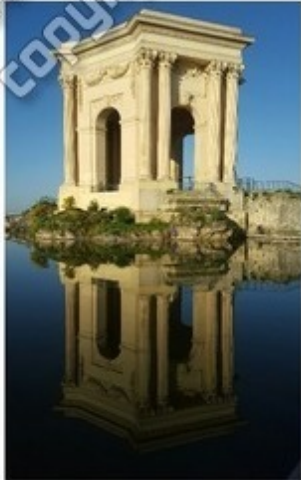


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Les marqueurs tumoraux, le retour?

Dr Pierre-Jean Lamy

Institut d'Analyse Génomique, imagenome-Inovie Montpellier, France,



53^e Journées de Biologie Praticienne
6 décembre 2019



imagenome

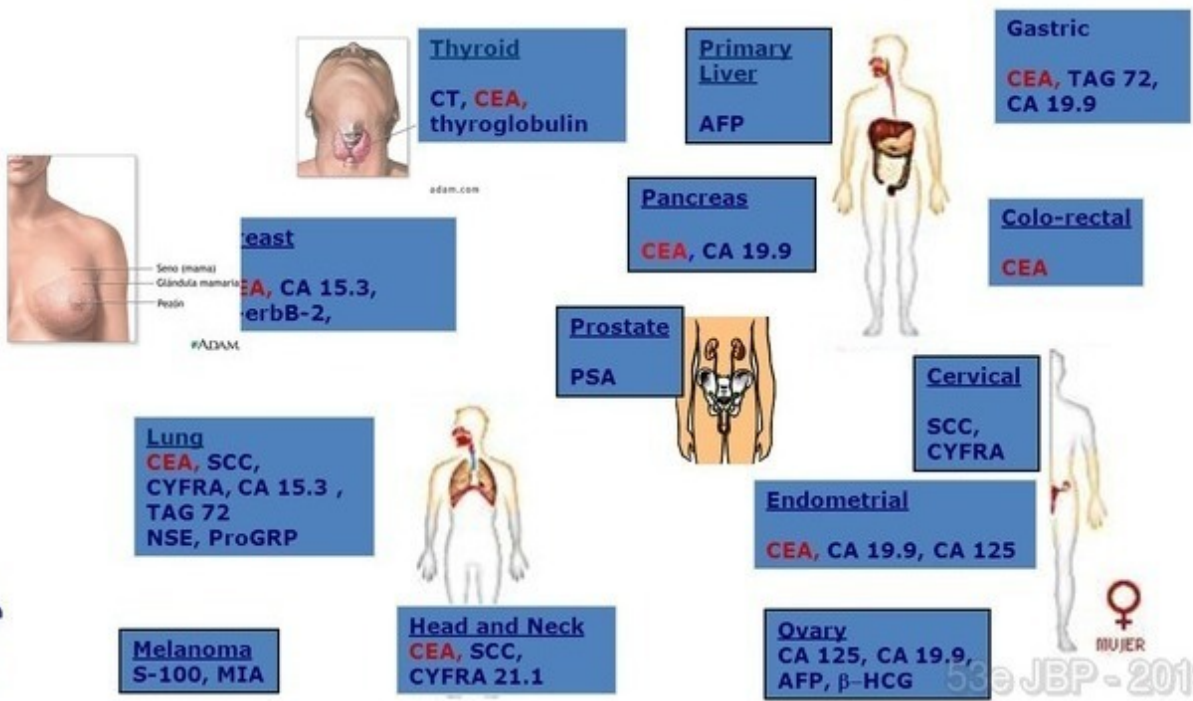
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Liens d'intérêts

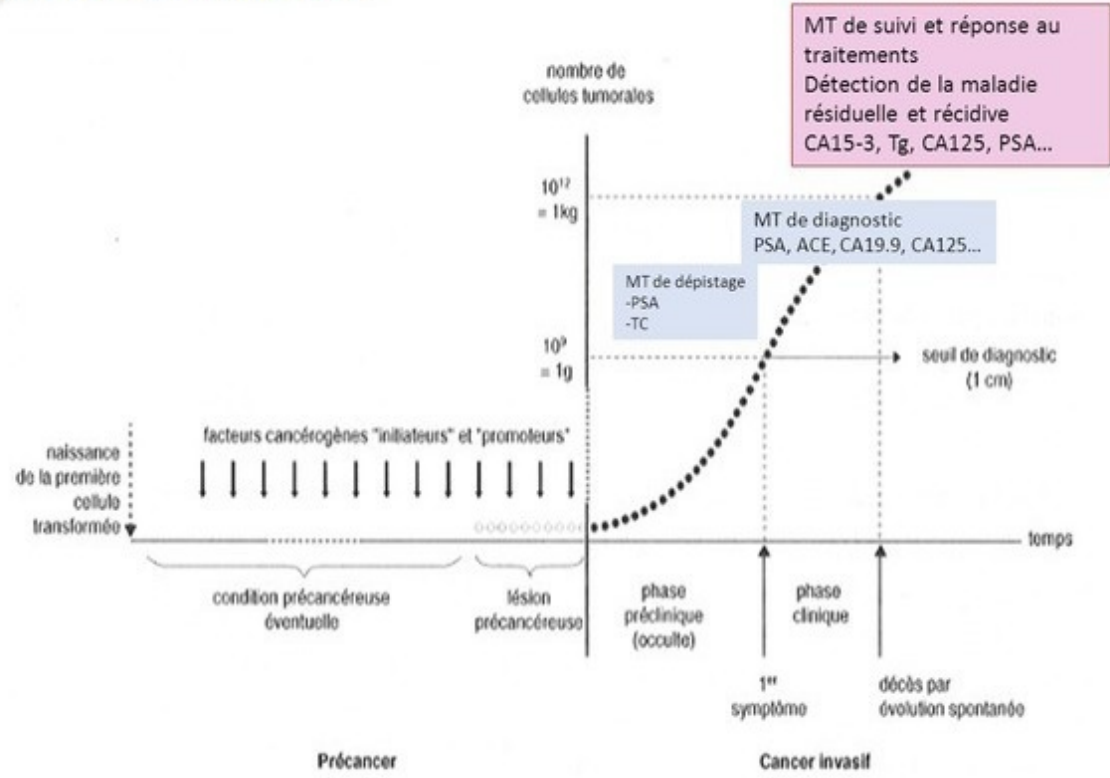
- Grant/Research Support: Agena Bioscience, Beckman Coulter, ID-Solution, Cepheid, Foundation medicine
- Consultant: Agena Bioscience, AstraZeneca, Beckman Coulter, Bristol-Myers Squibb, Ipsen, Lilly, Myriad Genetics, Roche, Roche diagnostics, VitaDX

Les marqueurs (encore) utilisés en routine



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Histoire naturelle des cancers



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Marqueurs et cancer



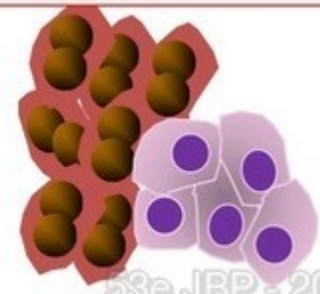
	Cell number	Vascularization	Tumor spread	
Stage	I	II	III	IV
Sensibility	35%	55%	78%	94%
Median (ng/ml)	15	30	90	150

CA15-3 in breast cancer at time of diagnostic



La quantité fait le diagnostic
Des élévations non spécifiques

<LOD 1ng/mL



>50ng/mL

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Les MT sériques, quoi de neuf?

De la protéine à l'ADN

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cancer de l'ovaire

De la détection précoce au suivi

Un cancer silencieux et mortel

Ovarian Cancer 5-yr Survival Rate by Stage		
	Stage Distribution at Diagnosis	Survival Rate
Stage I	20-27%	73-93%
Stage II	5-10%	45-70%
Stage III	52-58%	21-37%
Stage IV	11-17%	11-25%

CA125 : l'échec des études de screening

Table 3. Effects of Ovarian Cancer Screening on Ovarian Cancer Mortality (Key Question 1)^{a,b}

Source	Screening Method	No. Analyzed		Ovarian Cancer Deaths, No. (%)		Ovarian Cancer Mortality per 10 000 Person-Years		Between-Group Difference in Mortality
		Screening Group	Control Group	Intervention	Control	Intervention	Control	
UKCTOCS, ³¹ 2016	CA-125 ROCA	50 624	101 299	160 (0.32)	358 (0.35)	2.9	3.3	HR, 0.89 (95% CI, 0.74-1.08); P = .23 ^c
	TVU	50 623	101 299	163 (0.32)	358 (0.35)	3.0	3.3	HR, 0.91 (95% CI, 0.76-1.09); P = .31 ^c
PLCO, ²¹ 2011	CA-125 + TVU	34 253	34 304	118 (0.34)	100 (0.29)	3.1	2.6	Rate ratio, 1.18 (95% CI, 0.82-1.71); P = NR ^d
UK Pilot, ³³ 1999 ^e	CA-125	10 958	10 977	9 (0.08)	18 (0.16)	NR	NR	Relative risk, 0.50 (95% CI, 0.22-1.11); P = .08 ^f

Abbreviations: CA-125, cancer antigen 125; HR, hazard ratio; NR, not reported; PLCO, Prostate, Lung, Colorectal and Ovarian Cancer Screening Trial; TVU, transvaginal ultrasound; UKCTOCS, UK Collaborative Trial of Ovarian Cancer Screening.

^a Includes ovarian, fallopian, and primary peritoneal cancers.

^b All studies were good quality.

^c Cox model.

^d Sequentially adjusted.

^e Does not include peritoneal cancer.

^f Calculated (article reports relative risk calculated in terms of increased relative risk).

Sensibilité et spécificité sont fonction de la Prévalence

THE LANCET, FEBRUARY 6, 1988

MULTIMODAL APPROACH TO SCREENING FOR OVARIAN CANCER

IAN JACOBS

ISABEL STABILE

The frequency of ovarian cancer in women aged 45 years or over in England and Wales is 1 in 2500 per year.¹³ Therefore, an annual screening test for ovarian cancer, even with 100% sensitivity, would require 99.6% specificity to achieve a positive predictive value of 10% (ie, 9 false-positive tests for each case of ovarian cancer identified).

HE4 : Human Epididymis secretory protein

Average from Leave-one-out Analysis Marker Combination	Benign Cancer vs OC: Sensitivity at...		
	90% Specificity	95% Specificity	98% Specificity
CA125	61.2%	43.3%	23.9%
HE4	77.6%	72.9%	64.2%
CA125 + HE4	80.7%	76.4%	71.6%
CA125 + HE4 + SMRP	80.6%	74.7%	71.7%
CA125 + HE4 + CA72-4	82.1%	78.8%	71.5%

Moore RG et al. *Gynecol Oncol*. 2008;108:402-408.

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HE4 : Human Epididymis secretory protein 4

HE-4
-Fujirebio
-Roche
-Abbott

ROMA™ : Risk of Ovarian malignancy Algorithm (%) : orienter les patientes avec une masse pelvienne CA125 + HE4

Pre-menopausal: Predictive Index (PI) = $-12.0 + 2.38 * \text{LN}(\text{HE4}) + 0.0626 * \text{LN}(\text{CA 125})$

Postmenopausal: Predictive Index (PI) = $-8.09 + 1.04 * \text{LN}(\text{HE4}) + 0.732 * \text{LN}(\text{CA 125})$

Predicted Probability (PP) = $\frac{\exp(\text{PI})}{1 + \exp(\text{PI})}$

Calcul du risque de cancer OV

Guidelines FRANCOGYN, CNGOF, SFOG, and GINECO-ARCAGY : utilisation possible de ROMA au diagnostic ([J Gynecol Obstet Hum Reprod.](#) 2019 Jun;48(6):369-378. doi: 10.1016/j.jogoh.2019.03.017. Epub 2019 Mar 30)

Préménopause : bénéfique du à HE4
Post-ménopause : pas de supériorité par rapport au CA125 seul

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HE4 dans le suivi

Cancer disease evolution and clinical objectives during different disease stages

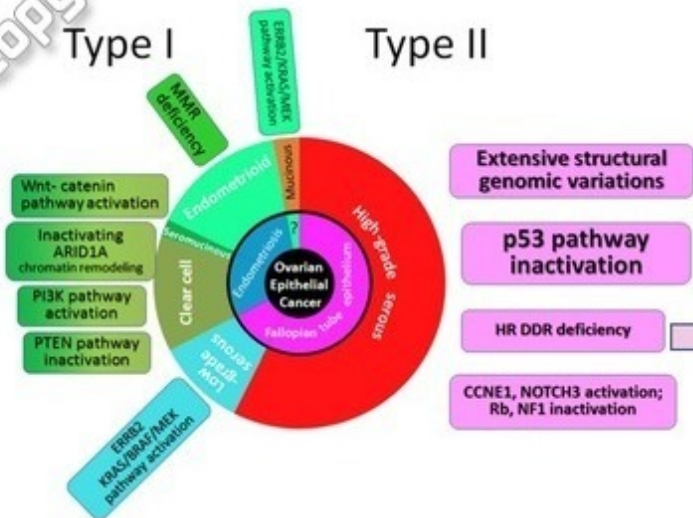


Process	Risk	Screening	Differential diagnosis	Classification of cancer: Histology, stage, grade	Monitoring of recurrence
Goal	Cancer prevention	Early detection	Diagnosis/risk of cancer	Guidance/selection of local or systemic therapy. Prediction/monitor of response	Early intervention
		CA125+HE4 + x + y ???	ROMA (HE4+ CA125) CE marked for determining risk of EOC in women with pelvic mass	CA125 and HE4 Therapy response after primary therapy	CA125 and HE4 CE marked & FDA cleared for monitoring of recurrent OvCa

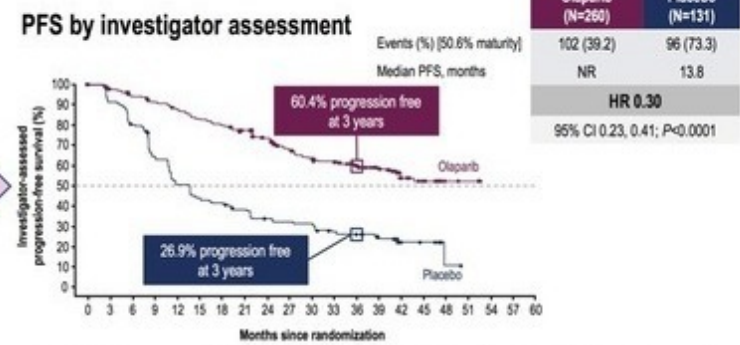
LAMY et al ASCO 2017

PJ Lamy 2019

Cancer de l'Ovaire : tout change!



ETUDE SOLO1 OLAPARIB et Cancer de l'ovaire avancé



Patientes mutées BRCA1 ou BRCA2 (HRD déficientes)

Rechercher les mutations BRCA1 et 2 devient le standard dans la prise en charge des cancers de l'ovaire

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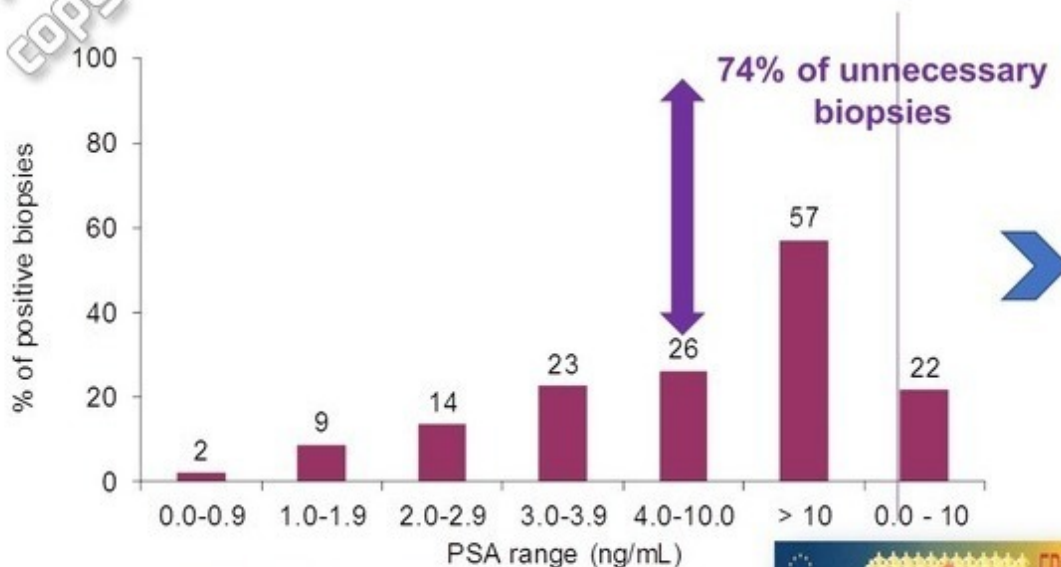


cancer de la prostate

De la détection précoce au suivi

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PSA in Screening for Prostate Cancer – Specificity



*Postma R, Schröder FH. Eur J Cancer 2005;41:825-33

** Thompson et al. Assessing Risk in PCPT JNCI Vol 98, No. 8, April 19, 2006



Essais ERSPC¹ et
PLCO² :
contradictoires

- 1: -20% de mortalité (cohorte suédoise)
- 2 : pas de bénéfice à faire du dépistage

Recommandations
d'arrêts du PSA qui
ont conduit à une
augmentation des Ca
métastatiques

Le PSA dans l'aide à l'indication de biopsie prostatique : recommandations nouvelles

Il faut adapter le suivi en fonction de l'âge et du risque (PSA tous les 1 à 5 ans)

Risque moyen = sans facteurs de risques identifiés à 50 (45-55) ans : **dosage initial de PSAT**

Population à faible risque : PSA < 1 ng/mL

PSAT tous les 5 ans et arrêt après 60 ans

Population à haut risque :

45-49 ans : PSA > 1,6 ng/ml

50-55 ans : PSA > 1,9 ng/ml

60 ans : PSA > 2 ng/ml

tous les ans jusqu'à 75 ans

PSAT > 4 : consultation en urologie

Population à risque intermédiaire :

45-49 ans : 1 < PSA < 1,6 ng/ml

50-55 ans : 1 < PSA < 1,9 ng/ml

60 ans : 1 < PSA < 2 ng/ml

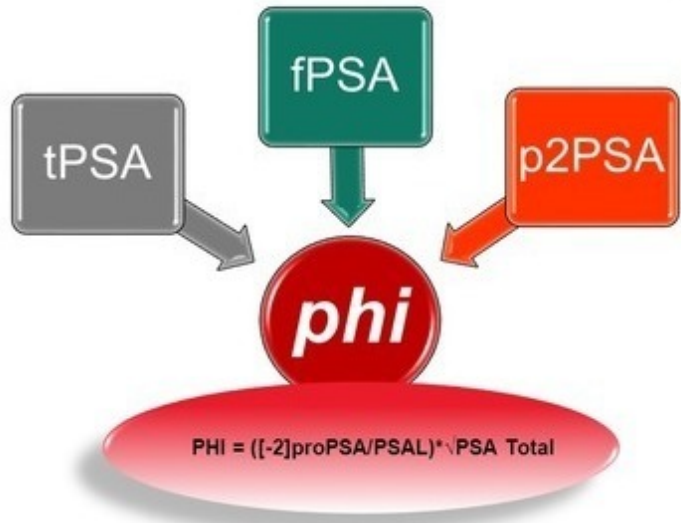
tous les 2 à 5 ans jusqu'à 75 ans

Rozet F et al. Recommandations en onco-urologie du CCAH Prog Urol 2016

Lamy PJ et al. Pertinence des prescriptions de PSA total et de PSA libre. Ann Bio Clin 2018

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« Prostate Health Index »: *phi*



- PHI : composite marker with PSA, FPSA and -(2)proPSA
- Five prospective studies
- 1 method (Beckman Coulter) with standardized PSA and FPSA

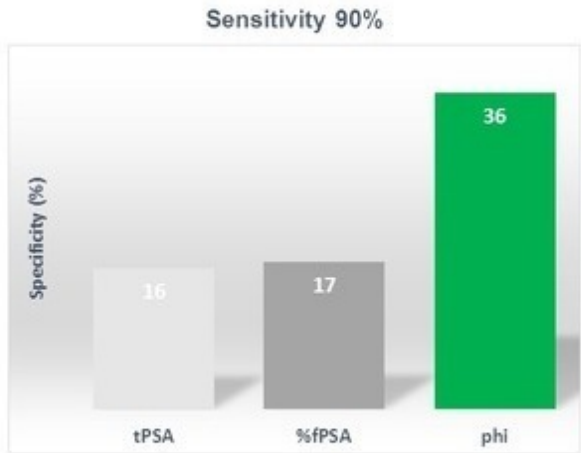
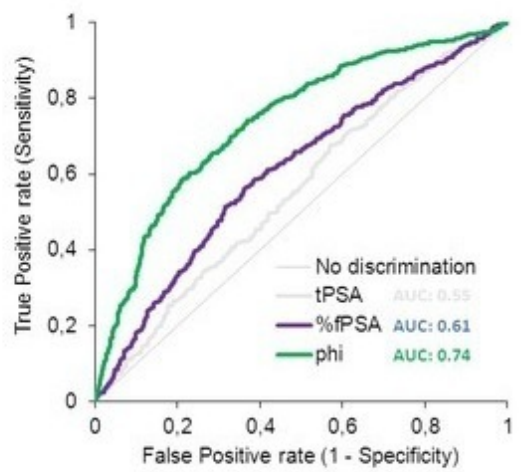


Guazzoni et al, 2011; Sokoll et al, 2010; Stephan et al, 2009; Catalona et al, 2011; Ulang et al, 2011

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Clinical Performances for phi

Patients (n) *	1362
PCa	694
No PCa	668



* : patients with tPSA 2 – 10 ng/mL and DRE non suspicious

Stephan et al. ClinChem 59:1 306–314 (2013)

Prodetect : une étude en vie réelle

- Blood and urine samples from patients with suspicion of PCa (Clinique BeauSoleil, Montpellier)

	Negative biopsies	Positive biopsies	p	ROC-AUC	AUC 95% CI
235 men	175 74,5%	60 25,5%			
tPSA ng/mL	6.7 [0.6-36.6]	6.8 [2.5-43.0]	p=0.19	0.56	[0.47-0.64]
fPSA ng/mL	1 [0.1-7.6]	0.8 [0.3-4.8]	p=0.02	0.60	[0.52-0.69]
PHI	37.0 [11.4-117.1]	49.3 [16.8-114.5]	p<0.001	0.71	[0.63-0.79]
PCA3	30 [2-371]	47 [10-333]	p<0.001	0.65	[0.57-0.72]

PJ Lamy et al. Ann Bio Clin 2013, PJ Lamy et al. ASCO 2014

PJ Lamy 2019

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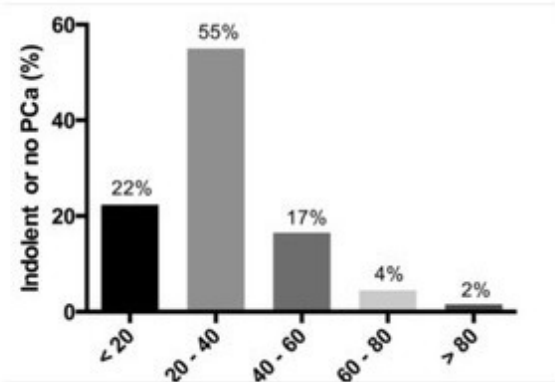


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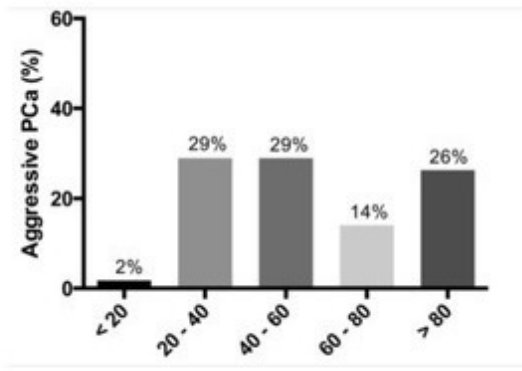
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DETECTION OF AGGRESSIVE PCA

PHI (BECKMAN COULTER)



Indolent cancers



Aggressives cancers

De la Calle J Urol 2015

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EVALUATION OF PROGNOSTIC BIOMARKERS OF PCA: A SYSTEMATIC REVIEW (ICF-URO):



PJ LAMY ET AL. EUR UROL FOCUS 2017

PHI

- *Patients eligible for a first or second biopsy and identification of patients at risk of aggressive cancer*

Prediction of tumour aggressiveness: according to the Gleason score or the Epstein criteria or Prostate Cancer Research International Active Surveillance (PRIAS) criteria assessed on biopsy, PHI showed discriminatory power [(LOE IA) and additional value compared to total and/or free PSA (LOE IA).

Loeb 2015 J Urol
Foley 2015 BJU Int
Nordstrom 2015 Urology

- Improve ROC-AUC + 2 to 11 %

Isharwal 2011 Urology
Tosolan 2012 J Urol
Hirama 2014 J Cancer Res
Guazzoni 2012 Eur Urol
Fossati 2015 Eur Urol

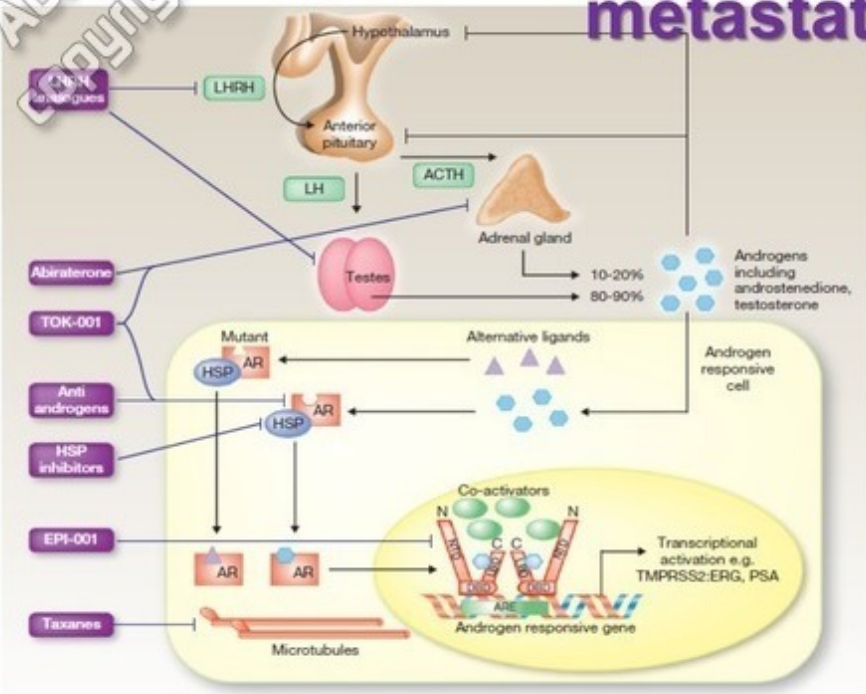
Benefits of phi to MRI for detection of significant Pca at repeat biopsy

Decision to biopsy	Sensitivity	Specificity	PPV	NPV	Non Significant biopsies	Gleason ≥ 7 missed
mpMRI	0.78	0.39	0.39	0.78	112	21
mpMRI or $\phi \geq 35$	0.99	0.17	0.38	0.97	165	1

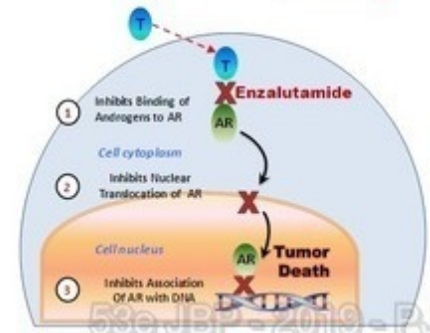
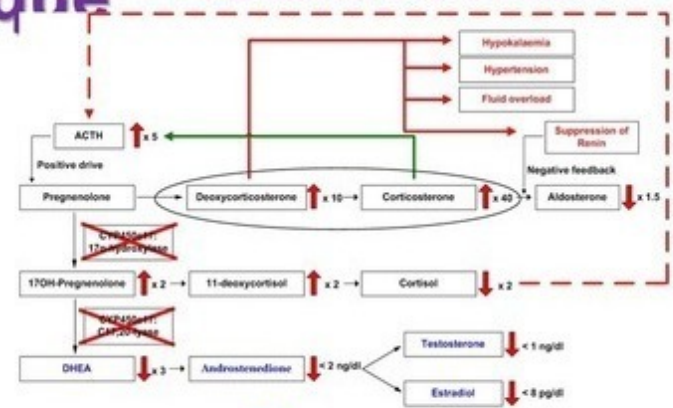


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La prostate au stade métastatique

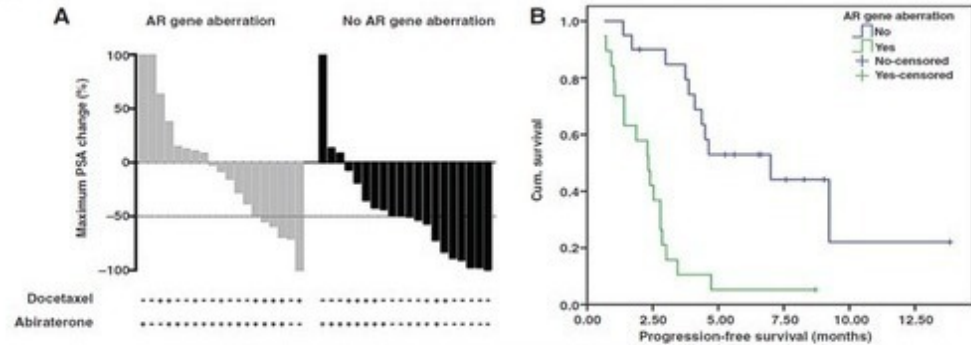


Abiraterone: CYP17 Inhibitor



Des marqueurs de résistance à l'hormonothérapie

Enza: ctDNA analysis for AR amp/mut



-Élévation du PSA (récurrence bioch)

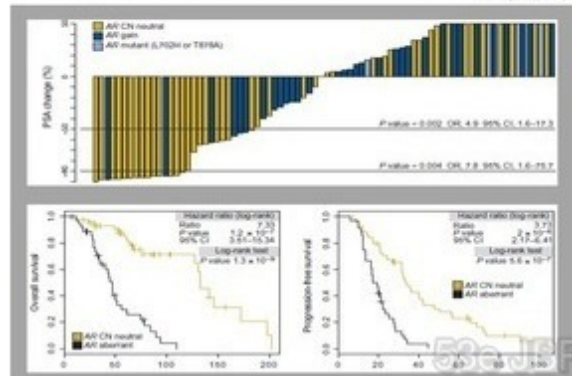
-Marqueurs moléculaires de l'ADNct

AR (activating) mutations

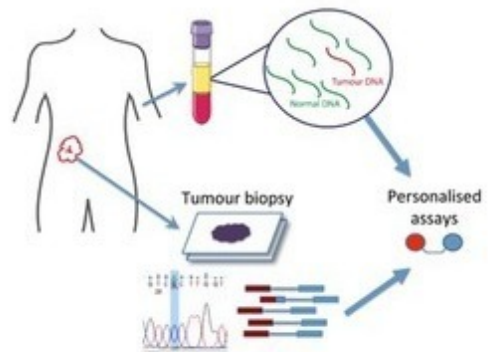
AR gene amplification

AR mRNA overexpression

AR splice variants (AR-V7)



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Une nouvelle ère pour les marqueurs tumoraux

LA BIOPSIE LIQUIDE

-CELLULES TUMORALES CIRCULANTES

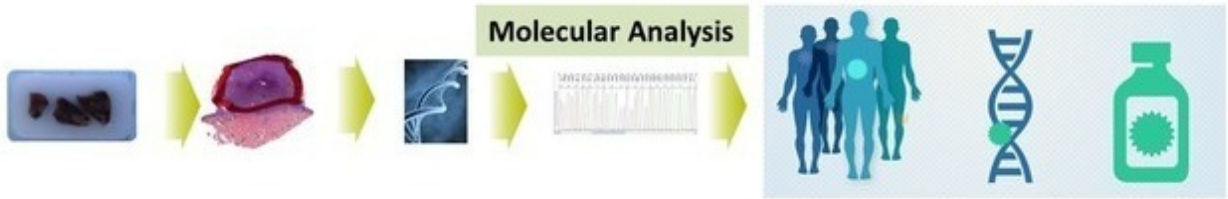
-ADN CIRCULANT

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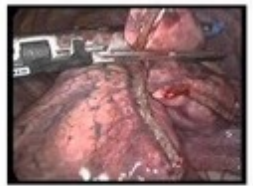
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Médecine personnalisée

Le bon traitement pour le bon patient



BIOMARQUEUR COMPAGNON DE LA THERAPIE



Lung biopsy



Breast biopsy

PJ Lamy 2019

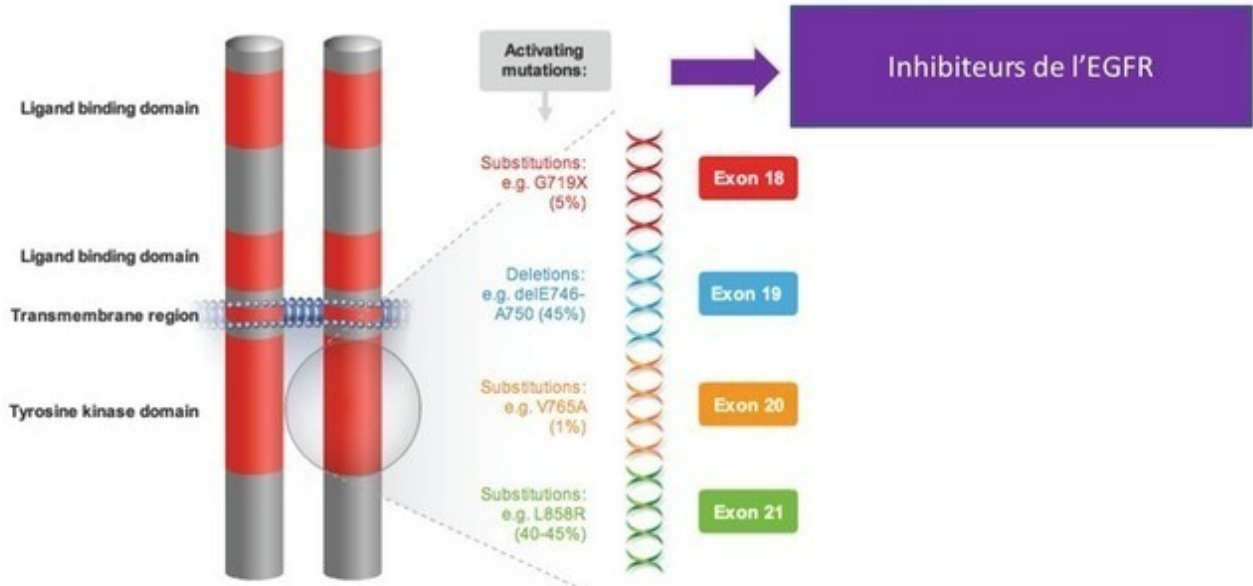


Prostate biopsy

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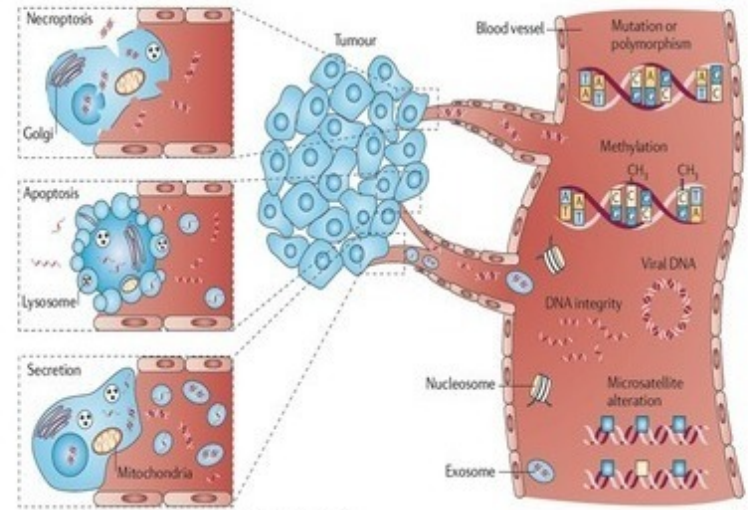
NSCLC mutation profile and targeted therapies




* T790M <5% at initial EGFR mutations, however it is the major resistance mutation (50%) after treatment with reversible TKIs

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Qu'est ce que la biopsie liquide?



From Schwartzenbach Nat Rev Cancer 2011

 Circulating tumor cells
Proteins (tumor markers)

Obtenir une information tissulaire sans acte invasif

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Le cancer et La biopsie liquide

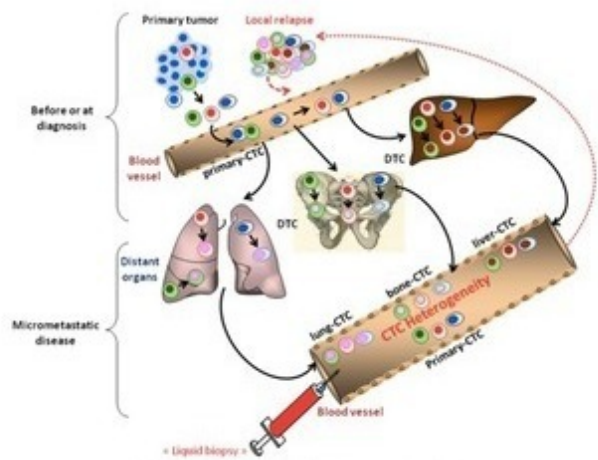
LES CELLULES TUMORALES CIRCULANTES

PJ Lamy 2019

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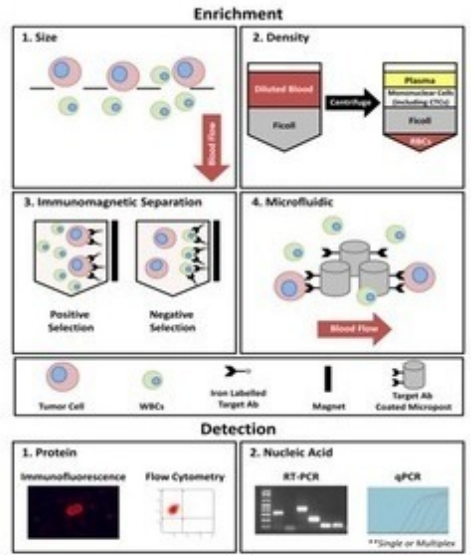
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Circulating Tumor Cells



Alix-Panabières Clin Chem 2013

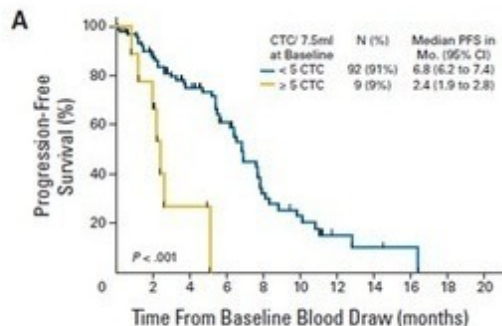
- CTC's are cells coming from the tumor or metastasis.
- They are related to the metastatic process



Applications des CTCs

• Enumeration des cellules

- Pronostic
- Détecter les récives



Prognosis value of CTC in NSCLC Krebs JCO 2011

- Caractérisation Moléculaire
- Pronostic et prédiction de réponse
 - Challenger avec l'ADN tumoral circulant
 - Étudier les mécanismes des transformation des cellules

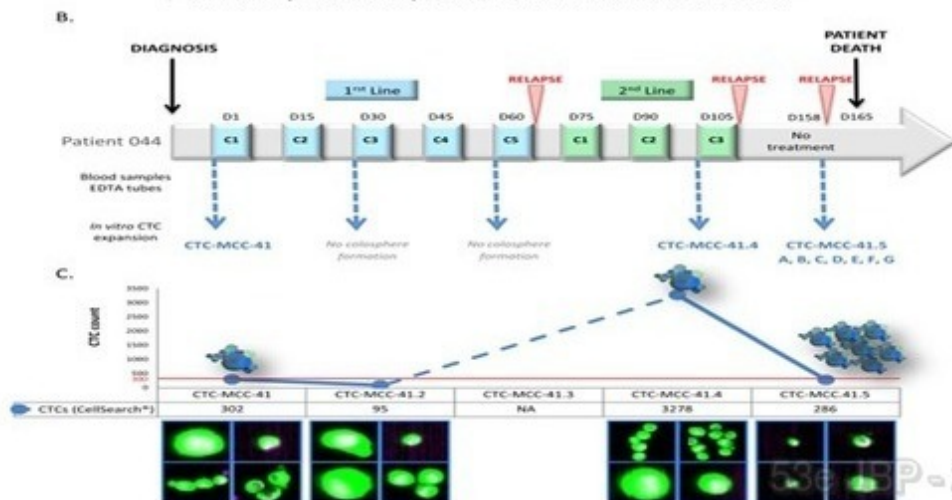
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OPEN

Autologous cell lines from circulating colon cancer cells captured from sequential liquid biopsies as model to study therapy-driven tumor changes

Received: 22 June 2018
Accepted: 18 October 2018
Published online: 29 October 2018

Alexandra Soler¹, Laure Cayrefourcq¹, Thibault Mazard², Anna Babayan³, Pierre-Jean Lamy^{1,4}, Said Assou⁵, Eric Assenat⁶, Klaus Pantel³ & Catherine Alix-Panabières¹

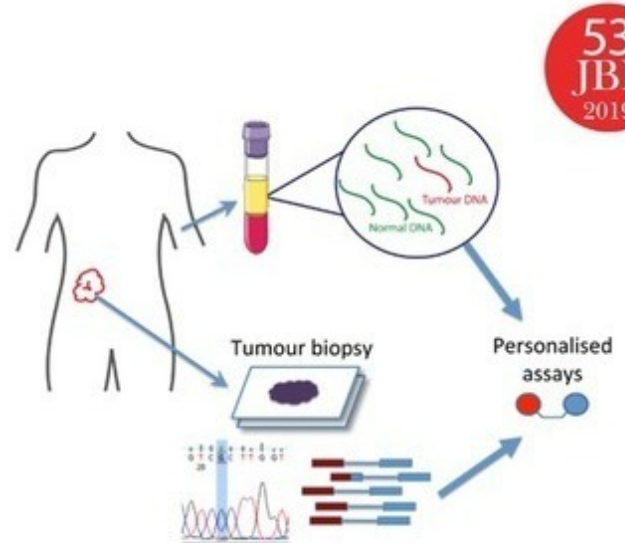


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Les CTC en routine?

- **ISET ? : NON** – pas de marquage CE ni de validation FDA (le site précise « pour la recherche)
- « Ce test ne constitue pas un diagnostic médical. Il est effectué à des fins exclusifs de recherche clinique » (CR de la société ISET)
- **CELL Search** validé FDA pour les cancers du sein de la prostate et du poumon
 - Y a –til un intérêt clinique? **pas encore**

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Le cancer et La biopsie liquide

L'ADN TUMORAL CIRCULANT

1948: 1ère publication sur l'ADNct



Les acides nucléiques du plasma sanguin chez l'Homme.

par P. MANDEL et P. MÉTAIS.

Sujet	Sexe	Age	Affection	P phospho- protéine mg.	P ribo- nucléique mg.	P desoxyri- bo- nucléique mg.	P total acides nucléiques mg.
1	F	42	Normal	0	5,0	1,2	6,2
2	F	22	"	0	4,0	0,4	4,4
3	H	24	"	0	5,2	1,3	6,5
4	F	27	"	0	4,7	0,3	5,0
5	F	20	"	0	3,7	0,8	4,5
6	H	48	"	0	4,6	1,3	5,9
7	H	45	"	0	4,5	0,6	5,1
8	F	26	"	0	5,0	0,2	5,2
9	F	37	"	0	4,8	0,6	5,4
10	H	39	"	0	5,0	0,9	5,9
11	H	62	Insuffis. card.	0	3,8	0,7	4,5
12	H	62	"	0	3,8	0,45	4,25
13	H	52	"	0	5,1	0,9	6,0
14	F	32	Endocard. maligne	0	3,35	0,65	4,0
15	"	"	"	0	3,5	0,8	4,3
16	F	5	Goutte	0	5,6	0,4	6,0
17	H	58	Basedow	0	3,6	0,3	3,9
18	H	58	Diabète	0	3,6	0,4	4,0
19	H	61	"	0	3,5	0,4	3,9
20	H	58	Cirrhose	0	5,3	1,2	6,5
21	F	52	Ictère	0	3,6	0,4	4,0
22	H	48	Goutte	0	3,5	1,0	4,5
23	H	"	"	0	2,66	0,8	3,46
24	H	33	"	0	5,5	0,5	6,0
25	H	"	"	0	4,75	0,75	5,5
26	H	26	Néphrite	0	3,75	0,7	4,45
27	H	37	Tuberculose	0	3,5	0,45	3,95
28	F	23	Grossesse 7 ^e m.	0	7,65	1,35	9,0
29	"	"	"	0	7,25	1,00	8,25

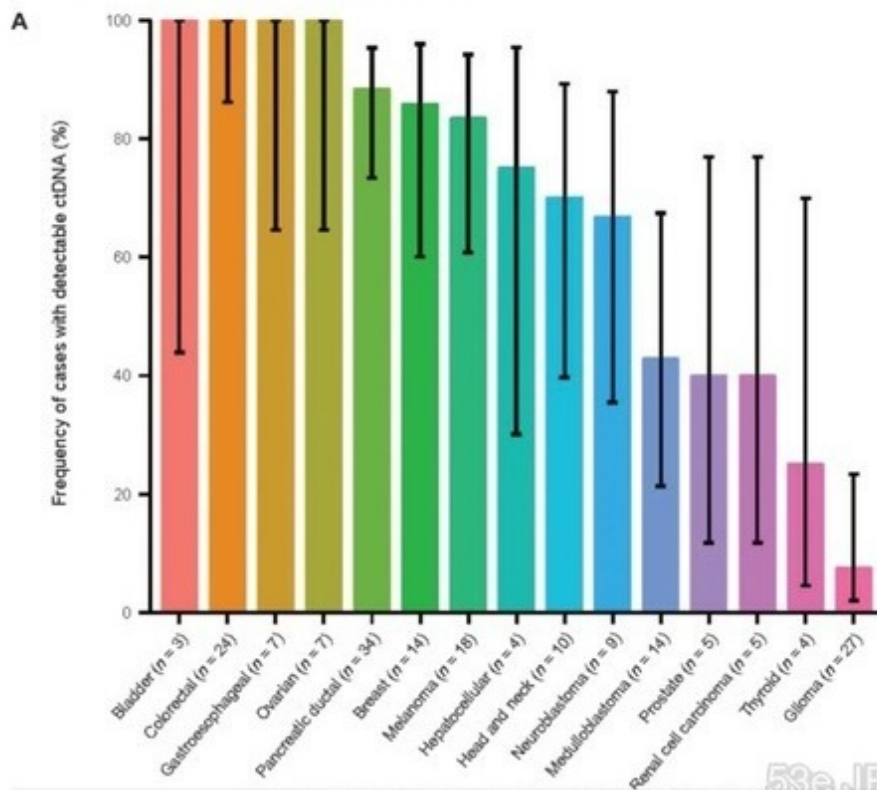


BIOLOGIE. COMPTES RENDUS. — N° 3-4, 1948. T. CXLII.

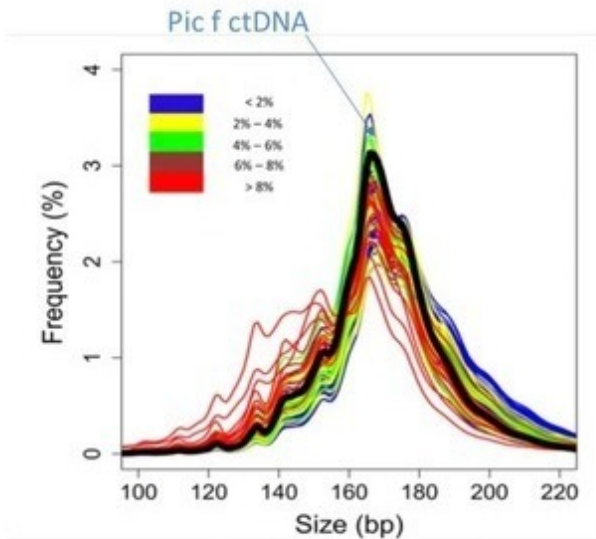


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ctDNA in various cancers

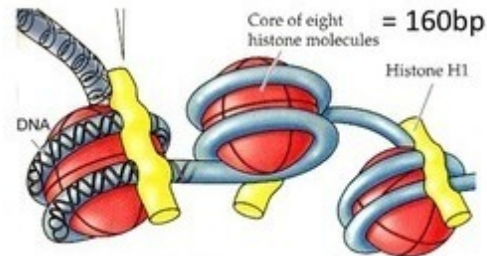


Taille de l'ADN tumoral circulant



plasma DNA in HCC patients (From Jiang pnas 2015)

- Apoptose lead to oligonucleosomal fragment (150-166 bp)



- Necrosis leads to longer fragment (300bp)

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Génotypage du cancer colo-rectal au diagnostic

nature
medicine

A. Thierry ... PJ Lamy 2014

Clinical validation of the detection of *KRAS* and *BRAF* mutations from circulating tumor DNA

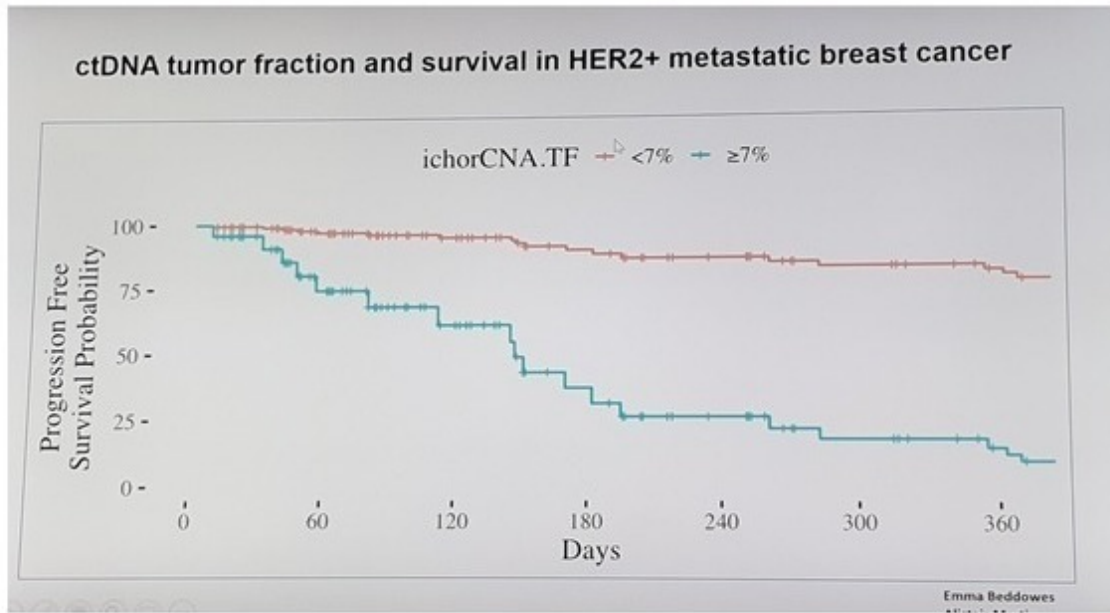
Double-blinded clinical study

Table 2 Concordance between tumor-tissue analysis and cfDNA analysis (n = 95)

		Tumor-tissue analysis					
		<i>KRAS</i>	Mutant	WT	Sensitivity	Specificity	Accuracy
cfDNA analysis	Mutant		36	1	92%	98%	96%
	WT		3	55			
	Total		39	56			
		<i>BRAF</i>	Mutant	WT	Sensitivity	Specificity	Accuracy
cfDNA analysis	Mutant		5	0	100%	100%	100%
	WT		0	90			
	Total		5	90			
		All mutations	Mutant	WT	Sensitivity	Specificity	Accuracy
cfDNA analysis	Mutant		41	1	93%	98%	96%
	WT		3	50			
	Total		44	51			

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Valeur pronostique dans le cancer du sein métastatique

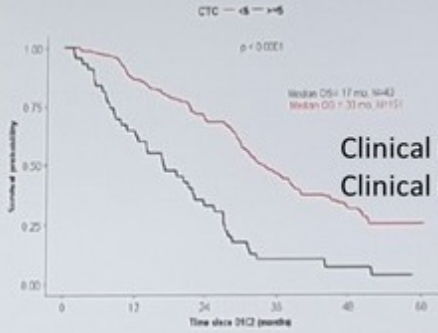
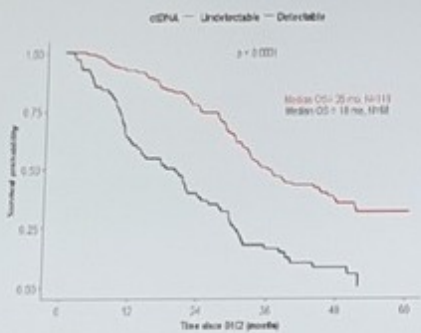


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Overall survival

According to ctDNA at C2

According to CTC at C2



Clinical model + CTC : Added value 17
Clinical model + ctDNA Added value 21

Prognostic factors	P-value	Hazard Ratio	95% H.R Confidence Limits	
Detectable ctDNA at C2	0.0005	2.100	1.379	3.199
CTC ≥ 5 at C2	0.0037	1.954	1.243	3.072
Triple negative	<.0001	3.300	2.139	5.089
Grade = 3	0.0235	1.557	1.061	2.283
Visceral metastasis	0.1489	1.446	0.876	2.387

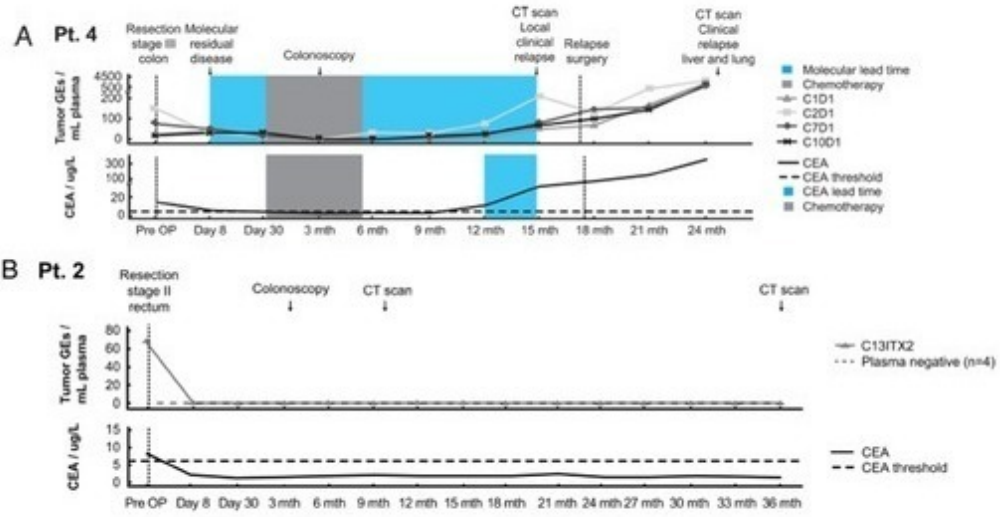
Pierga ASCO 2019

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Suivi du cancer colorectal : détecter les récives

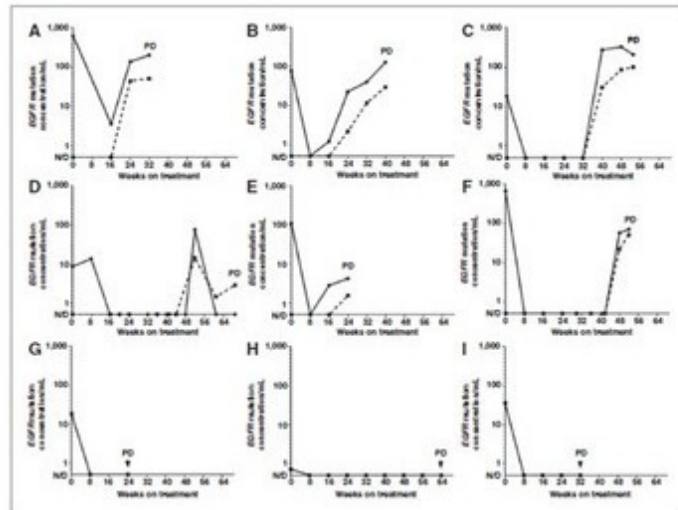
Rheinert et al. Gut 2015

Plasma DNA from 2 to 4 mL plasma
CEA on Cobas (Roche)



Maladie résiduelle et récidive dans le cancer du poumon

Mutations in ctDNA
 _____ EGFR exon 19
 ----- T790M



Patients with resistance mutations (T790M) detected 4 to 24 weeks before progression

Oxnard GR Clin Cancer Res 2015

PJ Lamy 2019

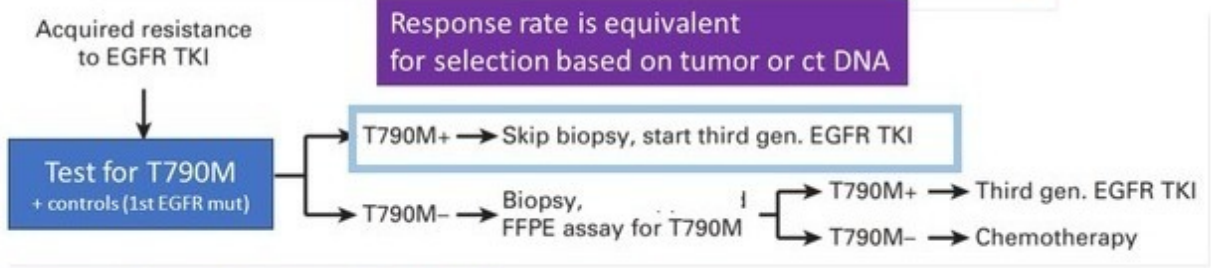
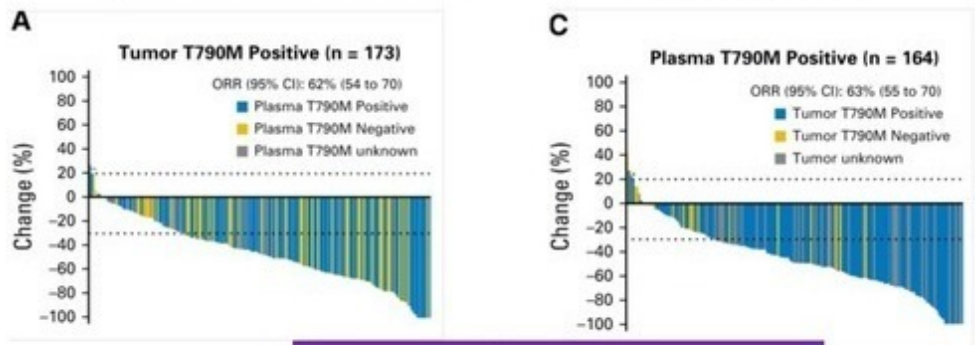
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Prédire la réponse : AURA clinical trial



Waterfall plots for best percentage change in target lesion diameter in patients with T790M mutation in tumor or plasma



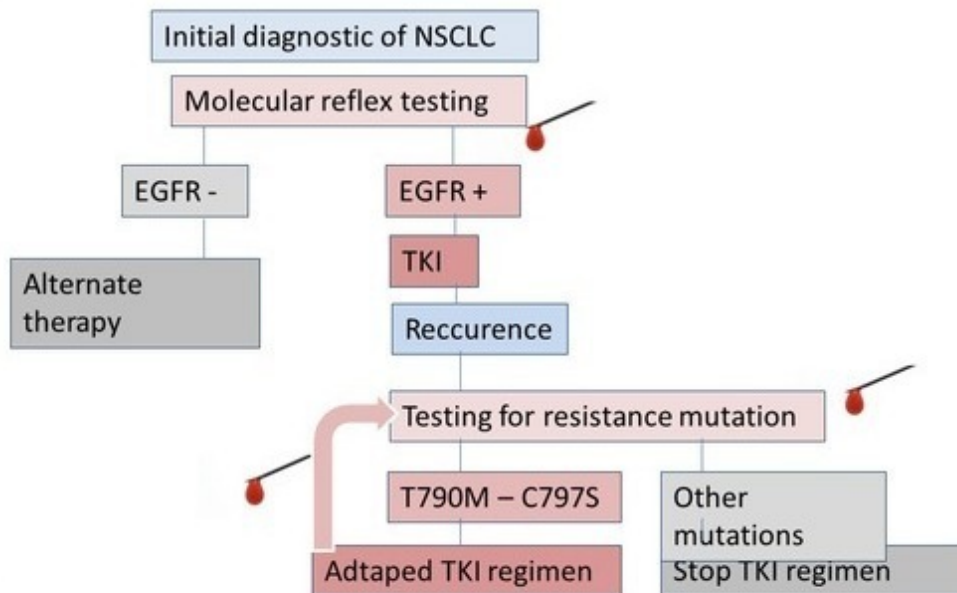
Confirmed NEJM Mok et al 10 dec 2016

PJ Lamy 2019

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NSCLC mutation profile and EGFR inhibitors



CAP/IASLC/AMP: Molecular Testing Guidelines

« ctDNA could be used for clinical settings in which tissue is limited and/or insufficient for molecular testing”

Neal I. Lindeman JTO 2018



***PIK3CA* mutations early persistence in cell-free tumor DNA as a negative prognostic factor in metastatic breast cancer patients treated with hormonal therapy**

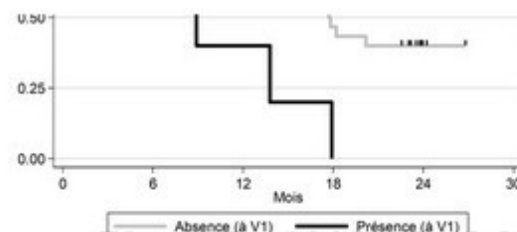
ORIGINAL ARTICLE

Alpelisib for *PIK3CA*-Mutated, Hormone Receptor-Positive Advanced Breast Cancer

Fabrice André, M.D., Eva Ciruelos, M.D., Gabor Rubovszky, M.D., Mario Campone, M.D., Sibylle Loibl, M.D., Hope S. Rugo, M.D., Hiroji Iwata, M.D., Pierfranco Conte, M.D., Ingrid A. Mayer, M.D., Bella Kaufman, M.D., Toshinari Yamashita, M.D., Yen-Shen Lu, M.D., *et al.*, for the SOLAR-1 Study Group*

sample was not associated with 1-year PFS

- Persistence of a detectable circulating mutation at T1 was highly significant of a worse 1-year PFS (40% vs. 76.7%; $p=0.0053$)



ADN ct : Un niveau de concentration très faible

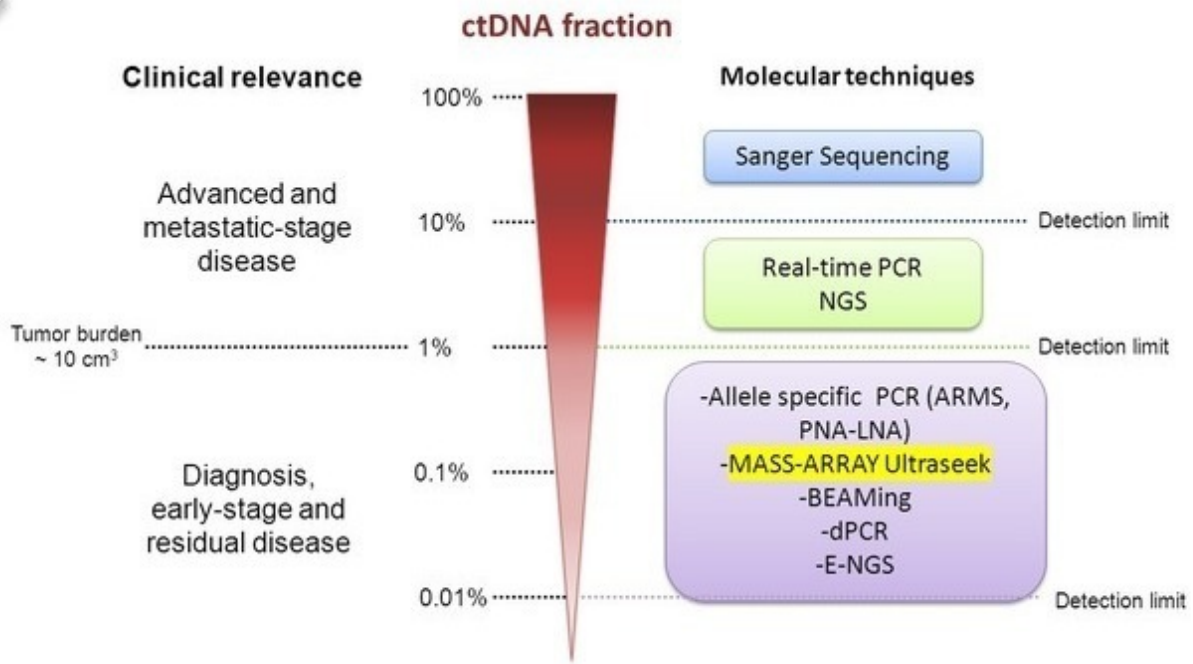


ng DNA	Total Copies	Mutant Allele Frequency Copies						
		1%	0.50%	0.25%	0.10%	0.05%	0.02%	0.01%
10	3000	30	15	7.5	3	1.5	0.6	0.3
20	6000	60	30	15	6	3	1.2	0.6
30	9000	90	45	22.5	9	4.5	1.8	0.9
40	12000	120	60	30	12	6	2.4	1.2
50	15000	150	75	37.5	15	7.5	3	1.5
60	18000	180	90	45	18	9	3.6	1.8
70	21000	210	105	52.5	21	10.5	4.2	2.1
80	24000	240	120	60	24	12	4.8	2.4
90	27000	270	135	67.5	27	13.5	5.4	2.7
100	30000	300	150	75	30	15	6	3
500	150000	1500	7500	375	150	75	30	15

10 ng x 1000 (convert to picograms)/3.3 picograms (10^{-12} g) of DNA per haploid genome = 3030 total copies of DNA

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ADNct : Un problème de sensibilité



Un problème de spécificité

Hématopoïèse clonale

- Reliée à l'âge: 1% < 40 yo to 20% > 70 yo
- Individus sains : prédire les risques d'hémopathies malignes ou pathologies cardiaques
- Évolution sous clonales des progéniteurs (stem-cells)
- Clonal population with unique mutation that could find in ctDNA
- KRAS/JAK2/TP53....

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2019



LE DÉPISTAGE PAR L'ADN TUMORAL CIRCULANT

PJ Lamy 2019

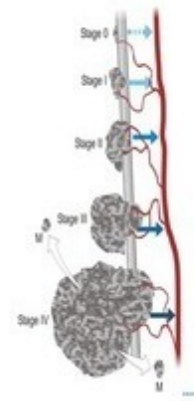
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Méthylation du gène SEPTINE 9

Un TEST DE DEPISTAGE NON INVASIF du Cancer Colo-Rectal

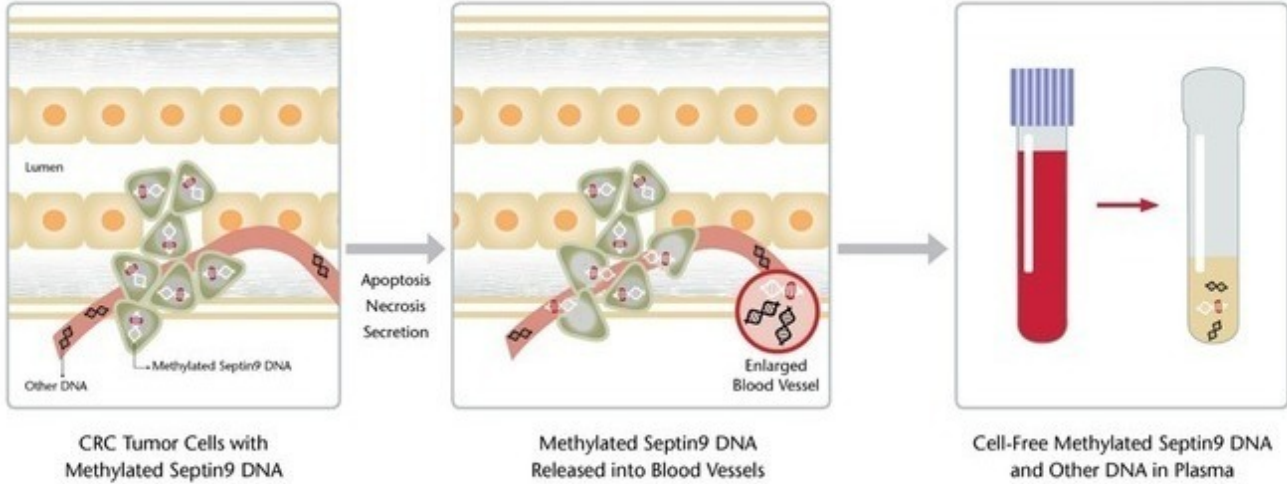
- **Septin9** : Simple blood-based tests widely seen as best way to close the “screening gap”
- Epi proColon® - Septin 9 is based on a single epigenetic biomarker: **methylated Septin9**
- High analytical **sensitivity** (6pg/ml), **specific** for colorectal cancer
- Equal capability to detect **left and right** sided cancerous lesions



Park et al. 2010. Am. J. Gastro.
Tetzner et al. UEGW 2011

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ADN libre circulat sanguin



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Comparison avec les autres tests

Method	Specificity	Sensitivity
Colonoscopy ¹	95%	95%
gFOBT ² (occult blood test)	99.7%	37.1%
iFOBT or FIT ³ (immunological test)	93.7%	69.2%
eipi ^{pro} colon ⁴ 2.0 €	99.3%	80.6%

¹ Zauber AG et. al. Technology assessment report, project ID CRCC0608, 2009 ²Allison et al. 1996 NEJM, ³Park et al. 2010. Am. J. Gastro.
⁴Tetzner et al. UEGW 2011



Nasopharyngeal cancer and EBV ctDNA

- Epstein Barr Virus : an oncogene of NPC
- 20 174 subjects screened
- 1,5 % (n=309) with 2 positive consecutive ctDNA tests
- 0,17 % (n=34) with cancer (a majority of low stage)



How To Birth A Billion-Dollar Industry

Asian Scientist Magazine - 13 févr. 2019

... testing grow from an idea to an actual product, Professor **Dennis Lo** and his team found that liquid biopsy **screening** could detect **NPC** at ...

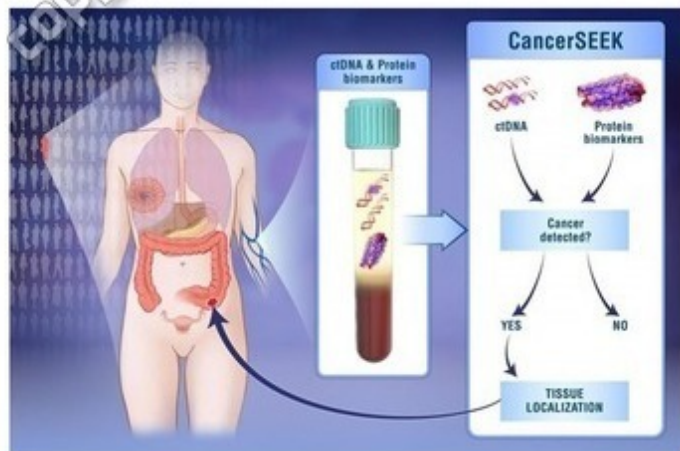


Les marqueurs tumoraux circulants

LE RETOUR?

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CancerSEEK test



ovary, liver, stomach, pancreas, esophagus, colorectum, lung breast.

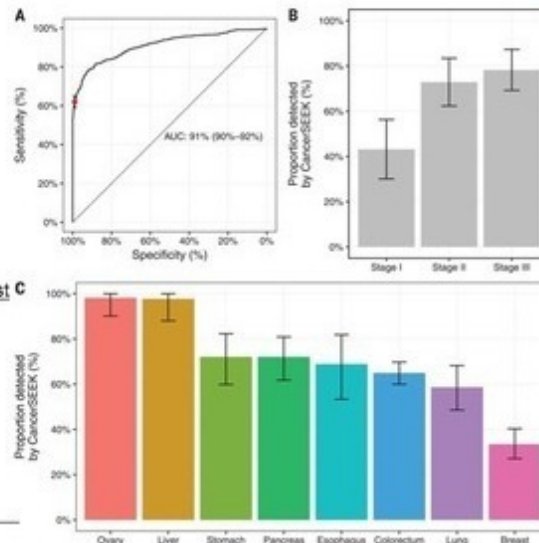
Cohen JD Science 2018

Gènes analysés

- TP53
- PTEN
- KRAS-NRAS-HRAS
- BRAF
- FGFR2
- CDKN2A
- PPP2R1A
- GNAS

Protéines incluses dans le test C

- CA-125
- CEA
- CA19-9
- Prolactin
- HGF
- OPN
- Myeloperoxidase
- TIMP-1



Conclusions

- Le cancer n'existe pas, il existe des cancers : Il n'existe donc pas de marqueur universel
- Les marqueurs moléculaires reflètent la diversité des cancers
- Les biomarqueurs protéiques sont peu spécifiques mais il peuvent être très sensibles
- Les algorithmes permettent d'inclure de multiples paramètres : marqueurs composites, moléculaires, protéiques... à associer avec les données cliniques, l'imagerie etc : BIG DATA!
- C'est avec le passé qu'on écrit l'avenir!

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Merci pour votre attention



Nicolas
Lozano



Leila
Gambier



Florian
Almela



Bastien
Pasquier



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