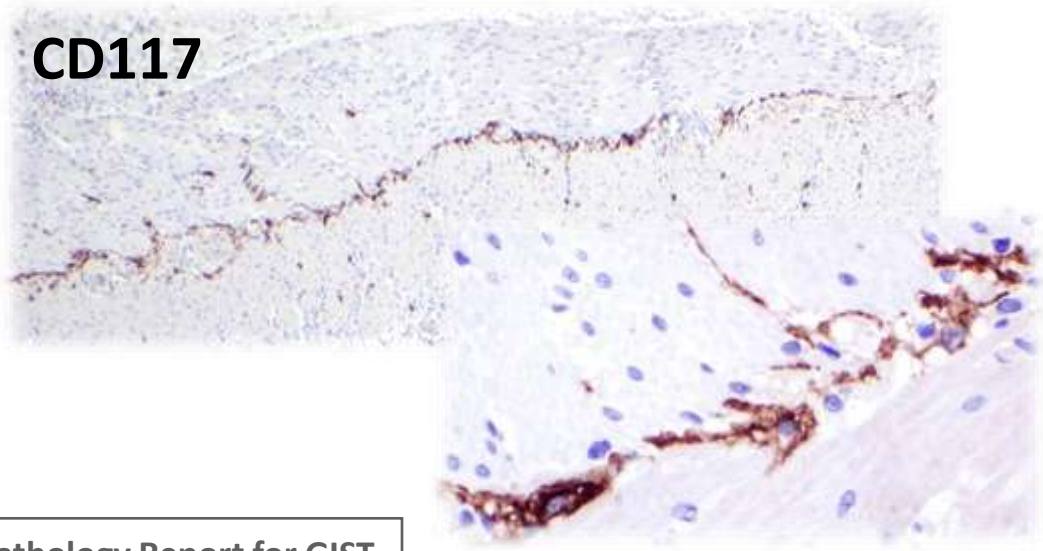
Immunohistochemical Profile of GISTs (Circa 1997 and prior)

Gastrointestinal Stromal Tumor



- **Arise from the interstitial cells of Cajal (ICC)**

- **ICC have a "pacemaker" function and are important in coordinating peristalsis**



Hornick & Lazar. GSI website: Understanding Your Pathology Report for GIST

Immunohistochemical Profile of GIST

H&E	CD117 (KIT)	CD34	Smooth muscle actin	S100 protein	Desmin	Pan-keratin
	95%	70%	30%	5%	2%	<1%
						
	+ +	+ +	+ +	+ +	+ +	+ +

KIT (CD117) +ve (95%)

CD34 +ve (70%)

SMA +ve (30-40%)

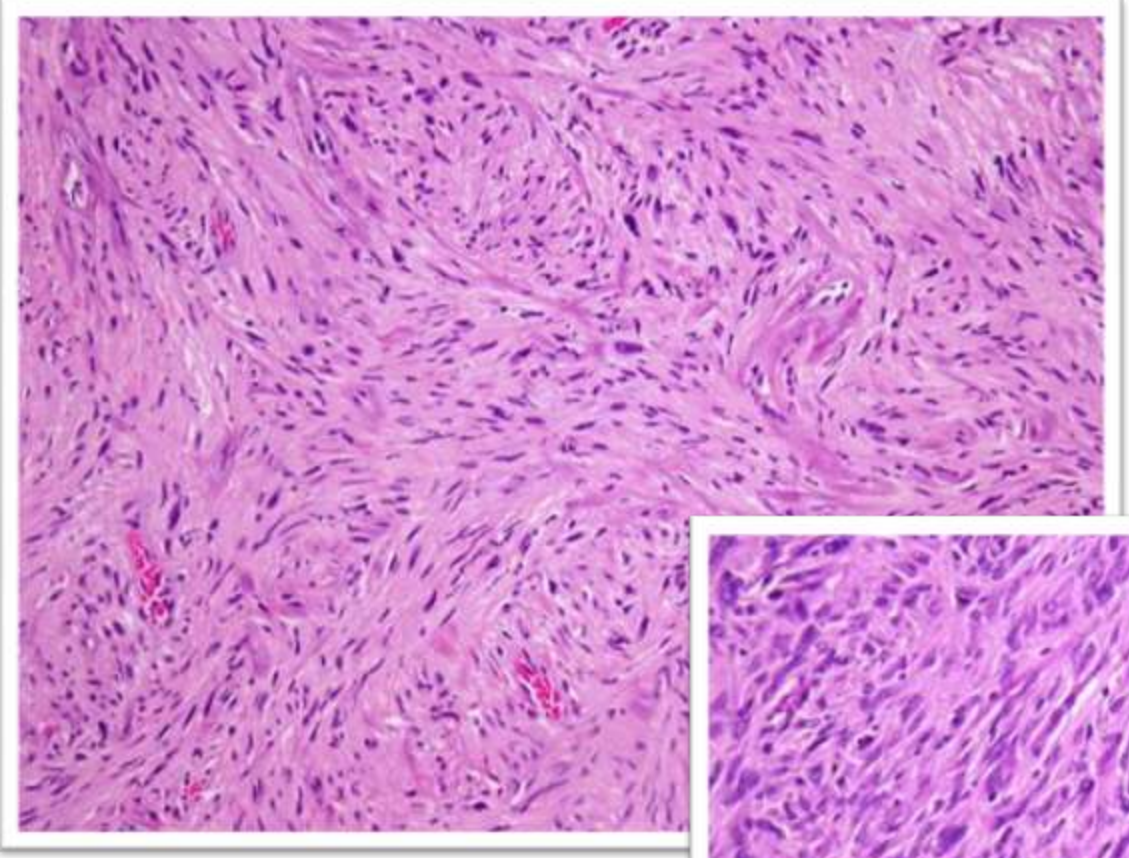
Desmin –ve

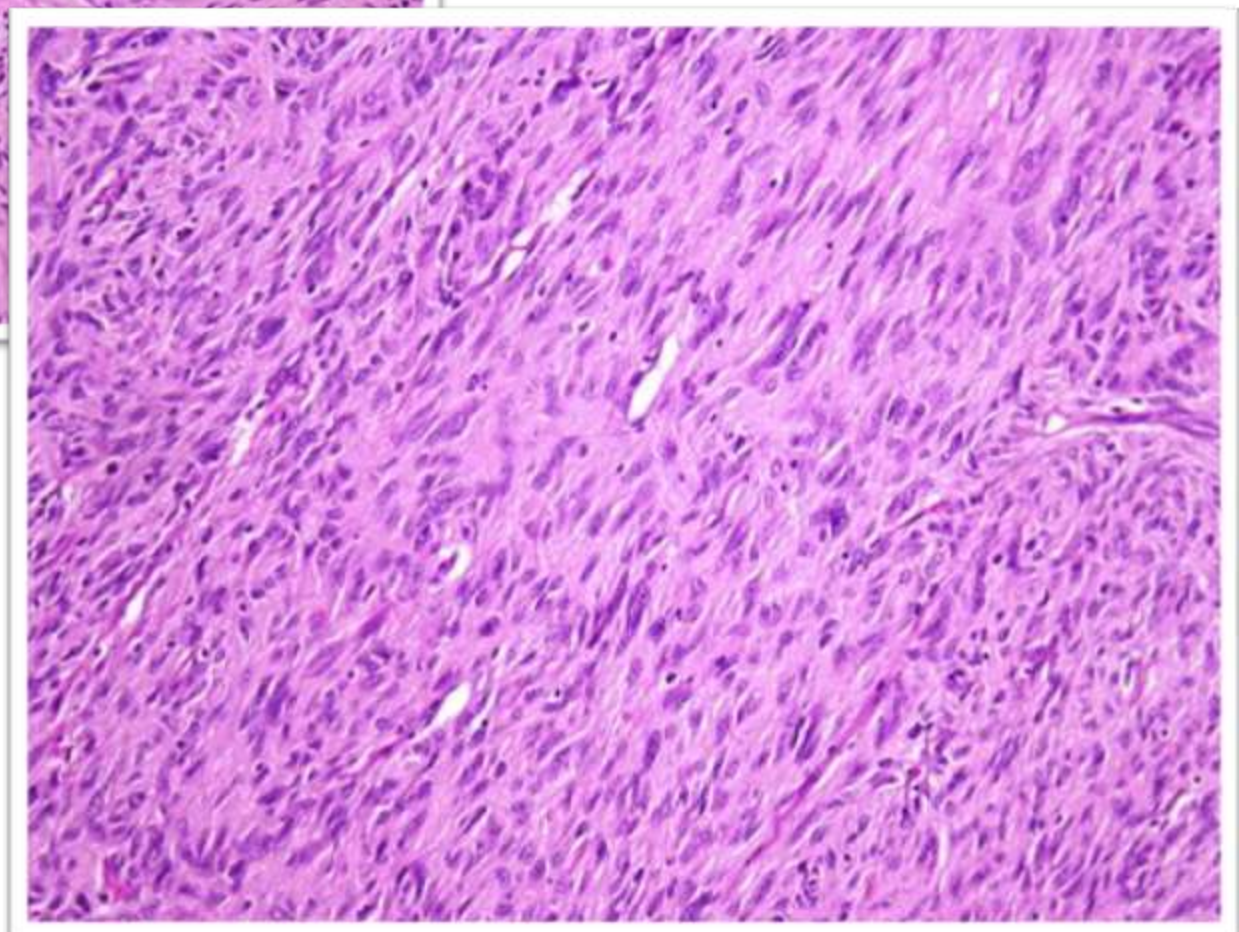
S-100 protein –ve

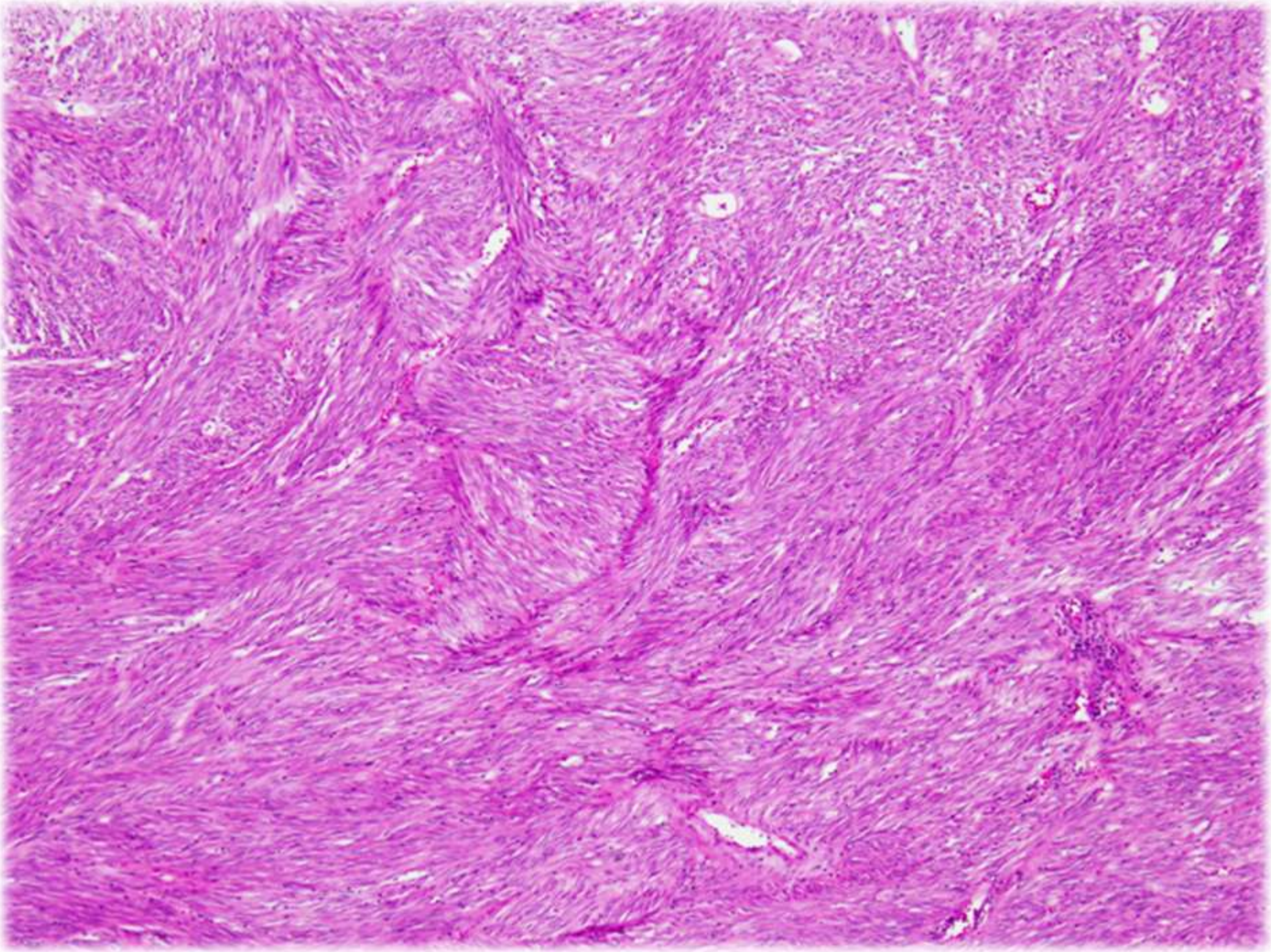
Keratin –ve

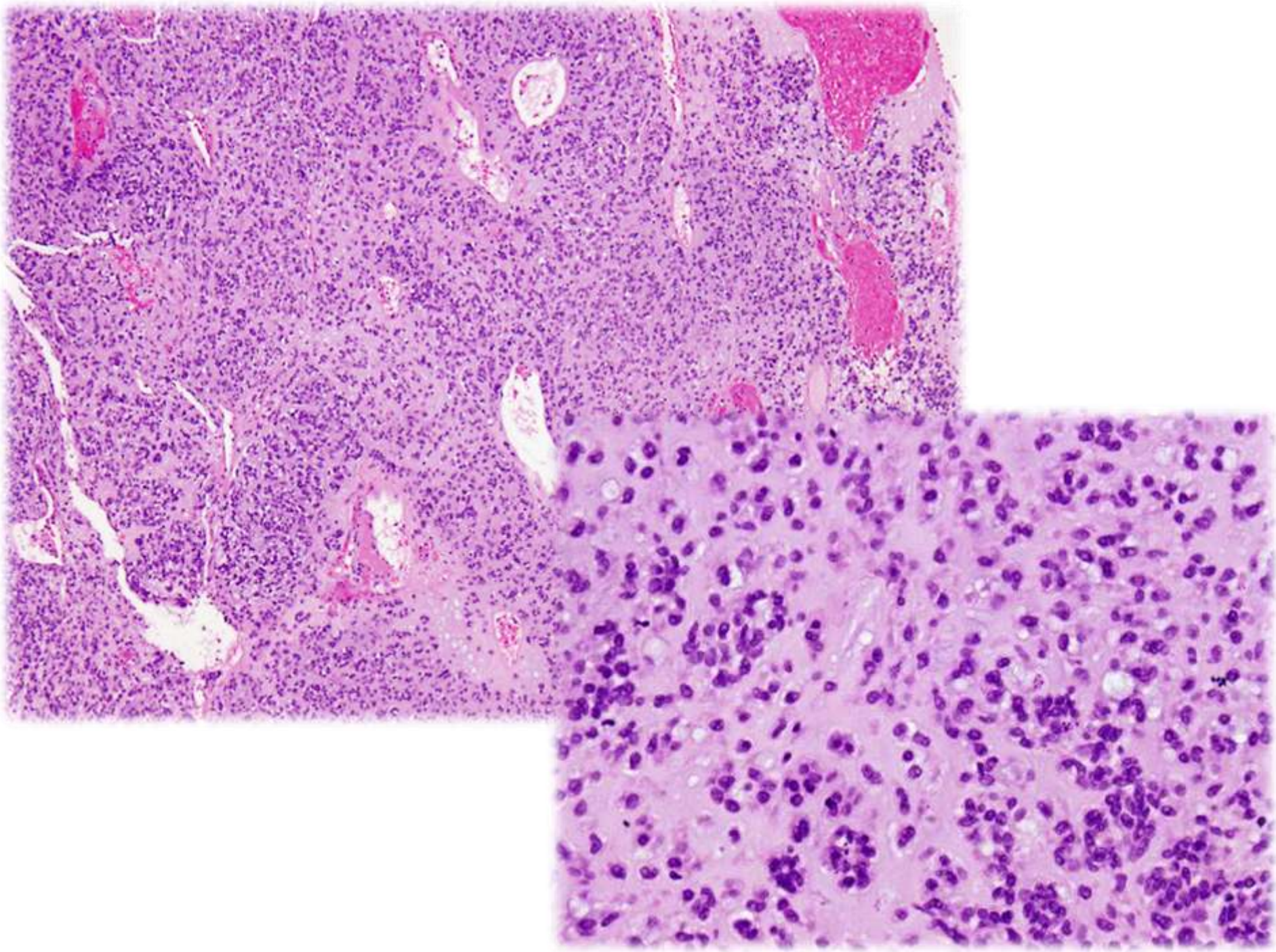
Liegl B et al. Hematol Oncol Clin North Am 2009; 23:49-68

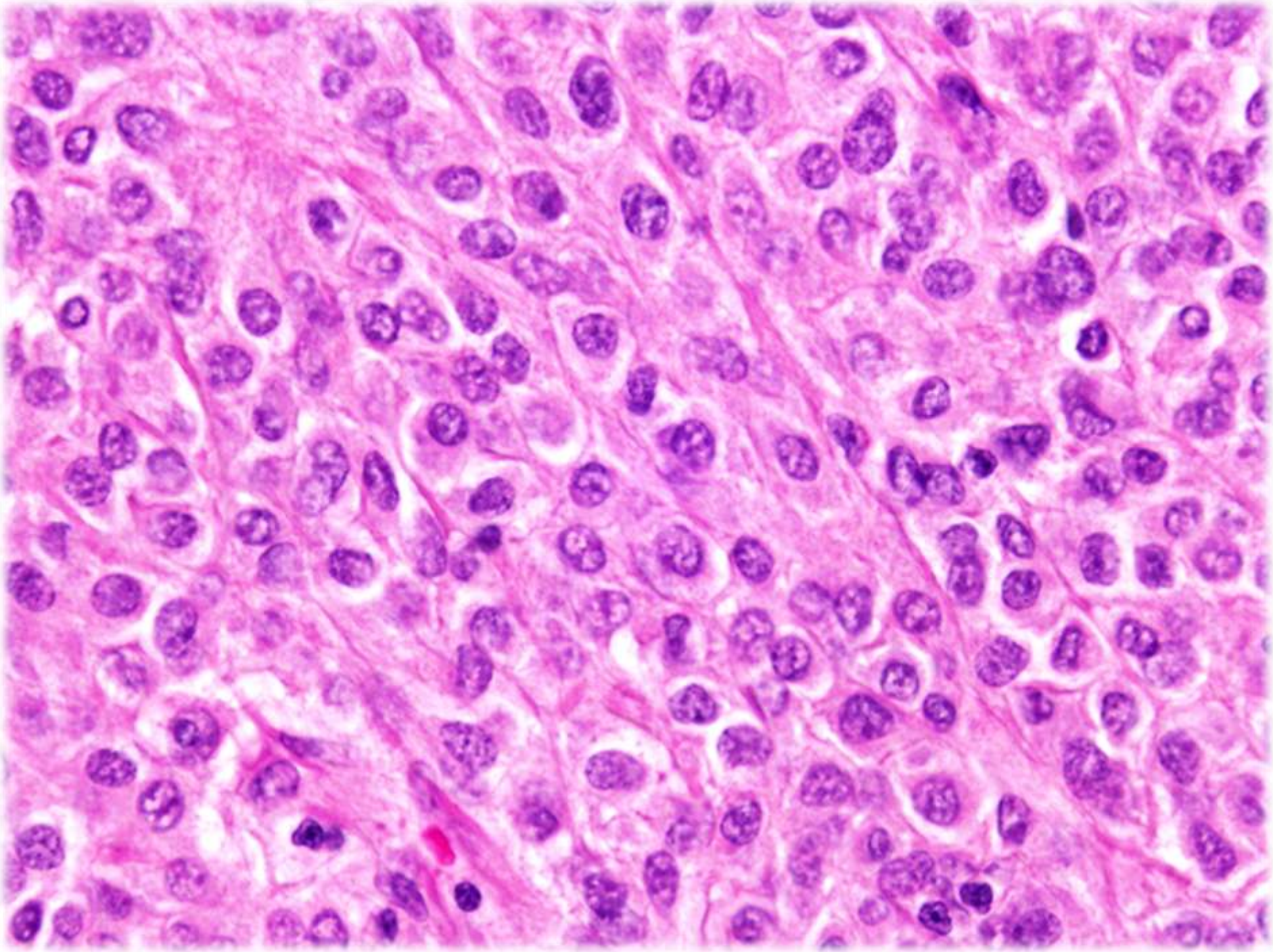
The many faces of GIST.

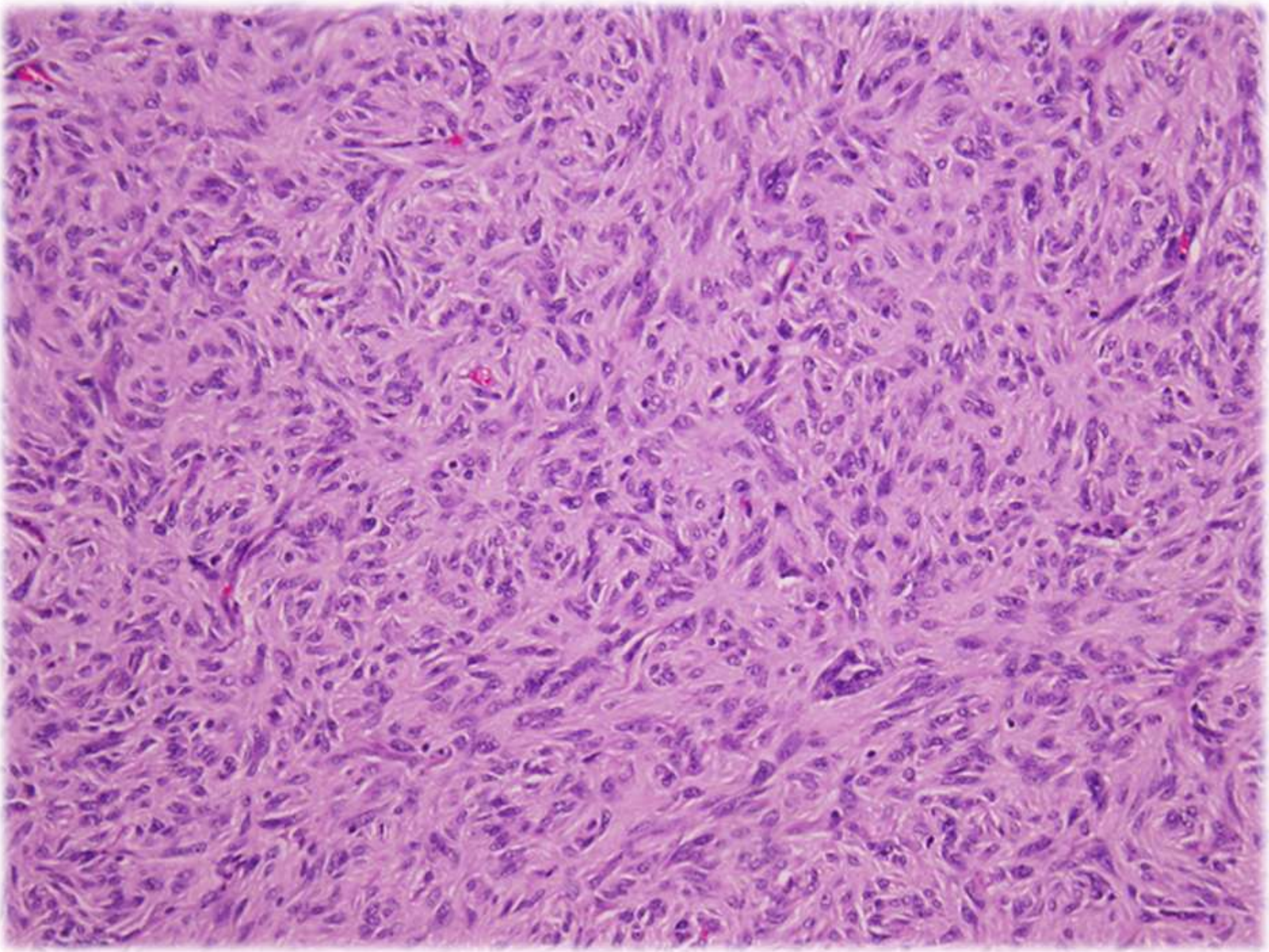


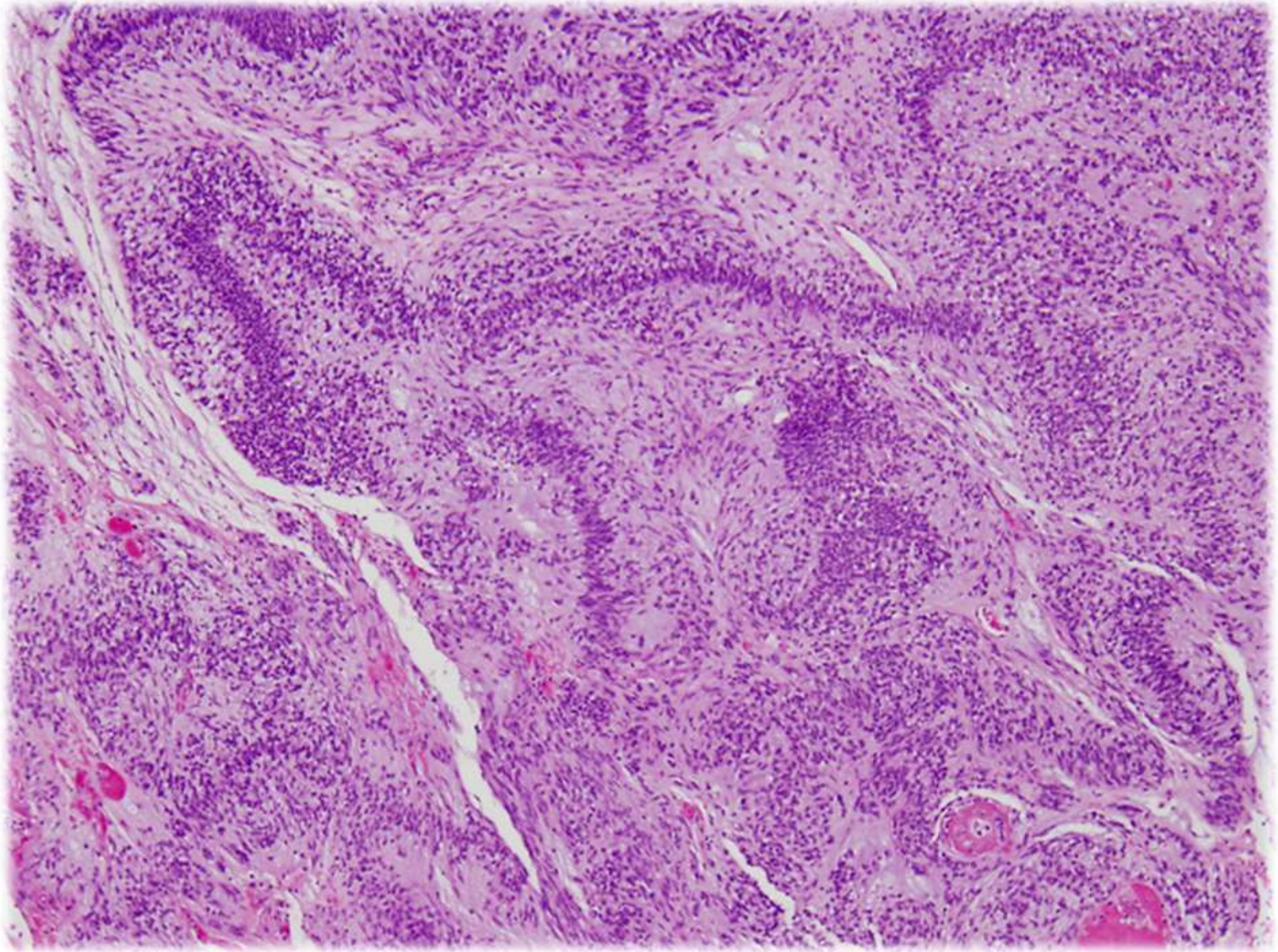


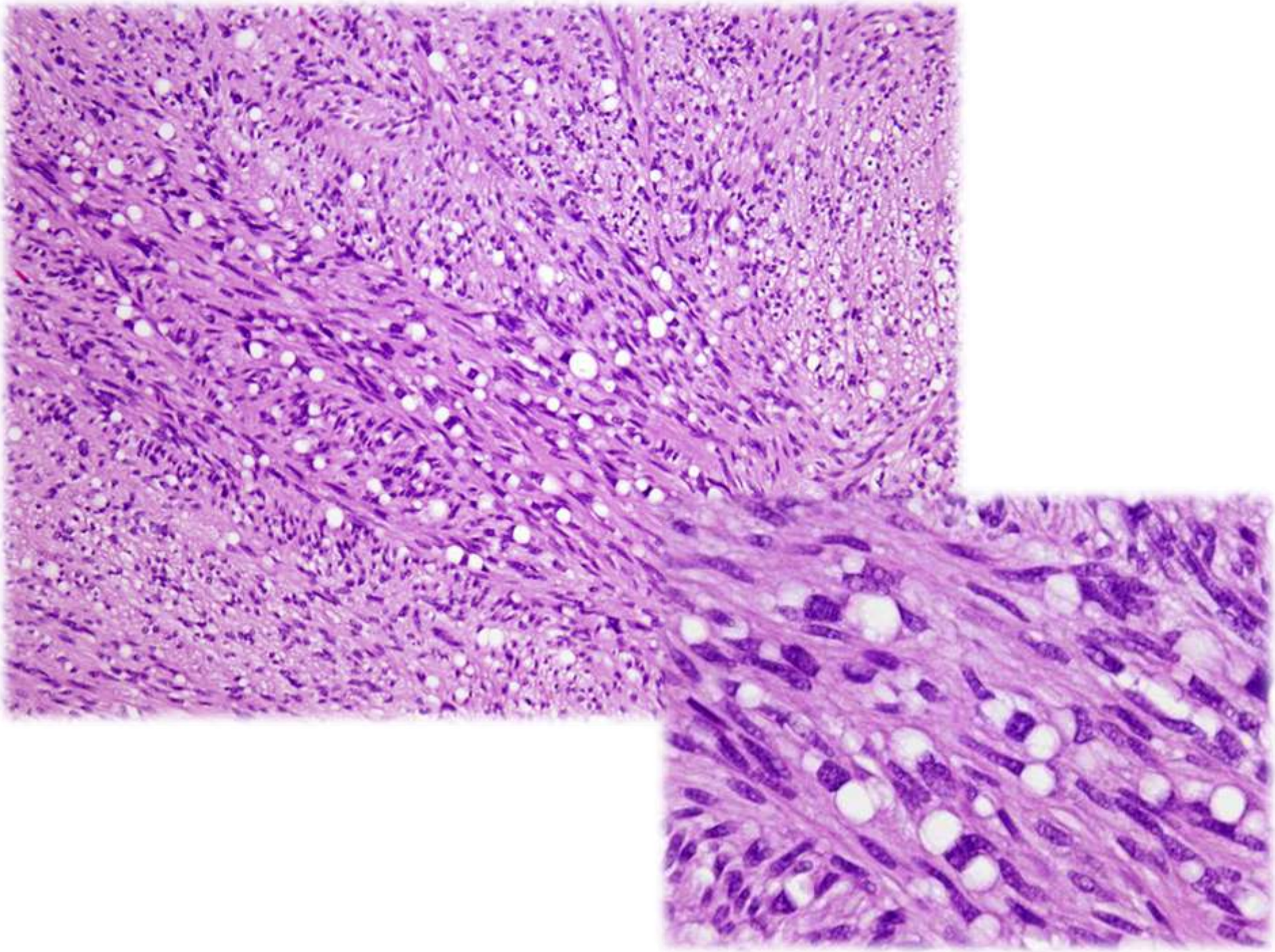


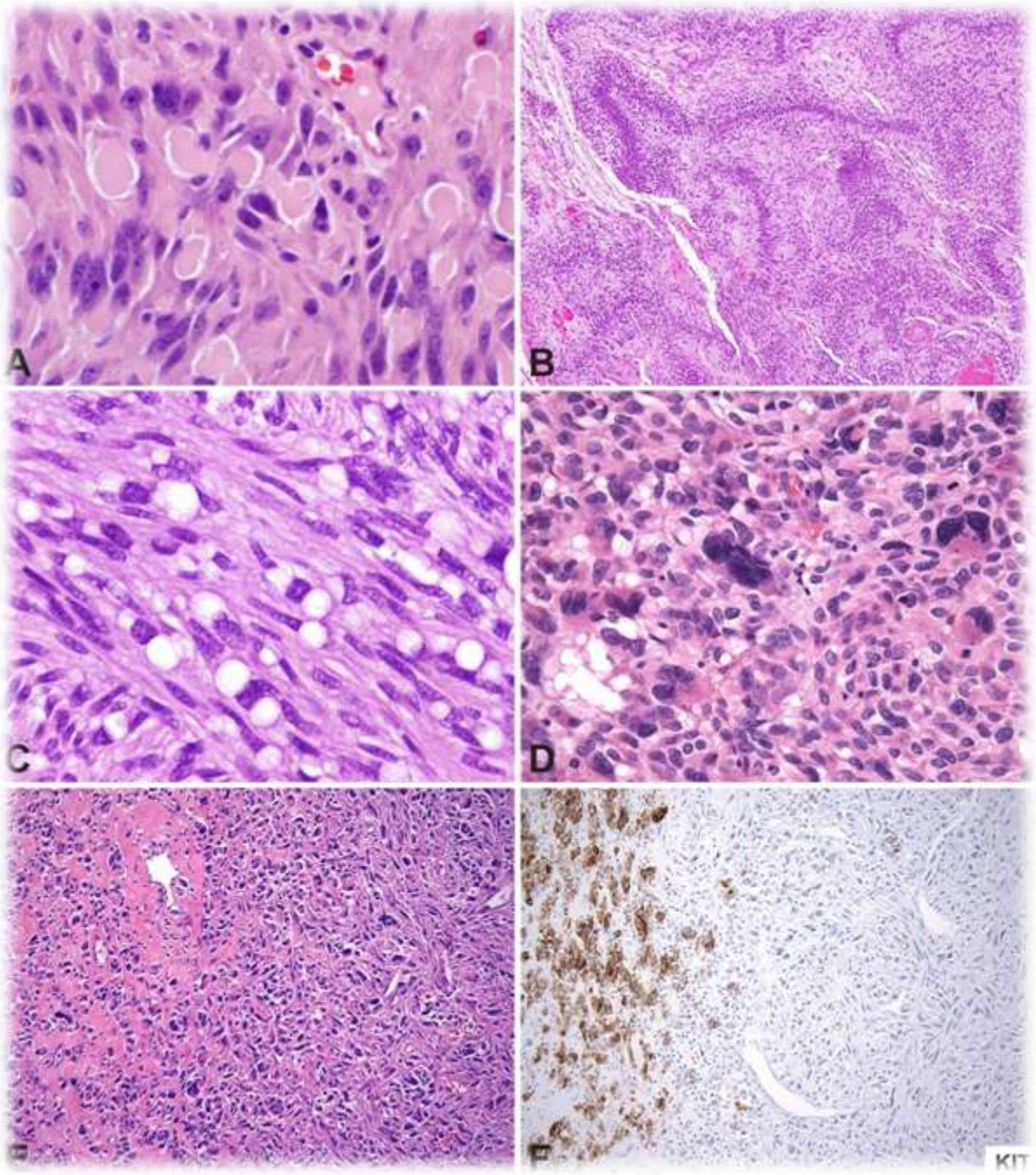


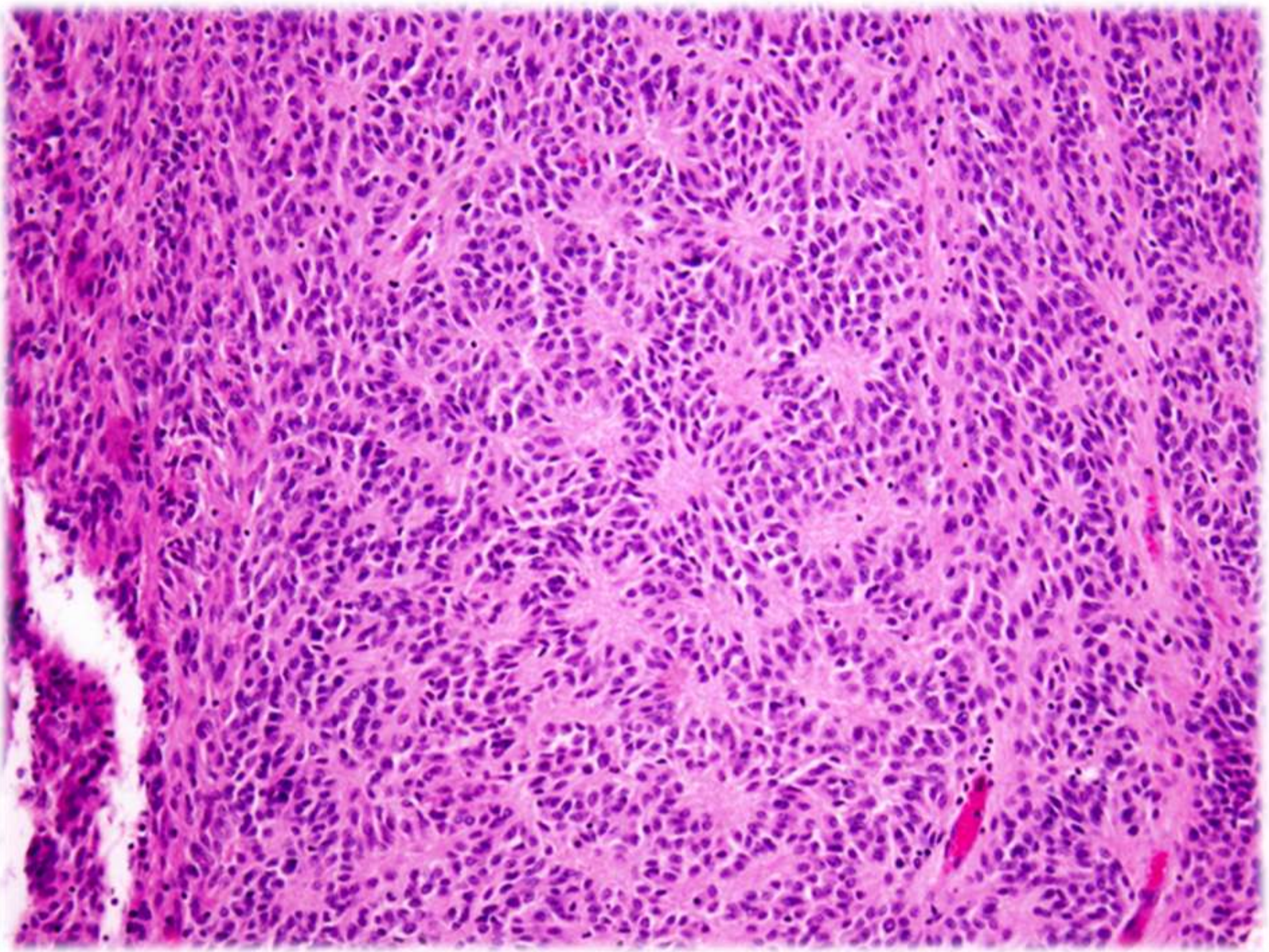


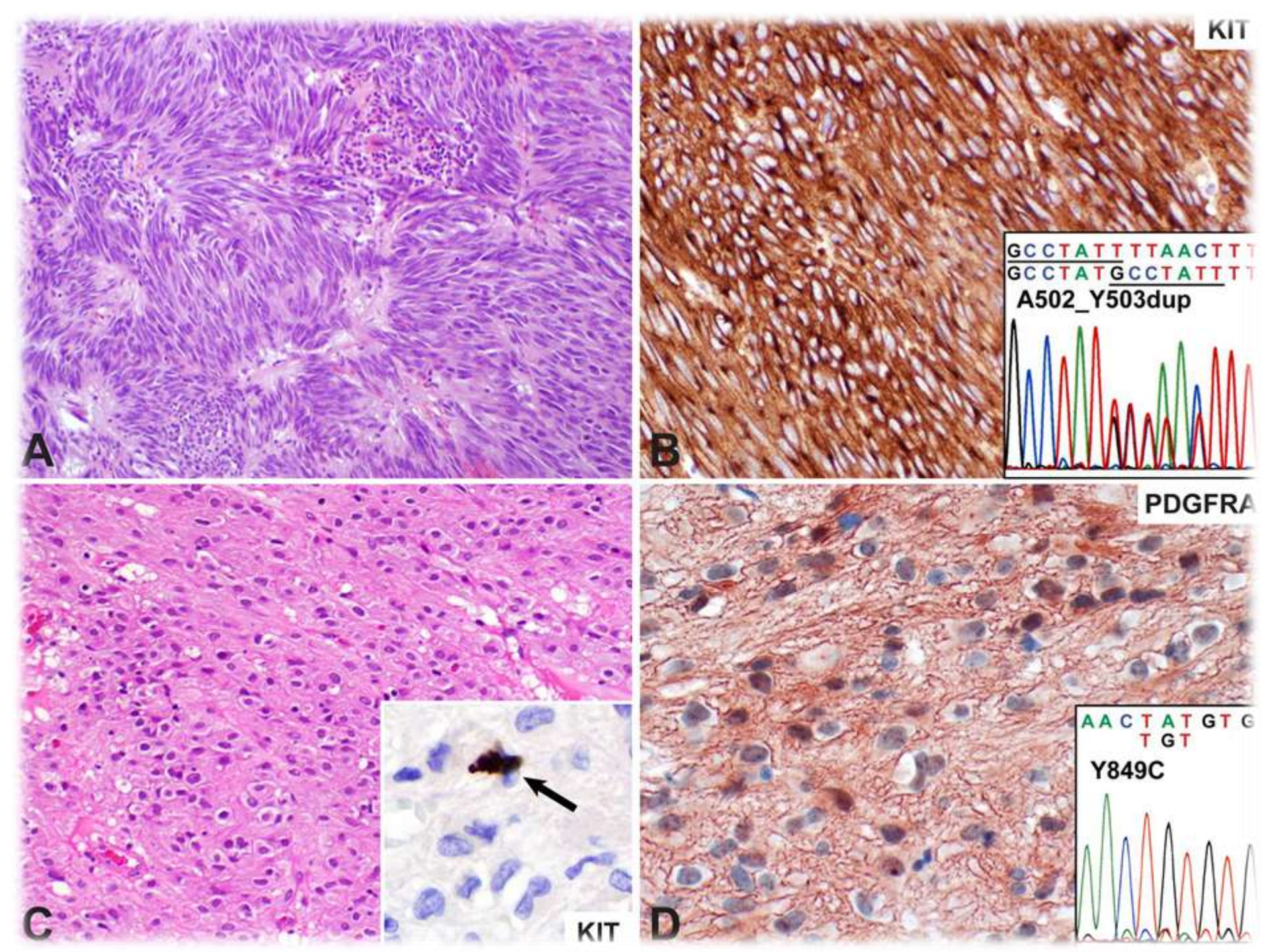


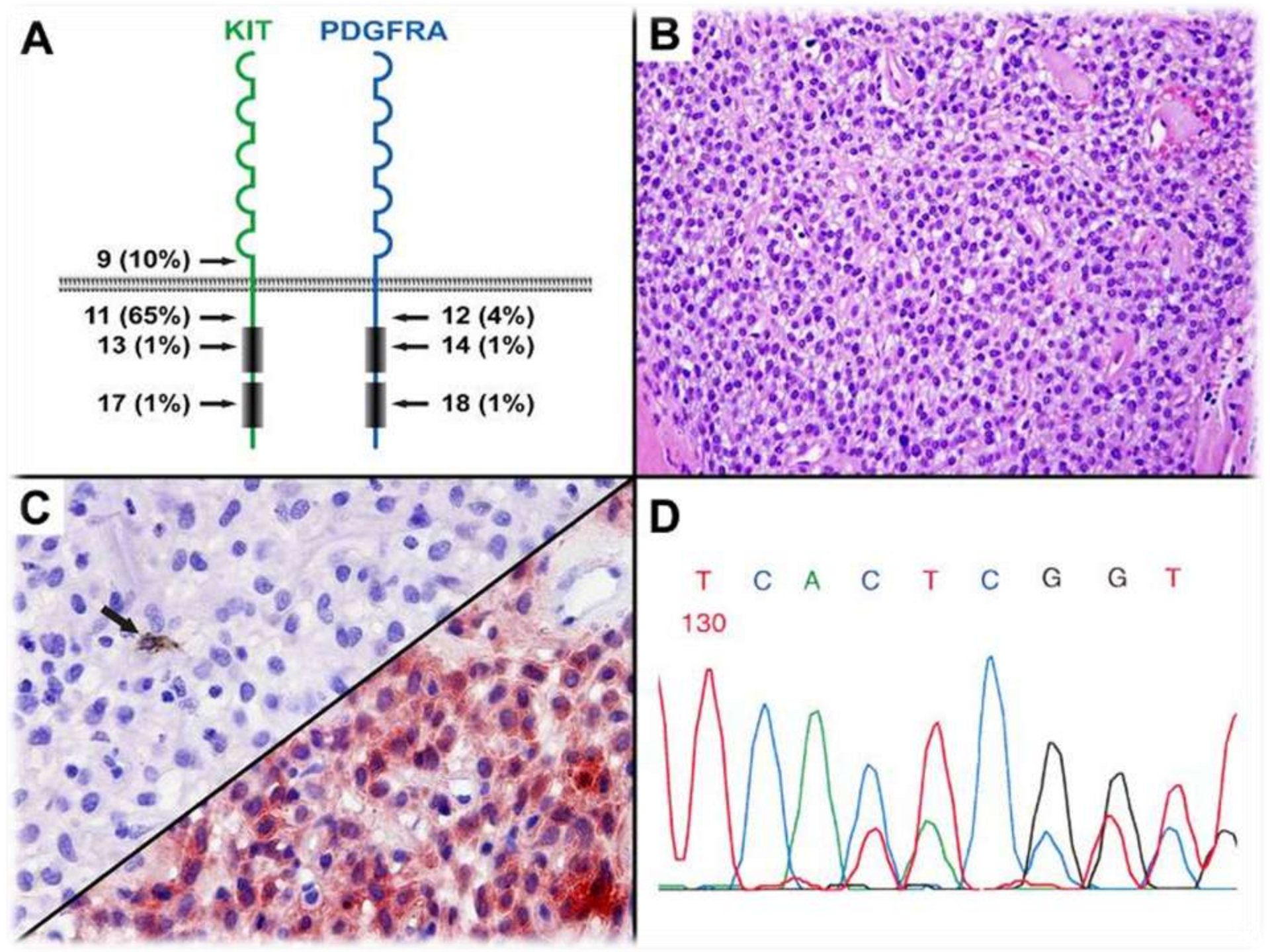


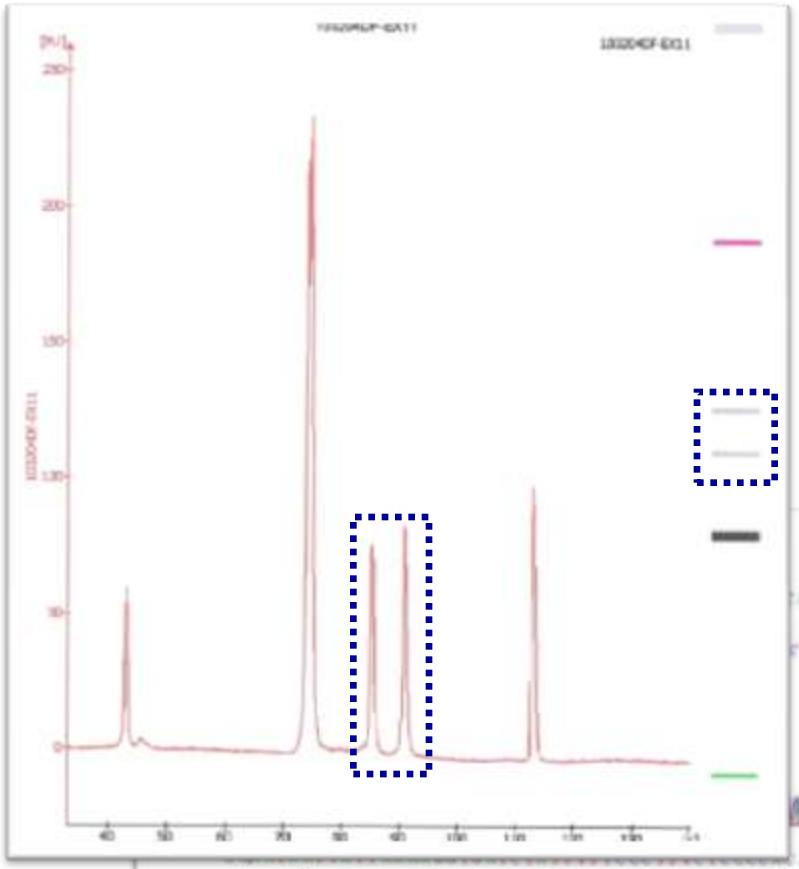



A
B
C
D
KIT

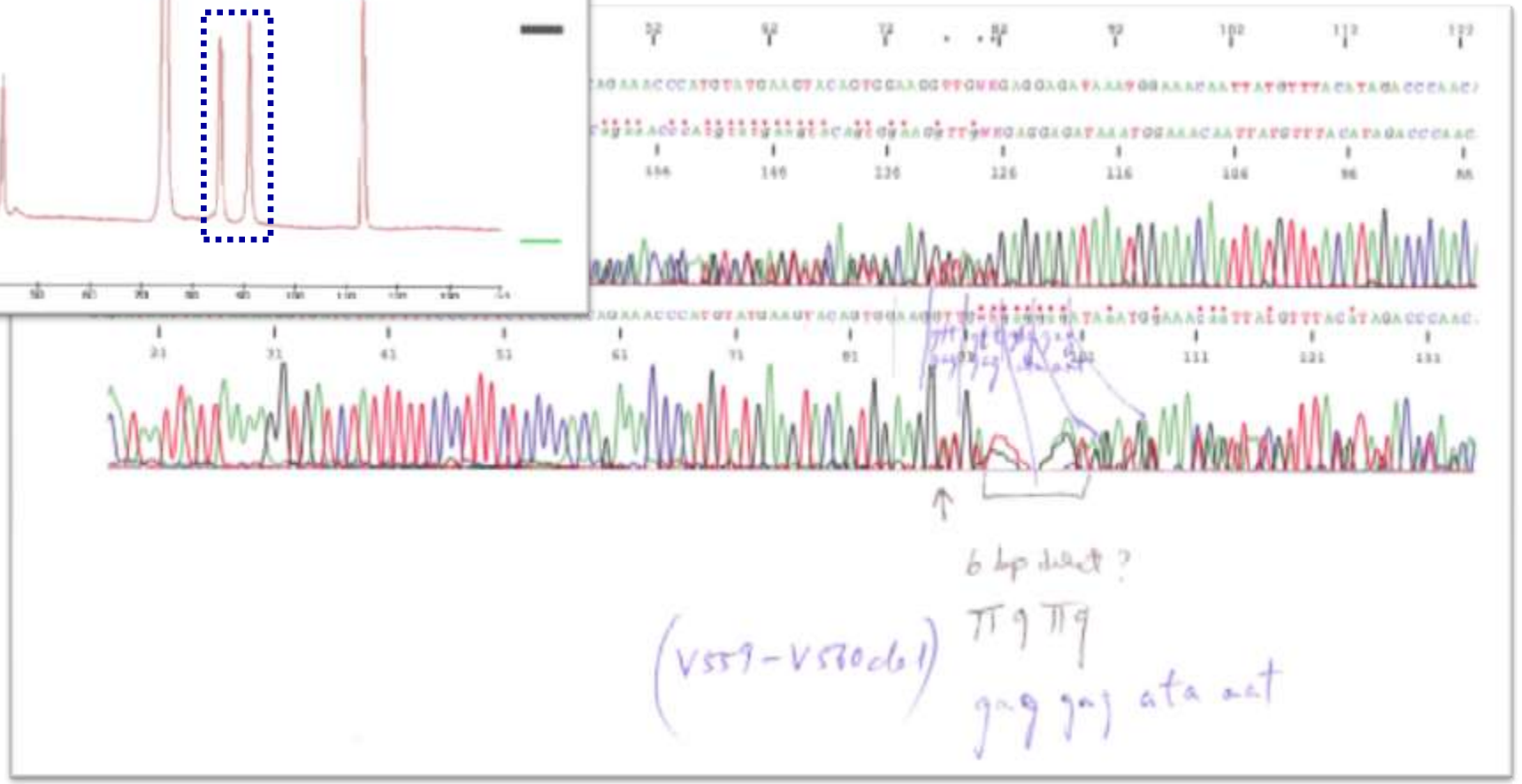



A
B
KIT
GCCTATTTTAACTTT
GCCTATGCCTATTTT
A502_Y503dup
C
KIT
D
PDGFRA
AACTATGTG
TGT
Y849C


A
KIT
PDGFRA
9 (10%)
11 (65%)
13 (1%)
17 (1%)
12 (4%)
14 (1%)
18 (1%)
B
C
D
T C A C T C G G T
130

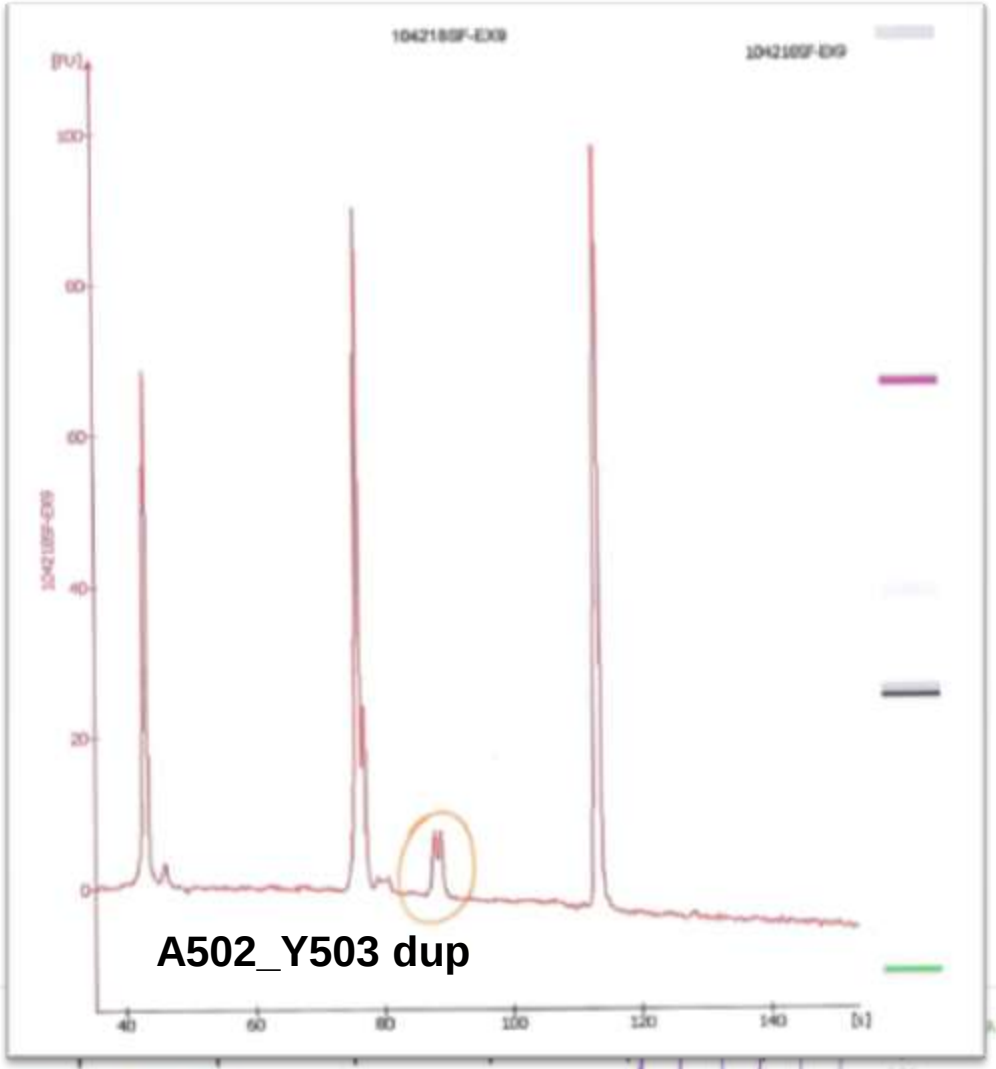


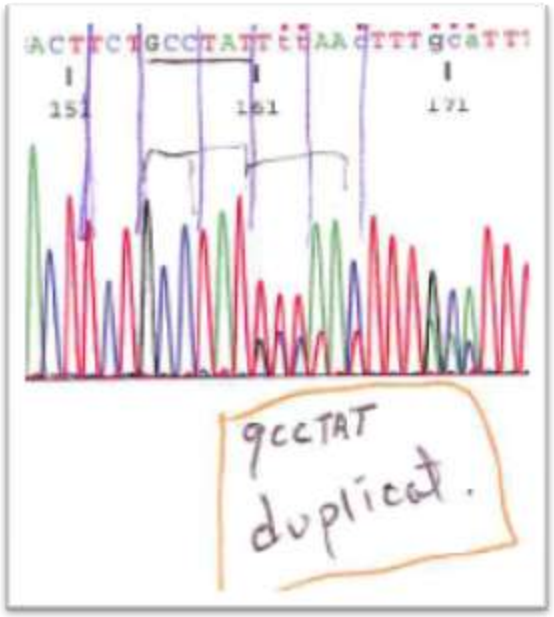
Exon 11
V559_V560del

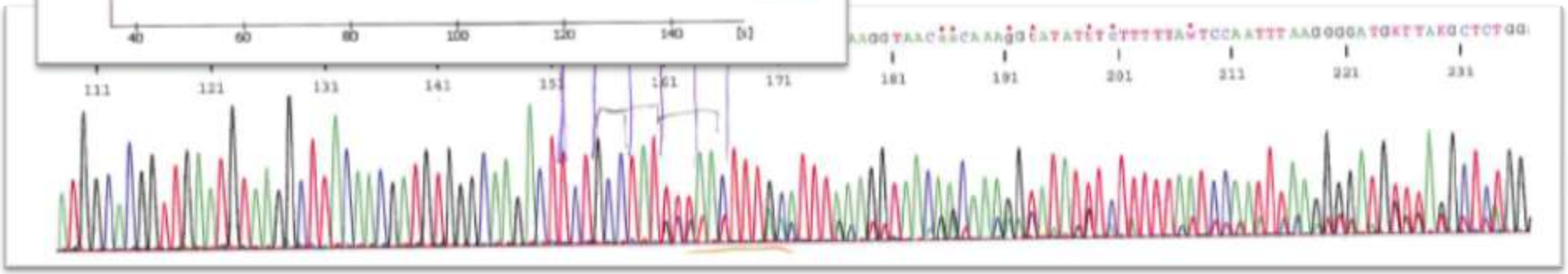


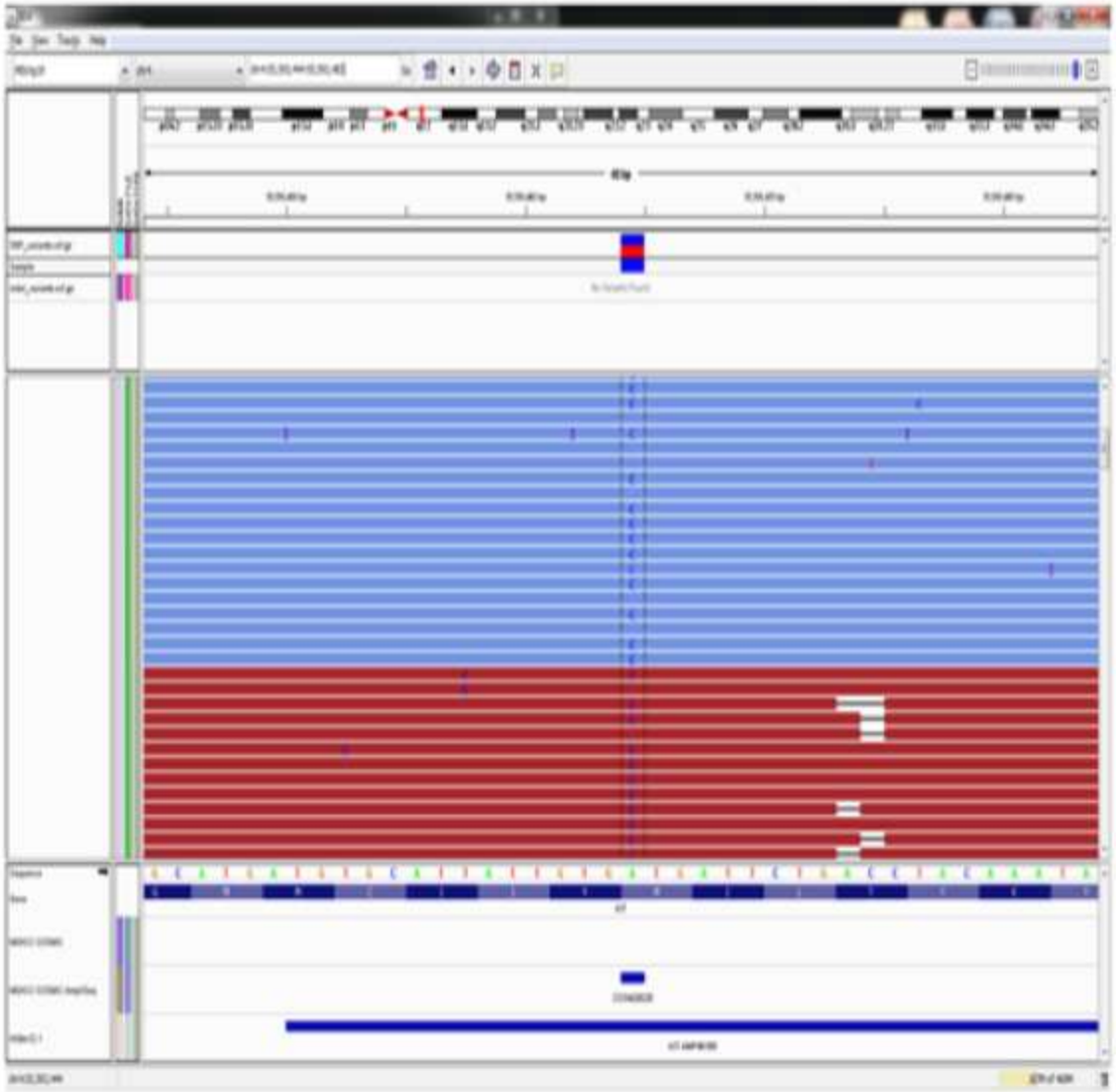
Exon 9

A502_Y503dup

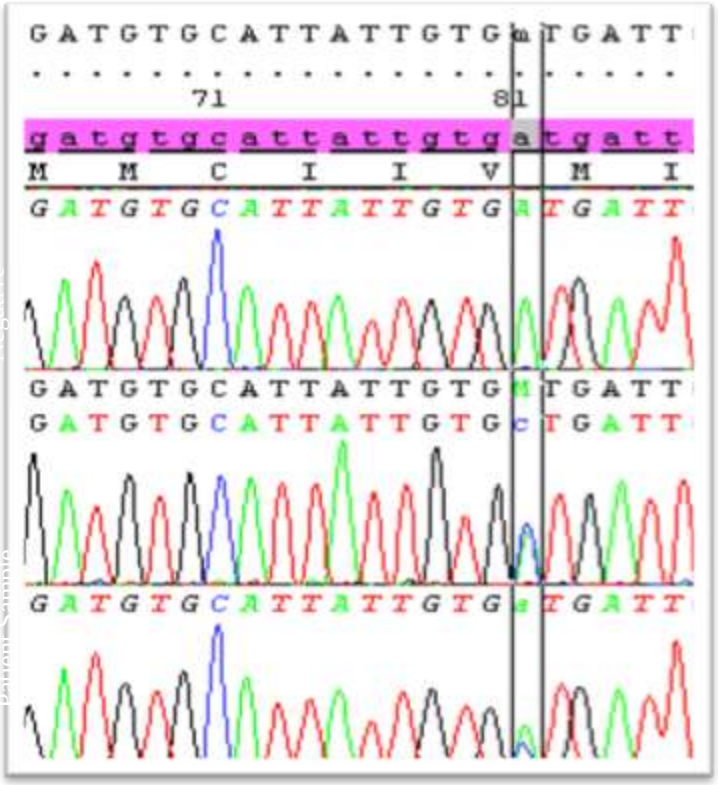




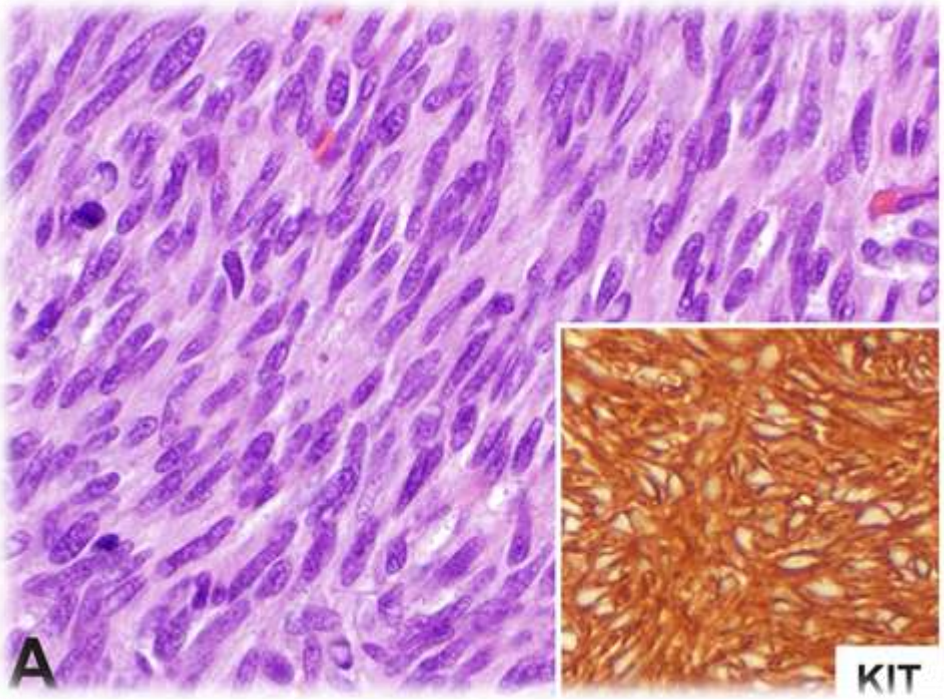


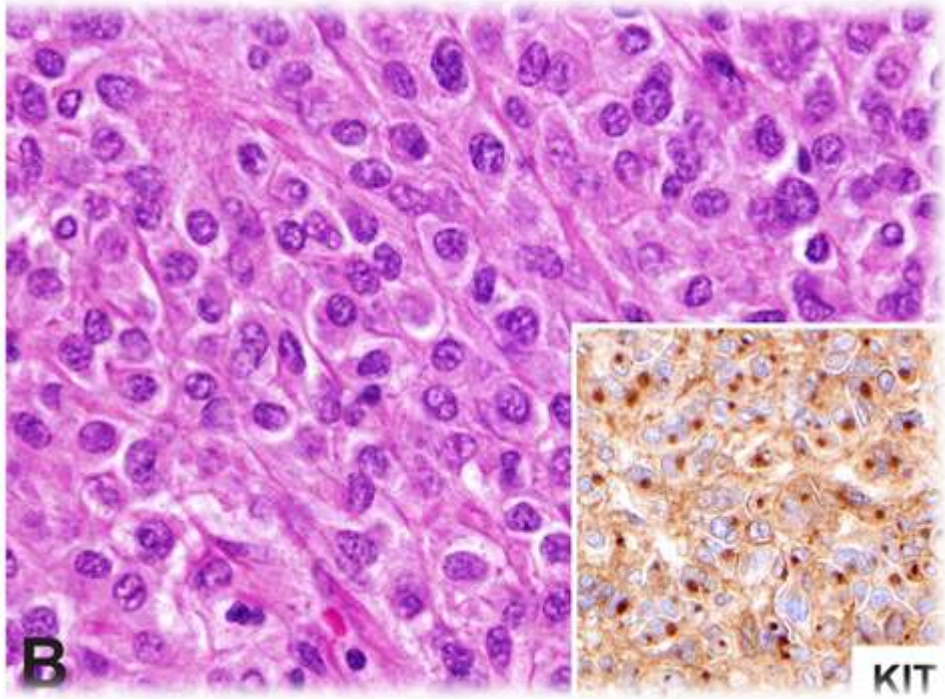


Detection of SNV in KIT Exon 10, currently not covered by Sanger

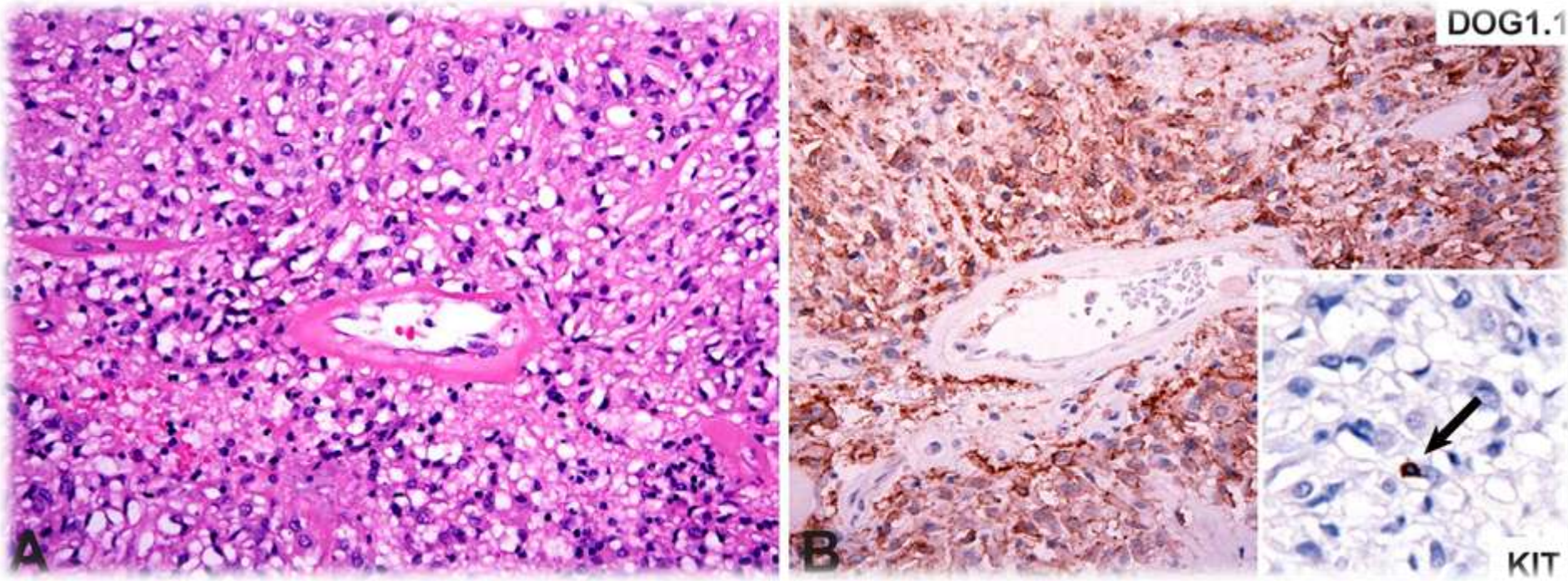


KIT immunoreactivity in GIST





KIT-negative GIST



Gastric GISTs with Distinctive Histology (Multinodular/Plexiform)

- **Pediatric GISTs**
  - **Female predominance (peak 2nd decade)**
  - **Indolent, but late metastases common**
  - **Molecular genetic basis unknown**

Carney Triad

- **Gastric GIST, pulmonary chondroma, paraganglioma**
- **Molecular genetic basis unknown**

Carney-Stratakis Syndrome

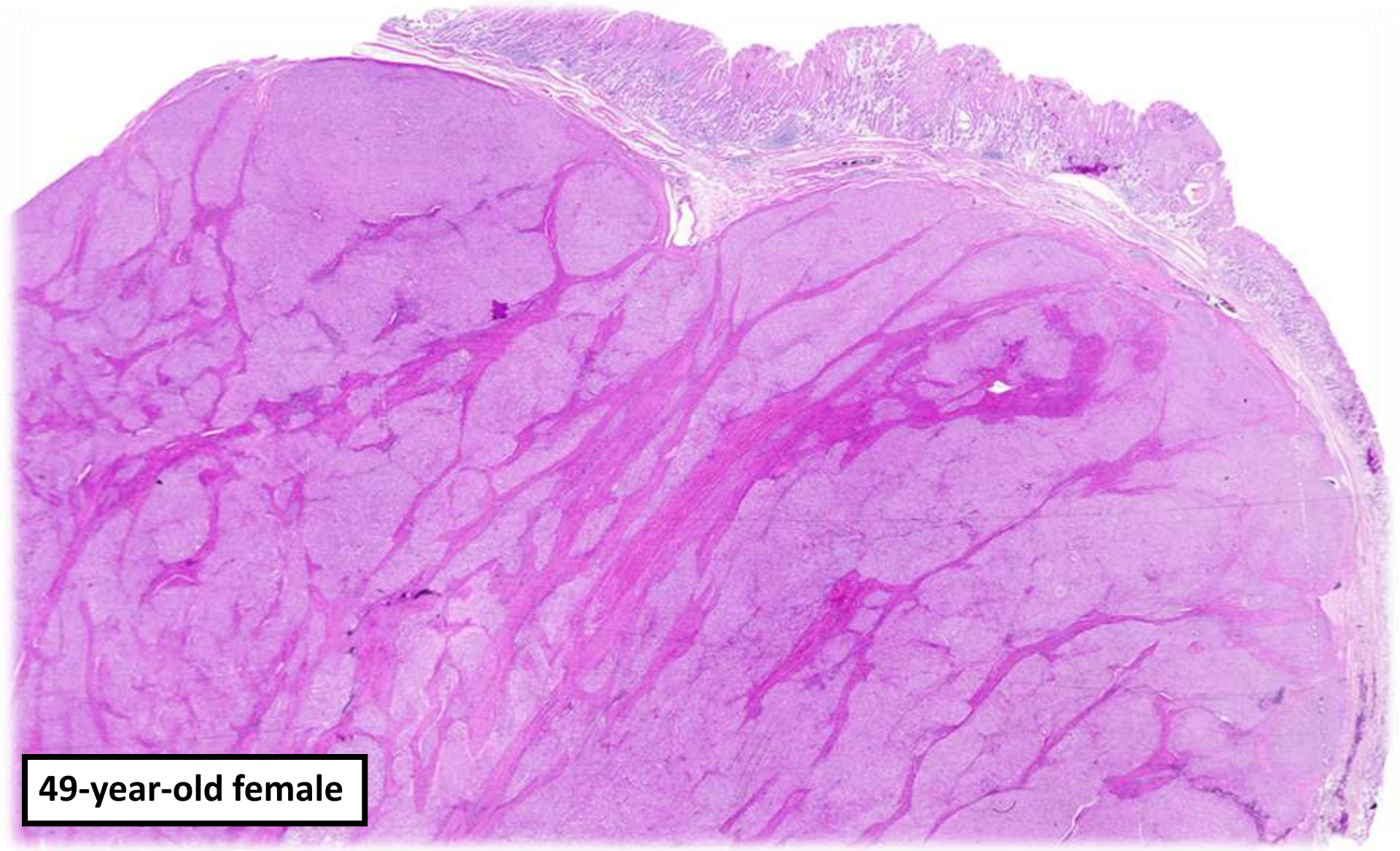
- **Gastric GIST and paraganglioma**
- **Germline mutations in succinate dehydrogenase subunit genes (*SDHA*, *SDHB*, *SDHC*, or *SDHD*)**

GIST with Distinctive Histology

- **Multinodular/plexiform growth pattern**
- **Epithelioid or mixed morphology**
- **“Pediatric-type” or “type 2” GISTs**
- **Loss of SDHB staining by IHC**
- **Lymph node metastases common**
- **Distant metastases common – clinically indolent**
- **Current risk assessment criteria do not reliably predict behavior**
- **No response to imatinib**

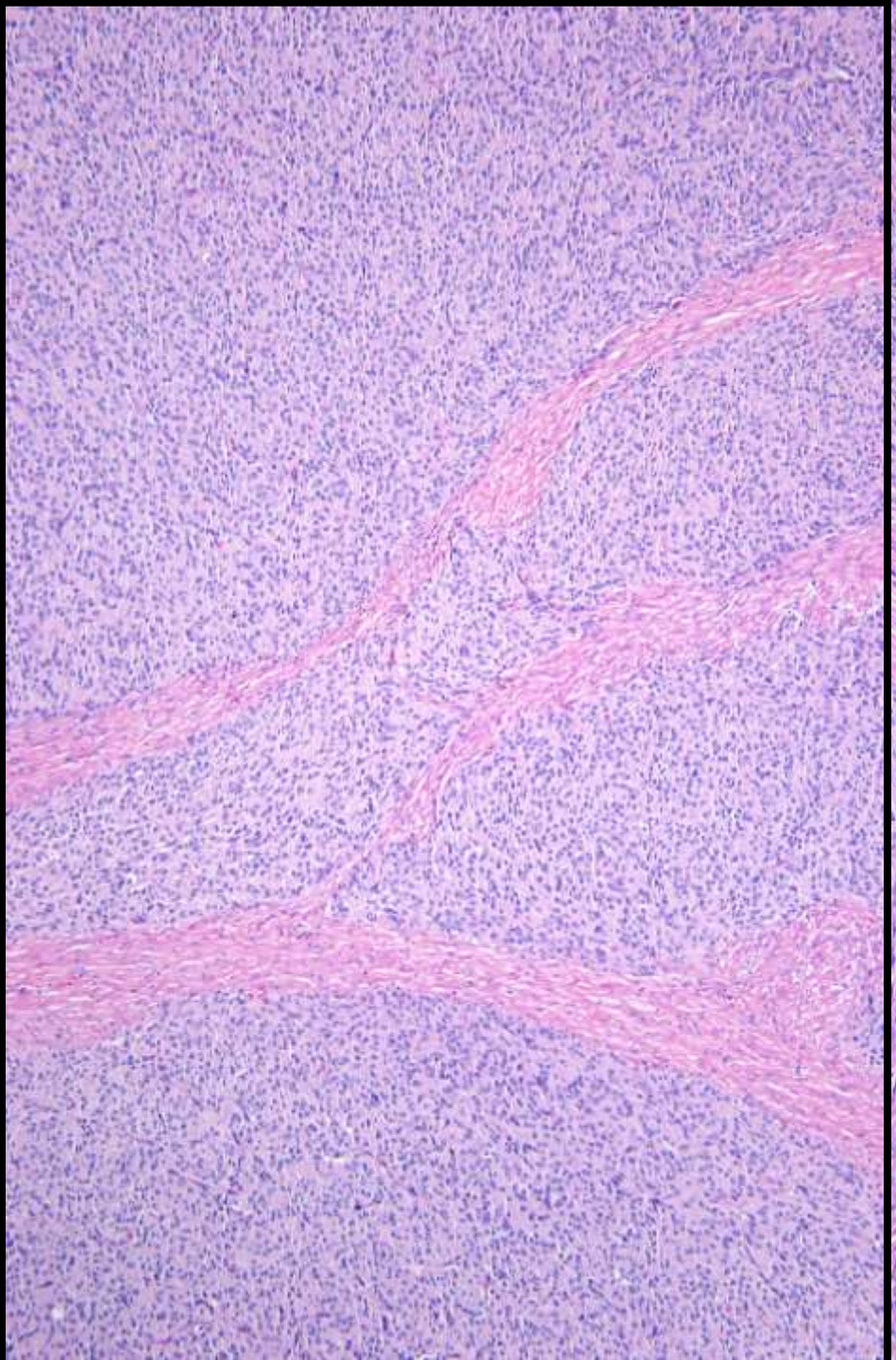
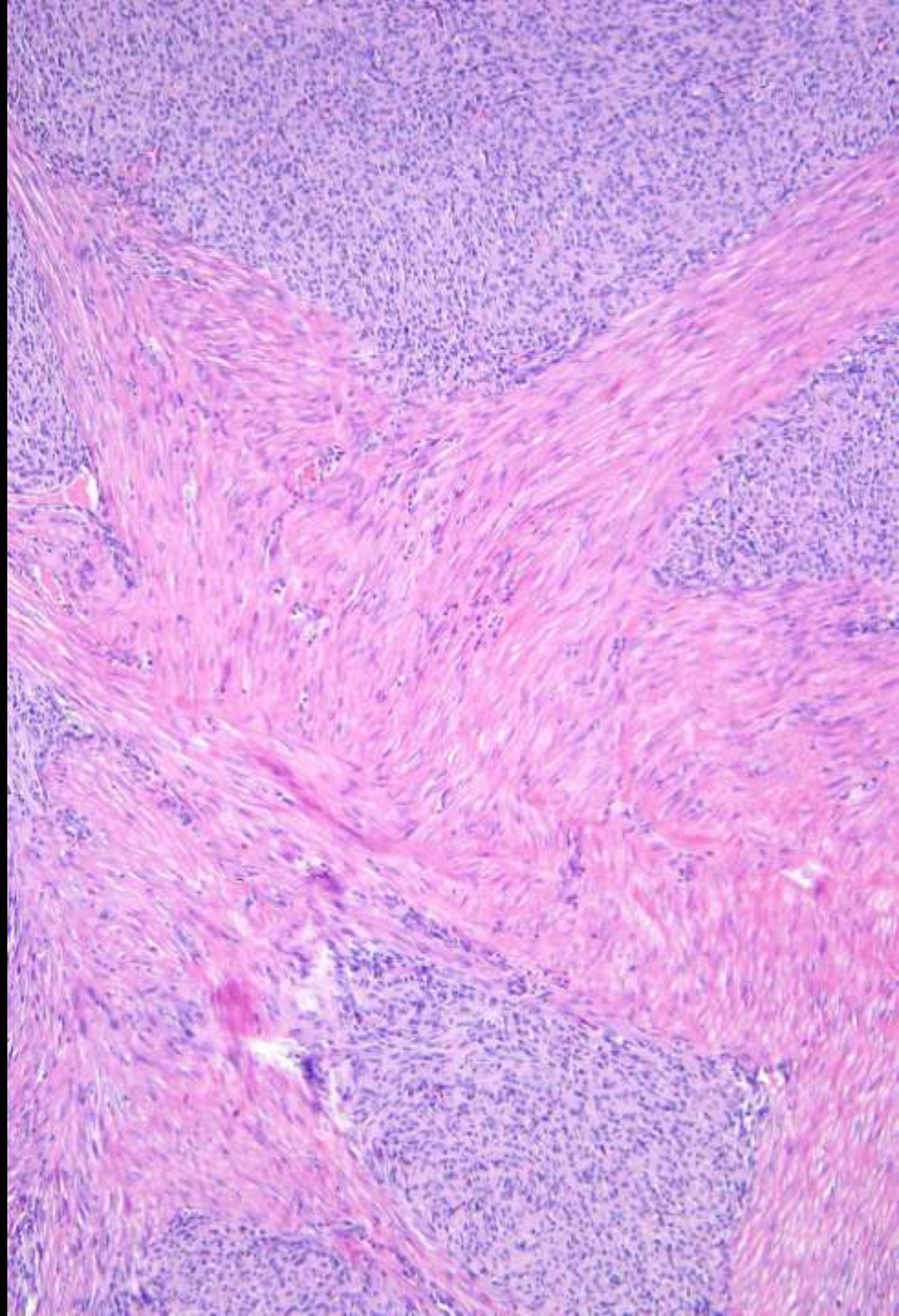
Courtesy of Jason Hornick, BWH/Harvard, Boston, MA

Pediatric-type GIST in an Adult

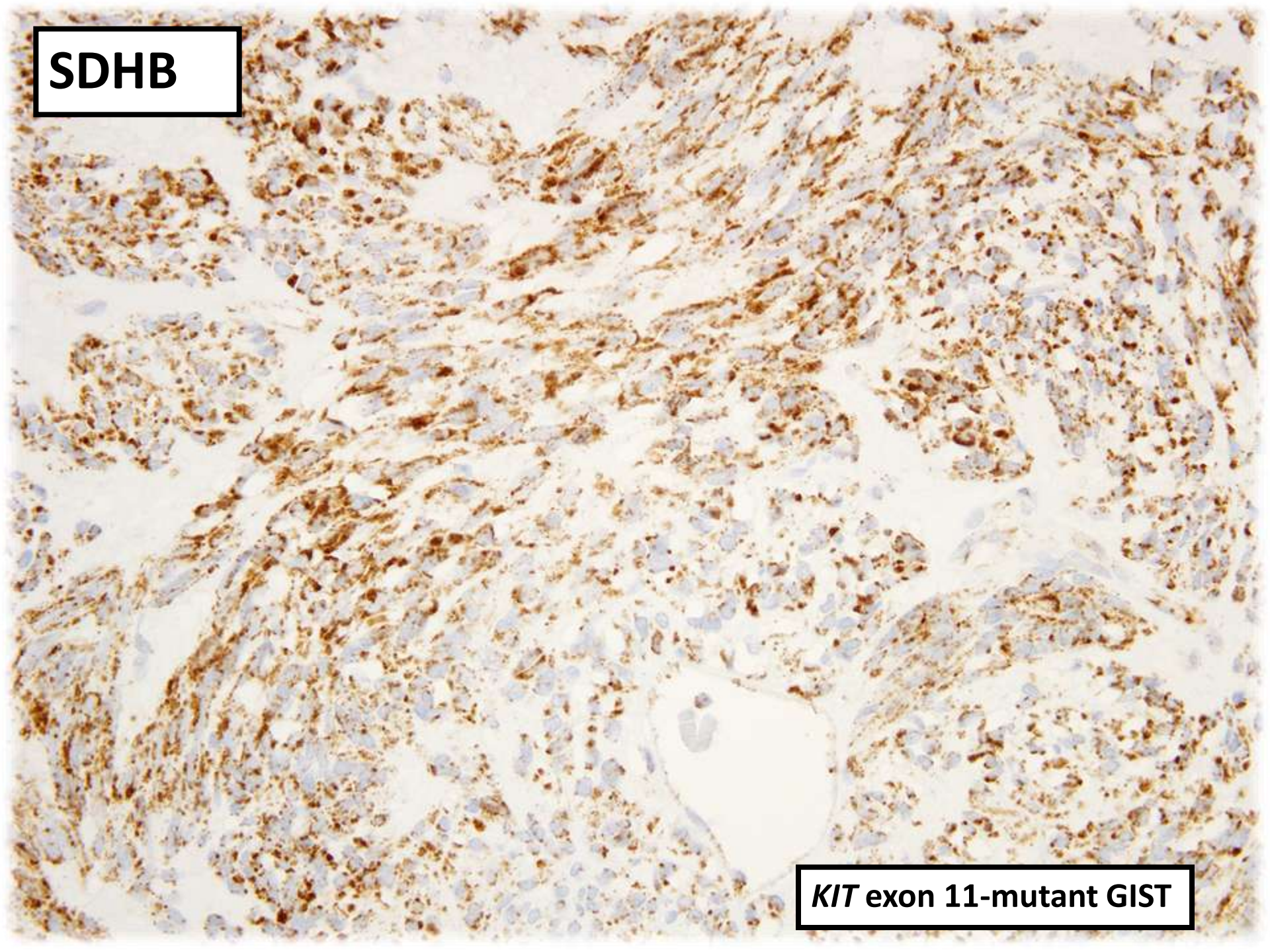


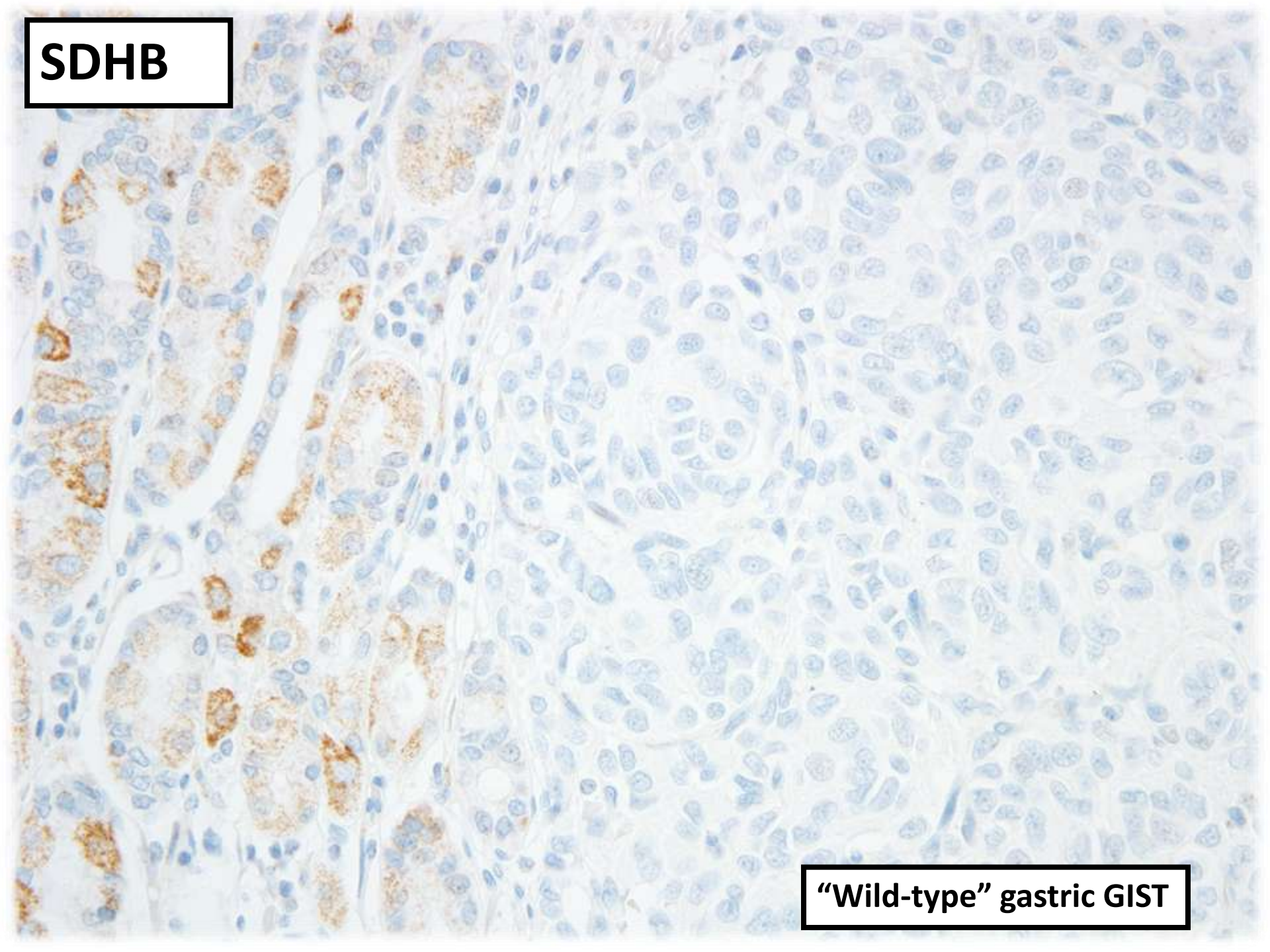
49-year-old female

Courtesy of Jason Hornick, BWH/Harvard, Boston, MA


Metastatic pediatric-type GIST


SDHB
KIT exon 11-mutant GIST


SDHB
“Wild-type” gastric GIST

Risk assessment in GIST

GIST – Prognostic Factors

Size

Mitotic Rate

Anatomic Location

Pleomorphism

Cellularity

Necrosis

Mucosal Invasion

Proliferation Markers (Ki-67, Mib-1, PCNA, etc)

DNA Flow Cytometry

Image Analysis

Nuclear Organizer Regions

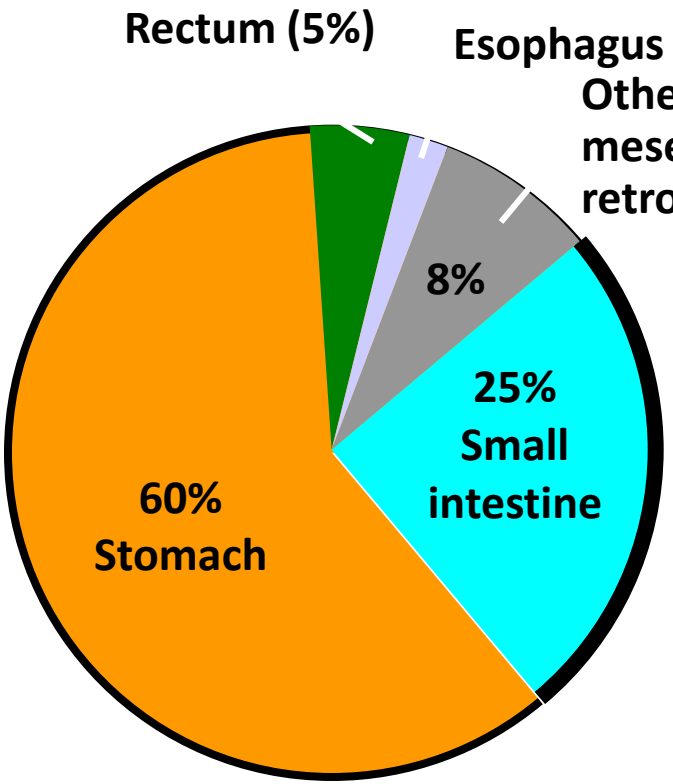
Problem – Small GISTs without mitoses can metastasize!

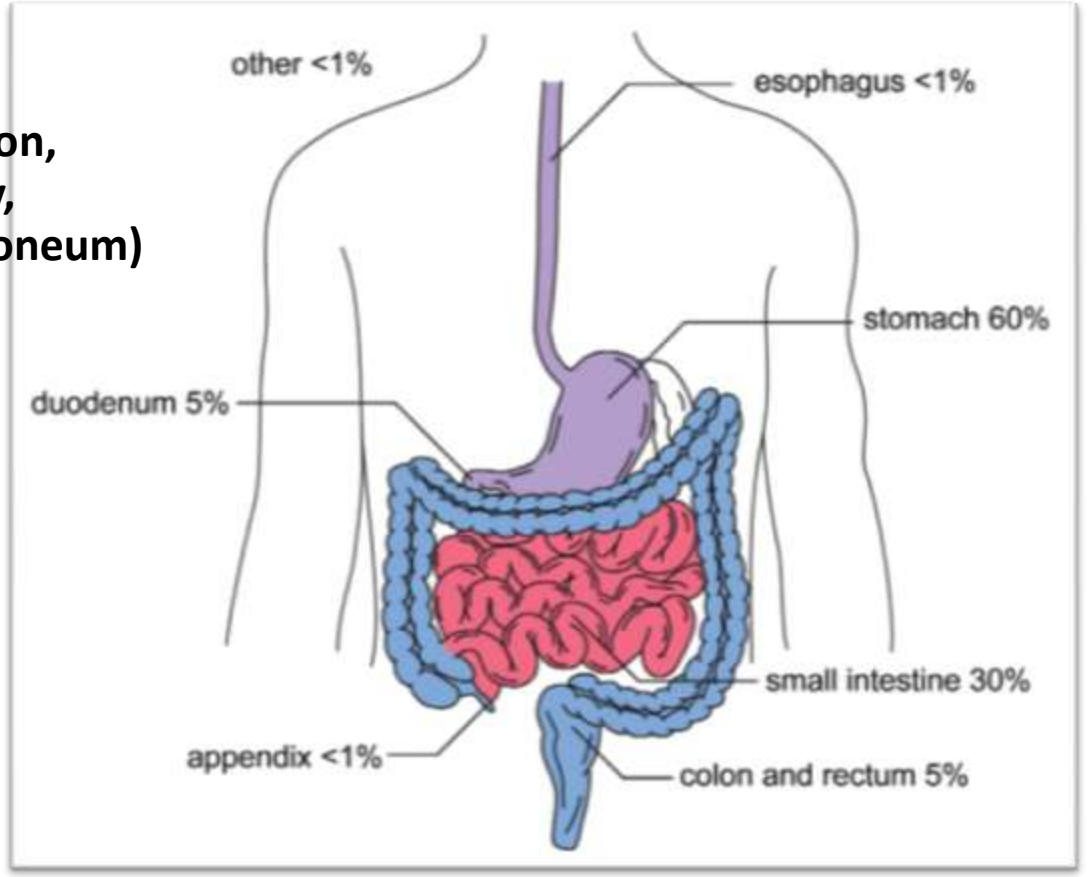
NIH Consensus Risk Assessment

	Size	Mitotic Count
Very Low Risk	< 2 cm	< 5/50 HPF
Low Risk	2-5 cm	< 5/50 HPF
Intermediate Risk	< 5 cm	6-10/50 HPF
	5-10 cm	< 5/50 HPF
High Risk	> 5 cm	> 5/50 HPF
	> 10 cm	Any Mitotic Rate
	Any Size	> 10/50 HPF

Fletcher et al., Hum Pathol, 2002

GIST: Sites of Involvement





Omentum, mesentery, pelvis and retroperitoneum = EGIST (<1%)

Hornick & Lazar. GSI website: Understanding Your Pathology Report for GIST.

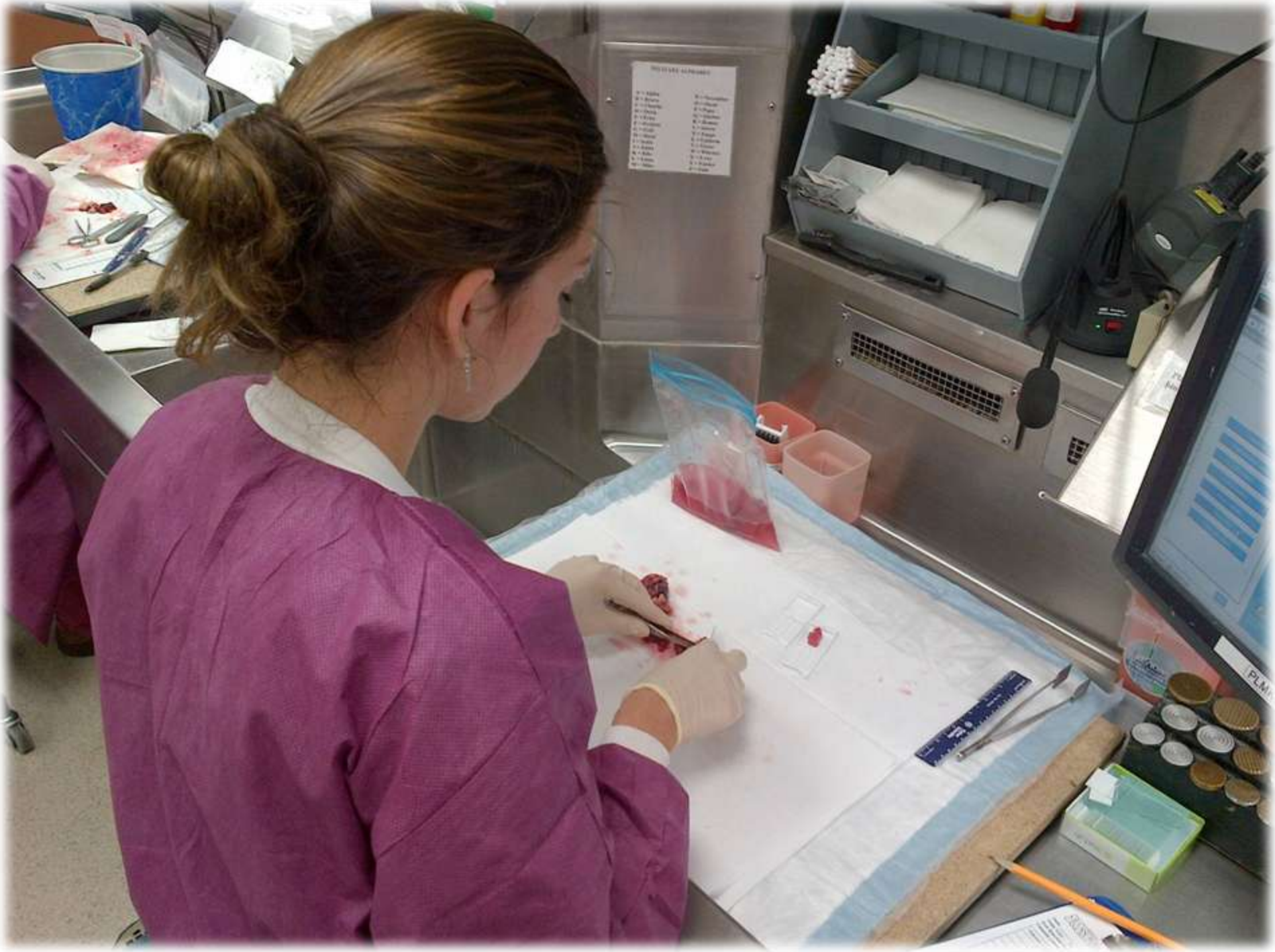
*2007/2010/2014 NCCN GIST Risk Assessment Guidelines****

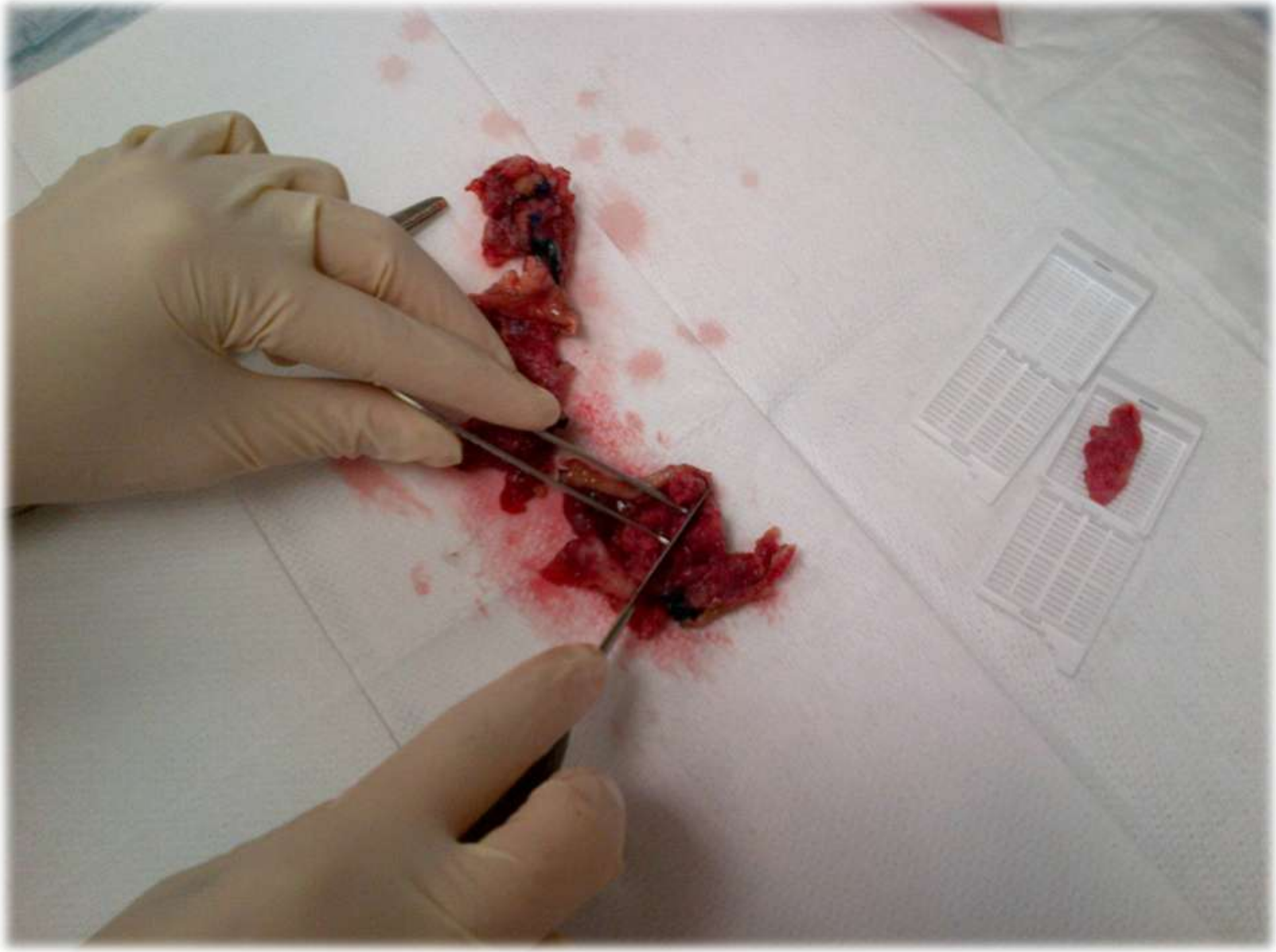
Tumor	Parameters	Risk of	Progressive	Disease# (%)	
	Size	Gastric	Duodenum	Jejunum/Ileum	Rectum
Mitotic	≤ 2 cm	None (0%)	None (0%)	None (0%)	None (0%)
Index	> 2 ≤ 5 cm	Very low (1.9%)	Low (8.3%)	Low (4.3%)	Low (8.5%)
≤ 5 per 50 hpf	> 5 ≤ 10 cm	Low (3.6%)	(Insuff. data)	Moderate (24%)	(Insuff. data)
	> 10 cm	Moderate (10%)	High (34%)	High (52%)	High (57%)
Mitotic	≤ 2 cm	None*	(Insuff. data)	High*	High (54%)
Index	> 2 ≤ 5 cm	Moderate (16%)	High (50%)	High (73%)	High (52%)
> 5 per 50 hpf	> 5 ≤ 10 cm	High (55%)	(Insuff. data)	High (85%)	(Insuff. data)
	> 10 cm	High (86%)	High (86%)	High (90%)	High (71%)

Miettinen *et al*. 2005 and 2006

GIST - Gross Appearance

Courtesy of Brian Rubin, Cleveland Clinic





*2007/2010/2014 NCCN GIST Risk Assessment Guidelines****

Tumor	Parameters	Risk of	Progressive	Disease# (%)	
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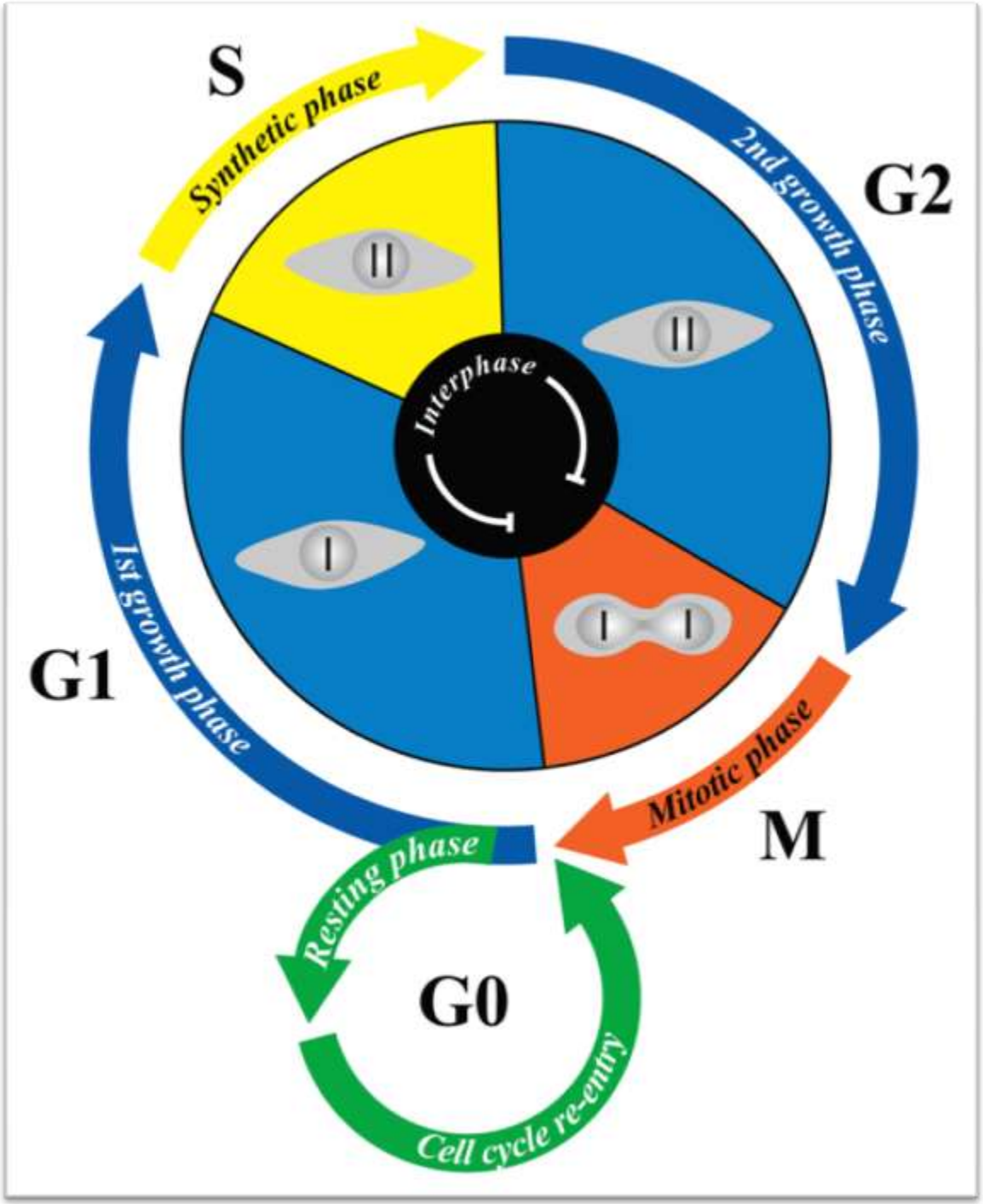
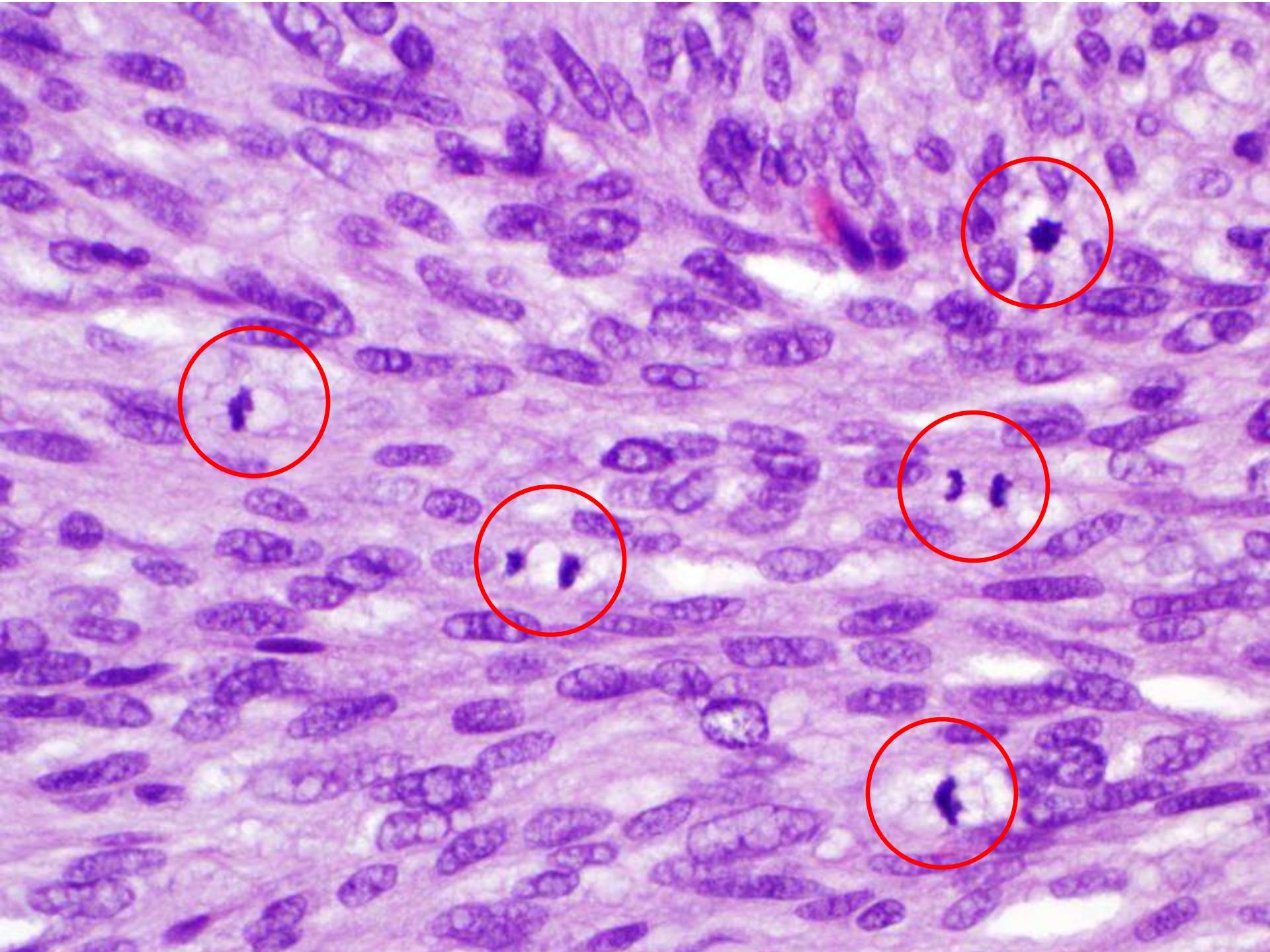
> 5 per 50 hpf	> 5 ≤ 10 cm	High (55%)	(Insuff. data)	High (85%)	(Insuff. data)
	> 10 cm	High (86%)	High (86%)	High (90%)	High (71%)

***Modified from Miettinen & Lasota, *Semin Diagn Pathol*, 2006 by Dr. Chris Corless, OHSU
Data based on long-term follow-up of 1055 gastric, 629 small intestinal, 144 duodenal and 111 rectal GIST

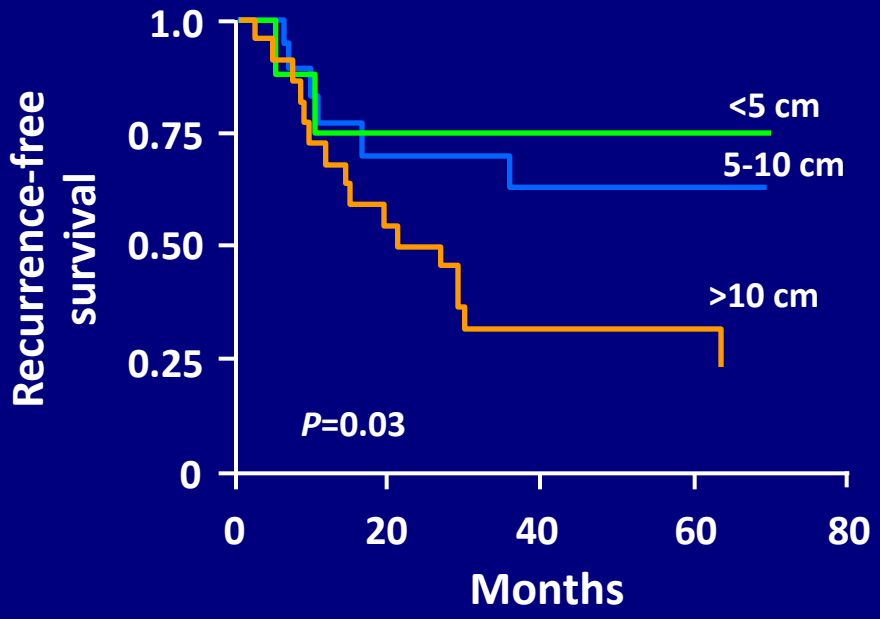
Miettinen *et al*. 2005 and 2006

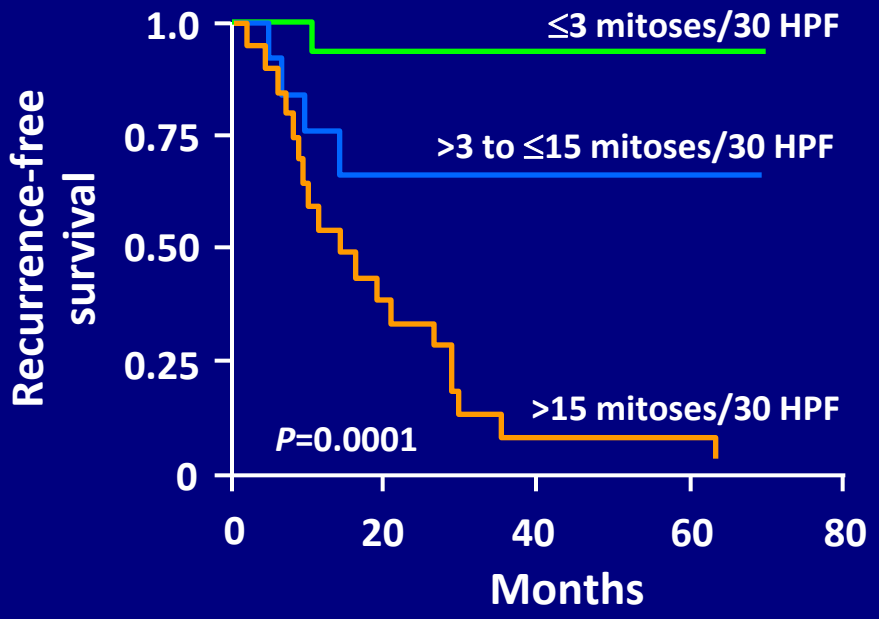

S
Synthetic phase
2nd growth phase
G2
Interphase
G1
1st growth phase
Mitotic phase
M
Resting phase
G0
Cell cycle re-entry



GIST - Recurrence-Free Survival Following Surgical Treatment of Primary GIST

- **Recurrence-free survival is predicted by tumor size and mitotic index**





Singer et al. *J Clin Oncol.* 2002;20:3898

FNCLCC Grading

- **All three numbers are summated to determine degree of differentiation**

Grade 1 : 2-3

Grade 2 : 4-5

Grade 3 : 6-8

- **Proven to correlated well with survival**

- ***Mitotic Count.*** **In the most mitotically active area, ten successive high-power fields (at 400x magnification=0.1734 mm^2) using a 40x objective.**

1 **0-9 mitoses per 10 HPFs**

2 **10-19 mitoses per 10 HPFs**

3 **>20 mitoses per 10 HPFs**

- ***Tumor necrosis.*** **Evaluated on gross examination and validated with histological sections**

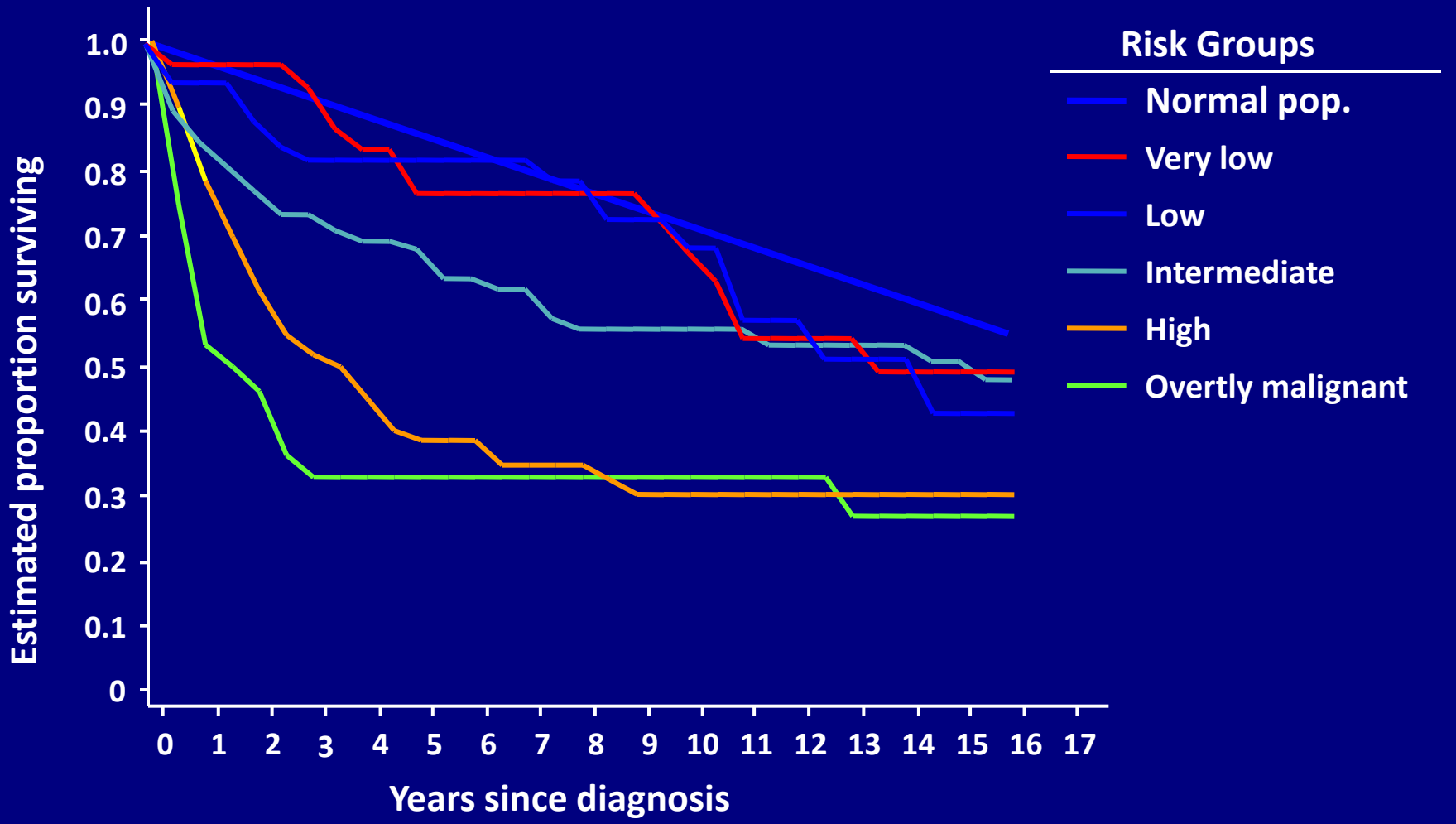
0 **No tumor necrosis**

1 **<50% tumor necrosis**

2 **>50% tumor necrosis**

- ***Degree of Differentiation.*** **1-3**

GIST - Overall Survival by Risk Group



Kindblom. at: http://www.asco.org

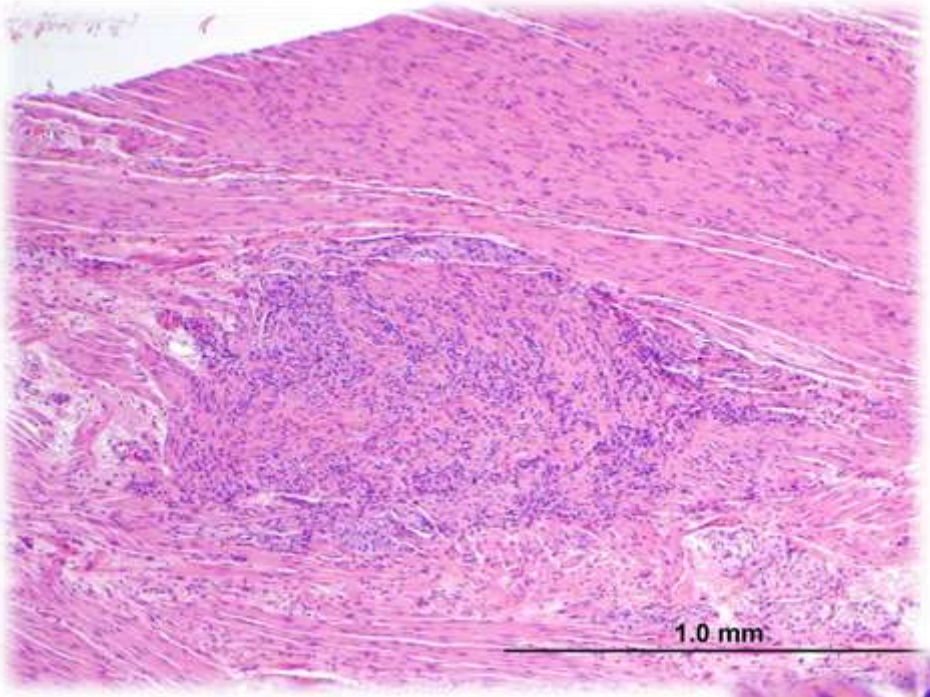
Clinical Characteristics of GIST

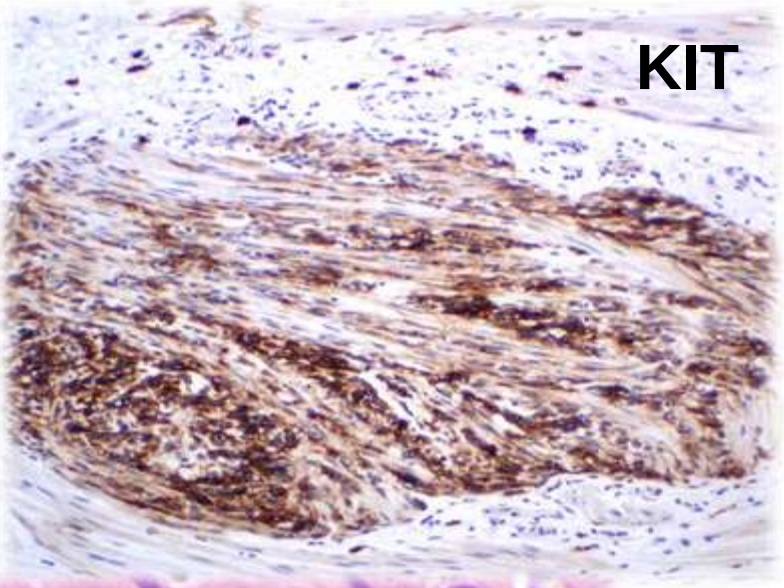
Wide age range – peak in 5^{th}-7^{th} decade

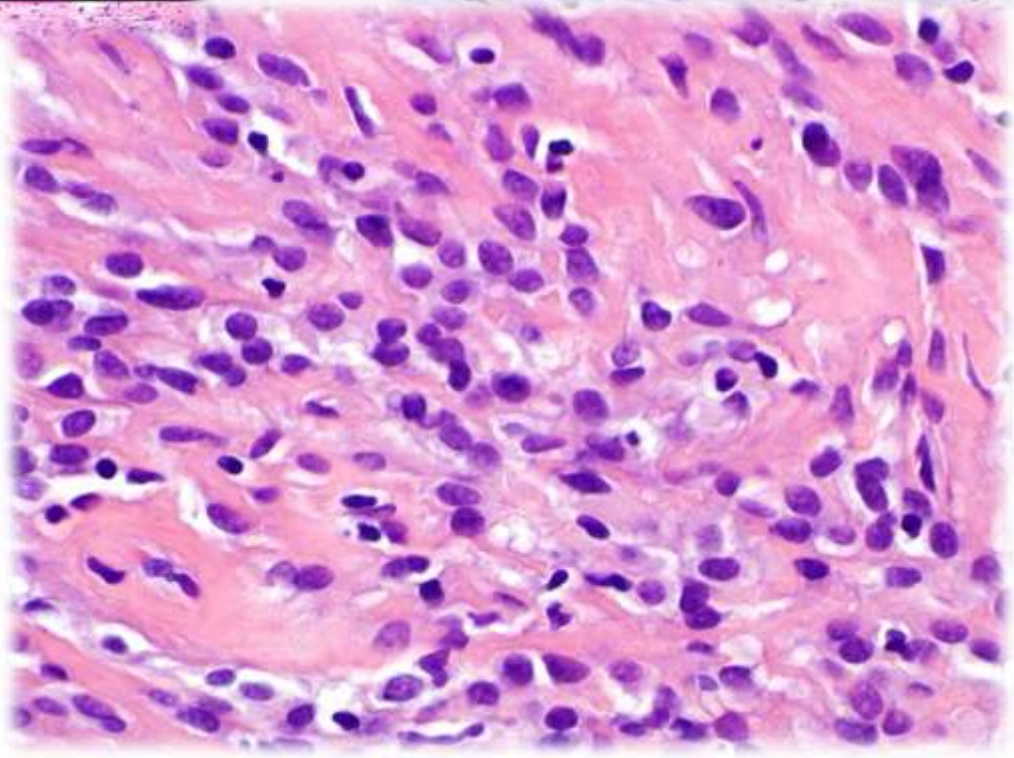
M = F

Small lesions = "incidentalomas"

Presenting symptoms include:
abdominal pain,
gastrointestinal bleeding,
early satiety,
symptoms referable to a mass



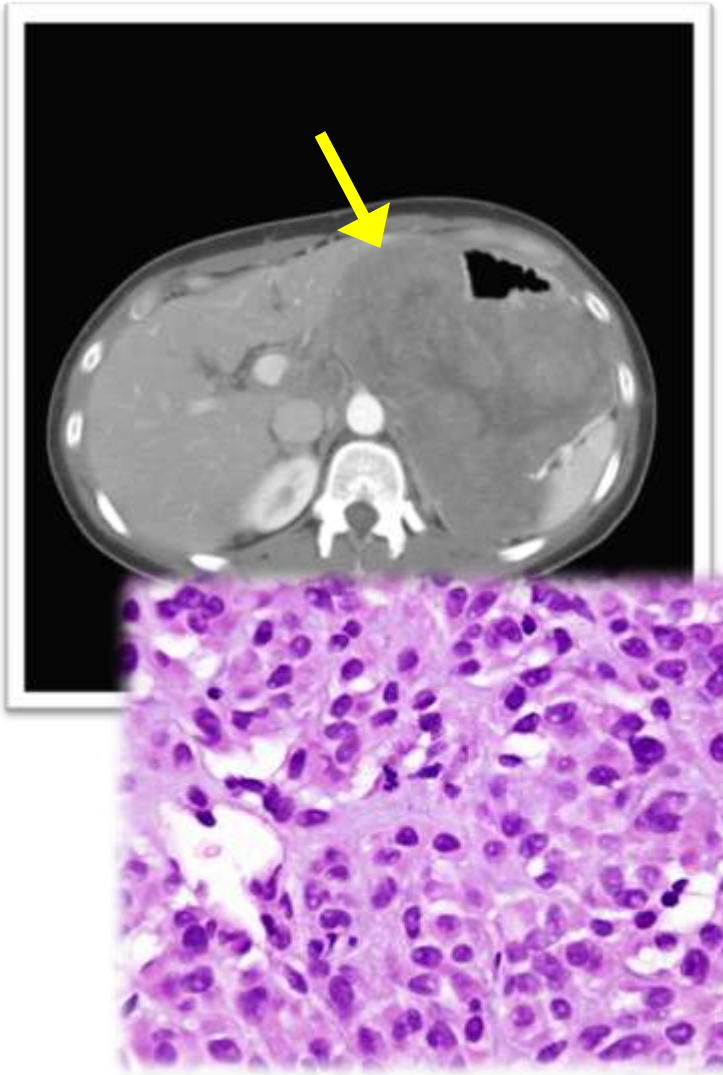


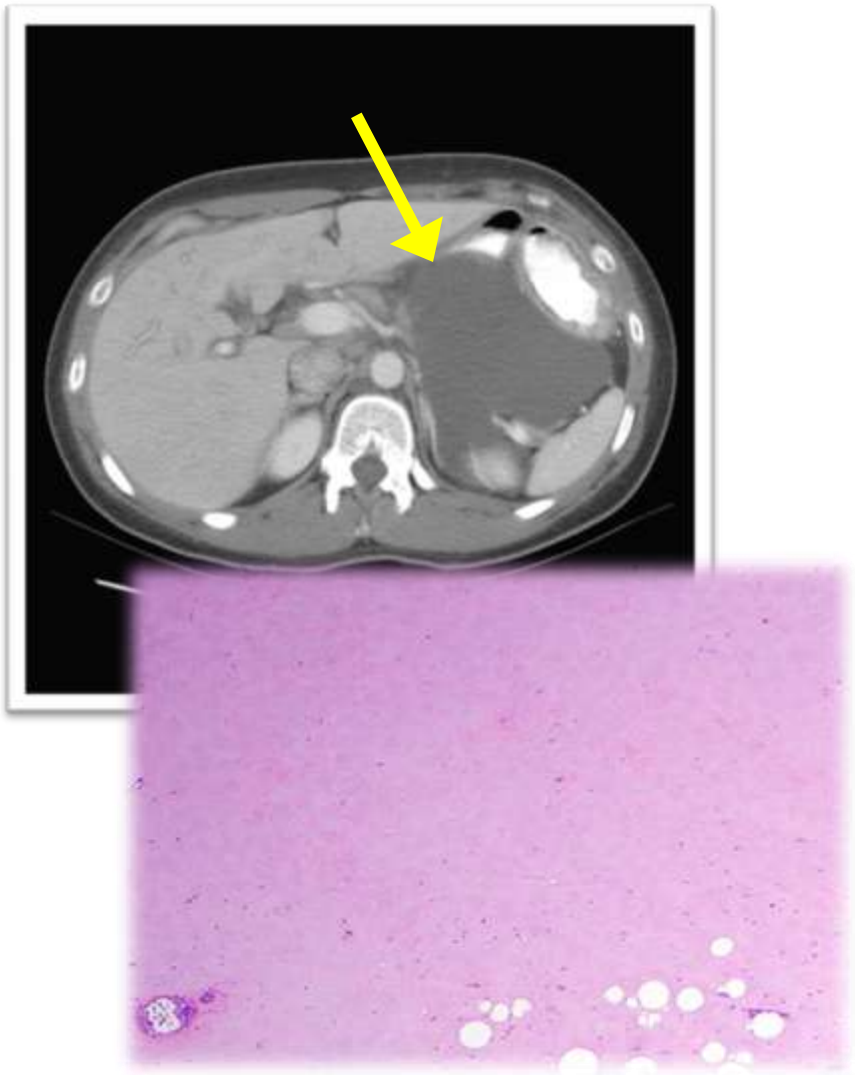


courtesy of Susan Abraham, UTMDACC, Houston, TX

Treatment can cause big changes.

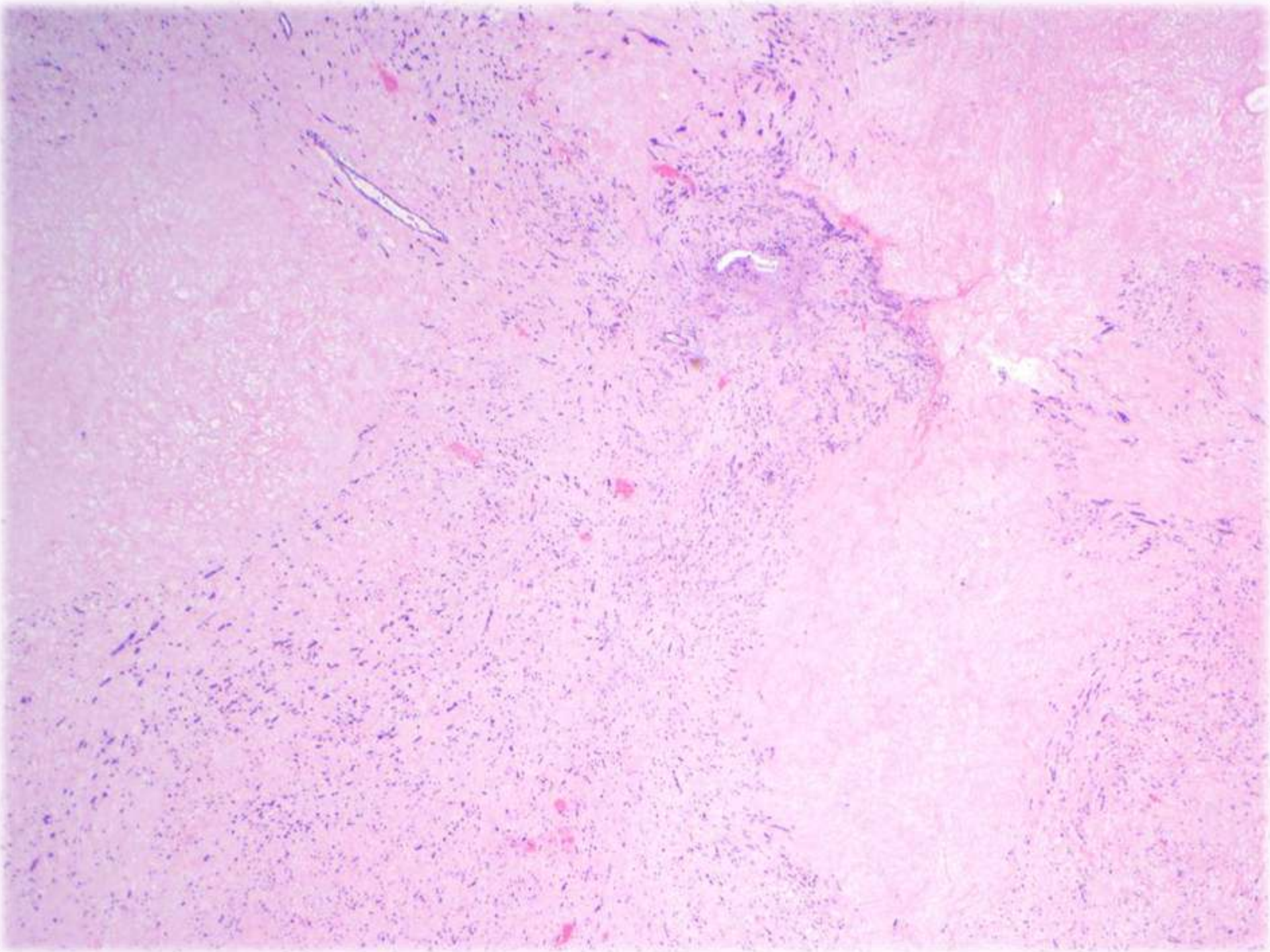
Treatment effect

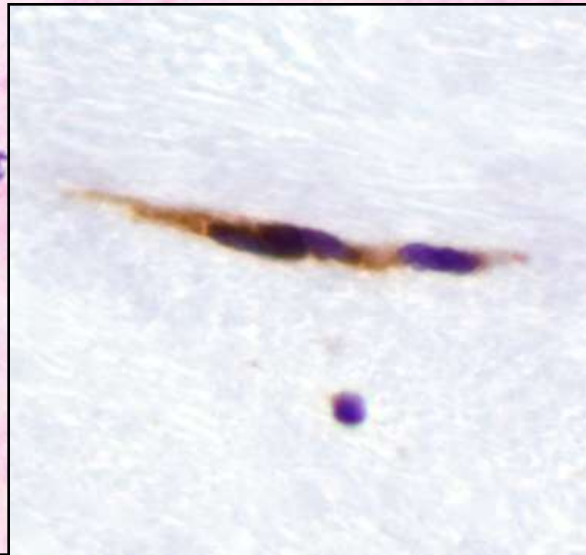




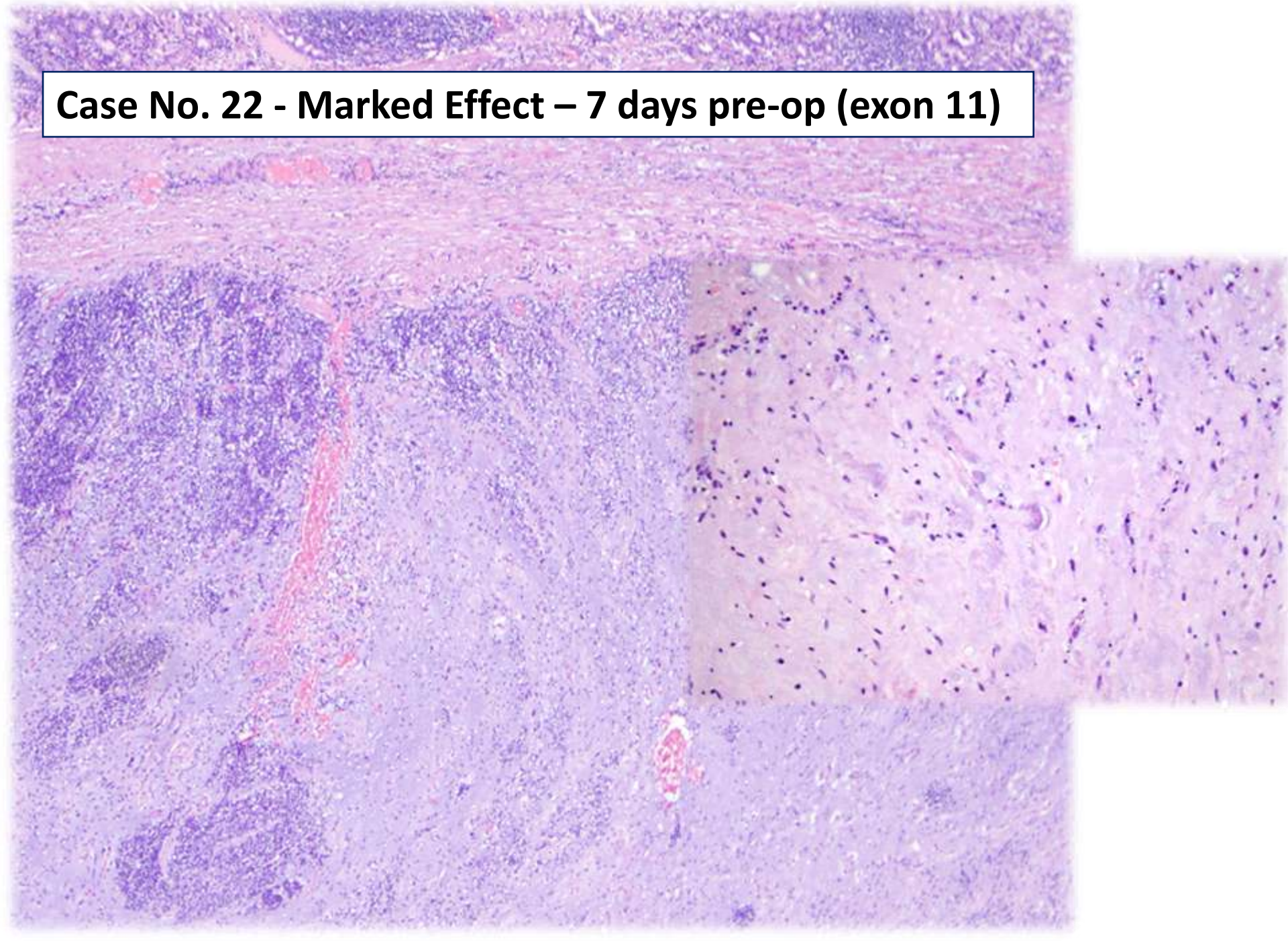
Pre-Imatinib

Post-Imatinib (8 weeks therapy)

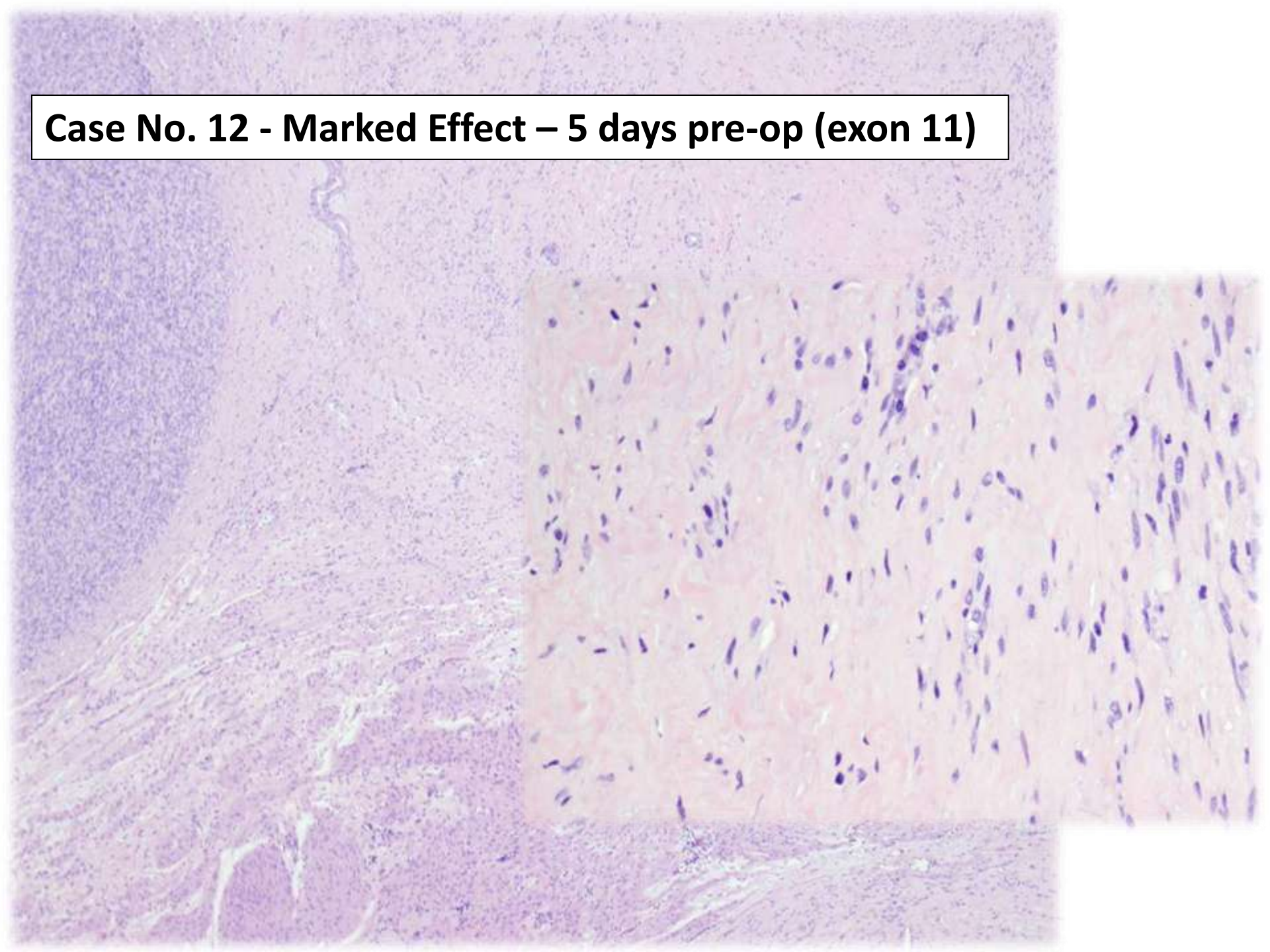




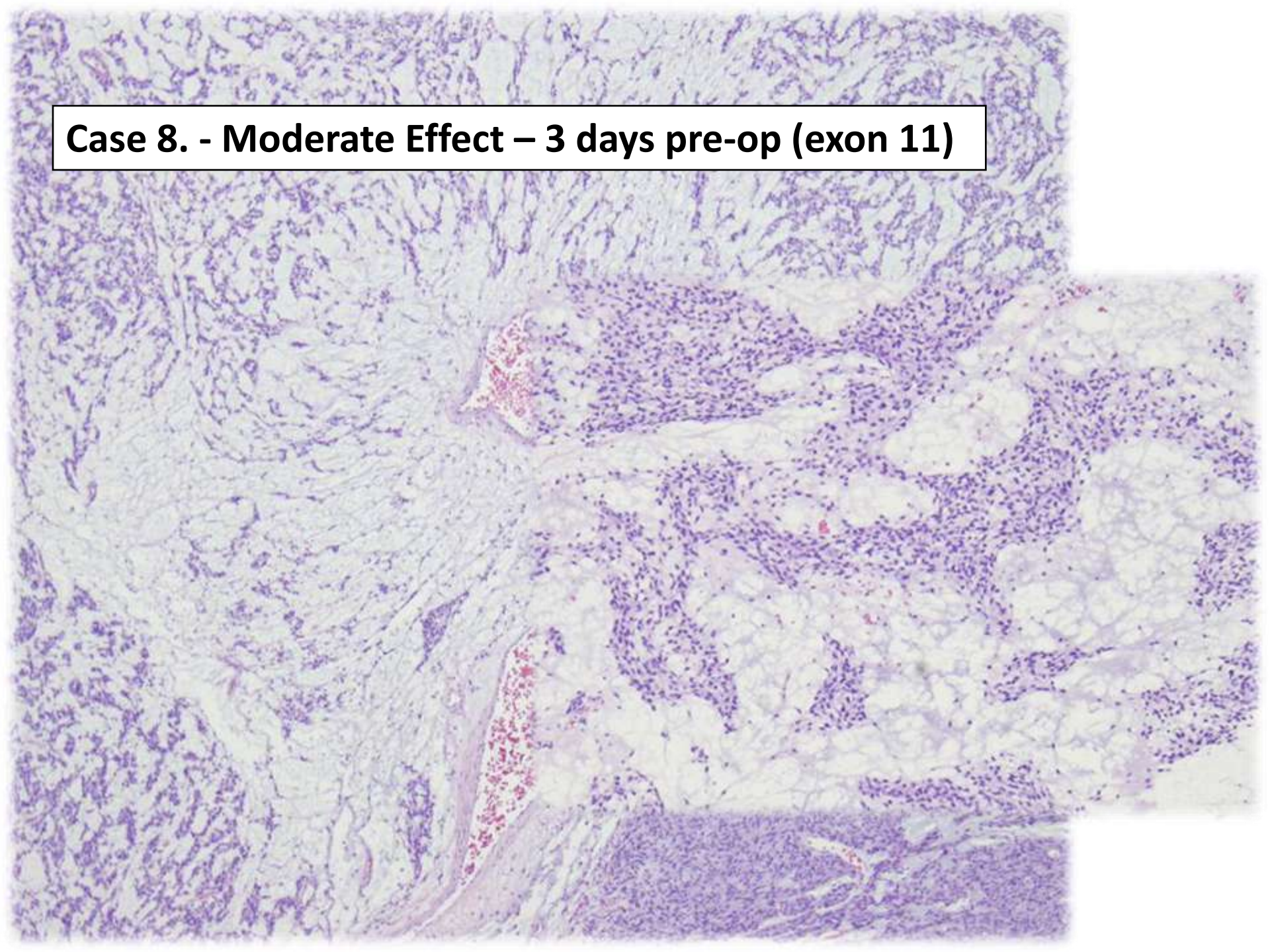
Case No. 22 - Marked Effect – 7 days pre-op (exon 11)

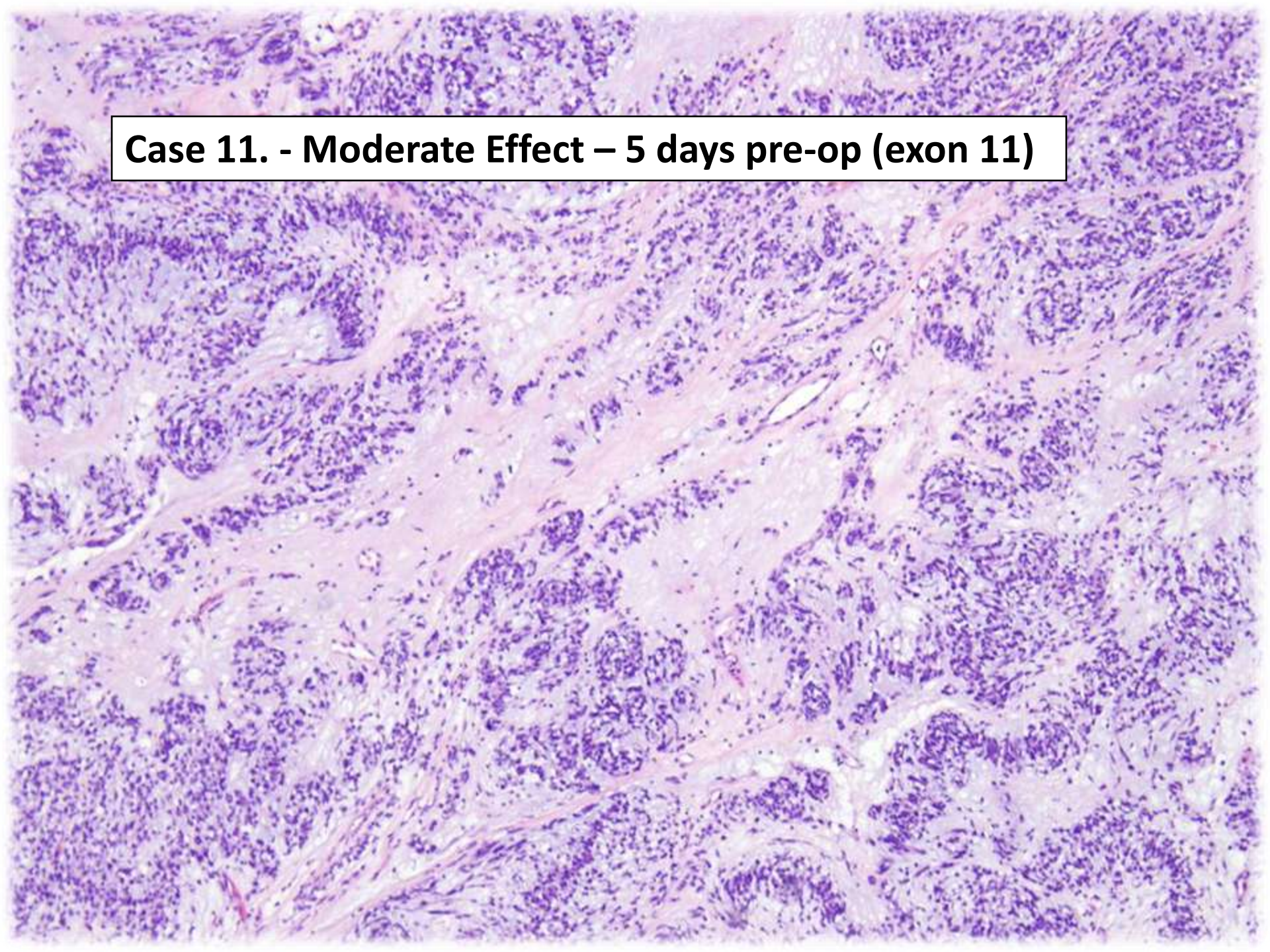


Case No. 12 - Marked Effect – 5 days pre-op (exon 11)

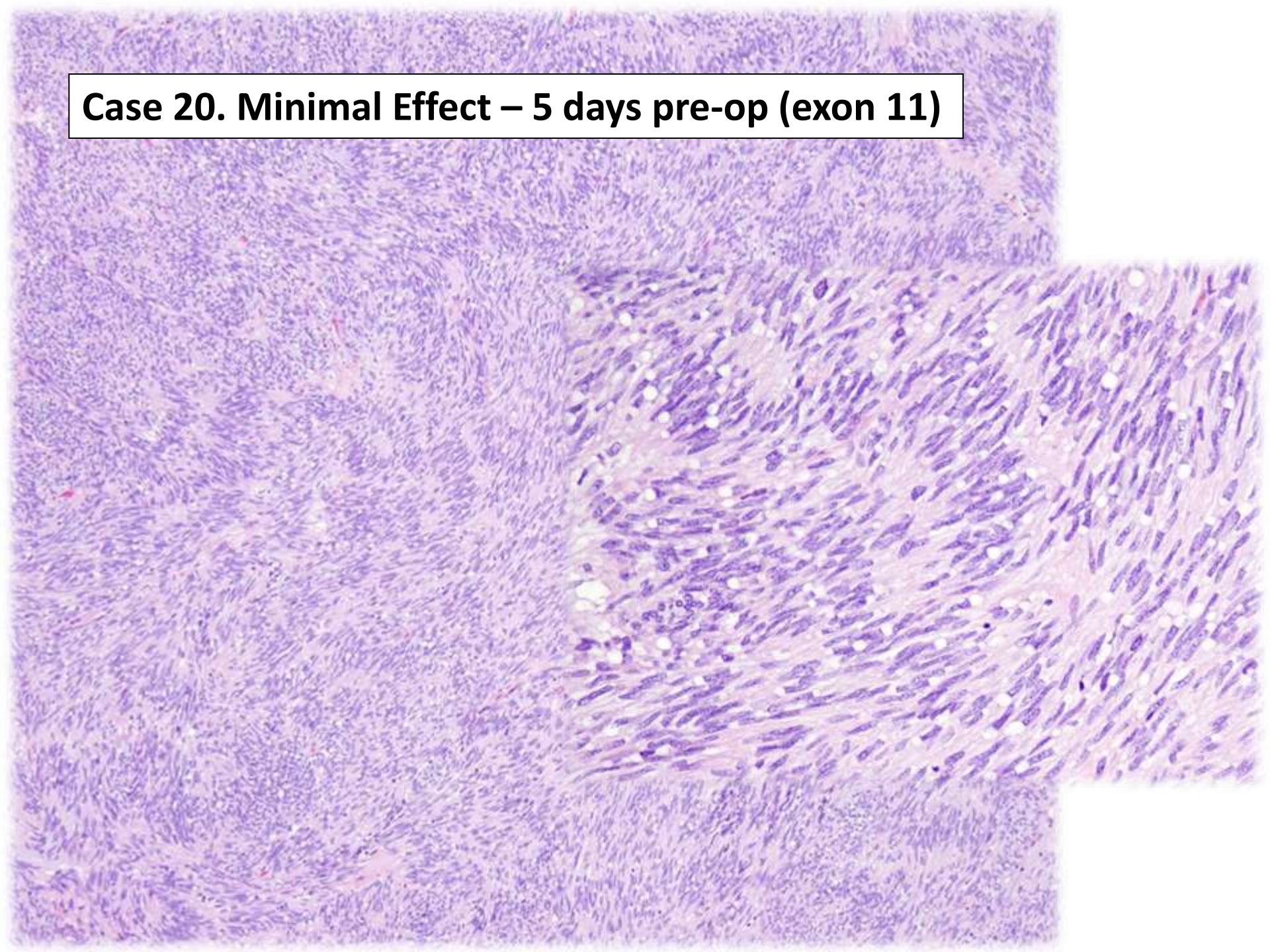


Case 8. - Moderate Effect – 3 days pre-op (exon 11)



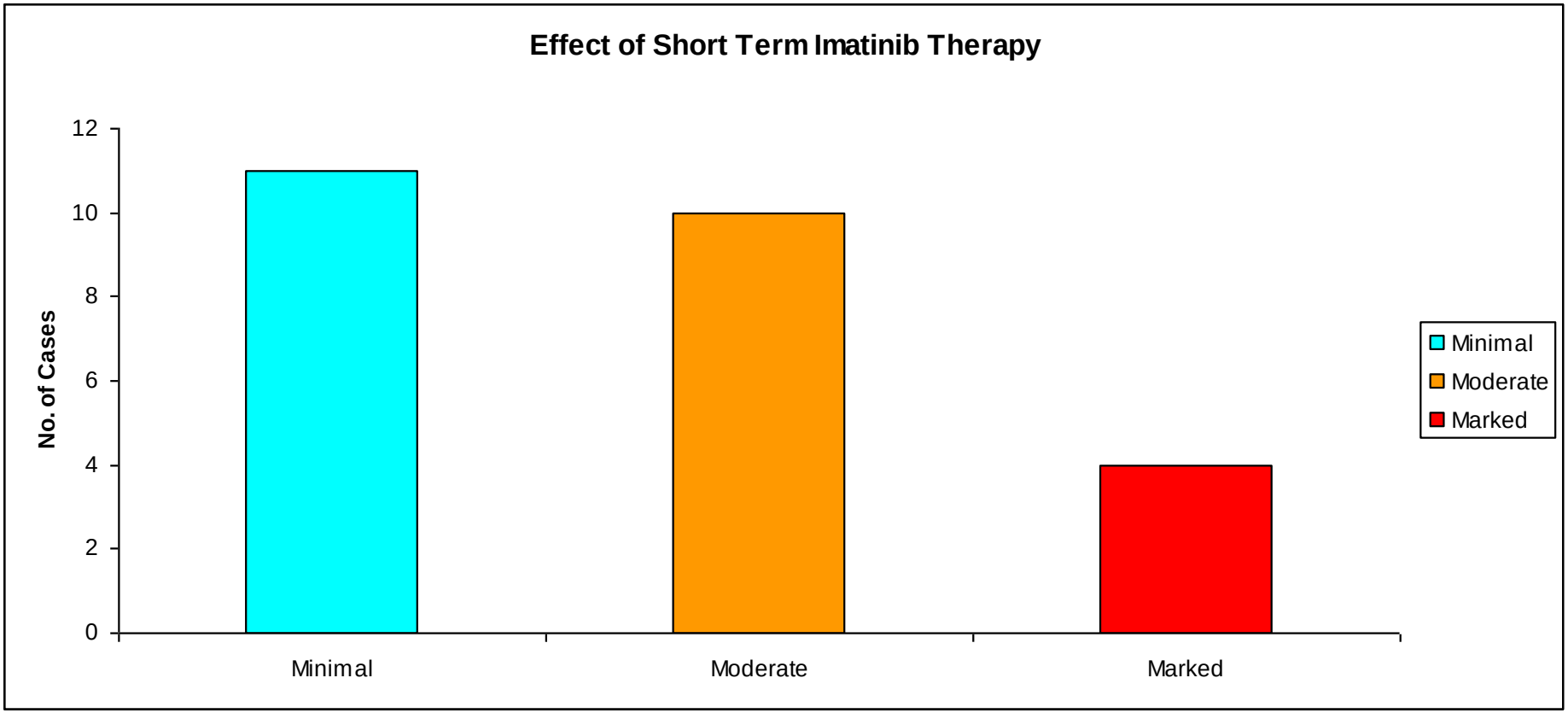

Case 11. - Moderate Effect – 5 days pre-op (exon 11)

Case 20. Minimal Effect – 5 days pre-op (exon 11)

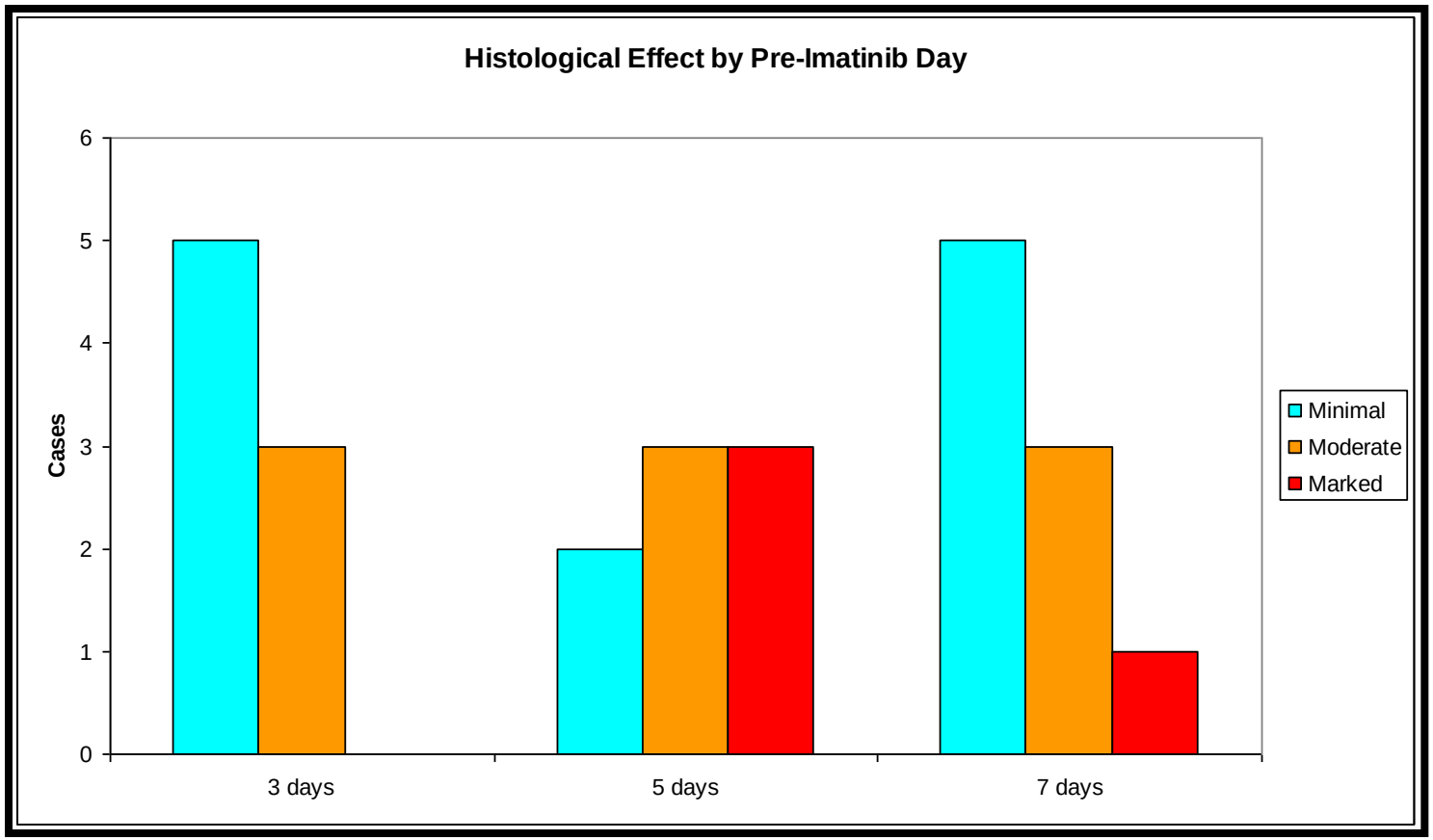


Results

- **Minimal effect: 11/25 (44%)**
- **Moderate effect: 10/25 (40%)**
- **Marked effect: 4/25 (16%)**

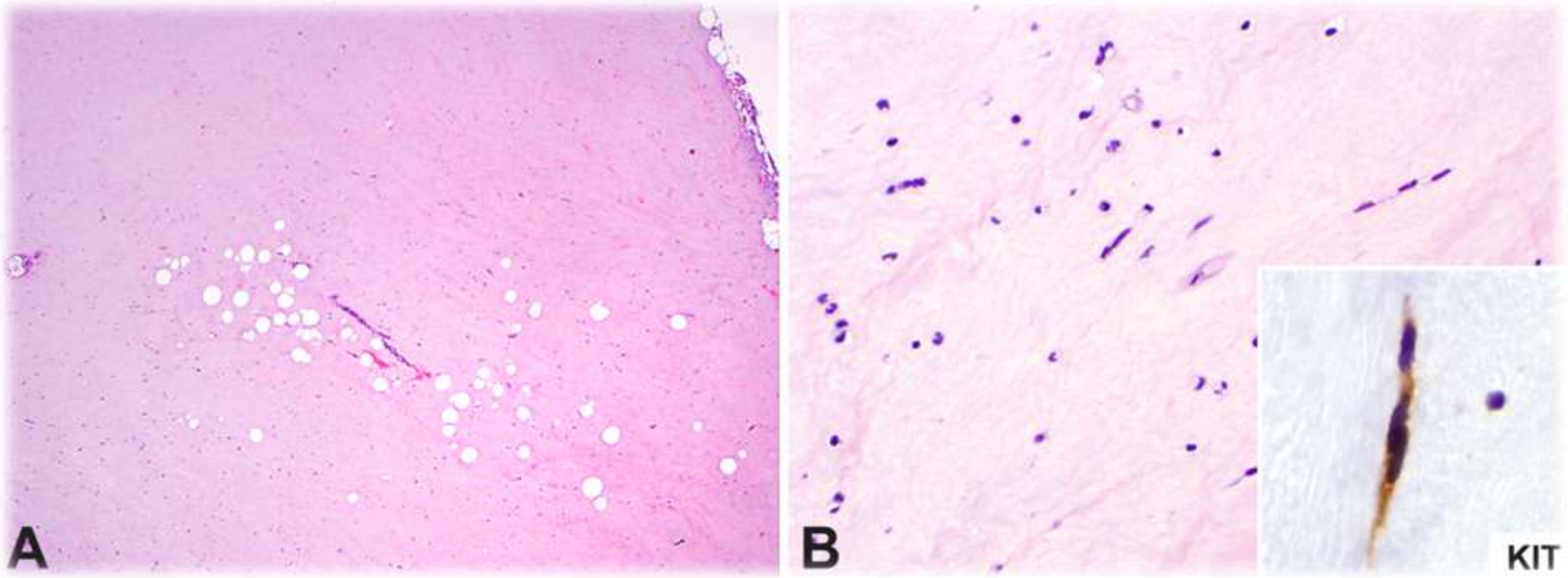


Early Histologic Effects of Imatinib Duration of Therapy

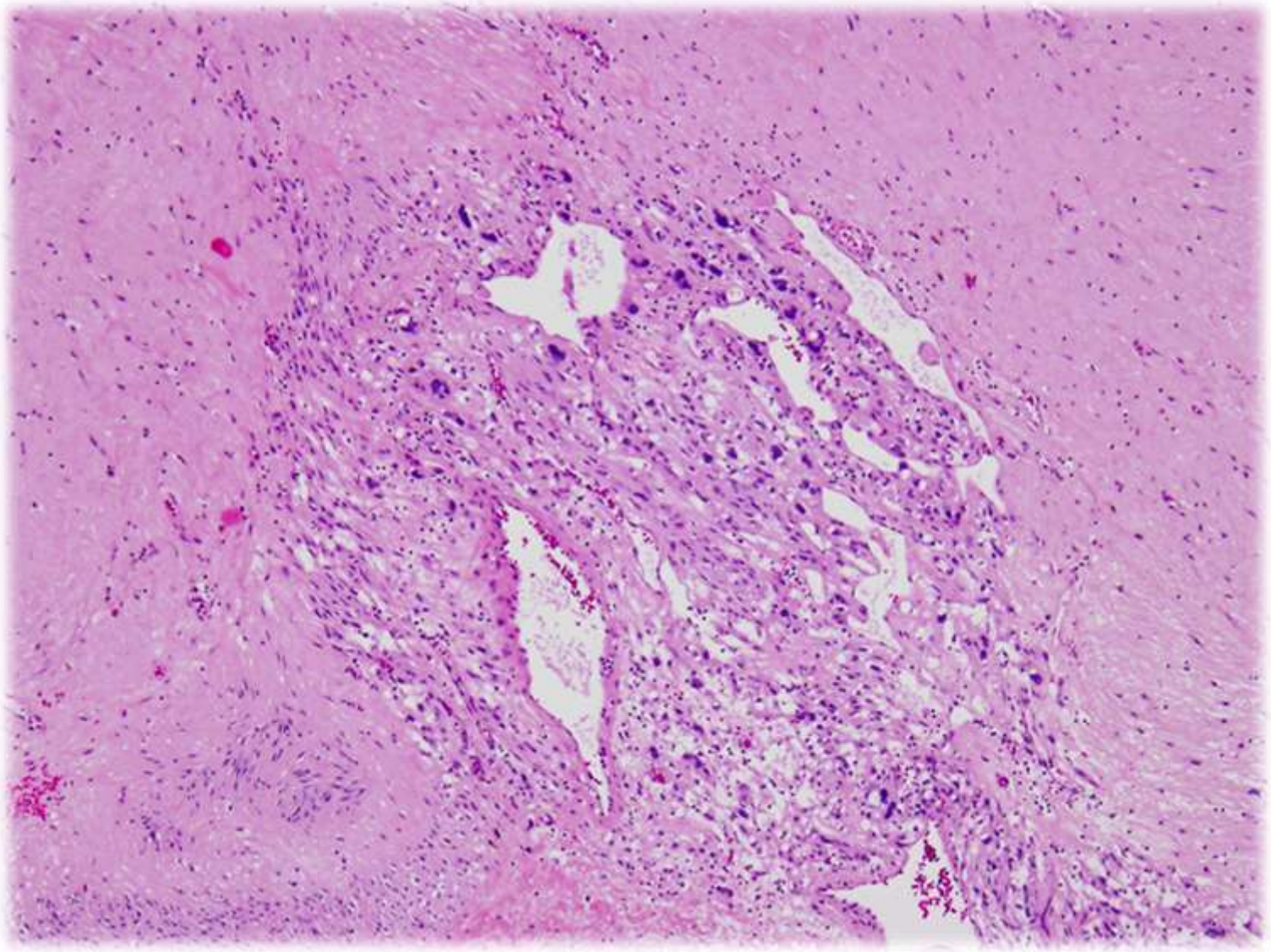


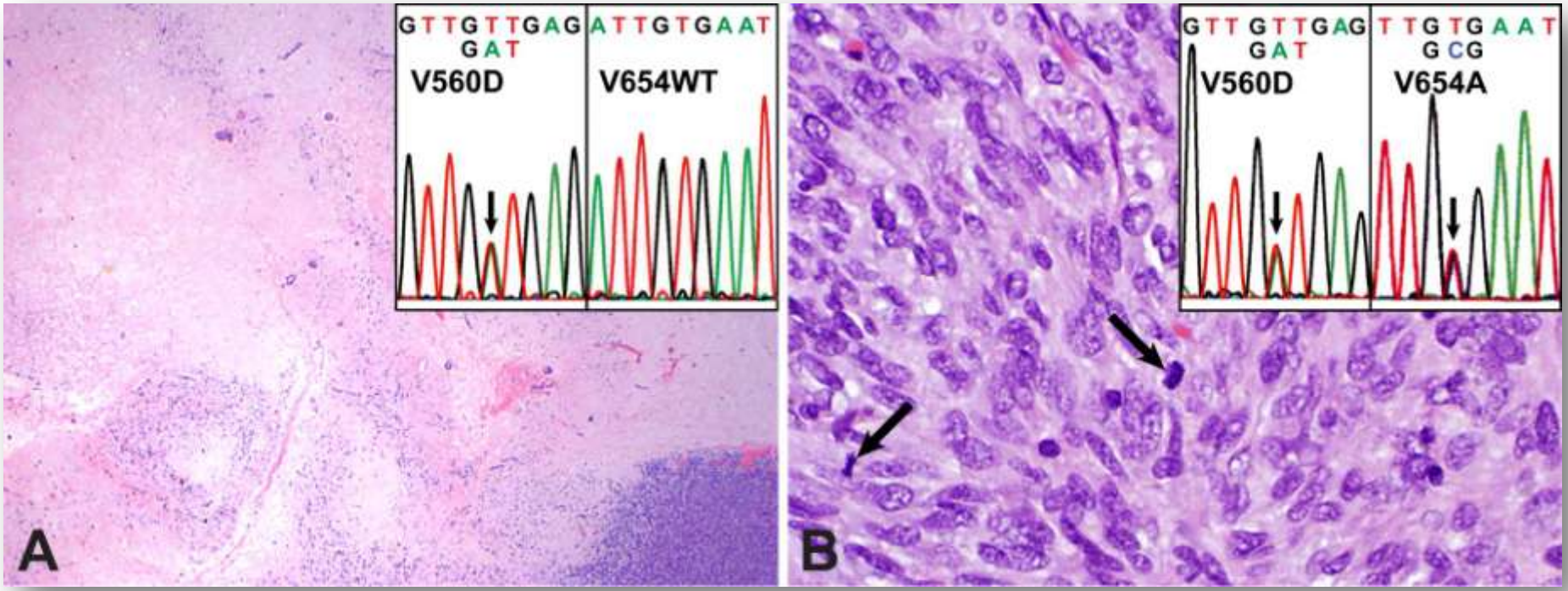
- **Minimal and Moderate effects were seen across all durations of therapy**
- **Marked effect appeared to be a late finding peaking at 5 days**

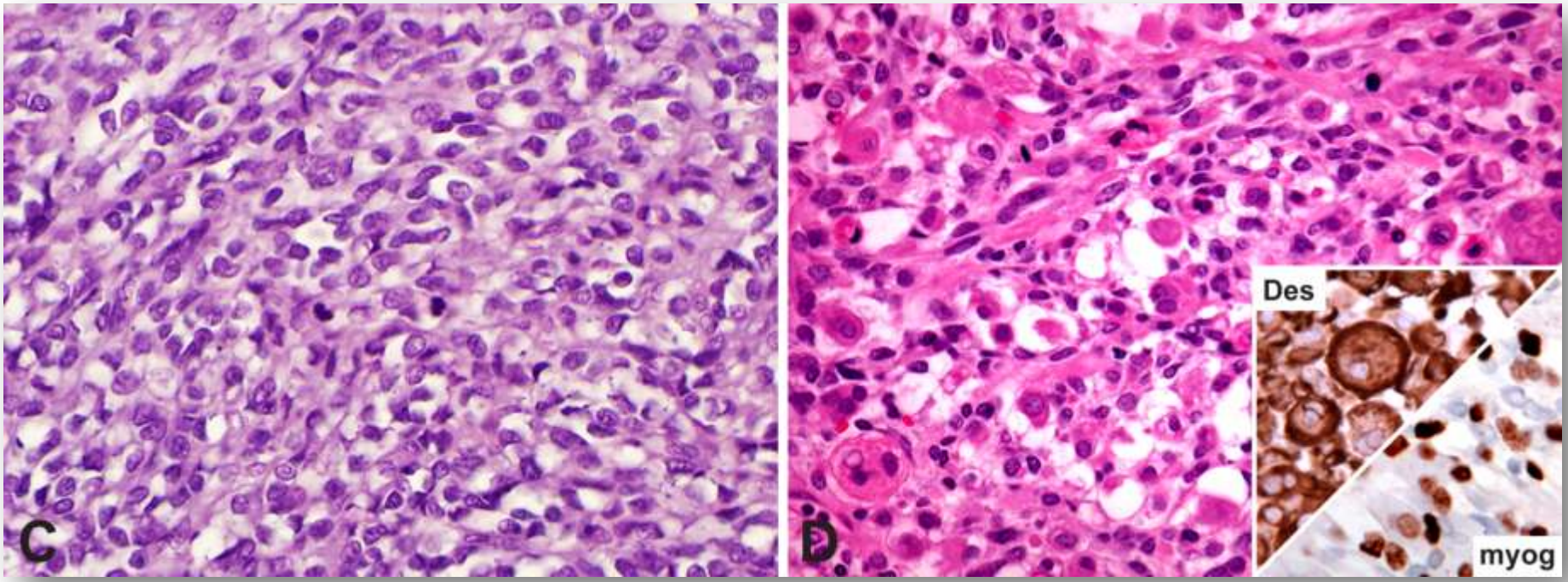
Long term Imatinib Tx



Long term Imatinib Tx

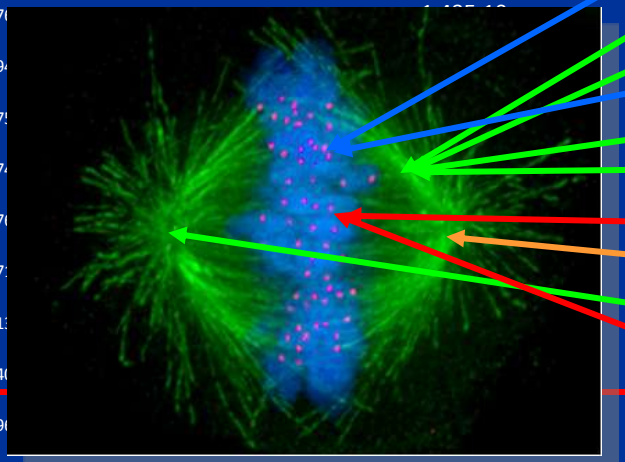



G T T G T T G A G
G A T
V560D
A T T G T G A A T
V654WT
A
G T T G T T G A G
G A T
V560D
T T G T G A A T
G C G
V654A
B


C
D
Des
myog

CINSARC : GO analysis of the 67 significant genes

GO.ID	selection	array	pValue	Z-Score	GO.Term
GO:0000775	10	37	1,06E-14	23,58	chromosome, pericentric region
GO:0005819	7	14	3,88E-12	27,03	spindle
GO:0005876				25,02	spindle microtubule
GO:0005694				12,73	chromosome
GO:0005875				11,42	microtubule associated complex
GO:0005874				7,08	microtubule
GO:0000776				13,42	kinetochore
GO:0005871				10,67	kinesin complex
GO:0005813				7,96	centrosome
GO:0000940				16,72	outer kinetochore of condensed chromosome
GO:0030496				10,84	midbody
GO:0005657	2	8	0,0010	10,12	replication fork
GO:0005814			0,0012	8,53	centriole
GO:0015630					
GO:0000922					
GO:0000785					
GO:0000786					
GO:0001939	1	3	0,0187	8,30	female pronucleus
GO:0005816	1	3	0,0187	8,30	spindle pole body
GO:0000930	1	4	0,0233	7,15	gamma-tubulin complex
GO:0005664	1	4	0,0233	7,15	nuclear origin of replication recognition complex
GO:0015030	1	4	0,0233	7,15	Cajal body
GO:0005881	1	6	0,0325	5,78	cytoplasmic microtubule
GO:0043234	2	64	0,0385	3,10	protein complex



CINSARC is a signature related to chromosome management and mitosis control associated with genome complexity

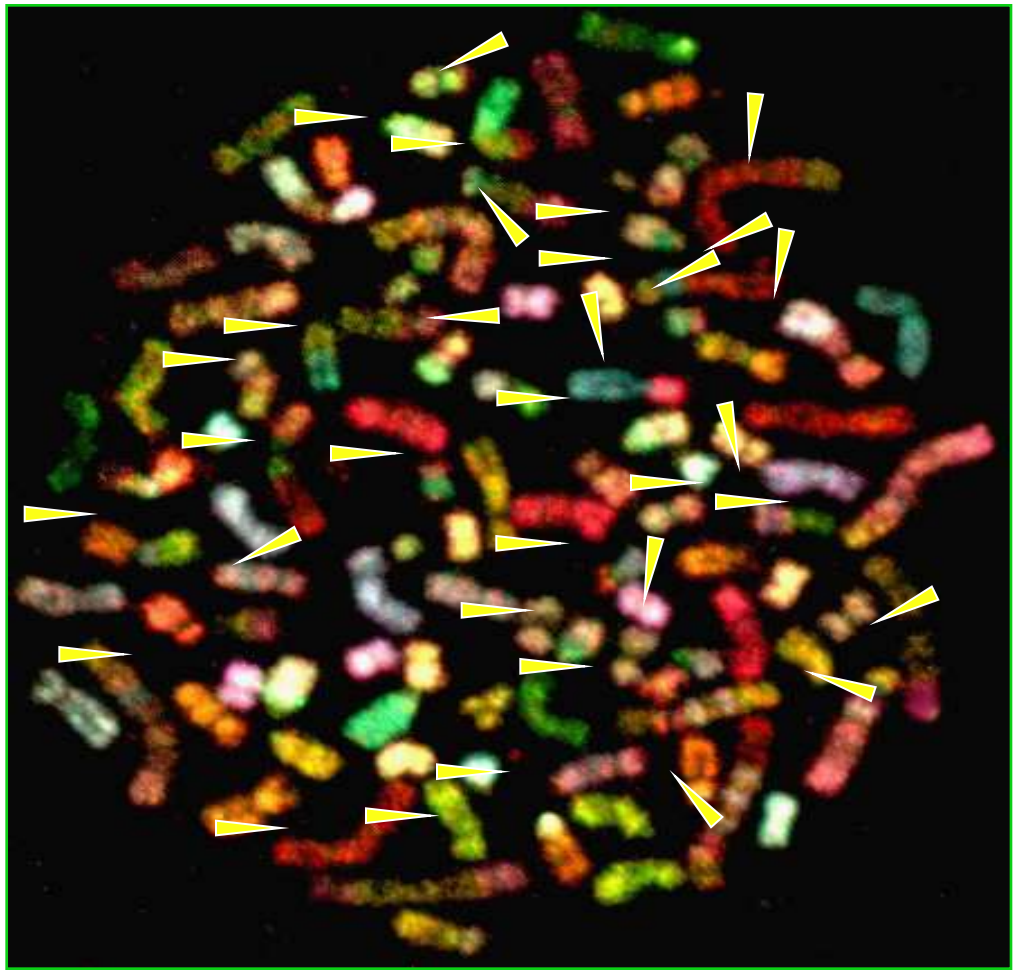
Courtesy of J-M Coindre & F Chibon, Bordeaux, France (Fresch Sarcoma Group)

Thank You

- **Brian Rubin, Cleveland Clinic.**
- **Jason Hornick, Brigham & Women's Hospital/Harvard**
- **Jean-Michel Coindre & Frederic Chibon, Bordeaux, France (French Sarcoma Group)**
- **Michael Heinrich & Chris Corless, University of Oregon.**
- **Jon Trent, University of Miami.**
- **Colleagues at UTMDACC.**

What is new and exciting in GIST pathology?

Chromosomal complexity and prognosis



97 chromosomes and more than 50 translocations

Courtesy of J-M Coindre & F Chibon, Bordeaux, France (Fresch Sarcoma Group)

Chromosomal complexity in sarcomas

- Which genes / pathways are related to the chromosomal complexity ?
- Is there a link between chromosomal complexity and prognosis ?

Courtesy of J-M Coindre & F Chibon, Bordeaux, France (Fresch Sarcoma Group)

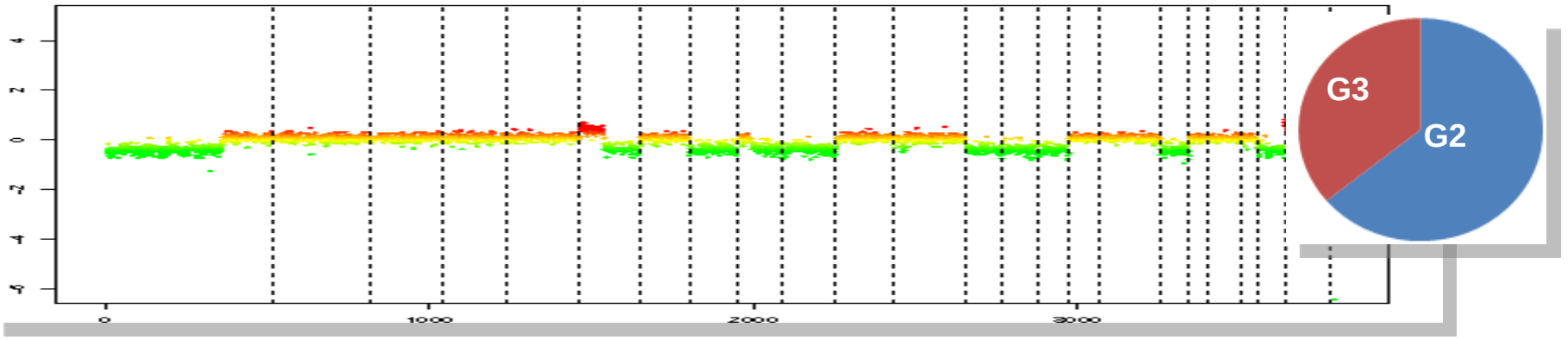
Chromosomal instability signature

Carter et al Nat Genet 2002

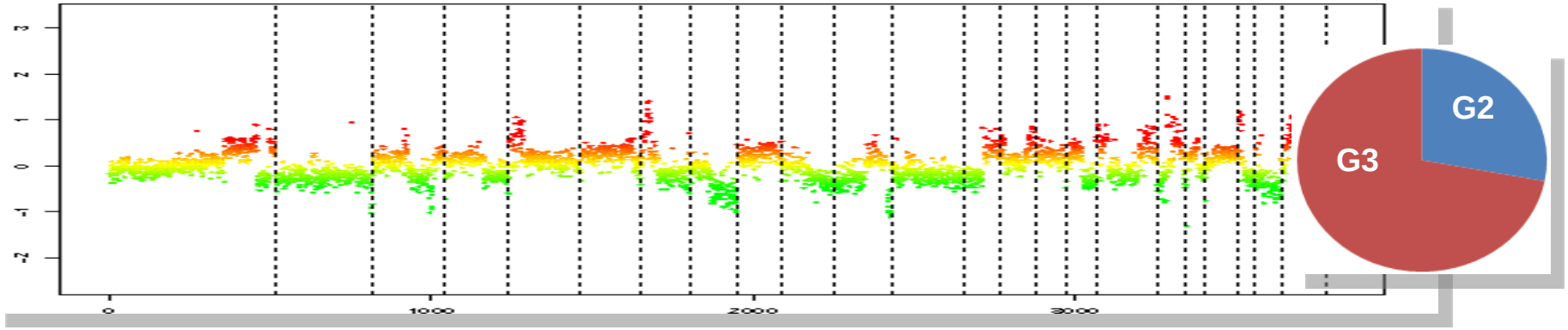
Courtesy of J-M Coindre & F Chibon, Bordeaux, France (Fresch Sarcoma Group)

CINSARC : arrayCGH analysis and correlation with FNCLCC grading

Arm



Rearranged



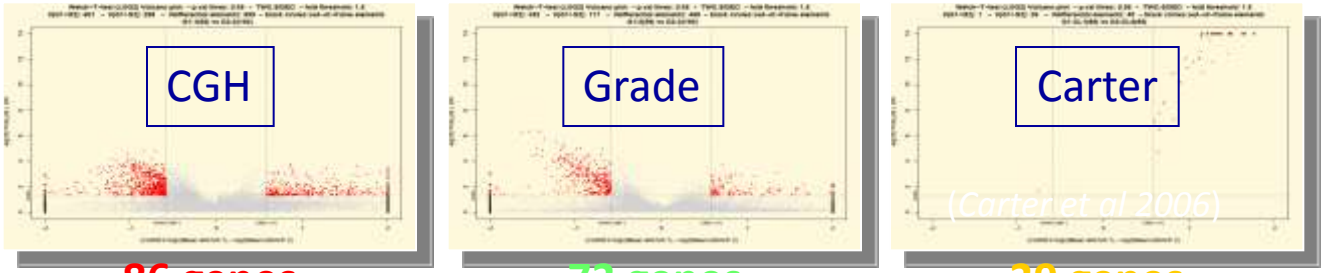
Courtesy of J-M Coindre & F Chibon, Bordeaux, France (Fresch Sarcoma Group)

Genomic complexity and prognosis
Possible approaches

Courtesy of J-M Coindre & F Chibon,
Bordeaux, France (Fresch Sarcoma Group)

Molecular grading in sarcomas

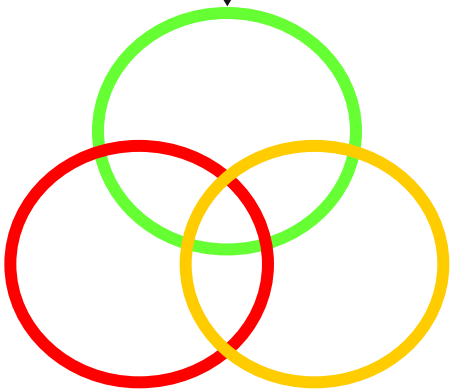
3 t tests to compare the expression profiles of tumors classified according to:



86 genes | 73 genes | 39 genes

GO analysis:
To identify the underlying pathways
Selection of genes involved in the most significantly overrepresented pathways ($p<10^{-5}$)

37 genes | 18 genes | 39 genes



67 genes

Courtesy of J-M Coindre & F Chibon, Bordeaux, France (Fresch Sarcoma Group)

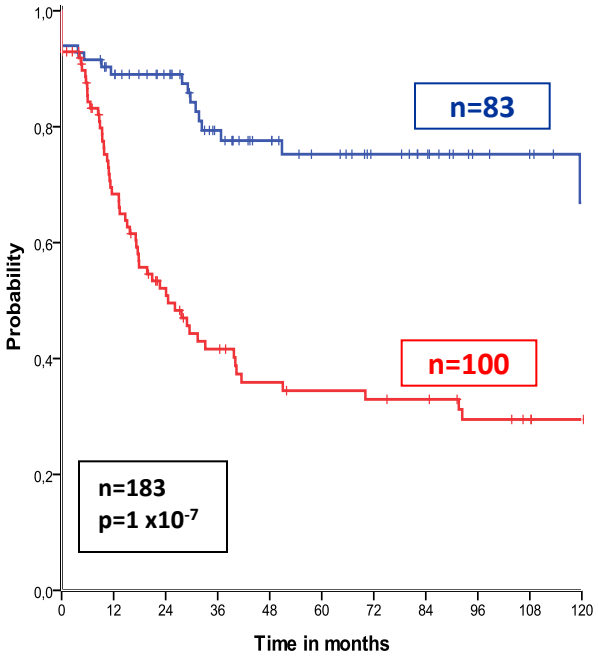
Complexity INdex In SARComas
CINSARC

Chibon et al, Nat Med 2010; 16: 781-7

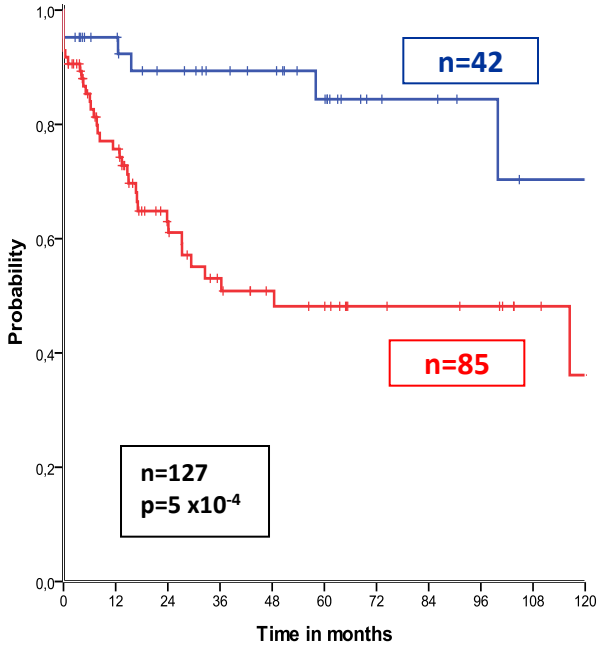
CINSARC: Prognostic signature ?

Prognostic value of CINSARC: Metastasis free survival

Cohort 1



Cohort 2

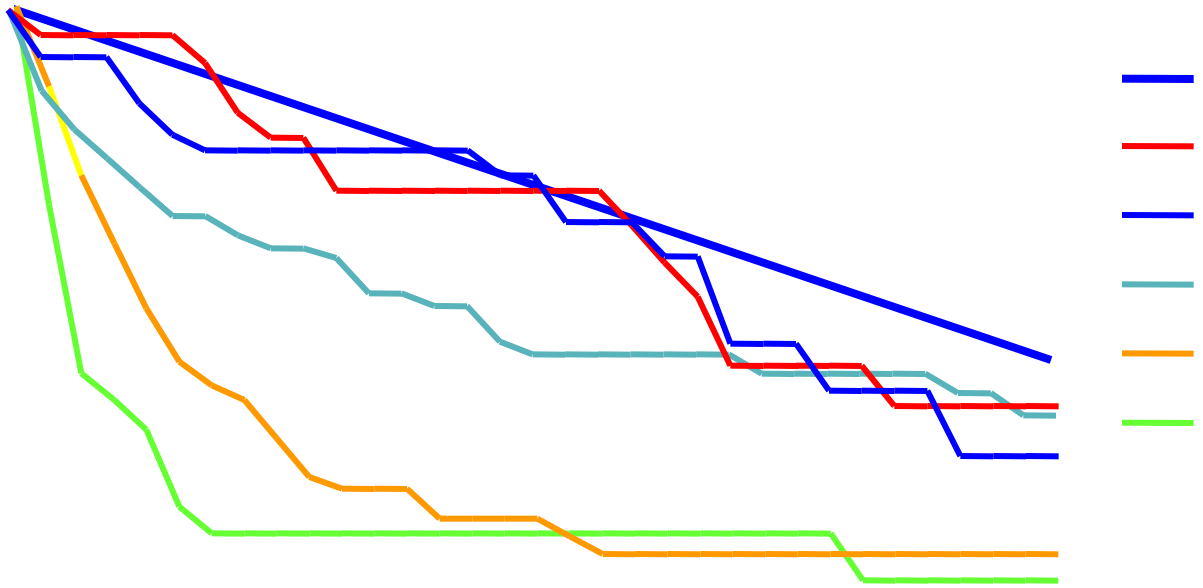


Multivariate analysis

CINSARC is an independent prognostic factor

Courtesy of J-M Coindre & F Chibon, Bordeaux, France (Fresch Sarcoma Group)

GIST - Overall Survival by Risk Group

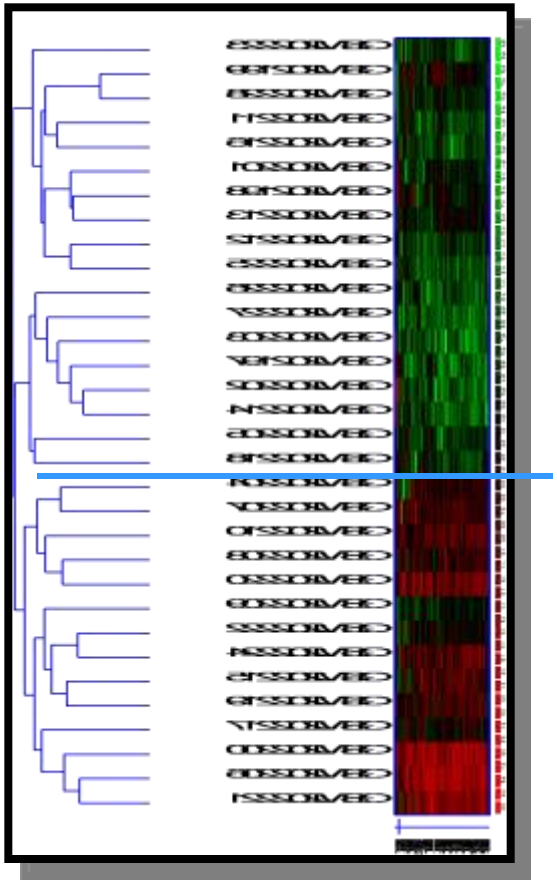


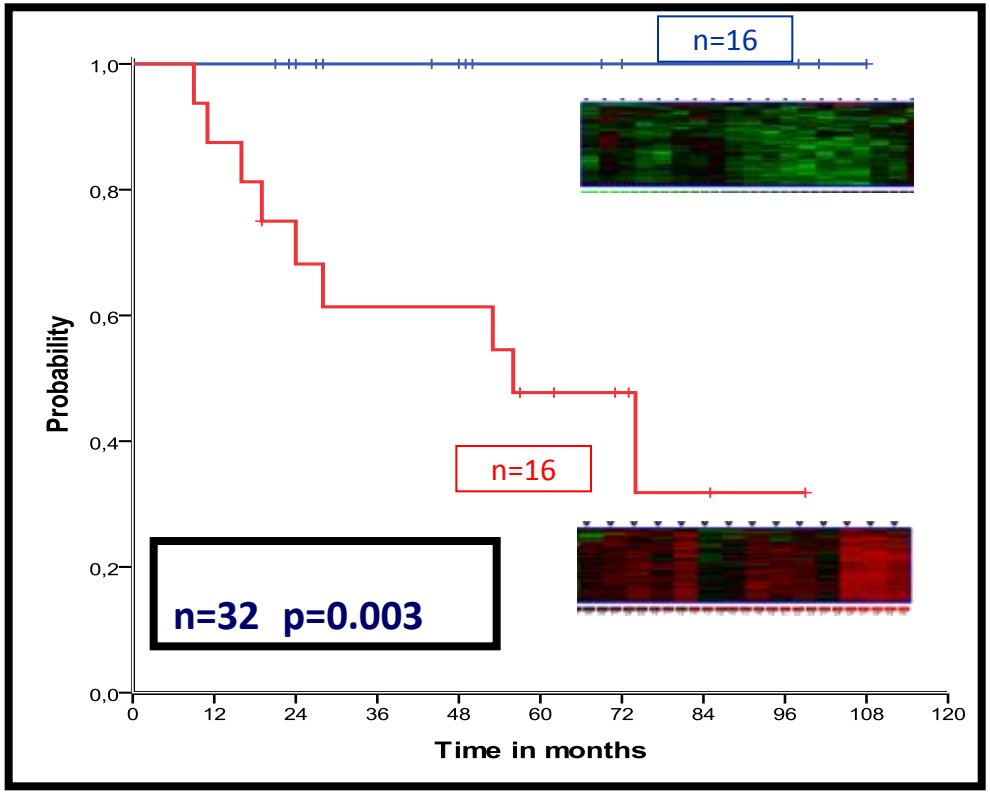
Kindblom. at: http://www.asco.org

CINSARC and GIST

In-silico study of 32 GISTs

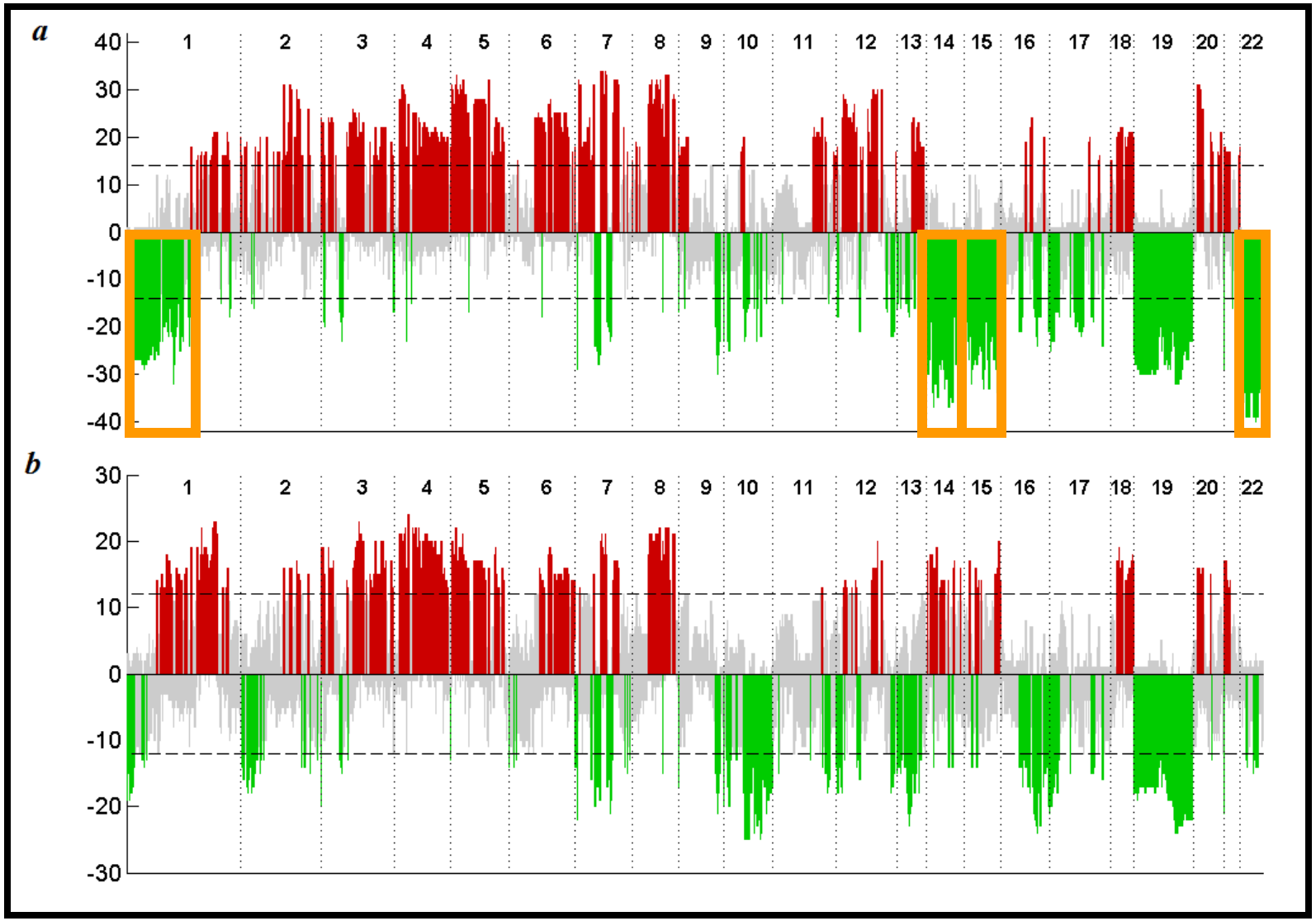
(Yamaguchi *et al* 2008)





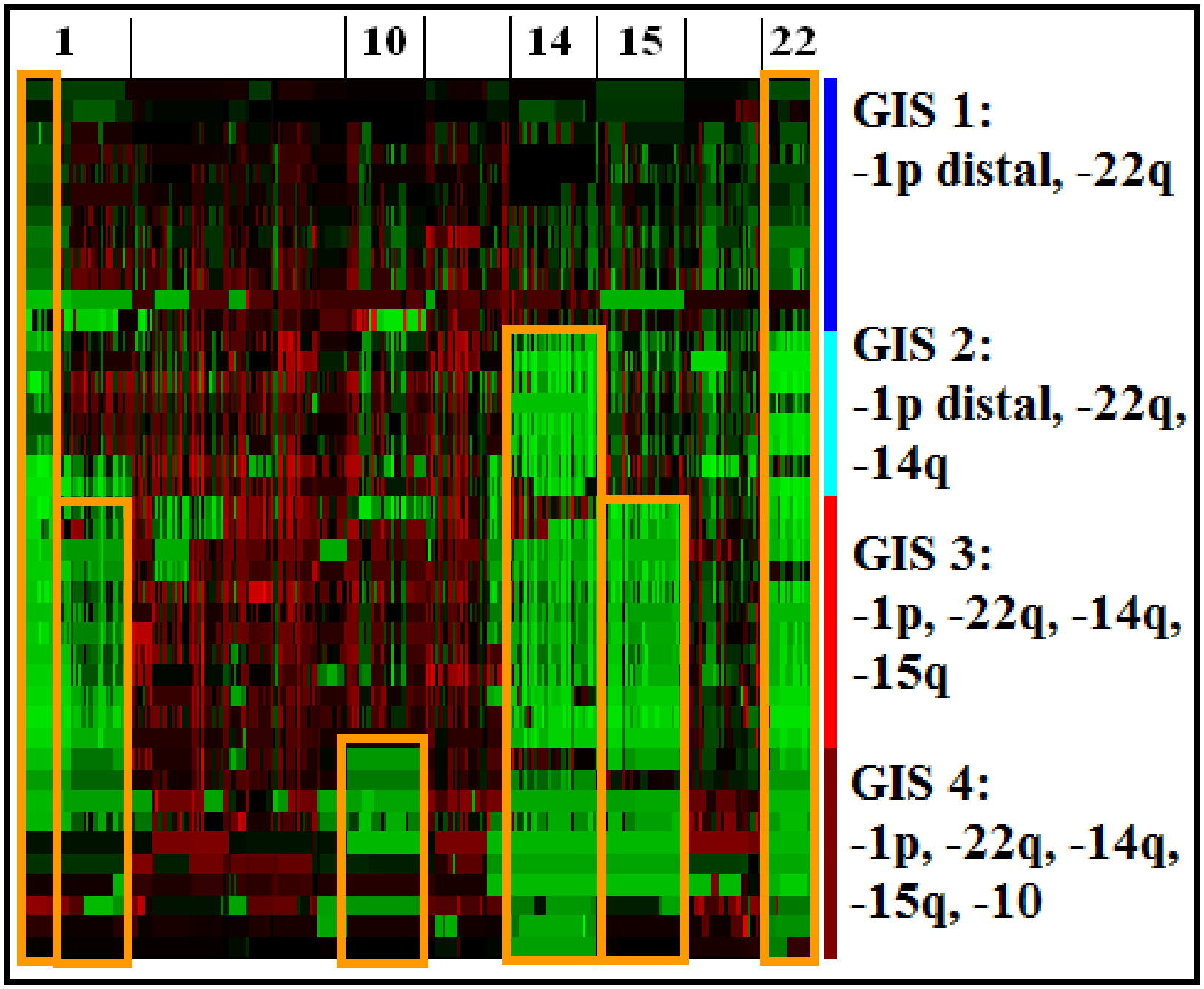
Courtesy of J-M Coindre & F Chibon, Bordeaux, France (Fresch Sarcoma Group)

GIST (n=42)

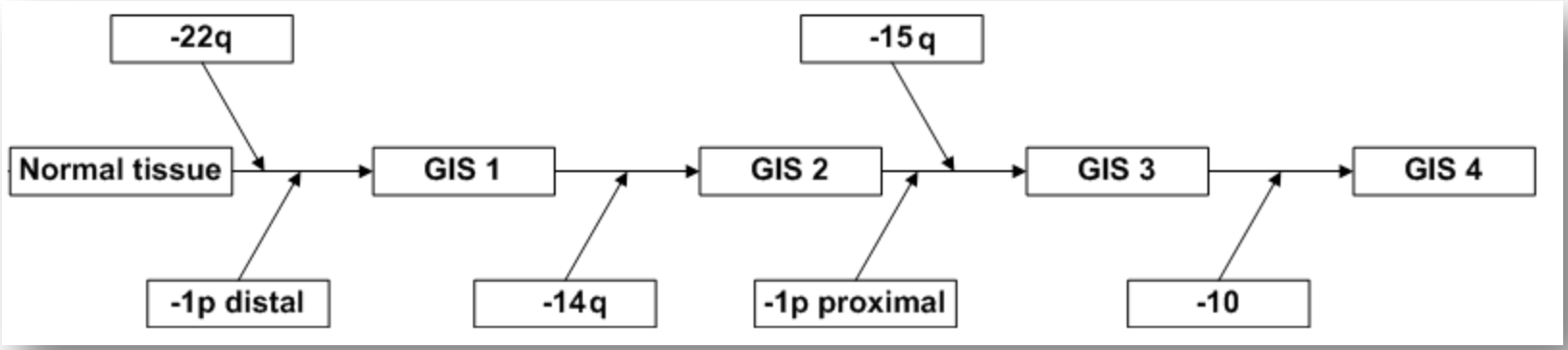


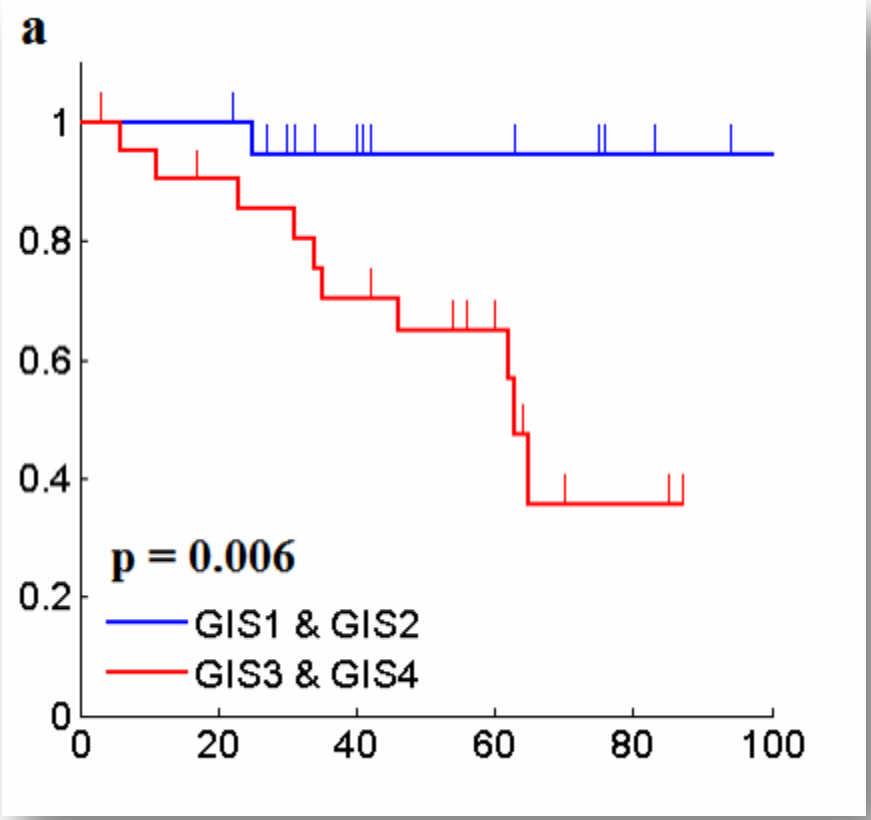
LMS (n=30)

Ylipää A, et al. Cancer 2011 117(2)380-9, 2011



Ylipää A, et al. Cancer 2011 117(2)380-9, 2011



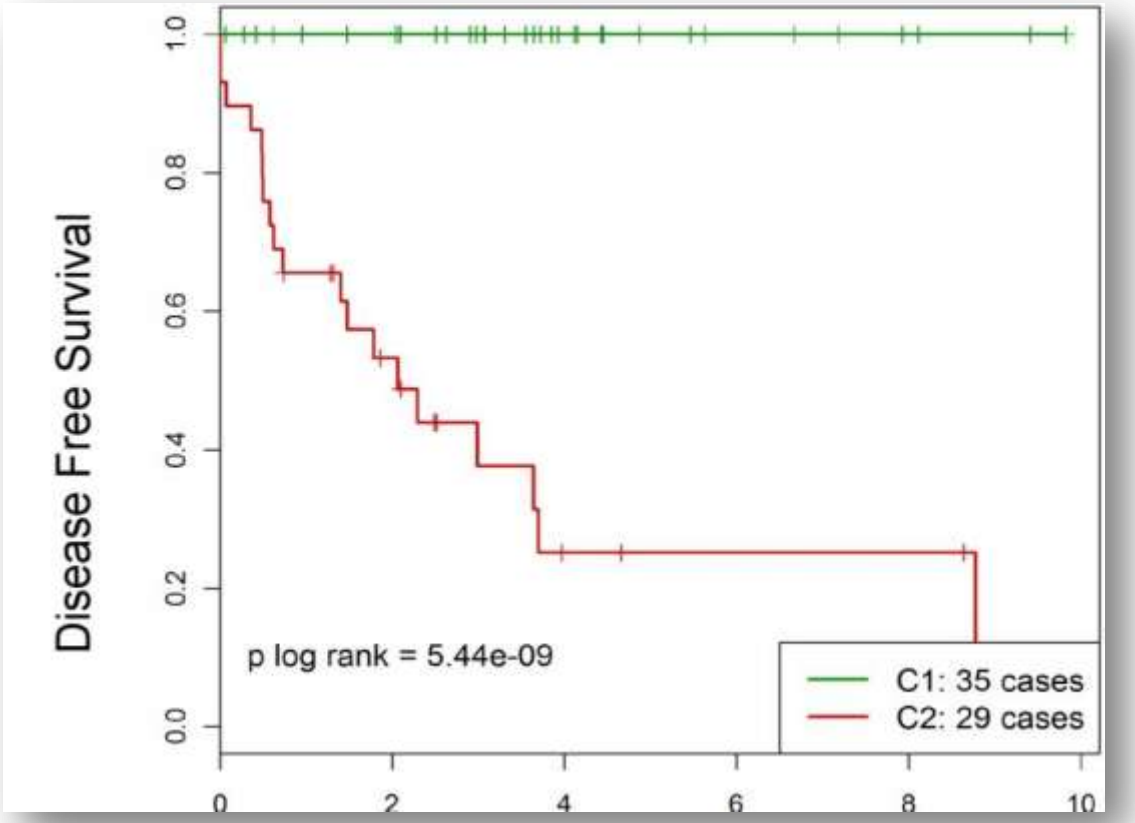


Ylipää A, et al. Cancer 2011 117(2)380-9, 2011

GIST and molecular signature

(Lagarde et al. Clin Cancer Res 2012;18: 826-838)

- 67 patients (Leuven + Bordeaux)
- Localised GIST
- No adjuvant treatment
- Frozen tissue from primary
- Miettinen classification
- Follow-up

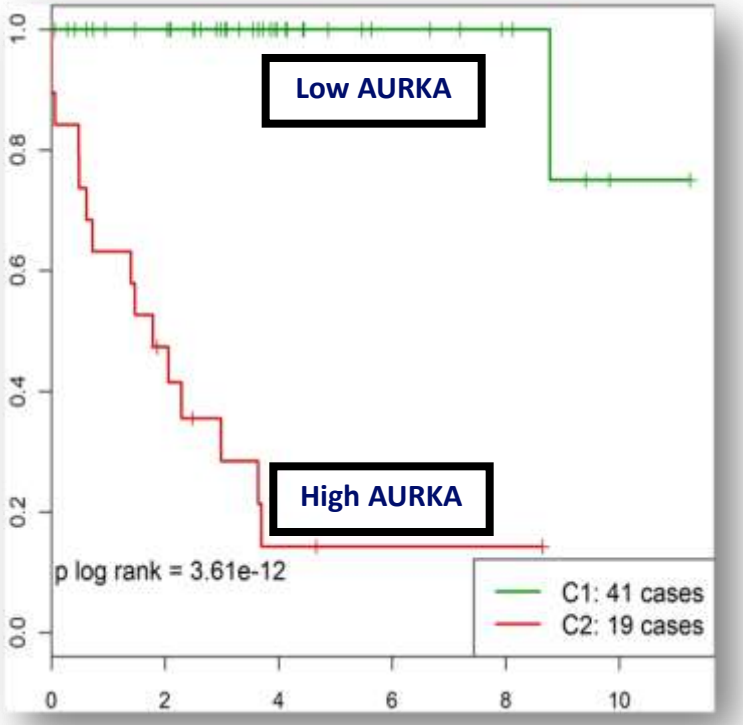


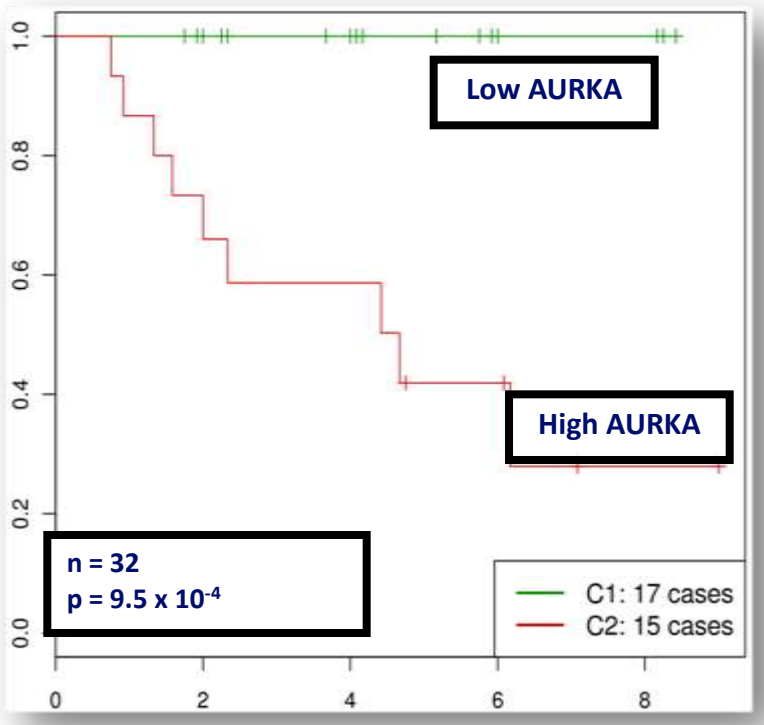
Courtesy of J-M Coindre & F Chibon, Bordeaux, France (Fresch Sarcoma Group)

GIST and molecular signature

(Lagarde et al. Clin Cancer Res 2012;18: 826-838)

AURKA is a prognostic factor in GIST





Courtesy of J-M Coindre & F Chibon, Bordeaux, France (Fresch Sarcoma Group)

AURKA – top ranked gene in CINSARC

- Gene maps to chromosome 20q13
- Mitotic centrosomal protein kinase
- Control of chromosome segregation
- Overexpression induces centrosome duplication/distribution abnormalities and aneuploidy
- Overexpression associated with poor prognosis in several cancers

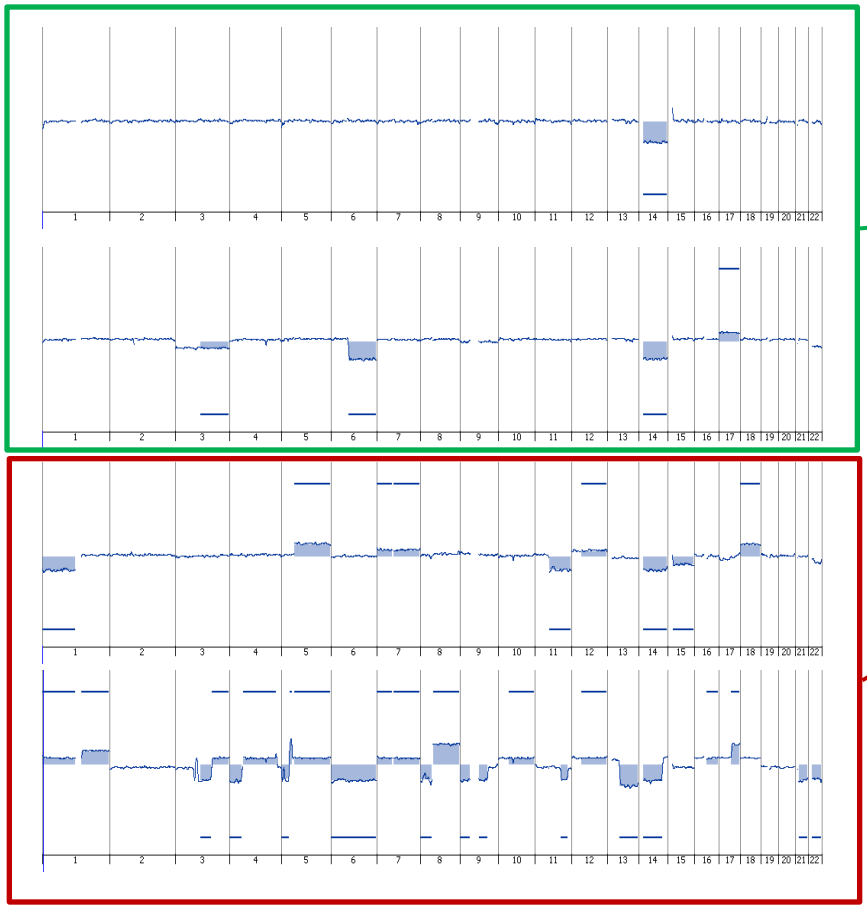
Courtesy of J-M Coindre & F Chibon, Bordeaux, France (Fresch Sarcoma Group)

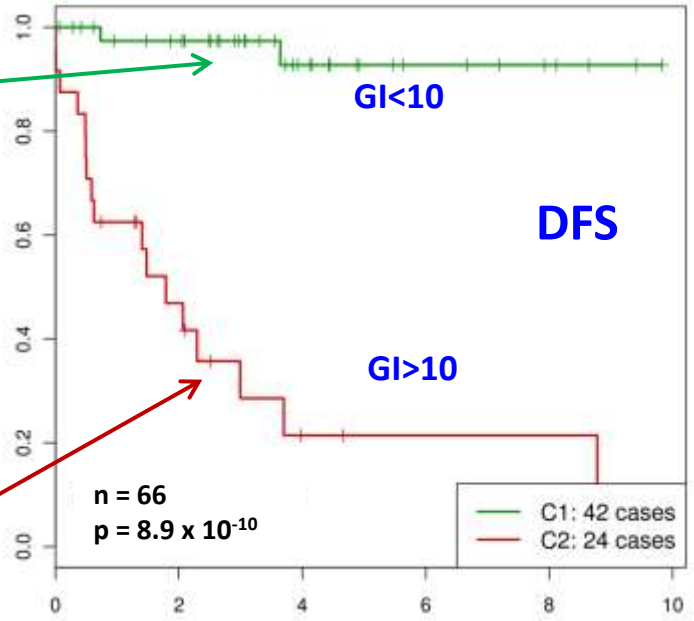
Prognosis in GIST

- ***AURKA* is overexpressed in aggressive GIST**
- **No amplification of *AURKA***
- **Deletion of p16 (*CDKN2A*) or *RB1***
- **Likely causal events leading to increase AURKA and CINSARC gene expression, chromosomal instability and complexity, and finally to metastasis**

Courtesy of J-M Coindre & F Chibon, Bordeaux, France (Fresch Sarcoma Group)

Genomic Index (GI) is a prognostic factor in GIST…

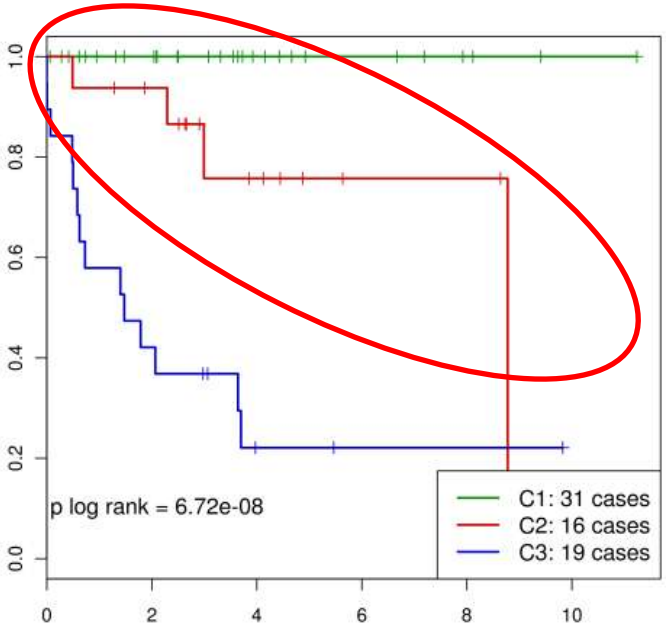


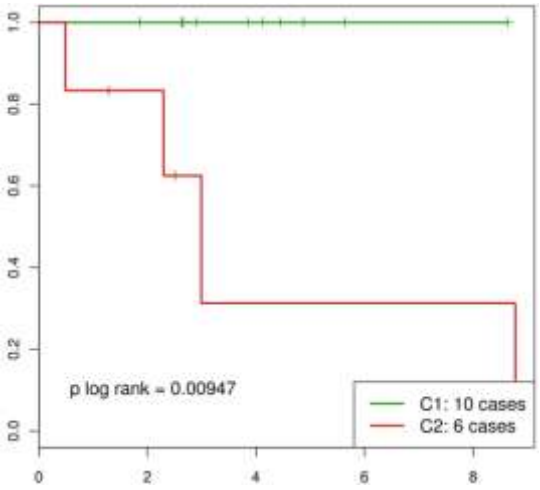


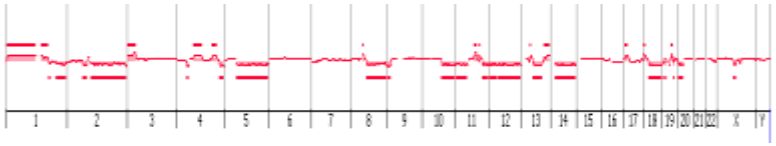
Courtesy of J-M Coindre & F Chibon, Bordeaux, France (Fresch Sarcoma Group)

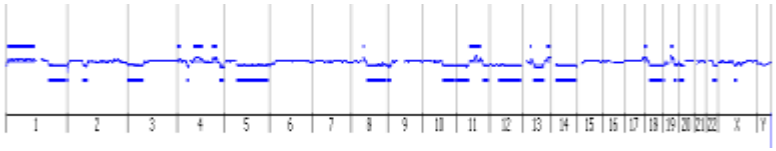
GIST and molecular signature

(Lagarde et al. Clin Cancer Res 2012;18: 826-838)





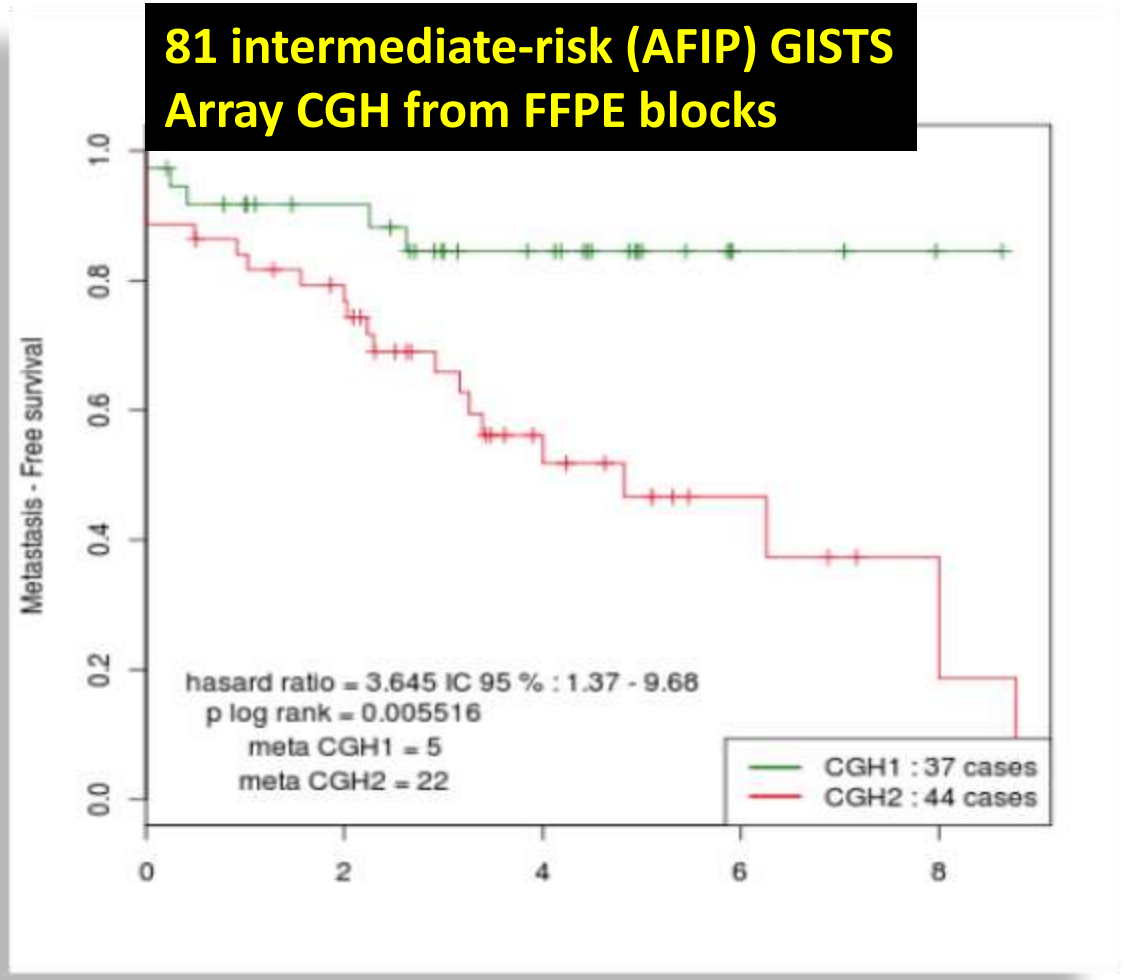




Courtesy of J-M Coindre & F Chibon, Bordeaux, France (Fresch Sarcoma Group)

Intermediate GIST and array-CGH

- Leuven (M Debiec-Rychter)
- Köln (E Wardelmann)
- Warsaw (P Rutkowski)
- Treviso (AP Dei Tos)
- French Sarcoma Group



Courtesy of J-M Coindre & F Chibon, Bordeaux, France (Fresch Sarcoma Group)