Ecografia tiroïdal i intel·ligència artificial

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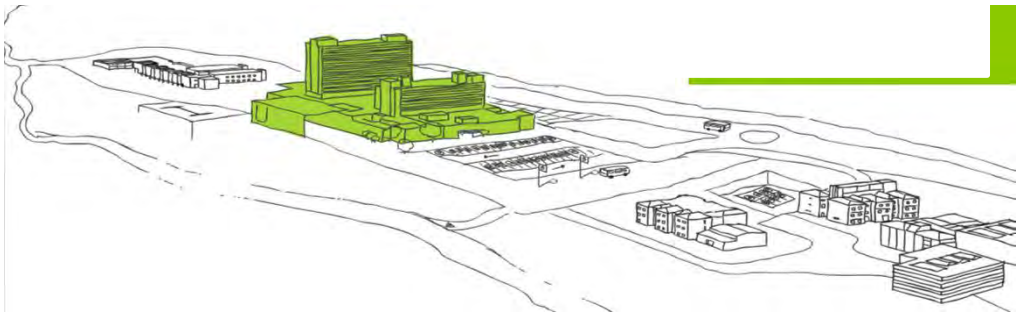
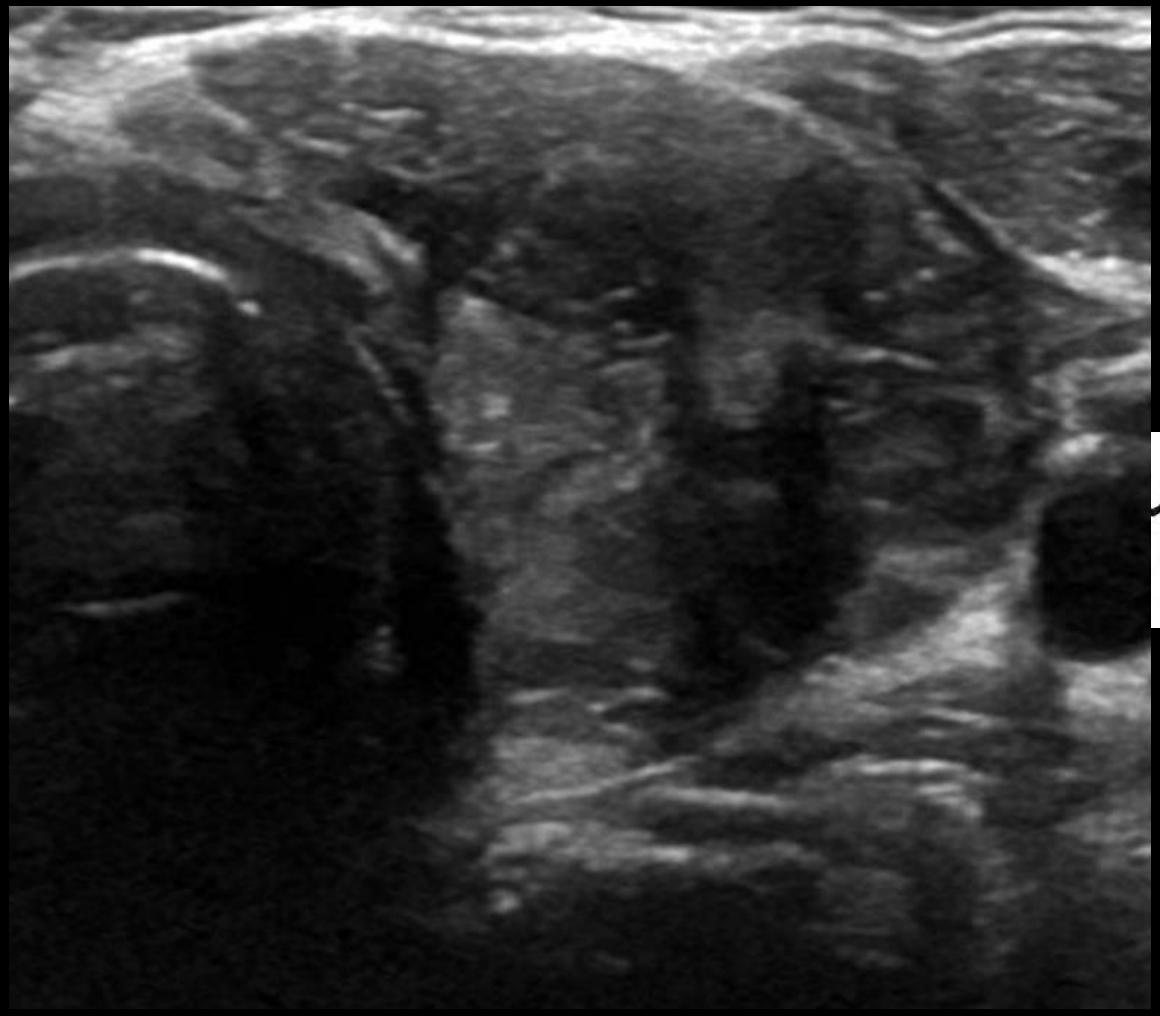
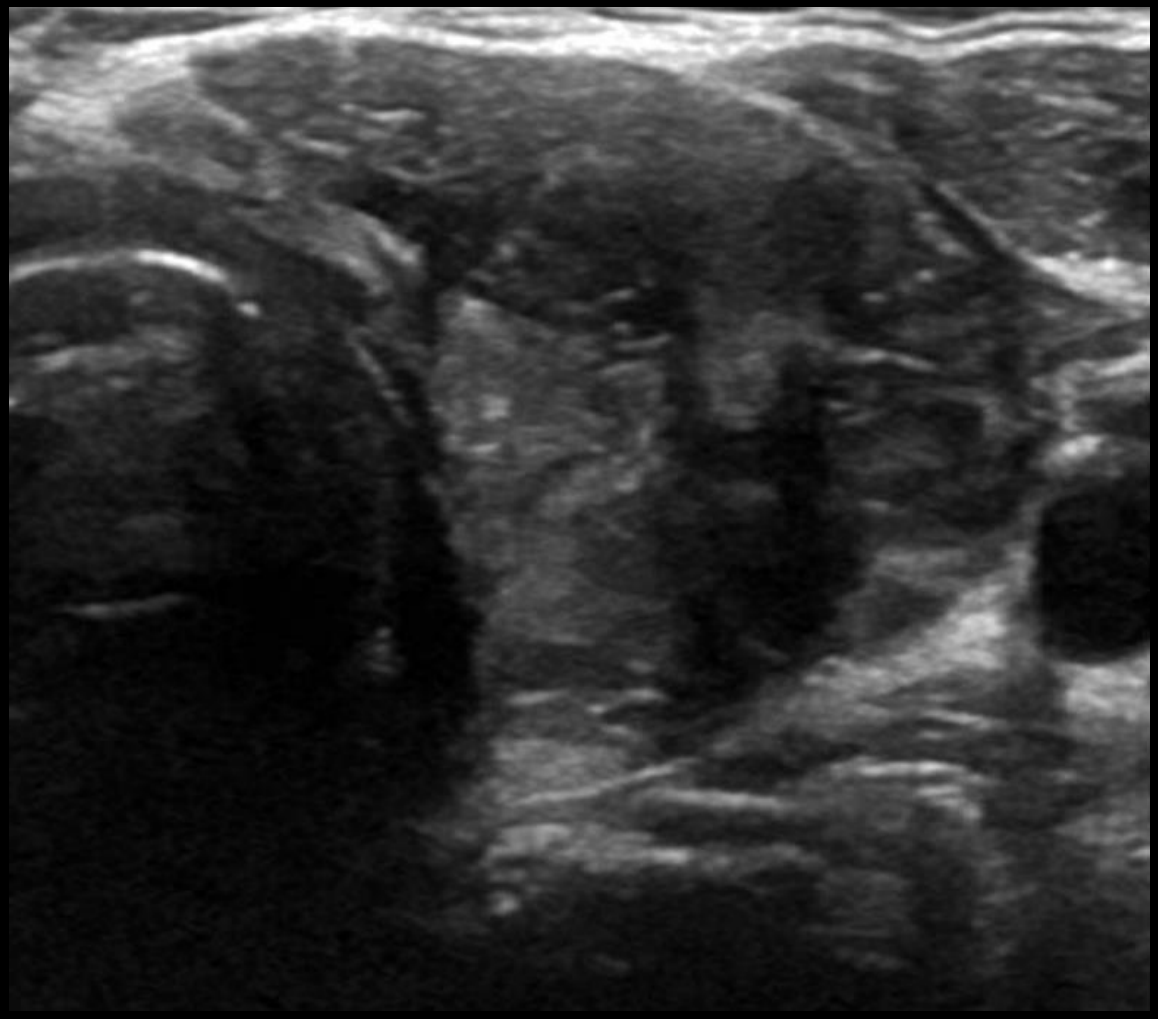
Badalona





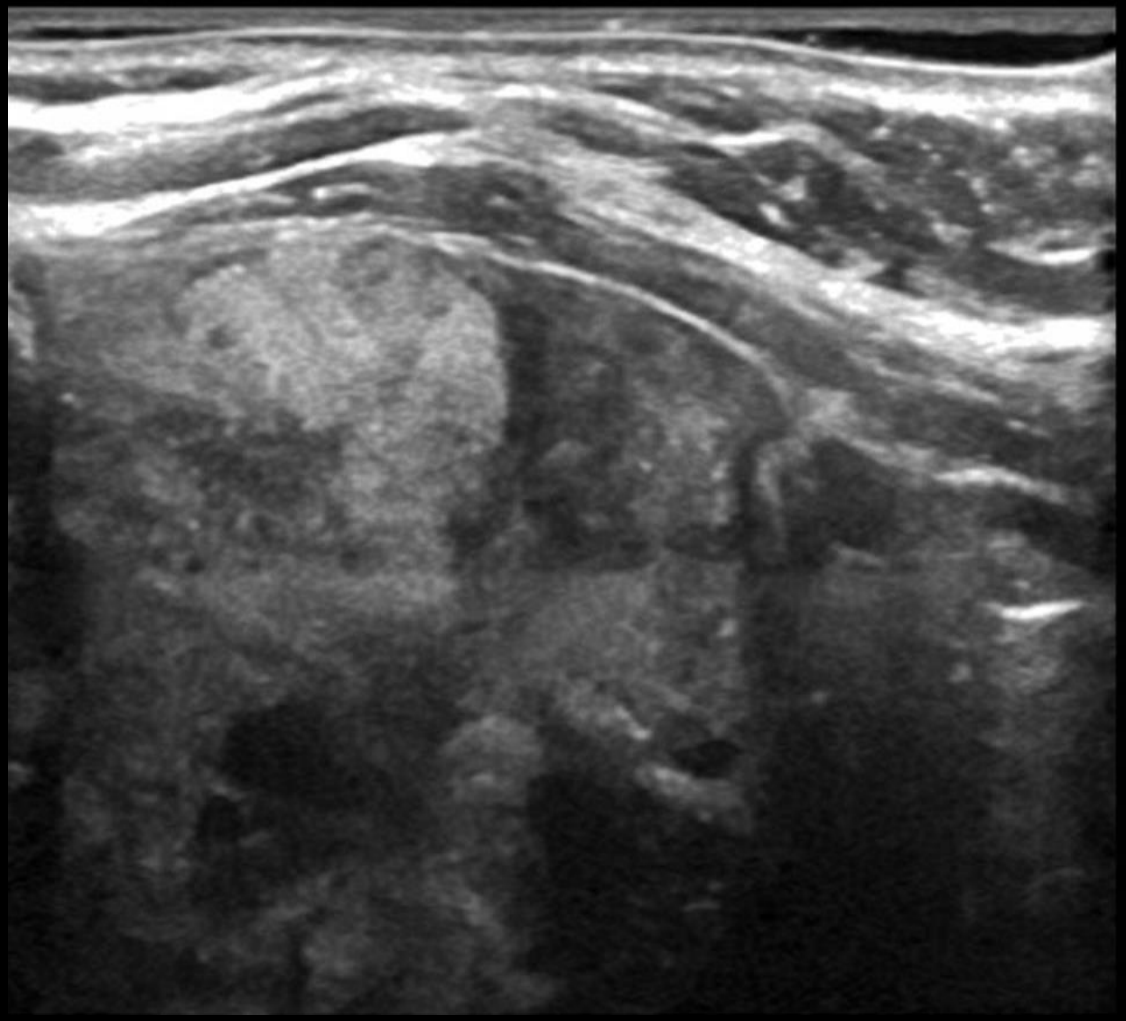
Classificació de risc TI-RADS ?



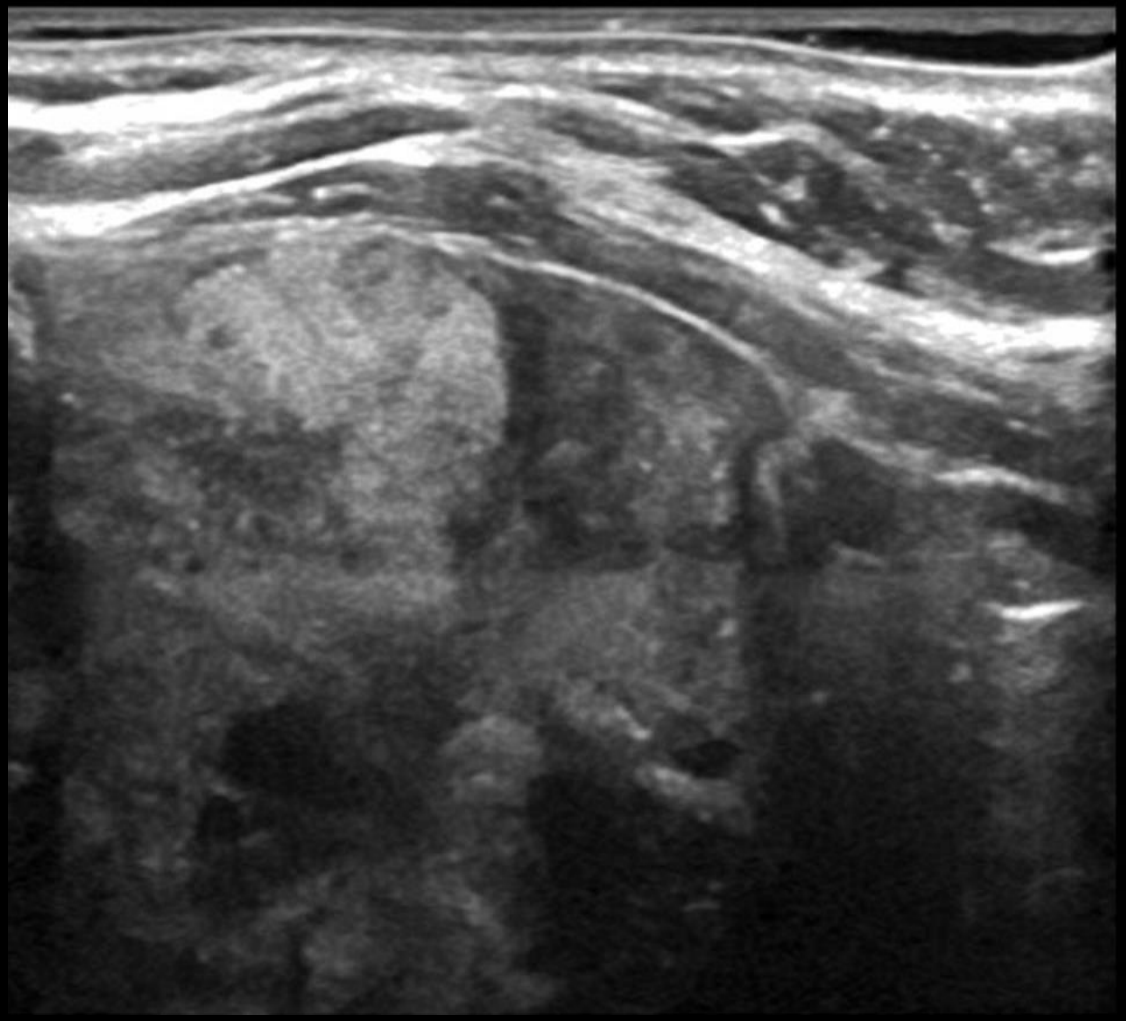
Classificació de risc TI-RADS ?

TI-RADS

3 :	44 %
4 :	22 %
5 :	33 %



Classificació de risc TI-RADS ?



Classificació de risc TI-RADS ?

TIRADS

2 :	11 %
3 :	66 %
4 :	22 %
5 :	11 %

Ecografia de la tiroide

Variabilitat interobservador

Table 1 Interobserver agreement for single US features,

	This study	
Echogenicity	0.56 (0.46–0.66)	0.66 (0.59–0.73)
Composition	0.52 (0.34–0.68)	0.5 (0.29–0.68)
Shape	N/A	N/A
Margin	0.51 (0.43–0.58)	0.44 (0.34–0.53)
Vascularity	N/A	N/A
Calcification	0.8 (0.63–0.93)	0.89 (0.75–1)
Micro-	0.49 (–0.28–1)	0.39 (–0.49–1)
Macro-	0.85 (0.59–1)	0.83 (0.6–1)
Echogenic foci	0.48 (0.3–0.64)	0.35 (0.17–0.52)
Capsule invasion	0.11 (–0.91–1)	0.4 (–1–1)

***Endocrine Connections* 2018**

Kappa	Interpretation
<0	Less than chance agreement
.01-.20	Slight agreement
.21-.40	Fair agreement
.41-.60	Moderate agreement
.61-.80	Substantial agreement
.81-.99	Almost perfect agreement

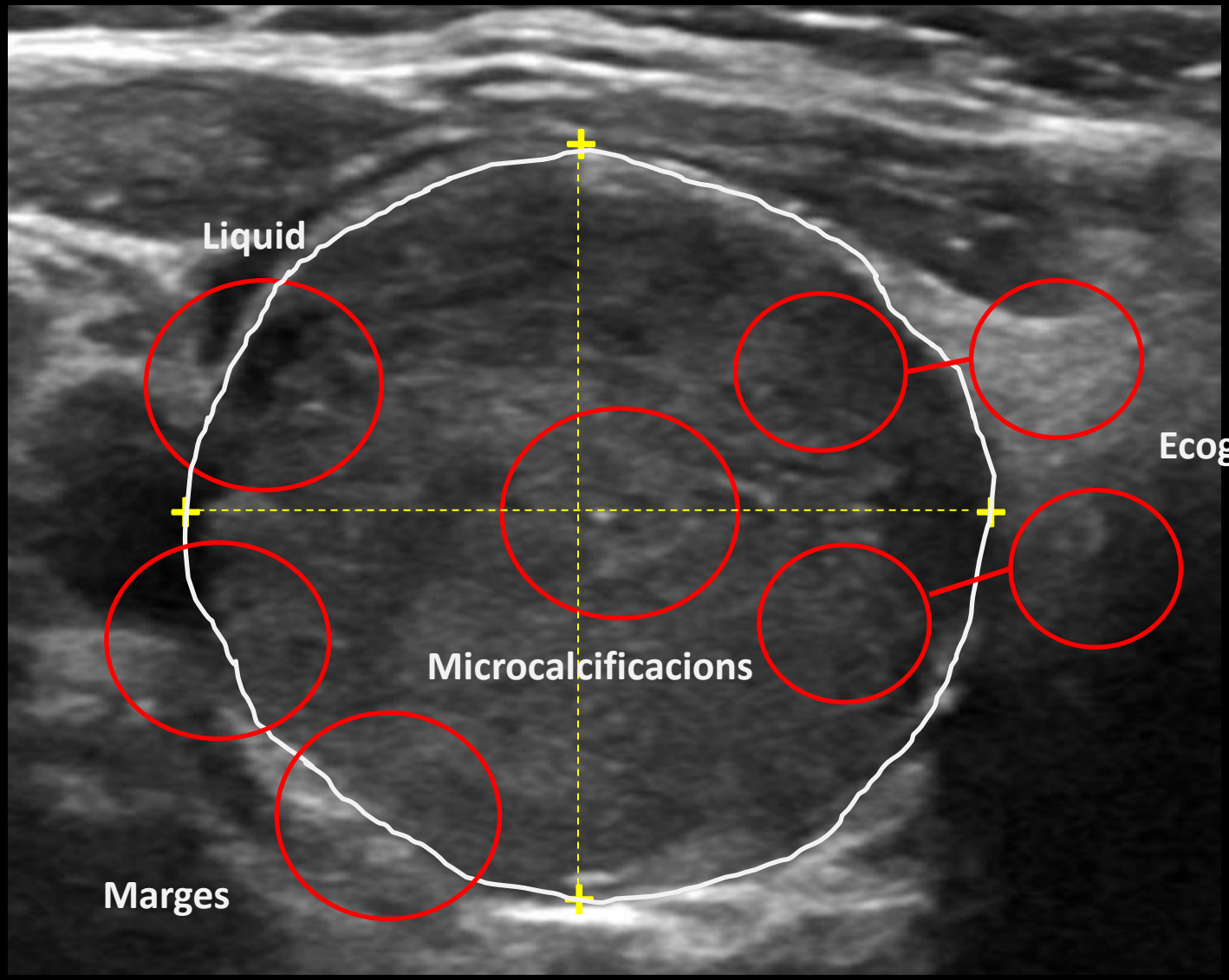
Source. Viera and Garrett (2005).

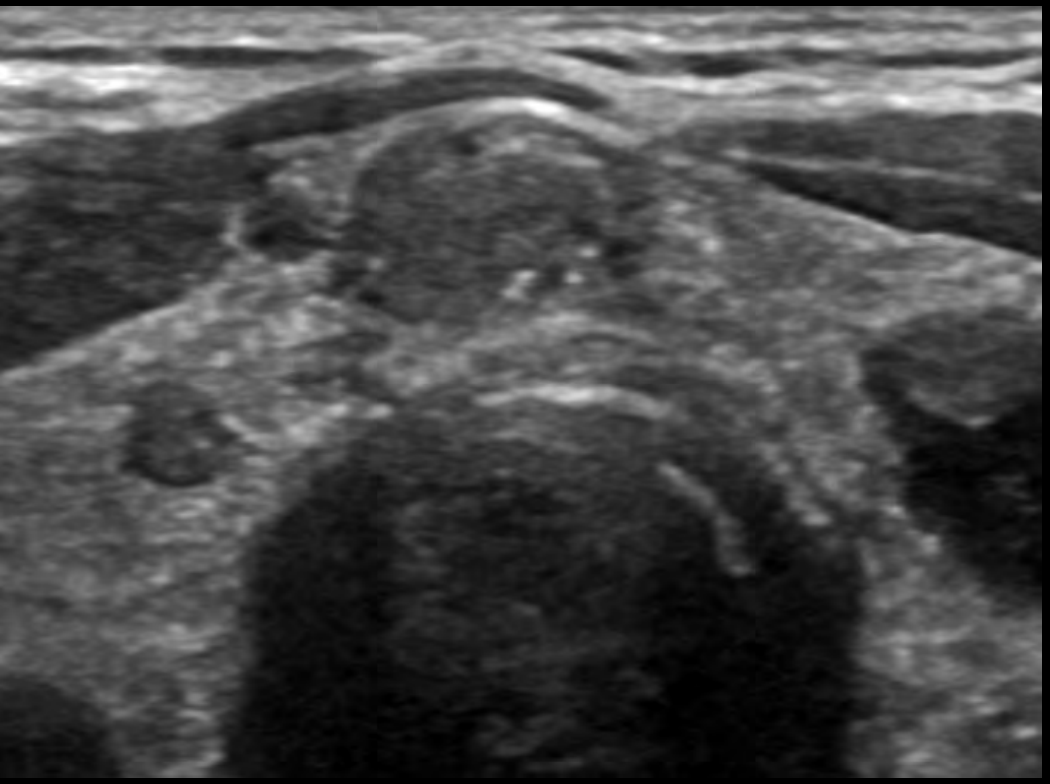
XXVè Congrès de la Societat Catalana d'Endocrinologia i Nutrició
Barcelona, 24 i 25 de novembre 2022

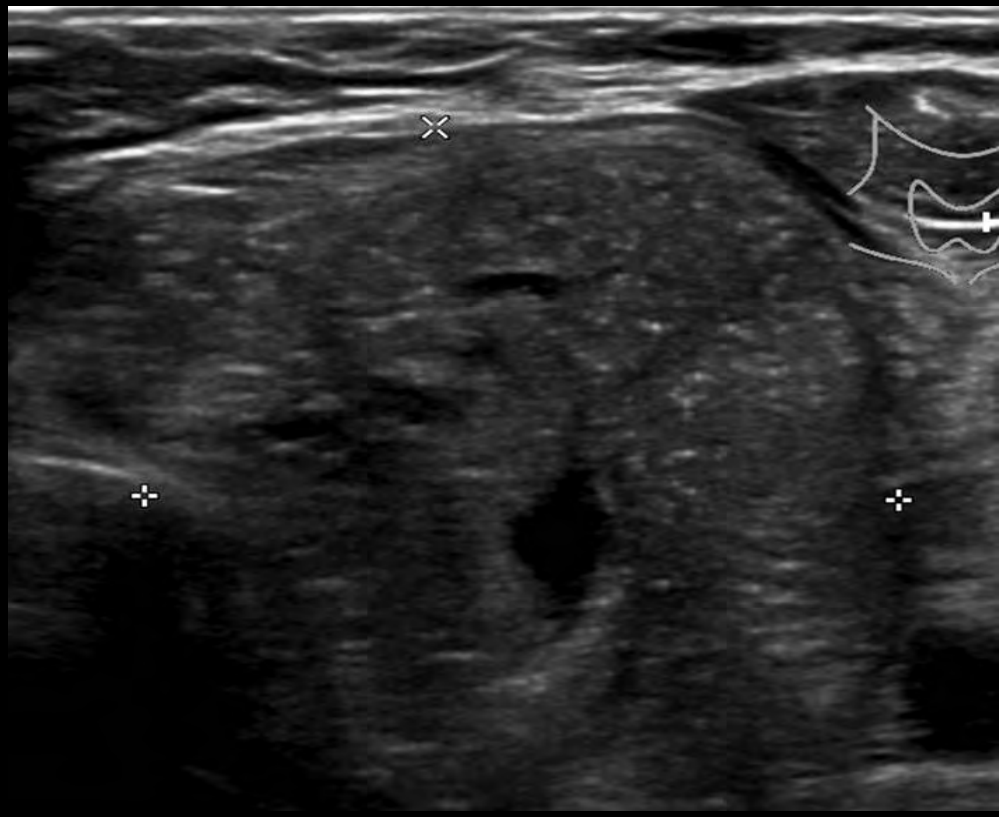
XXVè Congrès de la Societat Catalana d'Endocrinologia i Nutrició
Barcelona, 24 i 25 de novembre 2022

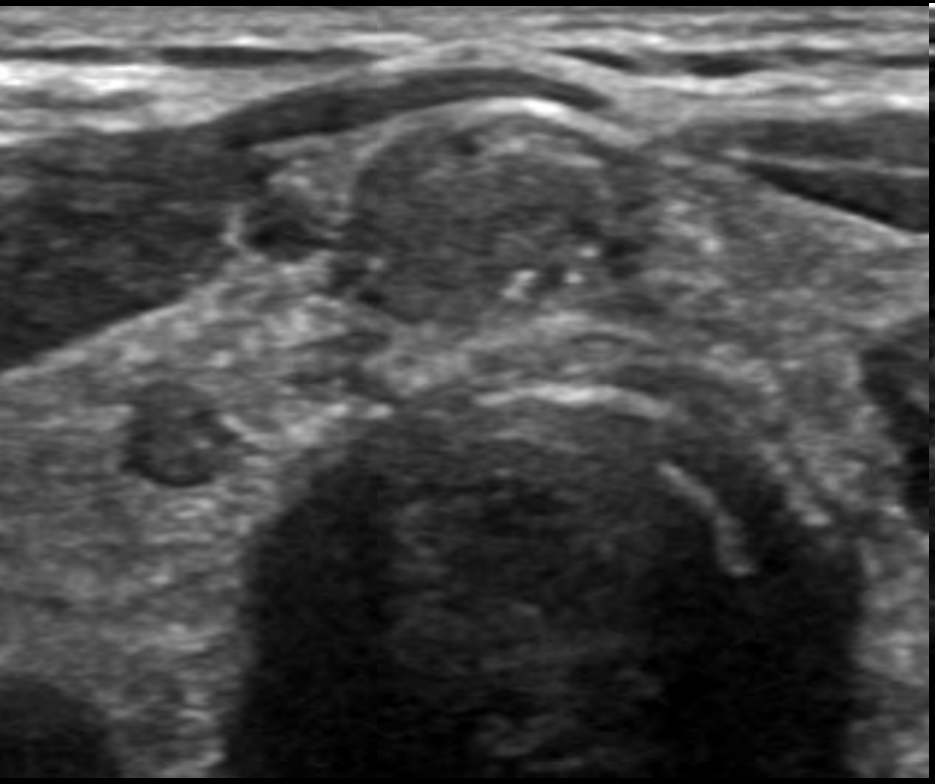
Forma

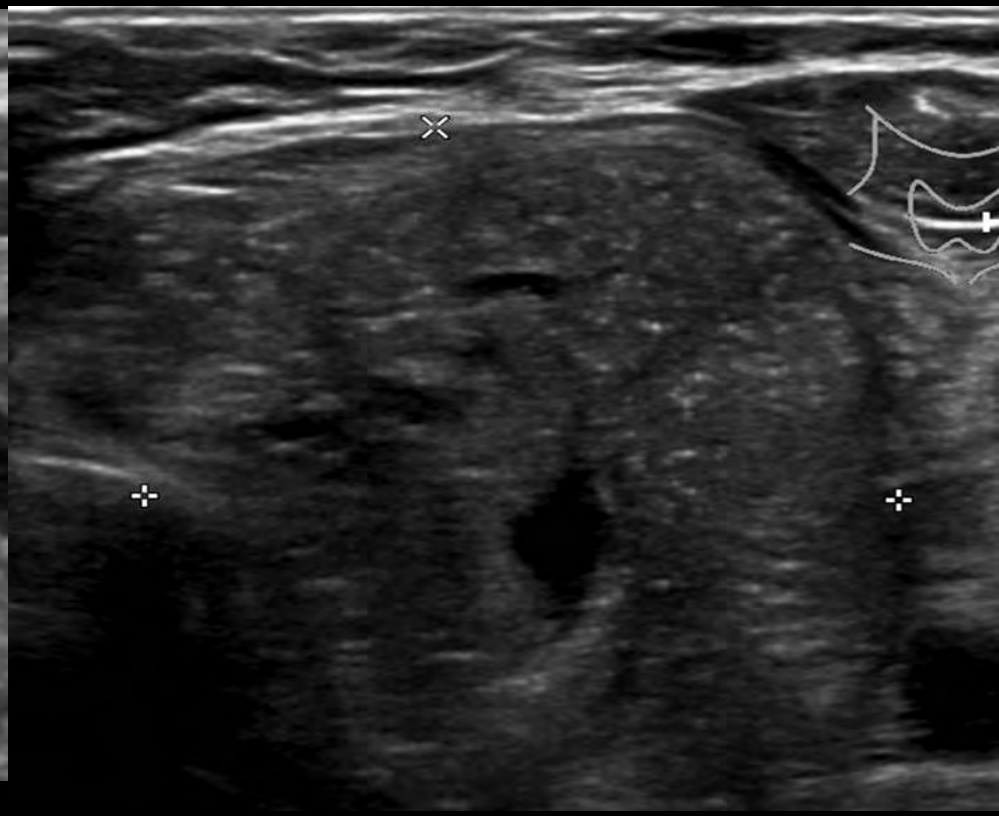
Grandària











Intel·ligència artificial en ecografia tiroïdal

Alexa,
Que et sembla
la imatge d'aquest nòdul?

Intel·ligència artificial en ecografia tiroïdal

Computer Assisted Diagnosis Systems (CAD)

Benigne,
No cal punció

Intel·ligència artificial

Artificial intelligence

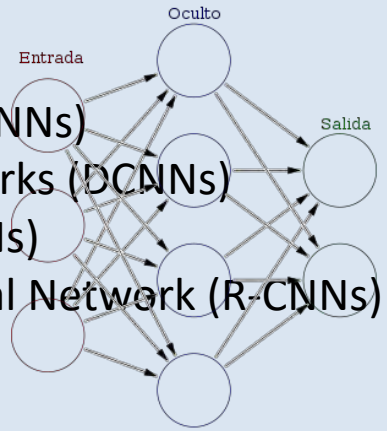
Machine learning

Deep learning

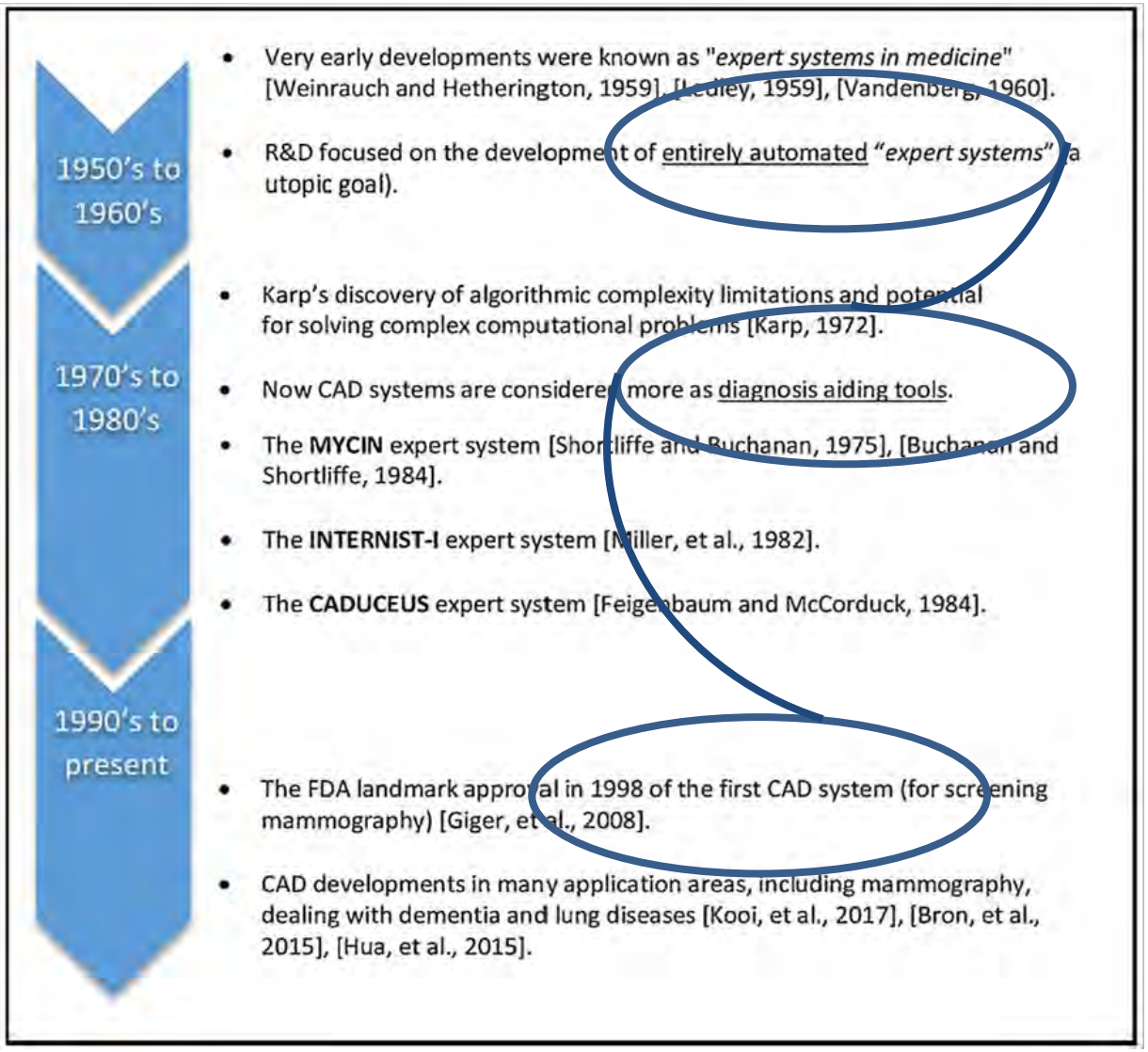
Support Vector Machines, Random forest,
Bayessian classifiers, k-nearest neighbor

Neural network architecture

Convolutional Neural Networks (CNNs)
Deep Convolutional Neural Networks (DCNNs)
Fully Convolutional Networks (FCNs)
Region Based Convolutional Neural Network (R-CNNs)
Faster R-CNN
Mask R-CNN

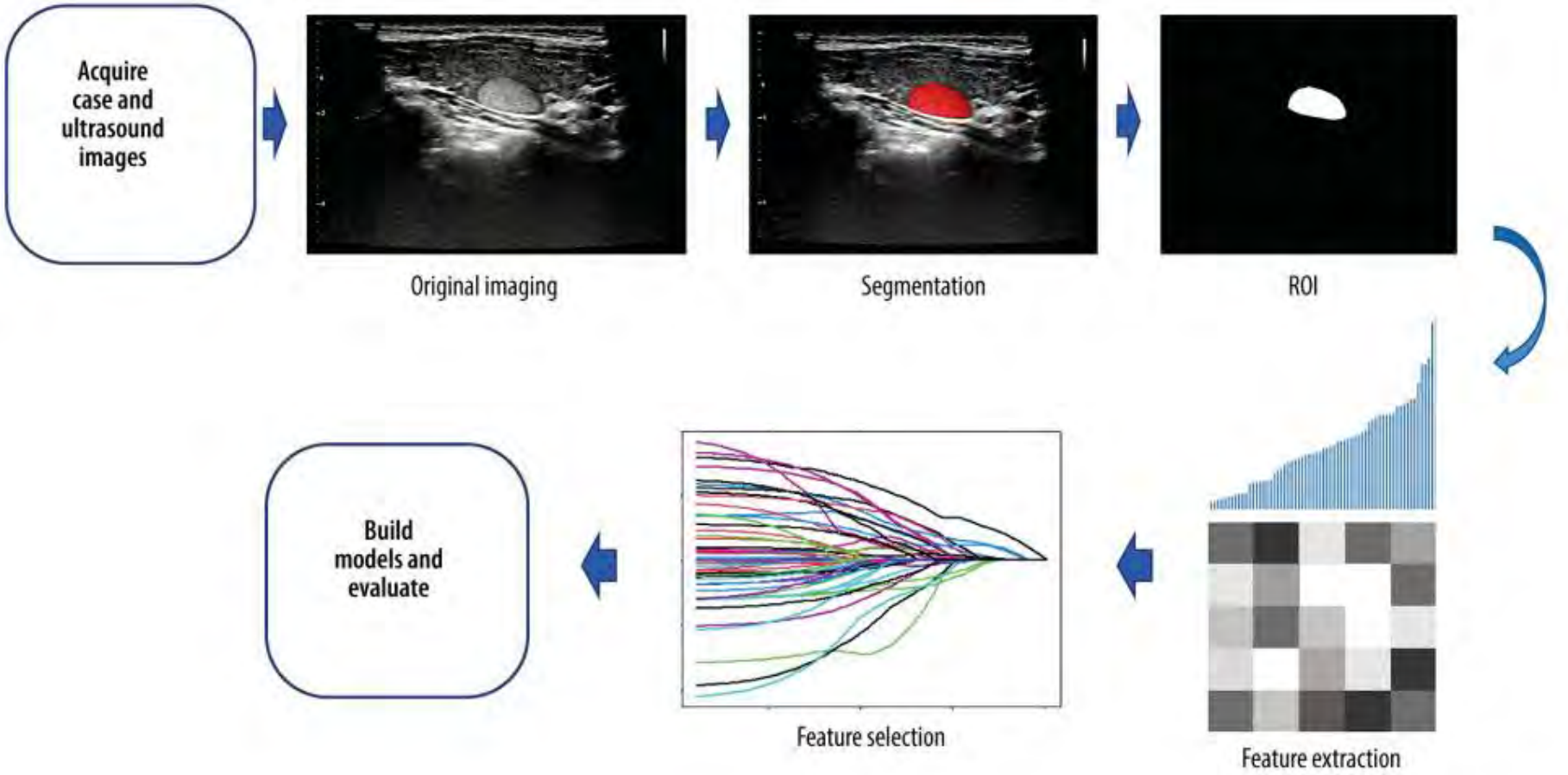


Intel·ligència artificial en Medicina

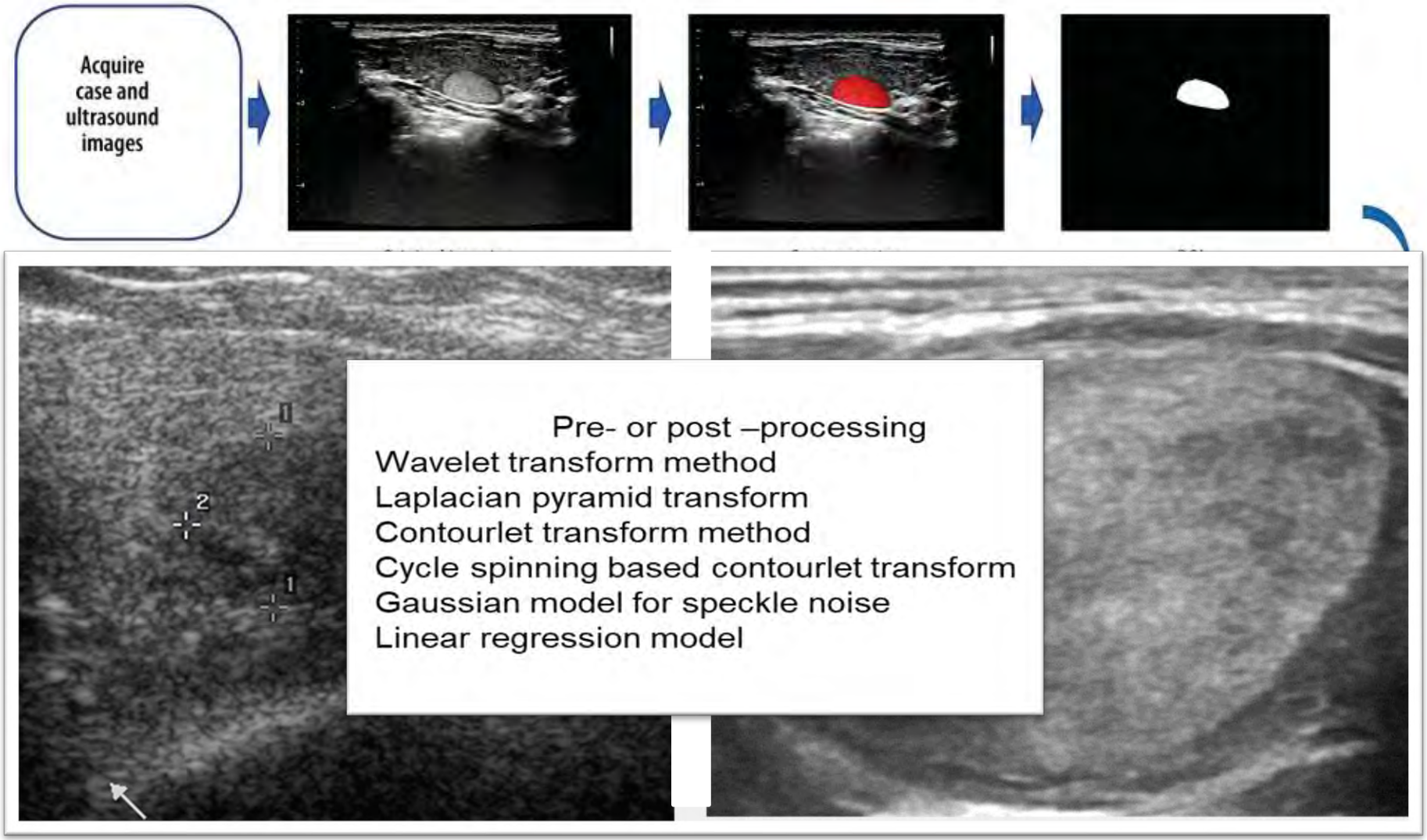


J Med Informatics 2019

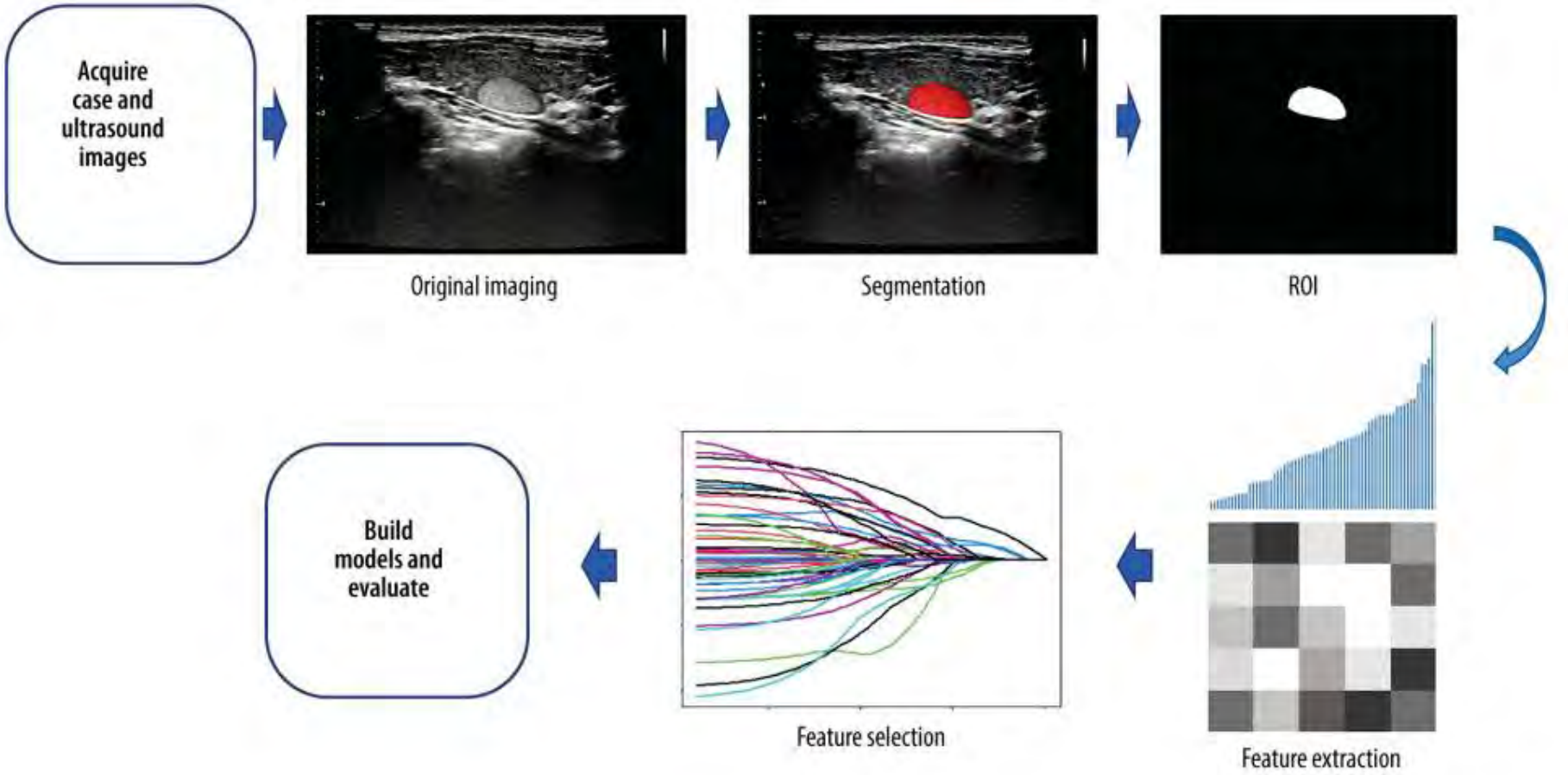
Intel·ligència artificial en ecografia



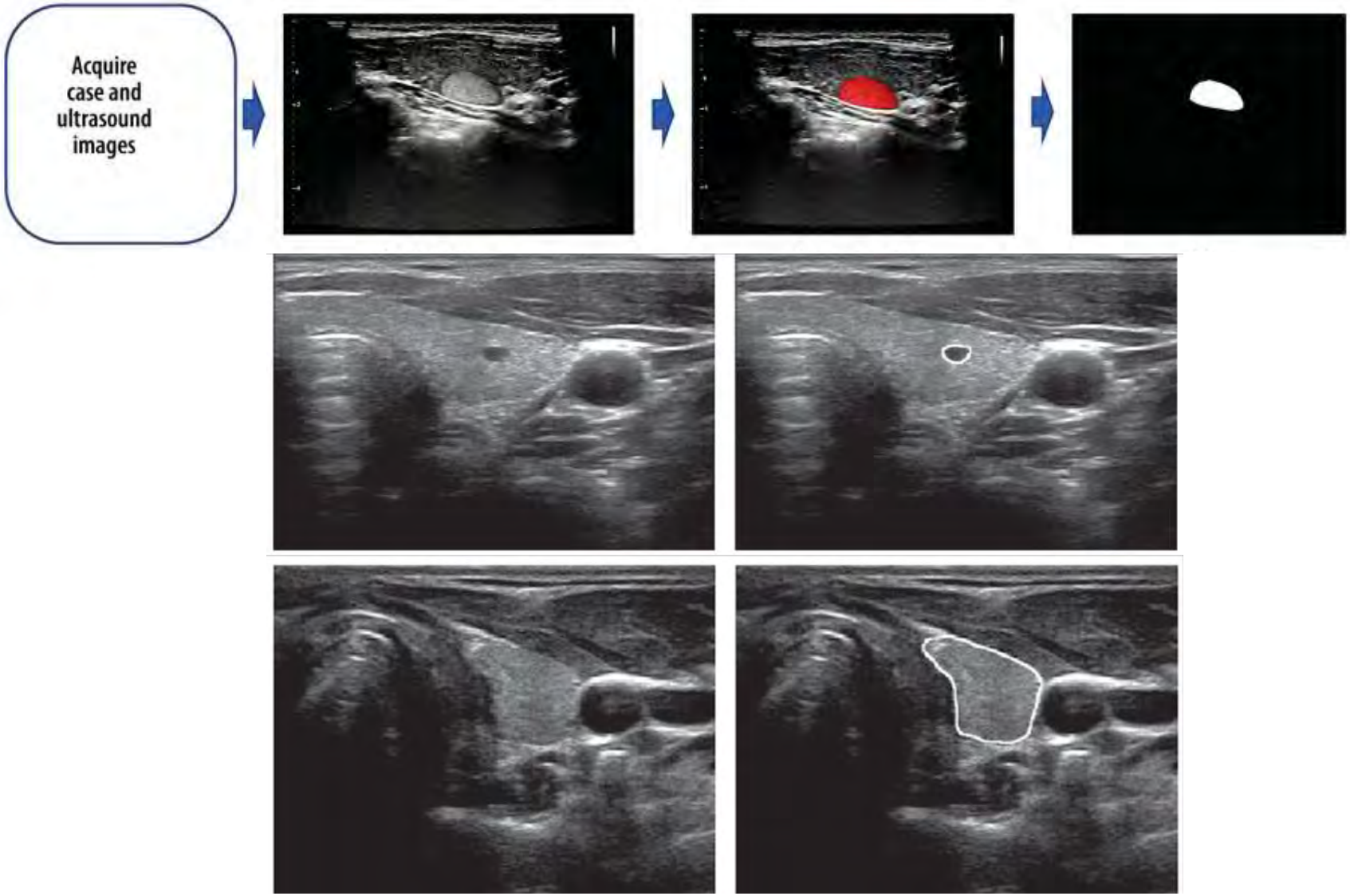
Intel·ligència artificial en ecografia



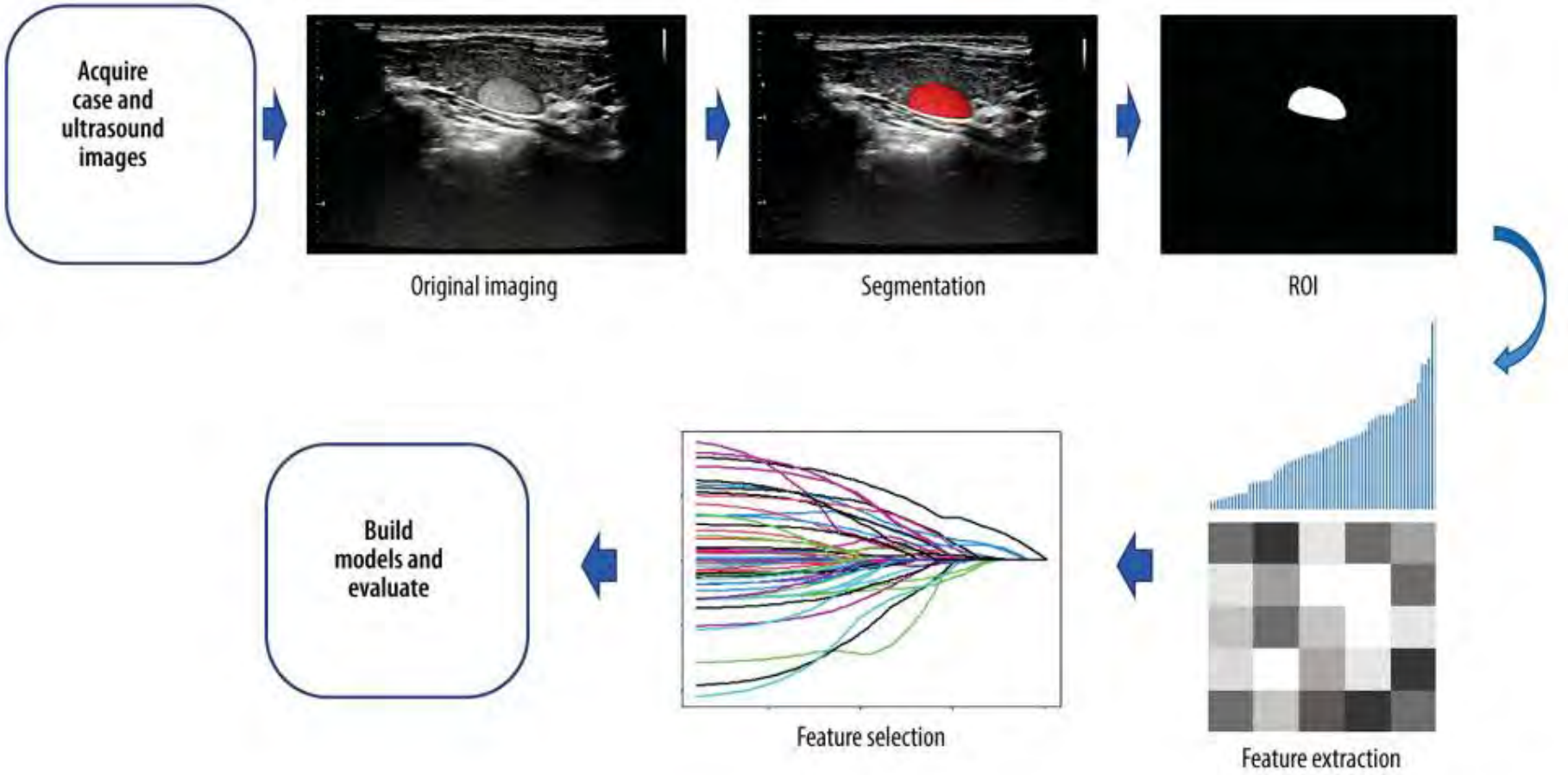
Intel·ligència artificial en ecografia



Intel·ligència artificial en ecografia



Intel·ligència artificial en ecografia

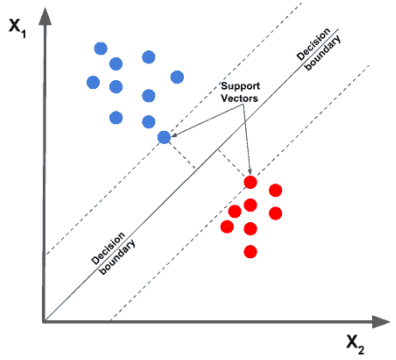


Intel·ligència artificial en ecografia

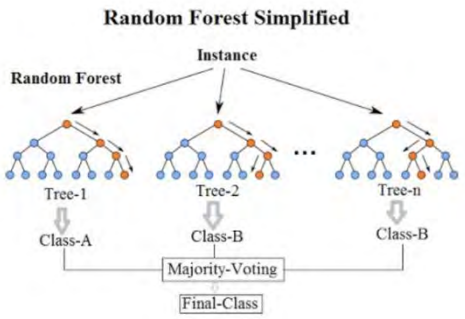
Identificació i anàlisi de les característiques

Metodologies no - CNN

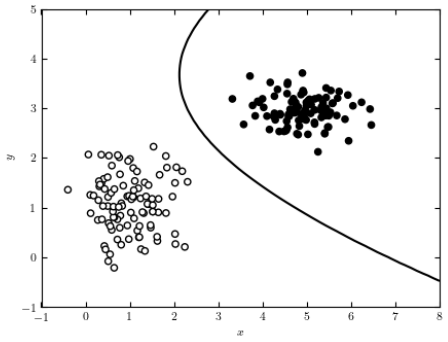
Support Vector Machines (SVM)



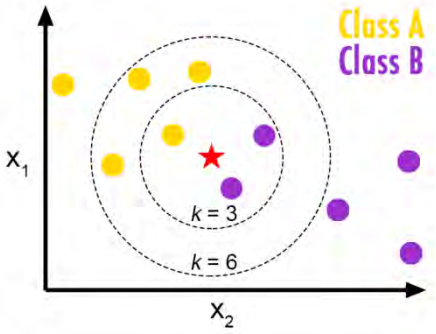
Random Forest (RF)



Bayesian classifiers



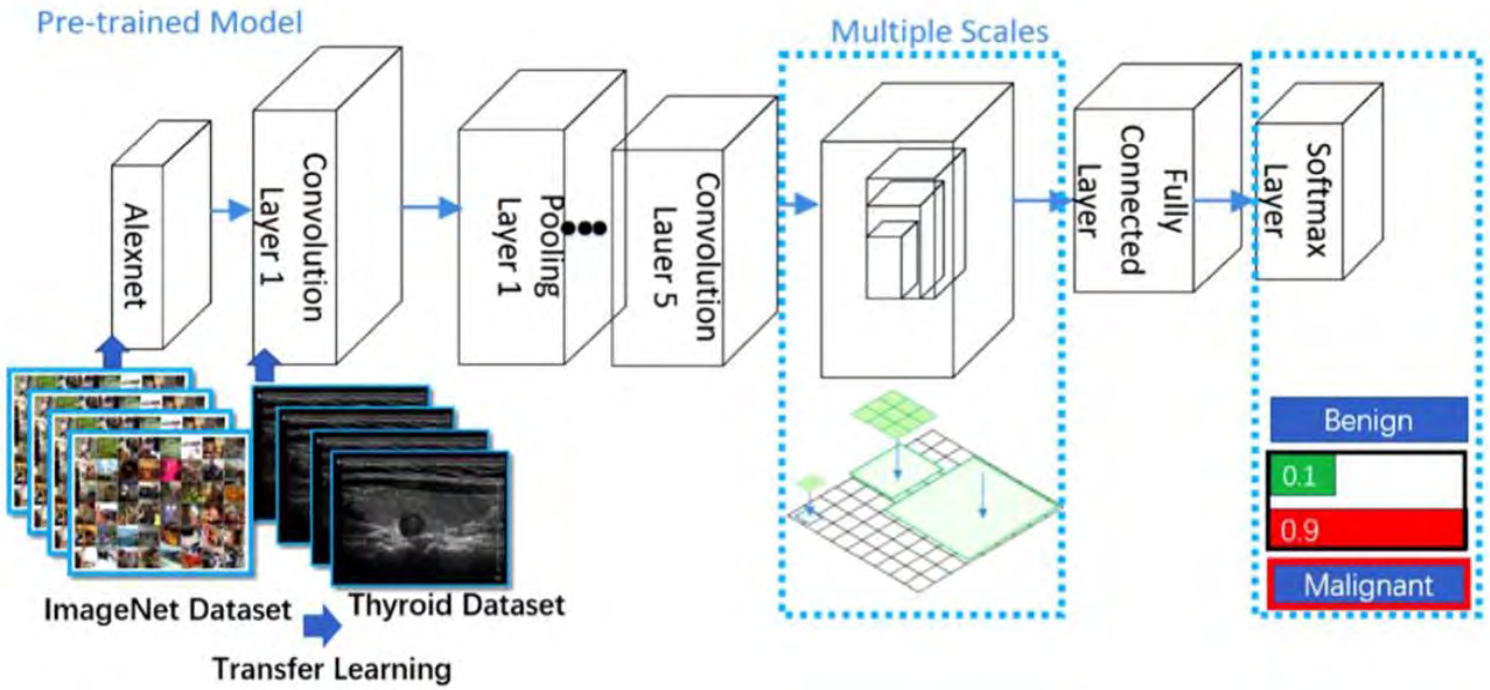
K-nearest neighbor (k-nn)



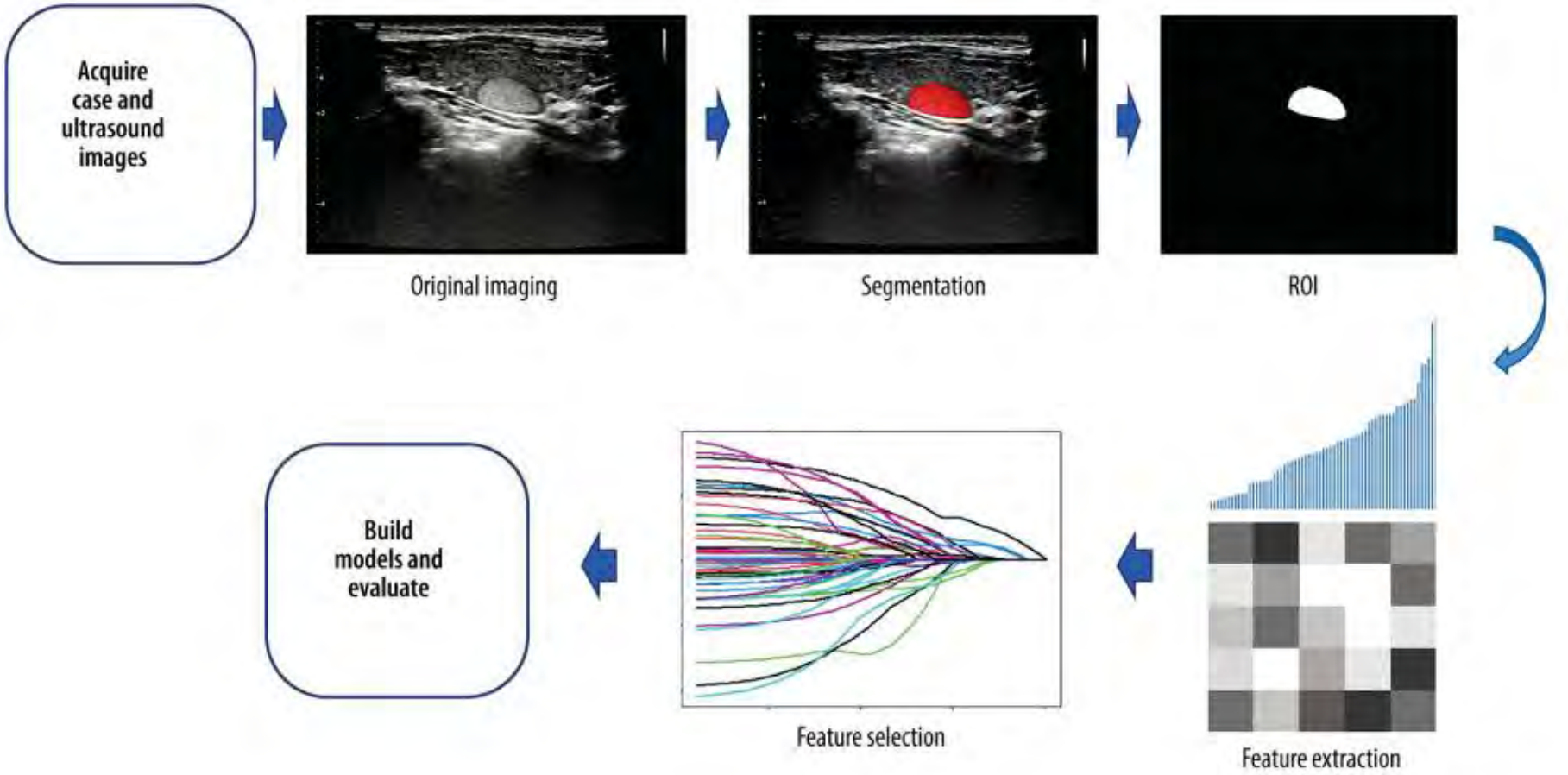
Intel·ligència artificial en ecografia

Identificació i anàlisi de les característiques

Metodologia de xarxa neuronal convolucional (CNN)

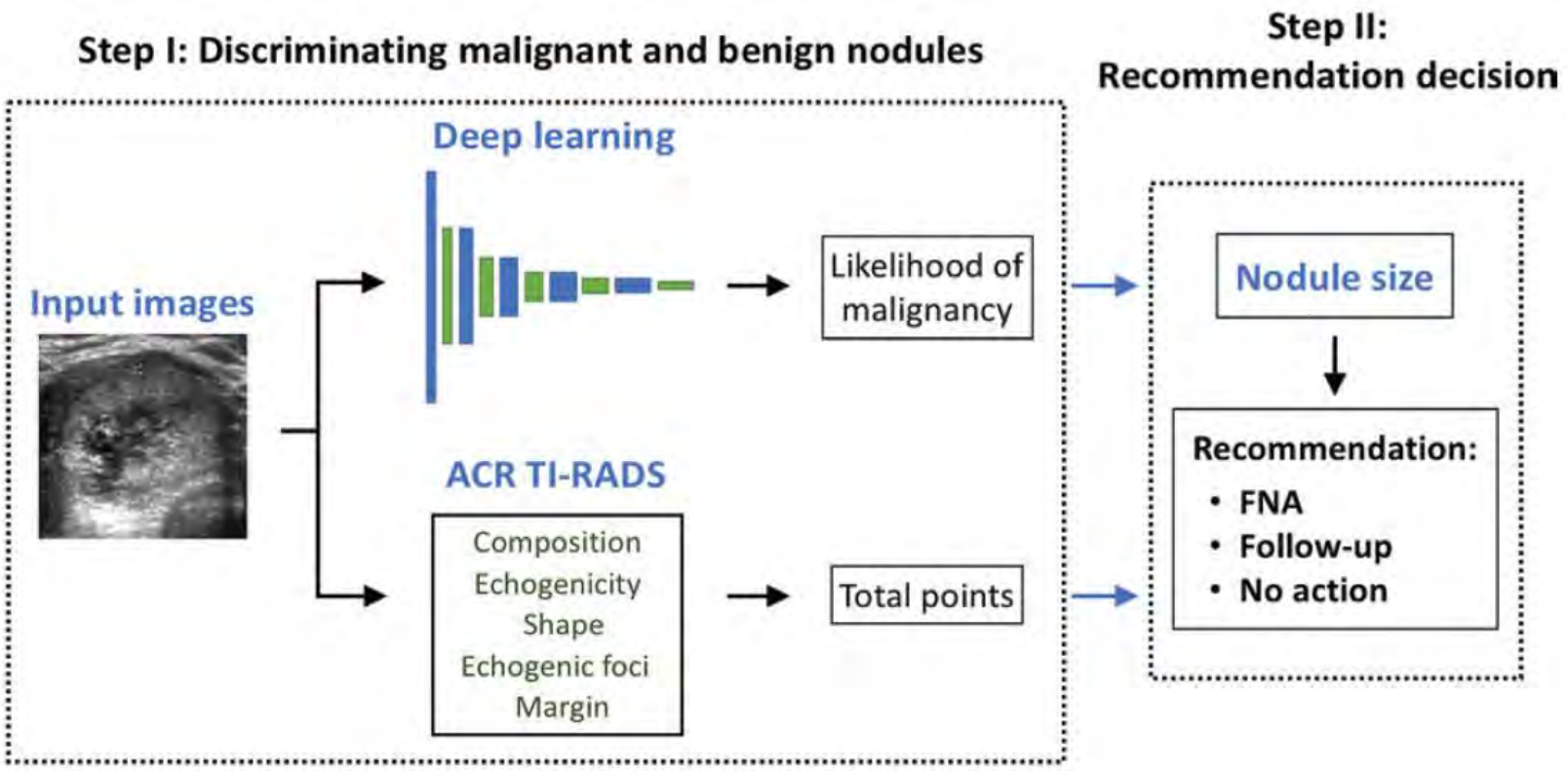


Intel·ligència artificial en ecografia



Intel·ligència artificial en ecografia

4.- Classificació automàtica. Recomanació



Systematic Review

Radiomic Detection of Malignancy within Thyroid Nodules Using Ultrasonography—A Systematic Review and Meta-Analysis

Eoin F. Cleere [1,2,*], Matthew G. Davey [1], Shane O'Neill [3], Mel Corbett [2], John P O'Donnell [4], Sean Hackin Ivan J. Keogh [2], Aoife J. Lowery [1,3] and Michael J. Kerin [1,3]

Intel·ligència artificial en ecografia

Author	Year	Study Type (LOE)	Radiomics	Country	US Device Brand	N Patients	Male	Female	Mean Age
Zhou	2020	RC (III)	CNN	China	Esaote/Phillips	105	25	80	47.9
Nguyen	2019	RC (III)	CNN	Korea	NS	61	NS	NS	NS
Wei	2020	RC (III)	CNN	China	NS	2489	614	1875	45.3
Park	2019	PC (II)	CNN	Korea	Samsung	265	52	213	47.1
Thomas	2020	RC (III)	CNN	USA	4 brands	103	NS	NS	NS
Wei (2)	2020	RC (III)	Non-CNN	China	5 brands	NS	NS	NS	47
Liu	2019	RC (III)	CNN	China	Vinno	131	54	77	46.7
Stib	2020	RC (III)	CNN	USA	Siemens/GE/Phillips	571	234	337	52.9
Ye	2020	RC (III)	CNN	China	5 brands	166	46	100	44.6
Ma	2020	RC (III)	CNN	China	NS	211	34	177	NS
Koh	2020	RC (III)	CNN	Korea	11 brands	200	49	151	49.6
Kwon	2020	RC (III)	CNN	Korea	Phillips/Hitachi	762	NS	NS	NS
Kim	2019	RC (III)	Non-CNN	Korea	Samsung	106	29	77	48
Zhao	2020	RC (III)	Non-CNN	China	Phillips/Hitachi	174	44	130	45
Qin	2019	RC (III)	CNN	China	NS	233	NS	NS	NS
Zhu	2021	RC (III)	CNN	China	4 brands	102	0	102	54.8
Liu (2)	2019	RC (III)	CNN	China	GE	376	NS	NS	NS
Xia	2019	PC (II)	CNN	China	Samsung	171	32	139	47.2
Zhao	2021	RC (III)	Non-CNN	China	SuperSonic	102	25	77	50.6
Lee	2019	RC (III)	CNN	Korea	Phillips/Hitachi	519	93	426	47.5
Ataide	2020	RC (III)	Non-CNN	Germany	NS	99	NS	NS	NS
Chen	2020	RC (III)	Non-CNN	China	GE/Hitachi	1480	302	1178	45.6
Zhu (2)	2021	RC (III)	CNN	China	Phillips/GE/Toshiba	261	64	197	52
Shi	2020	RC (III)	CNN	China	Esaote/Hitachi/Toshiba	NS	NS	NS	NS
Barczyński	2020	PC (II)	CNN	Poland	Samsung	50	9	41	47.5
Zhang	2020	RC (III)	Non-CNN	Korea	Siemens	303	59	244	46.4
Wei (3)	2020	RC (III)	Non-CNN	China	Samsung	181	35	146	46
Colakoglu	2019	RC (III)	Non-CNN	Turkey	GE	198	48	150	44.5
Park	2021	RC (III)	Non-CNN	Korea	Phillips	325	61	264	50.1
Nguyen	2020	RC (III)	CNN	Korea	NS	61	NS	NS	NS
Sun	2020	RC (III)	CNN	China	GE	338	134	416	43.8
Peng	2021	PC (II)	CNN	China	13 brands	2775	726	2049	42.2
Liu	2021	RC (III)	CNN	China	Siemens	163	48	115	44.3
Han	2021	RC (III)	CNN	Korea	Samsung	372	NS	NS	NS
Shin	2020	RC (III)	CNN	Korea	Samsung	340	79	261	47.2
Wang	2019	RC (III)	CNN	China	GE/Phillips	276	53	223	46.3
Zhu	2019	RC (III)	CNN	China	4 brands	467	97	370	45.3
Zhang (2)	2019	RC (III)	Non-CNN	China	Hitachi	2032	695	1337	42.3
Ko	2019	RC (III)	CNN	Korea	Phillips/Hitachi	150	23	127	49.7
Song	2019	RC (III)	CNN	Korea	Toshiba	100	NS	NS	NS
Li	2019	RC (III)	CNN	China	Phillips/Toshiba/GE	154	34	120	51
Wildman-Tobriner	2019	RC (III)	Non-CNN	UK	Siemens/GE/Phillips	94	21	73	52.6
Yu	2017	PC (II)	CNN	China	Phillips/Siemens	50	9	41	48.4
Buda	2019	RC (III)	CNN	USA	Siemens/GE/Phillips	91	NS	NS	52.3
Raghavendra	2018	RC (III)	Non-CNN	India	4 brands	344	NS	NS	44.1
Li	2018	RC (III)	CNN	China	NS	300	53	247	NS
Ma	2017	RC (III)	CNN	china	7 brands	4782	NS	NS	52
Raghavendra	2017	RC (III)	Non-CNN	India	GE	242	63	179	44.1
Zhu	2013	RC (III)	CNN	China	Siemens	618	161	528	47.7
Choi	2017	PC (II)	Non-CNN	Korea	Samsung	89	18	71	43.5
Gao	2017	RC (III)	CNN	China	Phillips/GE	342	70	272	44.8
Choi	2015	RC (III)	CNN	Korea	Phillips	85	24	61	52
Chi	2017	RC (III)	CNN	Canada	Toshiba	61	NS	NS	NS
Jeong	2019	PC (II)	CNN	Korea	Samsung	76	NS	NS	NS
Acharya	2012	RC (III)	Non-CNN	Singapore	NS	20	10	10	NS
Liang	2018	RC (III)	Non-CNN	China	Phillips	95	20	75	43.2
Prochazka (2)	2019	RC (III)	Non-CNN	Czechia	Phillips/GE	60	11	49	55.7
Song	2015	RC (III)	Non-CNN	China	GE	147	32	115	NS
Ardakani	2015	RC (III)	Non-CNN	Iran	Medison	60	NS	NS	NS
Guan	2019	RC (III)	CNN	China	NS	399	NS	NS	NS
Xia	2017	RC (III)	Non-CNN	China	Siemens	187	36	151	50.8
Yoo	2018	PC (II)	CNN	Korea	Samsung	50	10	40	43.2
Tsantis	2009	RC (III)	Non-CNN	Greece	Phillips	85	NS	NS	NS
Liu	2008	RC (III)	Non-CNN	USA	NS	37	NS	NS	NS
Acharya	2013	RC (III)	Non-CNN	Italy	Esaote	20	10	10	52.8
Acharya (2)	2012	RC (III)	Non-CNN	Italy	Esaote	20	10	10	52.8
[illegible]	2013	RC (III)	Non-CNN	Italy	Esaote	20	10	10	52.8
Ardakani (2)	2015	RC (III)	CNN	Iran	Medison	60	NS	NS	NS
Wu	2016	RC (III)	CNN	China	Phillips	970	214	756	46.7
Cao	2019	RC (III)	Non-CNN	China	NS	120	NS	NS	NS
Wang (2)	2020	RC (III)	CNN	China	NS	1040	NS	NS	NS
Sun (2)	2020	RC (III)	CNN	China	NS	245	NS	NS	NS
Reverter	2019	RC (III)	Non-CNN	Spain	GE	300	45	255	55.5
Gitto	2019	RC (III)	Non-CNN	Italy	Samsung	62	12	50	60

NS: not specified, LOE: level of evidence, RC: retrospective cohort, PC: prospective cohort, CNN: convolutional neural network, non-CNN: analysis performed using a method other than a convolutional neural network.

***Diagnostics* 2022**

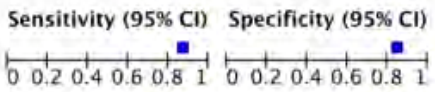
Germans Trias i Pujol Hospital

Intel·ligència artificial en ecografia

Sensibilitat i Especificitat

Study	TP	FP	FN	TN	Sensitivity (95% CI)	Specificity (95% CI)
Liu 2008	16	5	4	16	0.80 [0.56, 0.94]	0.76 [0.53, 0.92]
Tsantis 2009	29	1	2	53	0.94 [0.79, 0.99]	0.98 [0.90, 1.00]
Acharya 2011	10	0	0	10	1.00 [0.69, 1.00]	1.00 [0.69, 1.00]
Acharya 2012	10	0	0	10	1.00 [0.69, 1.00]	1.00 [0.69, 1.00]
Acharya 2012 (2)	10	0	0	10	1.00 [0.69, 1.00]	1.00 [0.69, 1.00]
Acharya 2013	10	0	0	10	1.00 [0.69, 1.00]	1.00 [0.69, 1.00]
Zhu 2013	390	48	75	217	0.84 [0.80, 0.87]	0.82 [0.77, 0.86]
Ardakani 2015	34	1	0	25	1.00 [0.90, 1.00]	0.96 [0.80, 1.00]
Ardakani 2015 (2)	34	0	0	26	1.00 [0.90, 1.00]	1.00 [0.87, 1.00]
Choi 2015	65	4	13	17	0.83 [0.73, 0.91]	0.81 [0.58, 0.95]
Song 2015	62	16	17	60	0.78 [0.68, 0.87]	0.79 [0.68, 0.87]
Wu 2016	468	111	39	352	0.92 [0.90, 0.94]	0.76 [0.72, 0.80]
Chi 2017	50	0	0	11	1.00 [0.93, 1.00]	1.00 [0.72, 1.00]
Choi 2017	39	15	4	44	0.91 [0.78, 0.97]	0.75 [0.62, 0.85]
Gao 2017	231	53	8	50	0.97 [0.94, 0.99]	0.49 [0.39, 0.59]
Kwon Seo 2017	28	13	11	178	0.72 [0.55, 0.85]	0.93 [0.89, 0.96]
Ma 2017	3314	623	708	3503	0.82 [0.81, 0.84]	0.85 [0.84, 0.86]
Raghavendra 2017	28	3	3	208	0.90 [0.74, 0.98]	0.99 [0.96, 1.00]
Xia 2017	70	6	19	108	0.79 [0.69, 0.87]	0.95 [0.89, 0.98]
Yu 2017	15	3	2	30	0.88 [0.64, 0.99]	0.91 [0.76, 0.98]
Li 2018	214	9	16	41	0.94 [0.90, 0.96]	0.82 [0.69, 0.91]
Liang 2018	43	9	9	34	0.83 [0.70, 0.92]	0.79 [0.64, 0.90]
Raghavendra 2018	52	33	4	255	0.93 [0.83, 0.98]	0.89 [0.84, 0.92]
Yao 2018	46	10	4	57	0.92 [0.81, 0.98]	0.85 [0.74, 0.93]
Buda 2019	13	40	2	44	0.87 [0.60, 0.98]	0.52 [0.41, 0.63]
Cao 2019	48	1	7	72	0.85 [0.72, 0.94]	0.99 [0.93, 1.00]
Colakoglu 2019	87	16	15	117	0.85 [0.77, 0.92]	0.88 [0.81, 0.93]
Gitto 2019	3	9	11	39	0.21 [0.05, 0.51]	0.81 [0.67, 0.91]
Guan 2019	195	24	14	166	0.93 [0.89, 0.96]	0.87 [0.82, 0.92]
Jeong 2019	39	9	5	47	0.89 [0.75, 0.96]	0.84 [0.72, 0.92]
Kim 2019	69	23	17	109	0.80 [0.70, 0.88]	0.83 [0.75, 0.89]
Ko 2019	90	9	10	41	0.90 [0.82, 0.95]	0.82 [0.69, 0.91]
Lee 2019	380	19	16	174	0.96 [0.94, 0.98]	0.90 [0.85, 0.94]
Li 2019	71	9	13	61	0.85 [0.75, 0.91]	0.87 [0.77, 0.94]
Liu 2019	72	5	0	54	1.00 [0.95, 1.00]	0.92 [0.81, 0.97]
Liu 2019 (2)	313	14	9	114	0.97 [0.95, 0.99]	0.89 [0.82, 0.94]
Nguyen 2019	47	4	3	7	0.94 [0.83, 0.99]	0.64 [0.31, 0.89]
Park 2019	142	26	14	104	0.91 [0.85, 0.95]	0.80 [0.72, 0.86]
Prochazka 2019 (2)	19	2	1	38	0.95 [0.75, 1.00]	0.95 [0.83, 0.99]
Qin 2019	123	2	10	113	0.92 [0.87, 0.96]	0.98 [0.94, 1.00]
Reverter 2019	117	51	18	114	0.87 [0.80, 0.92]	0.69 [0.61, 0.76]
Song 2019	47	22	3	28	0.94 [0.83, 0.99]	0.56 [0.41, 0.70]
Wang 2019	164	10	17	85	0.91 [0.85, 0.94]	0.89 [0.81, 0.95]
Wildman-Tobriner 2019	12	38	3	47	0.80 [0.52, 0.96]	0.55 [0.44, 0.66]
Xia 2019	86	50	9	35	0.91 [0.83, 0.96]	0.41 [0.31, 0.52]
Zhang 2019 (2)	661	208	89	1106	0.88 [0.86, 0.90]	0.84 [0.82, 0.86]
Zhu 2019	298	19	41	109	0.88 [0.84, 0.91]	0.85 [0.78, 0.91]
Ataide 2020	82	0	0	17	1.00 [0.96, 1.00]	1.00 [0.80, 1.00]
Barczynski 2020	9	8	1	32	0.90 [0.55, 1.00]	0.80 [0.64, 0.91]
Chen 2020	995	114	216	233	0.82 [0.80, 0.84]	0.67 [0.62, 0.72]
Koh 2020	90	41	8	61	0.92 [0.85, 0.96]	0.60 [0.50, 0.69]
Kwon 2020	402	98	35	228	0.92 [0.89, 0.94]	0.70 [0.65, 0.75]
Ma 2020	476	72	10	288	0.98 [0.96, 0.99]	0.80 [0.75, 0.84]
Nguyen 2020	48	4	2	7	0.96 [0.86, 1.00]	0.64 [0.31, 0.89]
Shi 2020	820	75	85	957	0.91 [0.89, 0.92]	0.93 [0.91, 0.94]
Shin 2020	31	25	65	227	0.32 [0.23, 0.43]	0.90 [0.86, 0.93]
Stib 2020	133	214	18	287	0.88 [0.82, 0.93]	0.57 [0.53, 0.62]
Sun 2020	407	22	15	106	0.96 [0.94, 0.98]	0.83 [0.75, 0.89]
Sun 2020 (2)	89	10	11	135	0.89 [0.81, 0.94]	0.93 [0.88, 0.97]
Thomas 2020	29	15	4	55	0.88 [0.72, 0.97]	0.79 [0.67, 0.87]
Wang 2020 (2)	1162	276	679	1117	0.63 [0.61, 0.65]	0.80 [0.78, 0.82]
Wei 2020	1280	258	188	763	0.87 [0.85, 0.89]	0.75 [0.72, 0.77]
Wei 2020 (2)	4903	172	284	2891	0.94 [0.93, 0.94]	0.94 [0.94, 0.95]
Wei 2020 (3)	84	39	8	73	0.91 [0.84, 0.96]	0.65 [0.56, 0.74]
Ye 2020	87	16	13	93	0.87 [0.79, 0.93]	0.85 [0.77, 0.91]
Zhang 2020	133	25	53	154	0.72 [0.64, 0.78]	0.86 [0.80, 0.91]
Zhao 2020	70	14	11	82	0.86 [0.77, 0.93]	0.85 [0.77, 0.92]
Zhou 2020	27	12	3	63	0.90 [0.73, 0.98]	0.84 [0.74, 0.91]
Han 2021	136	52	31	235	0.81 [0.75, 0.87]	0.82 [0.77, 0.86]
Liu 2021	86	9	22	58	0.80 [0.71, 0.87]	0.87 [0.76, 0.94]
Park 2021	48	52	20	205	0.71 [0.58, 0.81]	0.80 [0.74, 0.85]
Peng 2021	271	363	32	2109	0.89 [0.85, 0.93]	0.85 [0.84, 0.87]
Zhao 2021	27	12	6	61	0.82 [0.65, 0.93]	0.84 [0.73, 0.91]
Zhu 2021	38	7	7	50	0.84 [0.71, 0.94]	0.88 [0.76, 0.95]
Zhu 2021 (2)	504	48	26	454	0.95 [0.93, 0.97]	0.90 [0.88, 0.93]

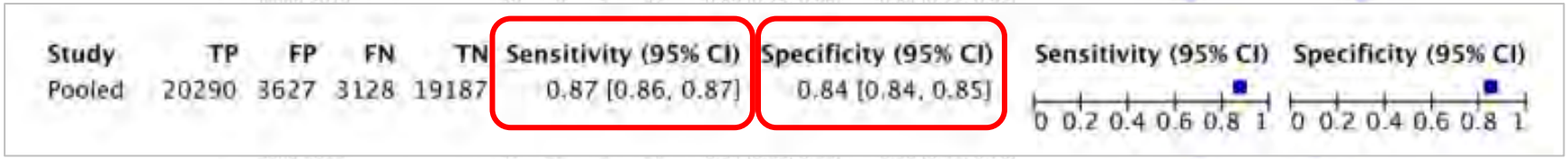
Study	TP	FP	FN	TN	Sensitivity (95% CI)	Specificity (95% CI)
Pooled	20290	3627	3128	19187	0.87 [0.86, 0.87]	0.84 [0.84, 0.85]



***Diagnostics* 2022**

Intel·ligència artificial en ecografia

Sensibilitat i Especificitat

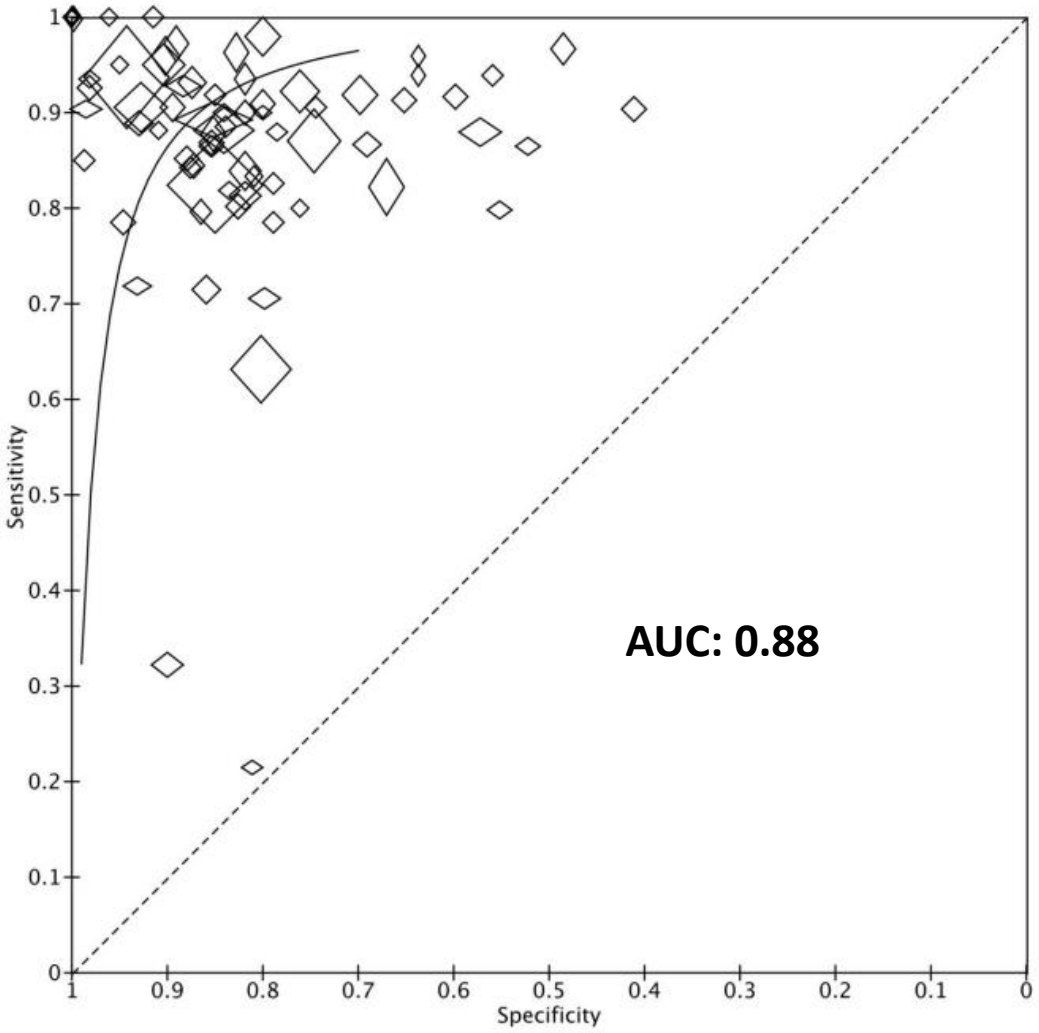


Study	TP	FP	FN	TN	Sensitivity (95% CI)	Specificity (95% CI)
Pooled	20290	3627	3128	19187	0.87 [0.86, 0.87]	0.84 [0.84, 0.85]

***Diagnostics* 2022**

Intel·ligència artificial en Ecografia Tiroidea

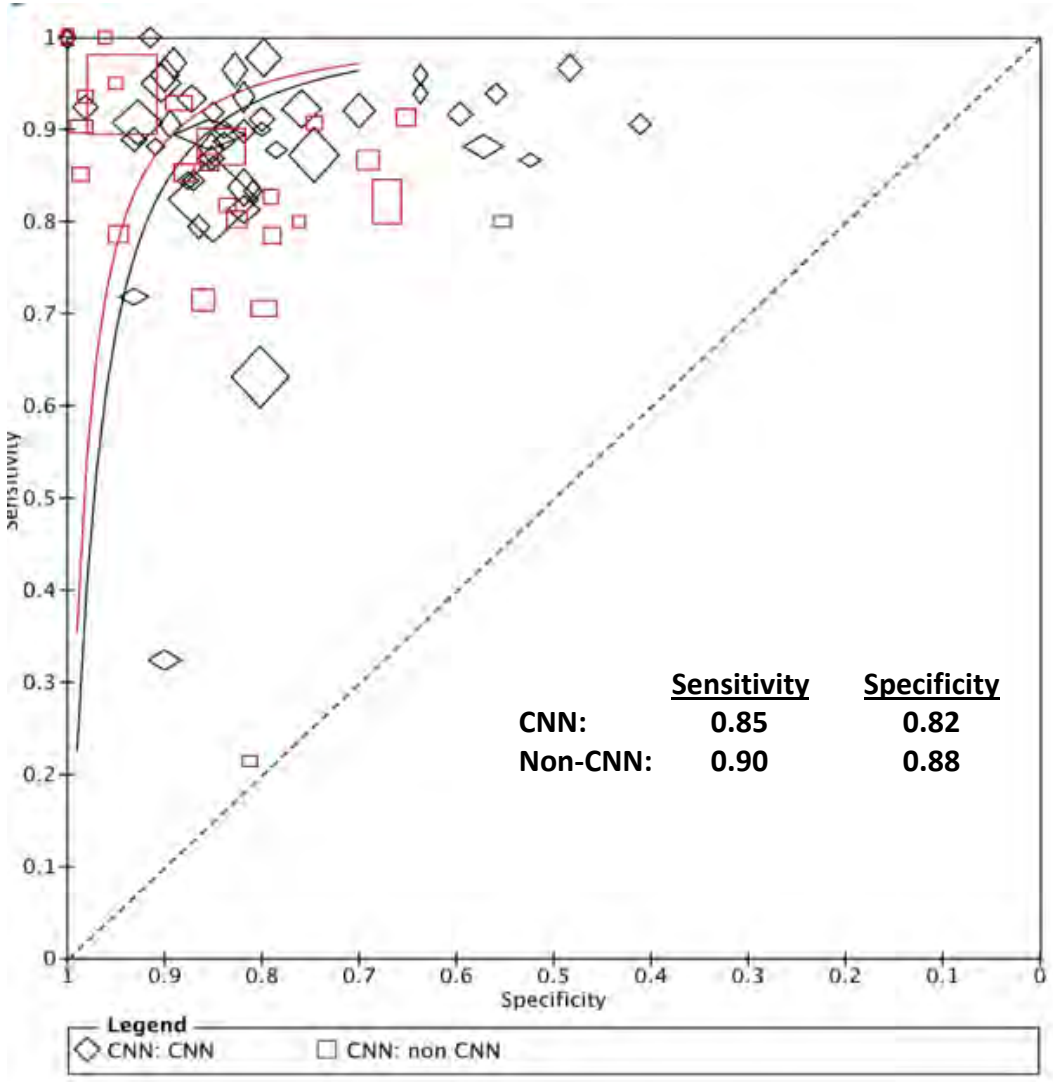
AUC calculada de l' analisis de ROC



***Diagnostics* 2022**

Intel·ligència artificial en Ecografia Tiroidea

ROC CNN
***vs.* no-CNN**

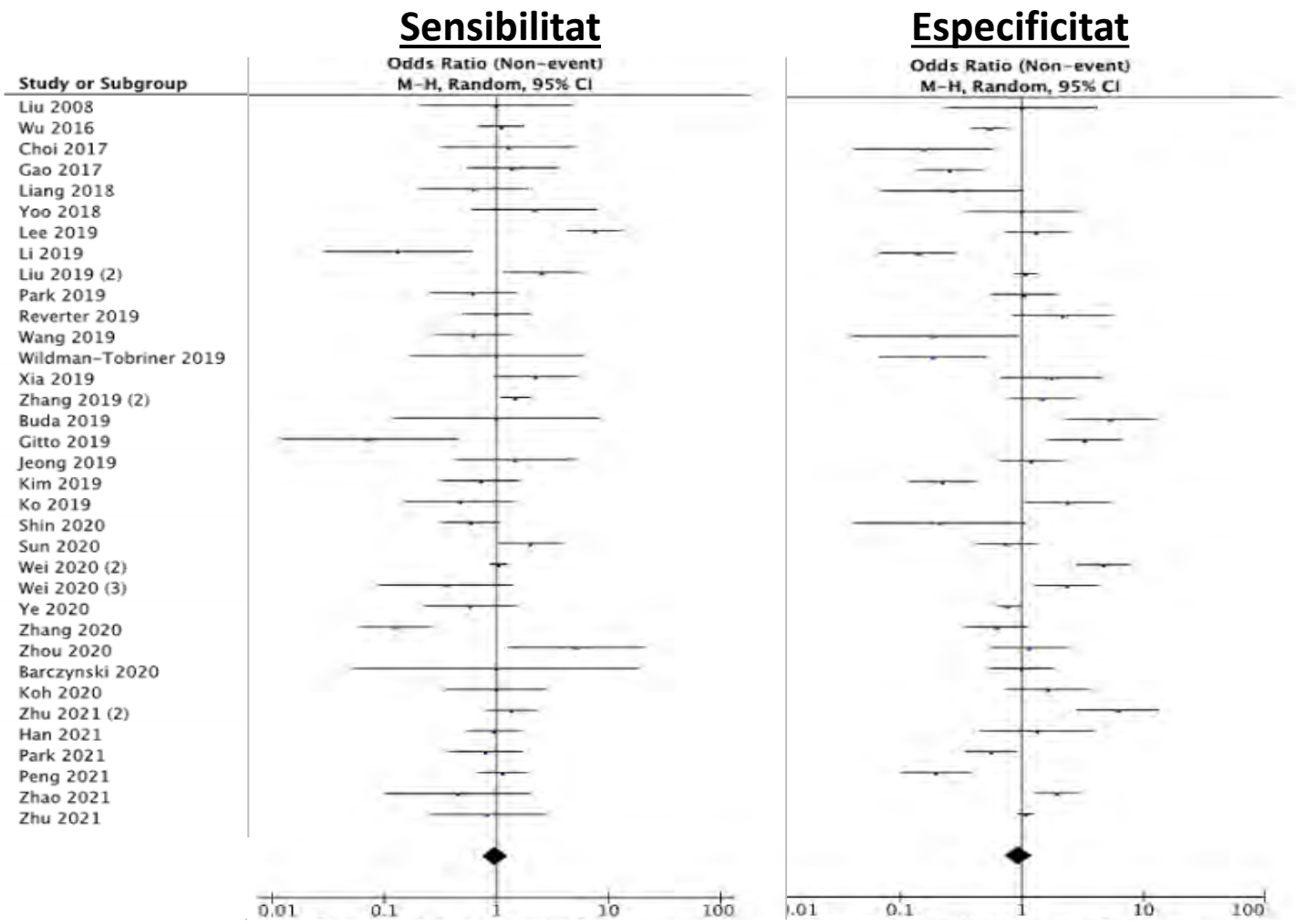


	Sensitivity	Specificity
CNN:	0.85	0.82
Non-CNN:	0.90	0.88

***Diagnostics* 2022**

Intel·ligència artificial en Ecografia Tiroidea

Observador *vs.* CAD



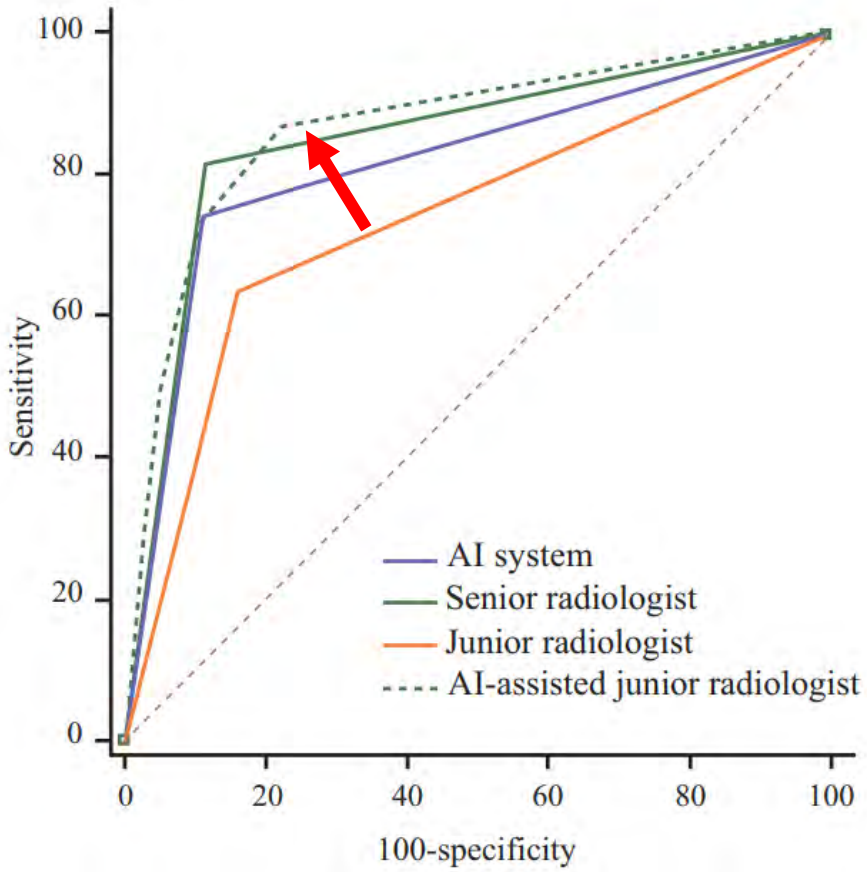
0.98 **Odds ratio** **0.93**

***Diagnostics* 2022**

Intel·ligència artificial en Ecografia Tiroidea

BENTHAM SCIENCE

A Comparison of the Performances of Artificial Intelligence System and Radiologists in the Ultrasound Diagnosis of Thyroid Nodules

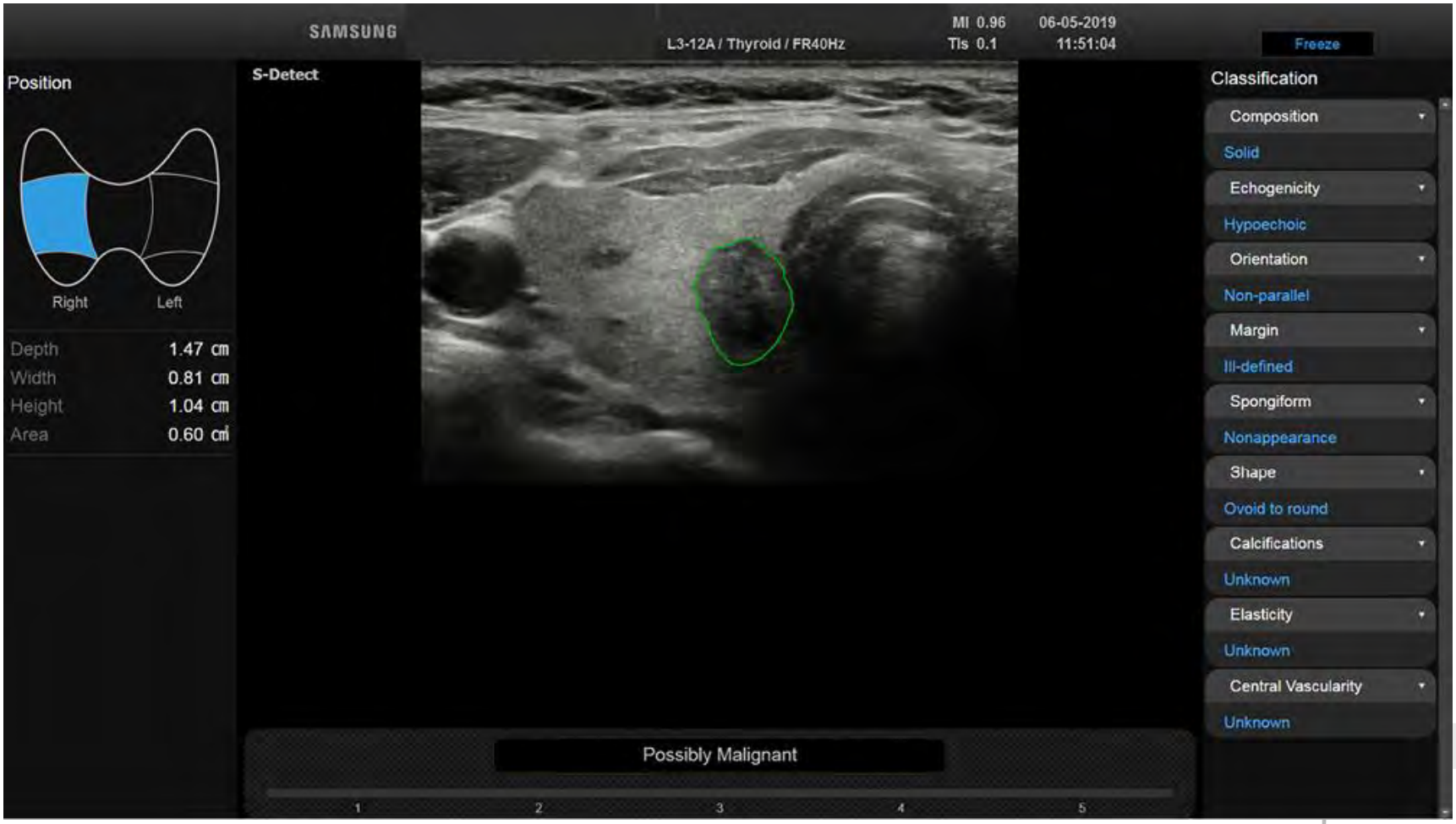


He LT. *Current Medical Imaging*, 2022

CAD comercialitzats

SAMSUNG

S-Detect™ for Thyroid



CAD comercialitzats

Detect-2 CAD for thyroid nodules

Rendiment diagnòstic

Diagnostic measure	Experienced radiologist	Computer-aided diagnosis	*p* value
Sensitivity	84.1 (37/44)	88.6 (39/44)	0.687
Specificity	96.4 (54/56)	83.9 (47/56)	0.016
Positive predictive value	94.9 (37/39)	81.3 (39/48)	
Negative predictive value	88.5 (54/61)	90.4 (47/52)	
Accuracy	91.0 (91/100)	86.0 (86/100)	0.267

Jeong EY, Eur Radiol 2019

CAD comercialitzats

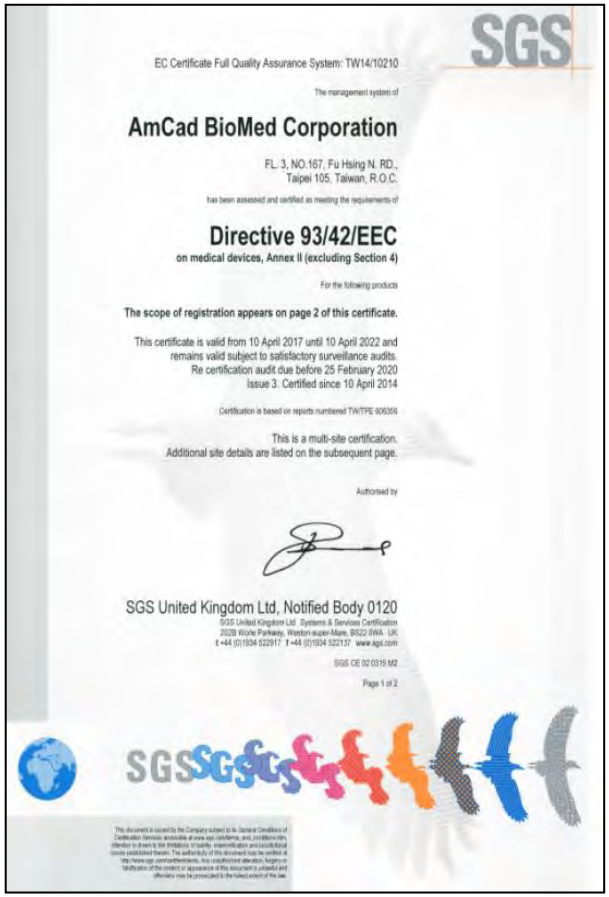
TABLE 1: Publications Describing the Performance of S-Detect (Samsung Medison)

First Author [Ref], Study Interpretation	No. of Nodules	Sensitivity		Specificity		PPV		NPV		Accuracy	
		%	*p*	%	*p*	%	*p*	%	*p*	%	*p*
Han [15]	454										
S-Detect 2		97.6		21.6		42.0		93.9		49.6	
Experienced radiologist		97.6	> .99	36.2	< .01					58.8	< .001
Kim [17]	218										
S-Detect 2		81.4		68.2		62.5		84.9		73.4	
Radiologist		84.9	.454	96.2	< .001	93.6		90.7		91.7	< .001
Radiologist and S-Detect		93.0	.016	67.4	< .001	65.0		93.7		77.5	< .001
Wei [20]	204										
S-Detect		91.3		65.2		68.3		90.1		77.0	
Radiologist 1		95.7	.29	37.5	< .001	55.7	< .001	91.3	.78	63.7	< .001
Radiologist 2		84.8	.18	49.1	.005	57.8	.001	79.7	.03	65.2	.001
Radiologist 3		83.7	.09	63.4	.83	65.3	.28	82.6	.05	72.5	.18
Radiologist 4		96.7	.13	75.0	.05	76.1	.02	96.6	.04	84.8	.01
Park [18]	286										
S-Detect (total)		90.4		58.5		73.3		83.5		75.9	
Subgroups (mean of 10 radiologists)		94.2	.14	76.9	.001	83.1	.001	91.7	.08	86.4	< .001
S-Detect vs experienced radiologists	184	90.8		58.1		71.2		84.8		75.5	
Experienced group (faculty)		92.9	.60	87.2	< .001	89.2	< .001	91.5	.32	90.8	< .001
S-Detect vs inexperienced radiologists	102	89.7		59.1		74.3		81.3		76.5	
Inexperienced group (fellows)		96.6	.15	56.8	.22	74.7	.27	92.6	.24	79.4	.41
Xia [21]	180										
S-Detect		90.5		41.2		63.2		79.5		67.2	
Radiologist		81.1		83.5		84.6		79.8		82.2	
Chung [13]	165										
S-Detect		92.0		87.9		57.5		98.4		88.5	
Resident		64.0	.008	86.4	.72	45.7	.16	93.1	.007	83.0	.14
Resident and S-Detect		68.0	.32	87.1	.66	48.6	.40	93.9	.29	84.2	.41
Fellow		72.0	.03	85.0	.40	46.2	.09	94.4	.02	83.0	.08

Wildman B. *AJR* 2022

CAD comercialitzats

AmCad BioMed Corporation®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The management system of

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FL. 3, NO.167, Fu Hsing N. RD.,
Taipei 105, Taiwan, R.O.C.

has been assessed and certified as meeting the requirements of

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on medical devices, Annex II (excluding Section 4)

For the following products

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This certificate is valid from 10 April 2017 until 10 April 2022 and remains valid subject to satisfactory surveillance audits.
Re certification audit due before 25 February 2020
Issue 3. Certified since 10 April 2014

Certification is based on reports numbered TW/PE 806356

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Additional site details are listed on the subsequent page.

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Page 1 of 2

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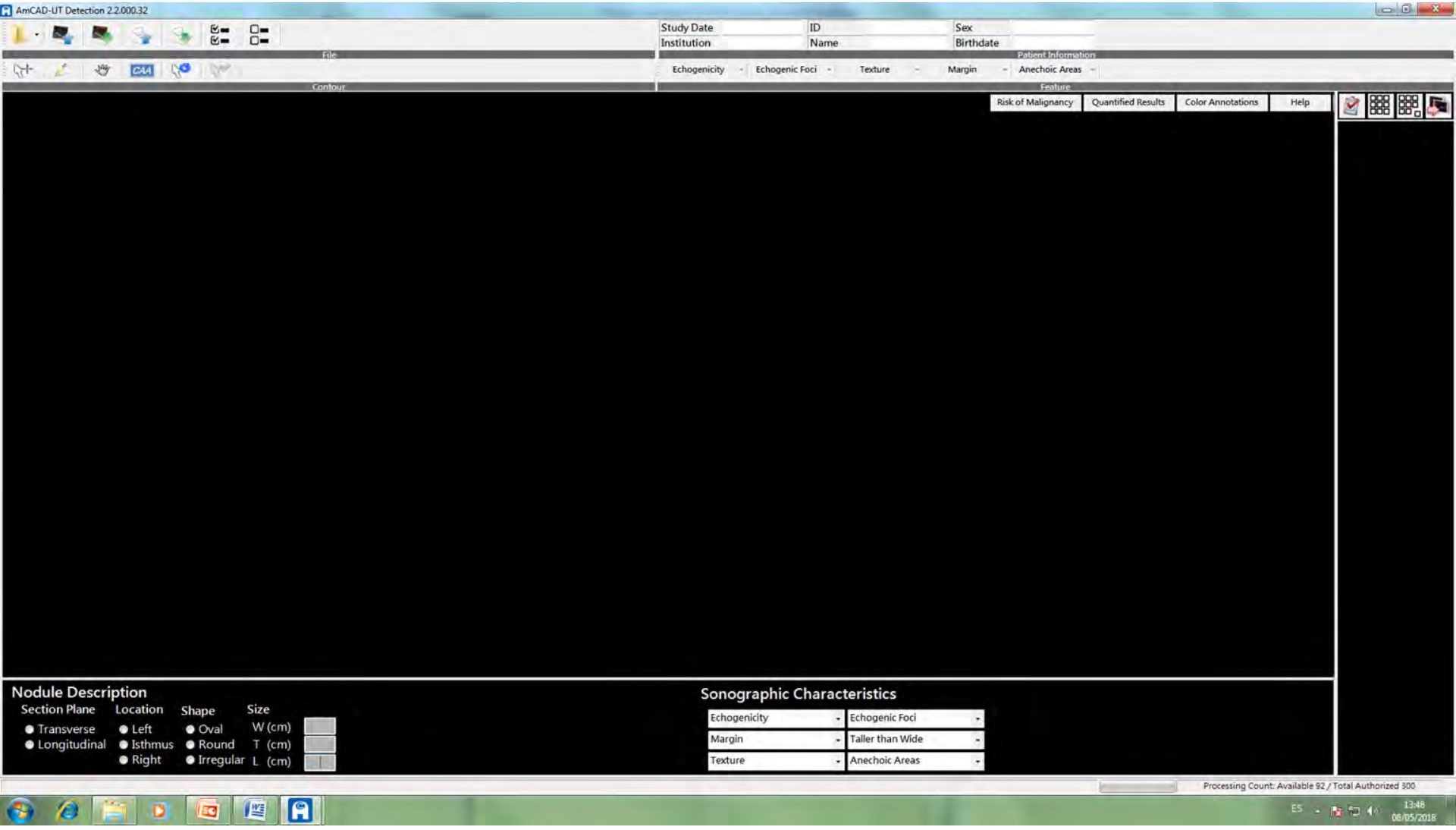
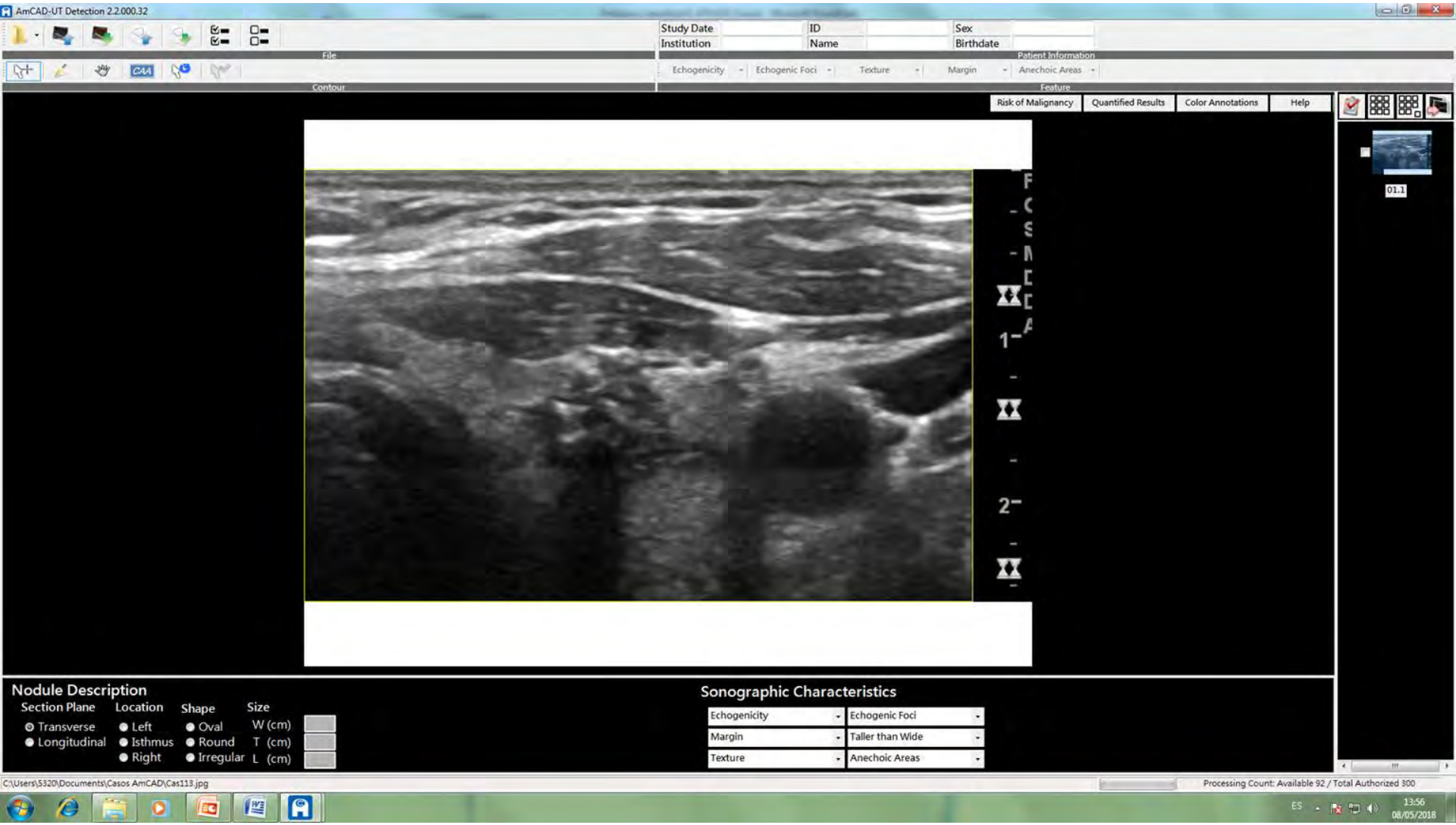
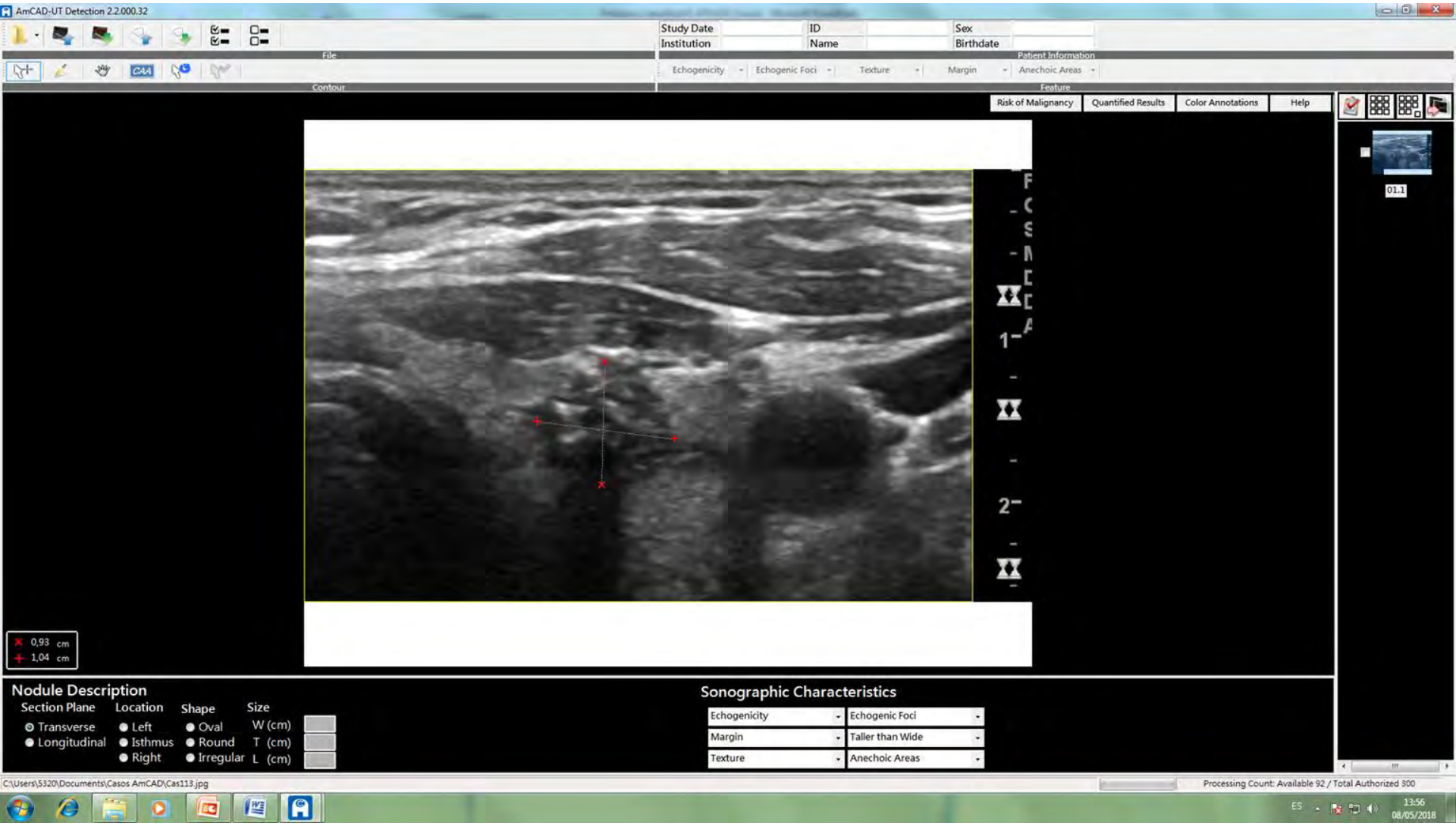
CAD comercialitzats



CAD comercialitzats



CAD comercialitzats



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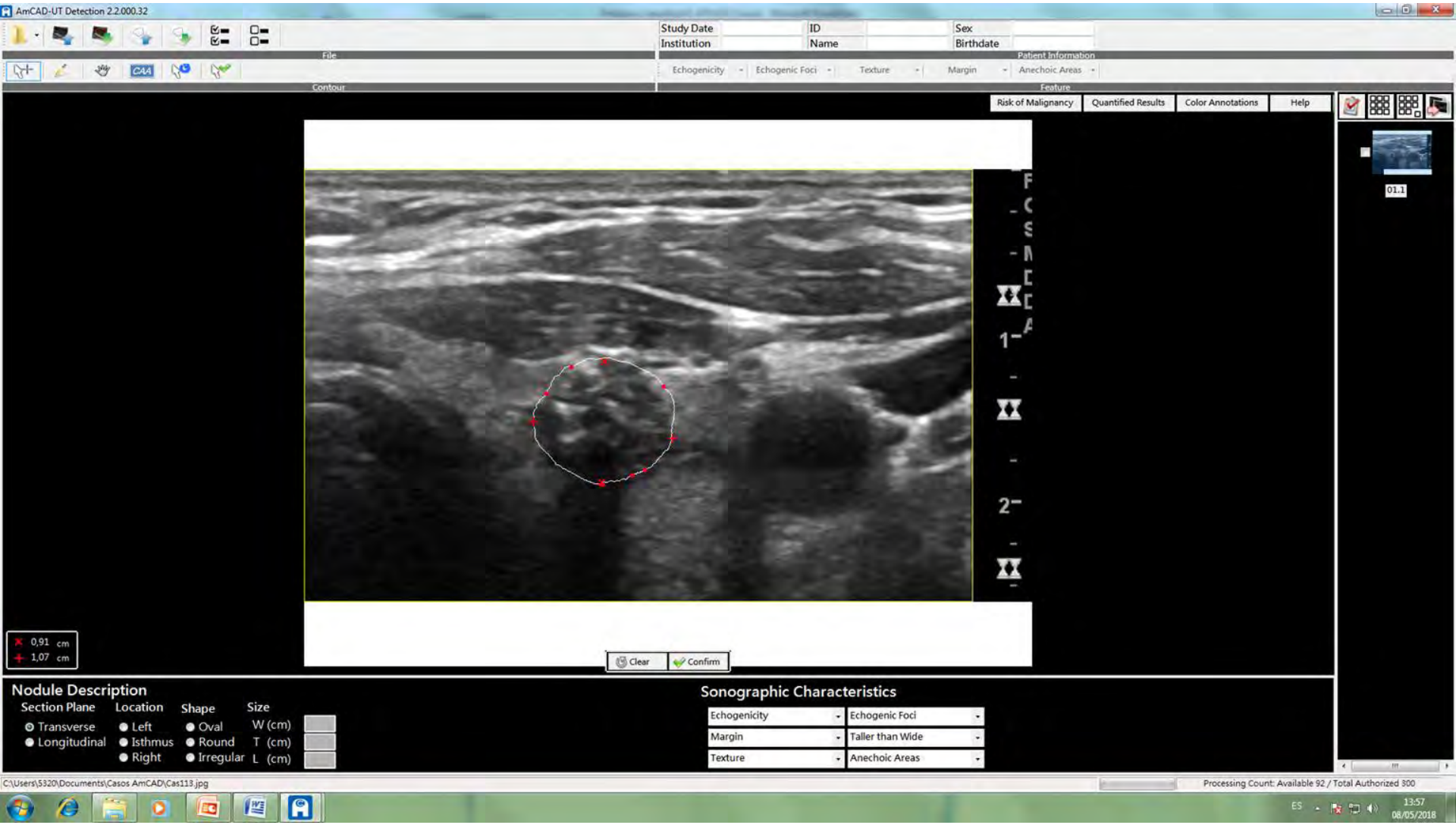

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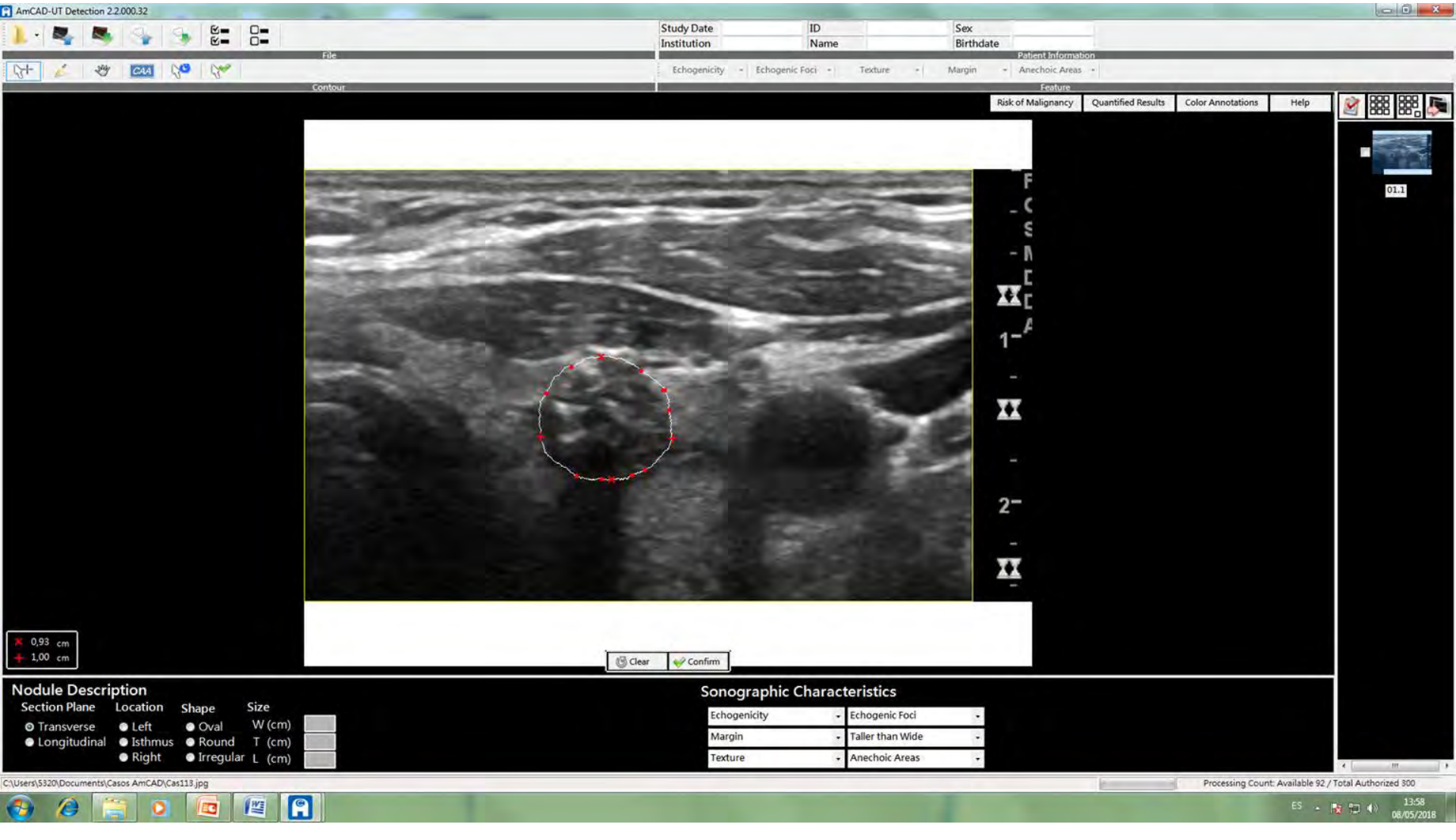

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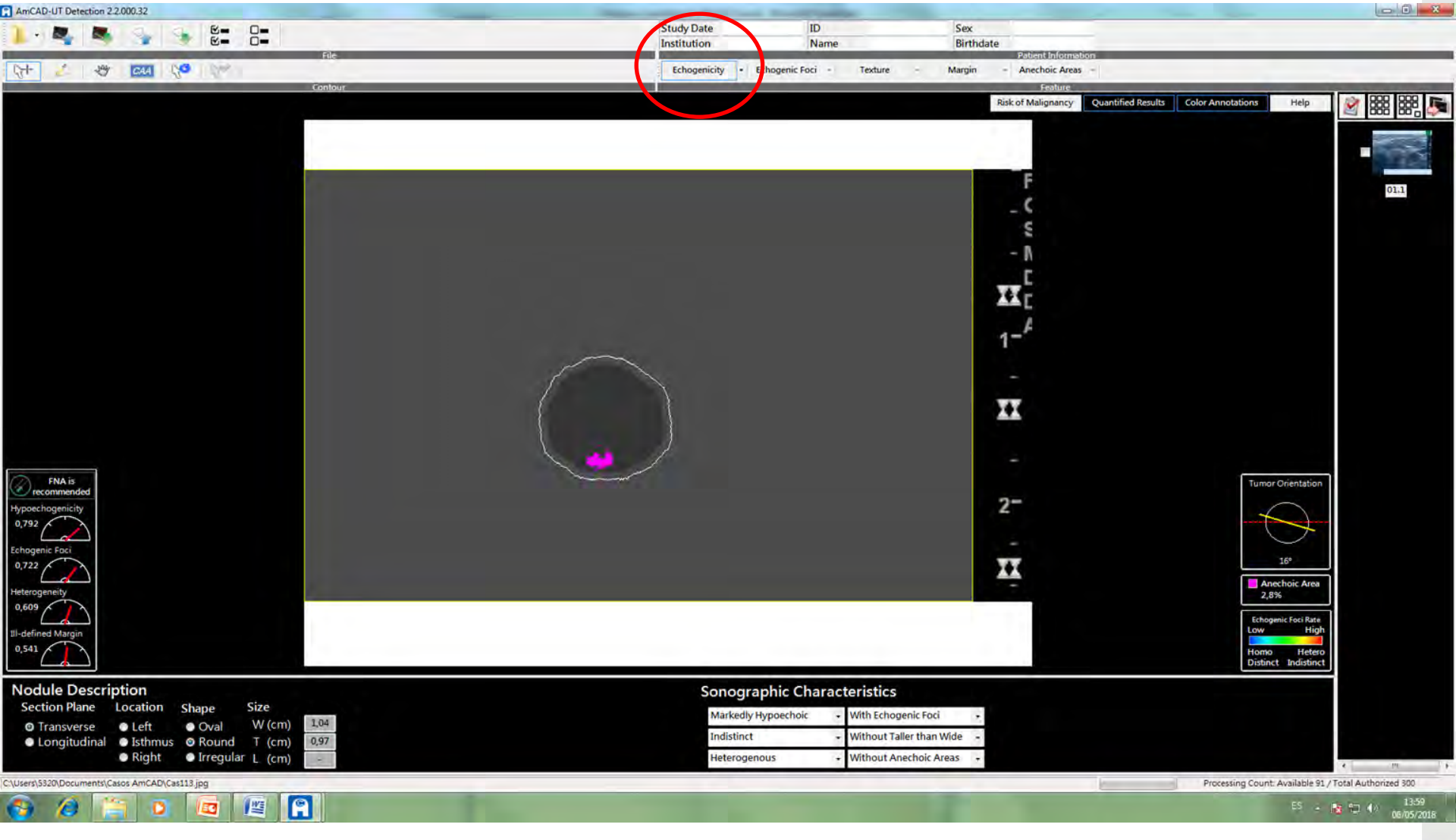

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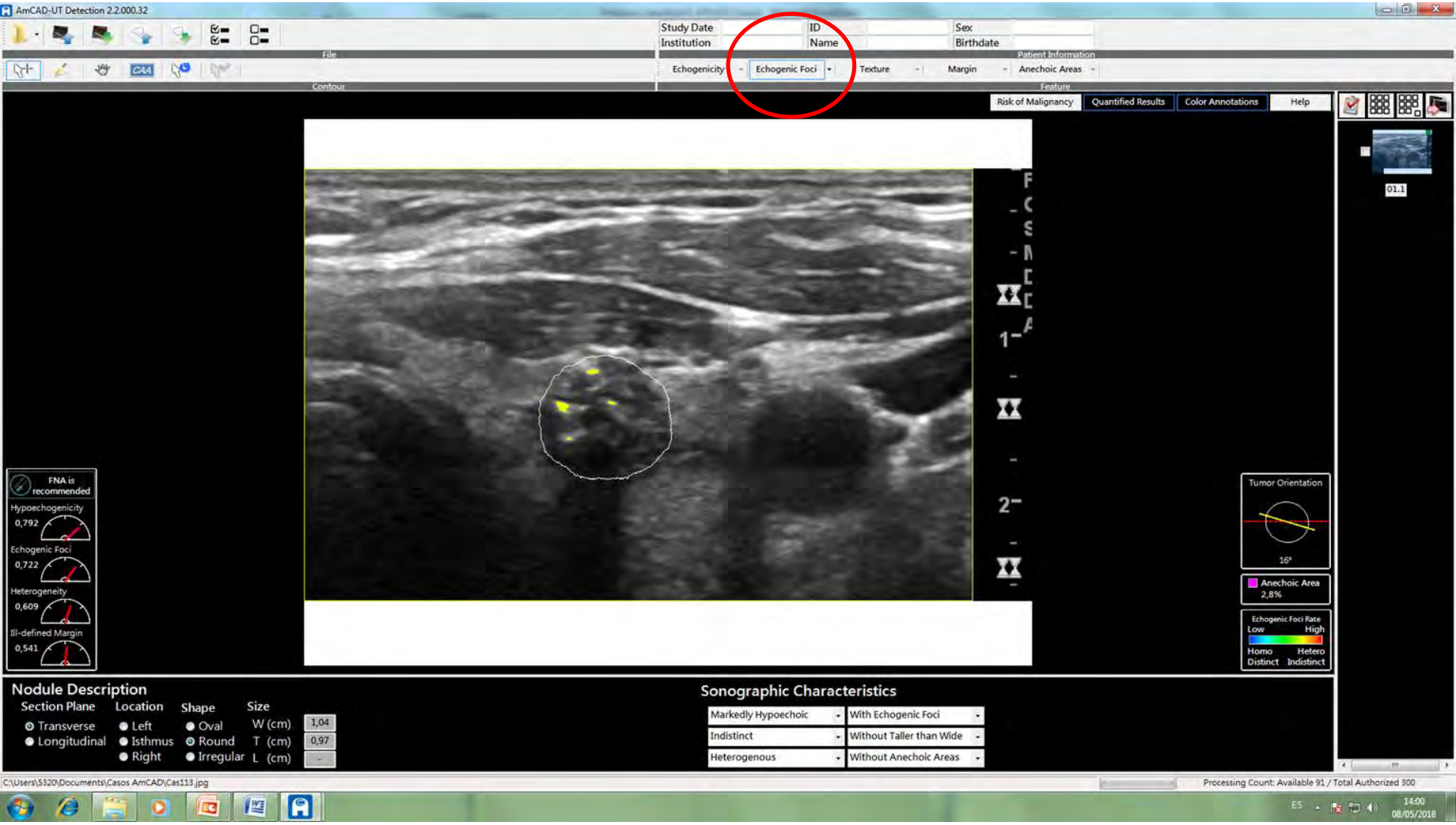

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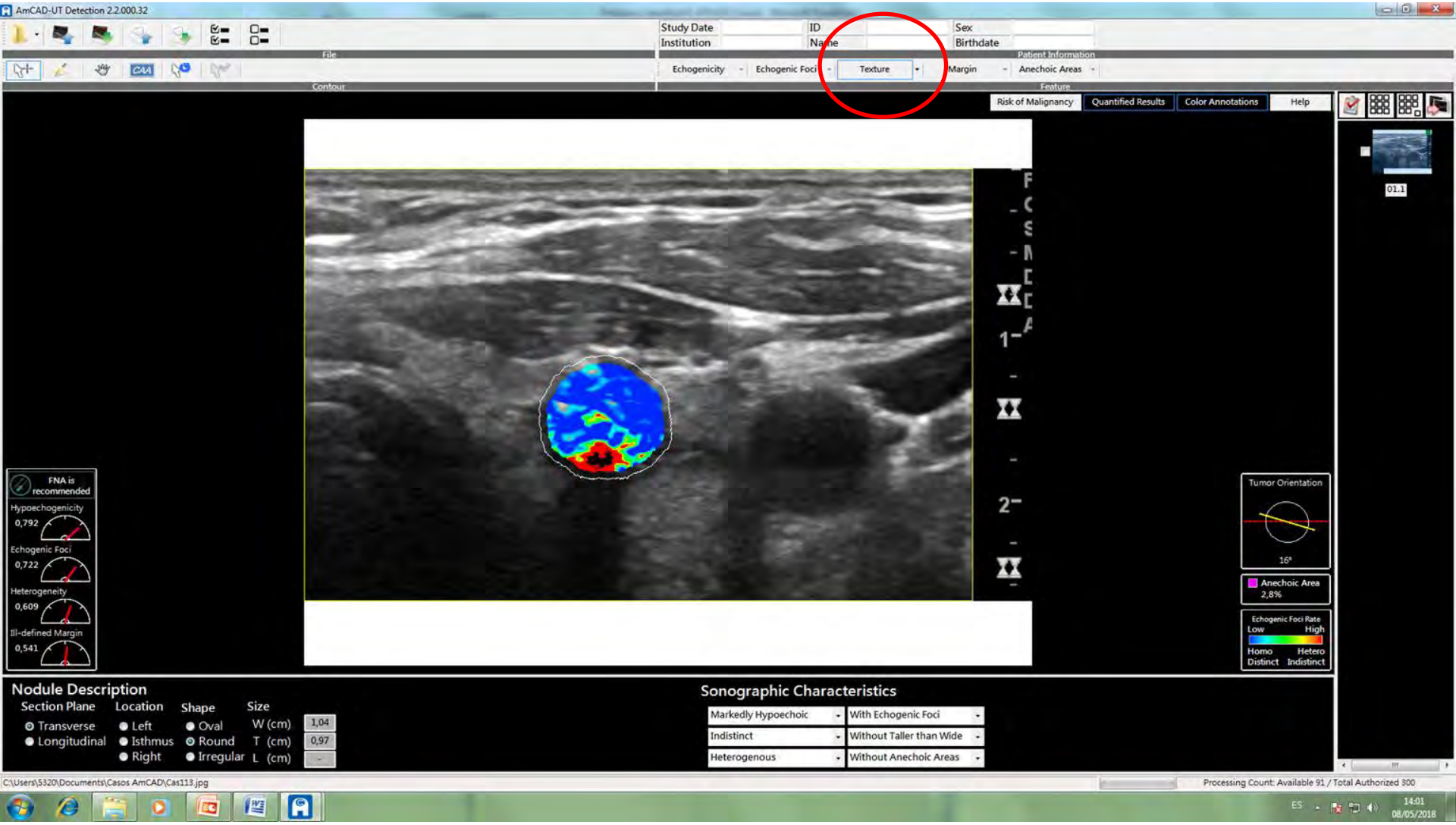

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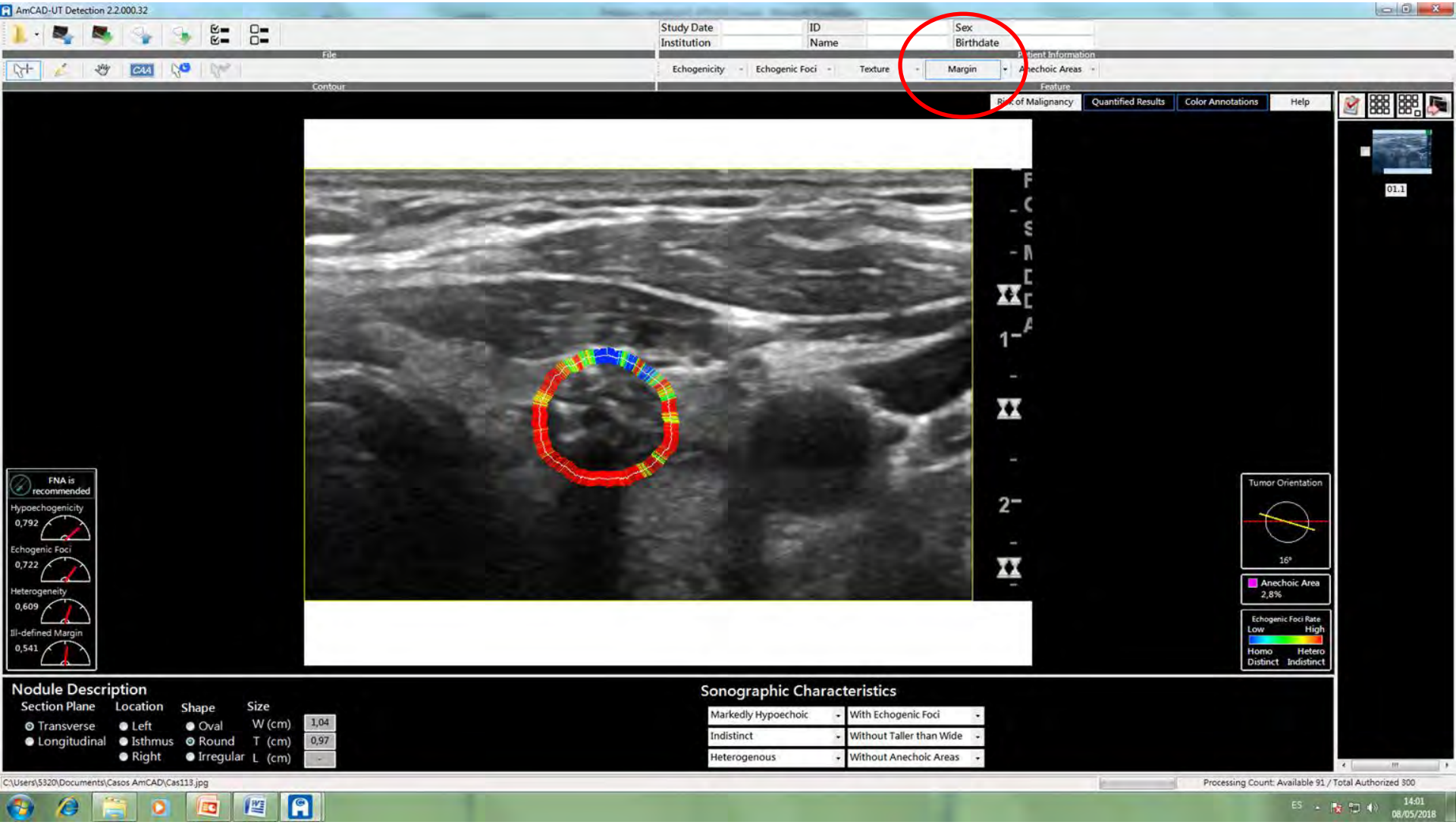

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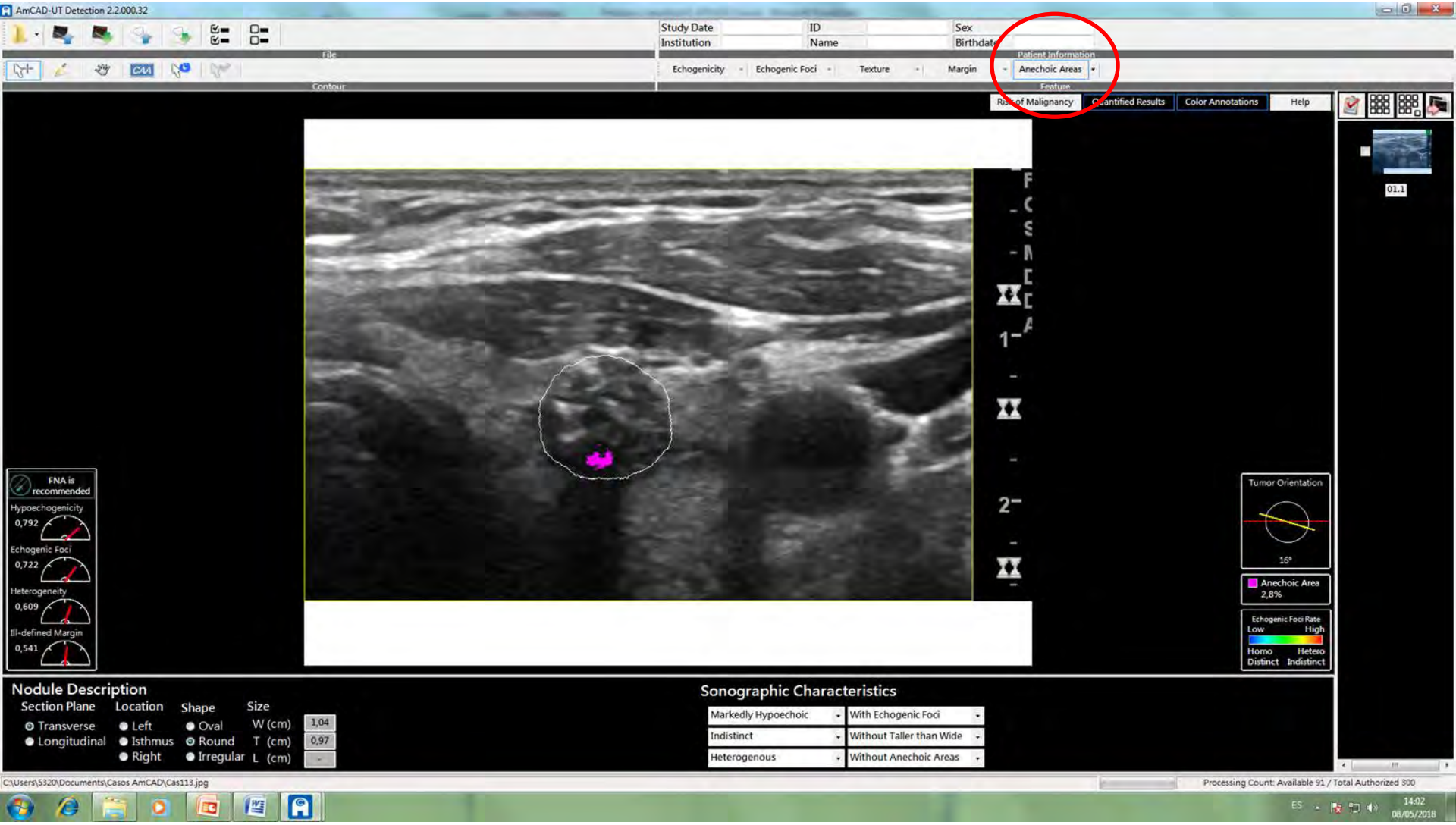

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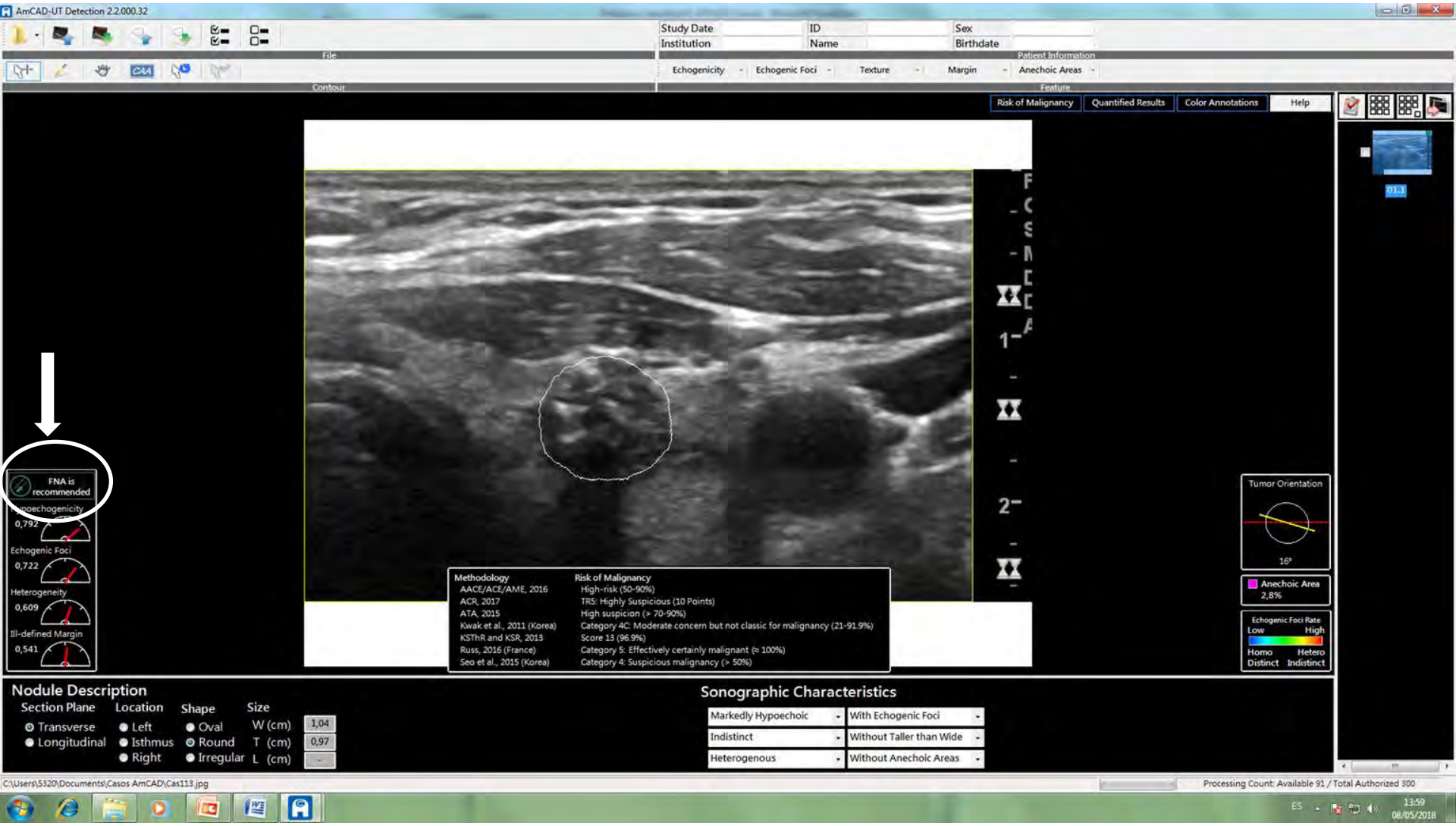

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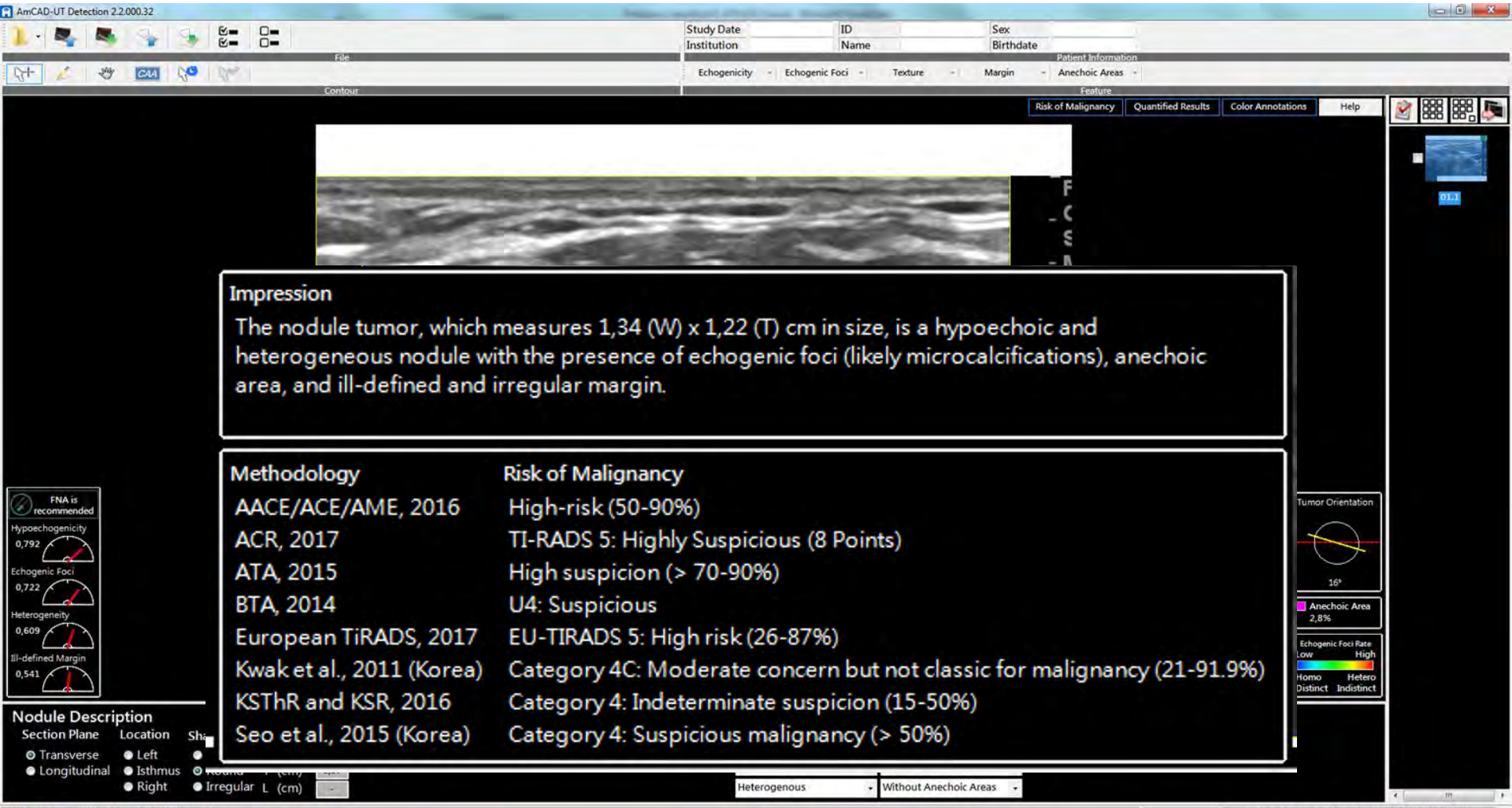
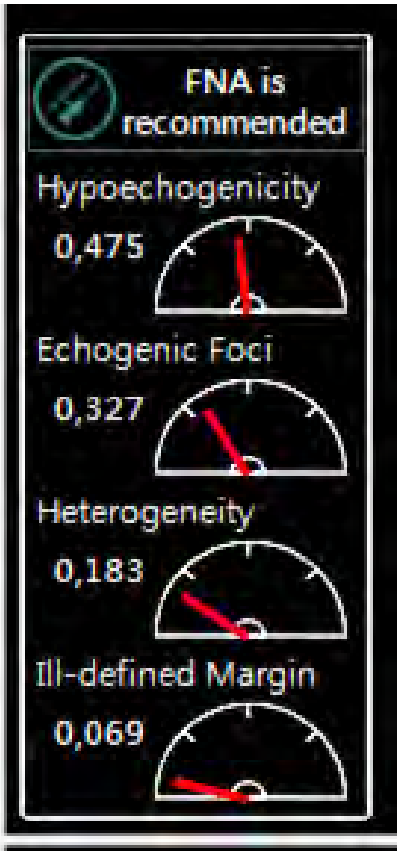
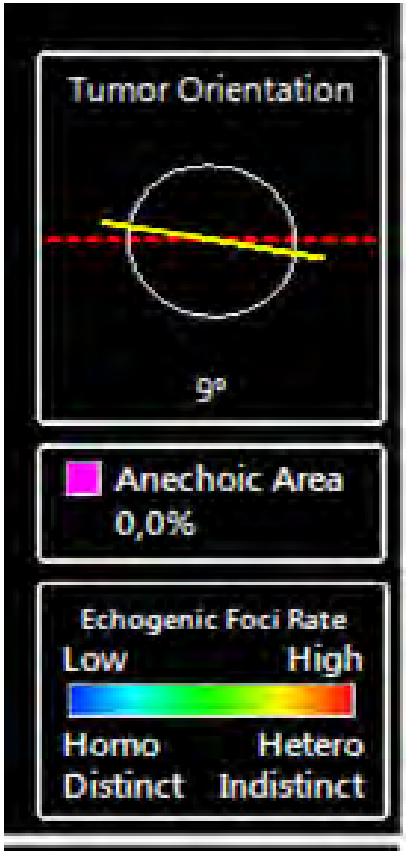
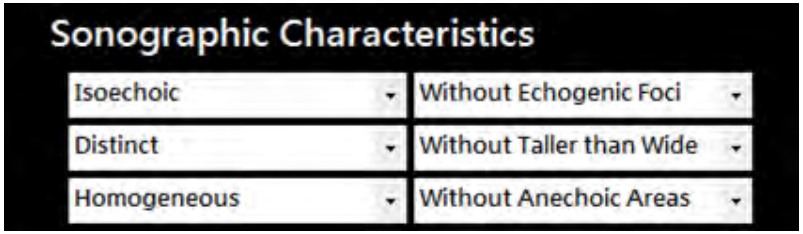


CAD comercialitzats

Taller than wide?







CAD comercialitzats

Am CAD -UT. Resultats

Diagnostic Performance Evaluation of a Computer-Assisted Imaging Analysis System for Ultrasound Risk Stratification of Thyroid Nodules

Jordi L. Reverter[1,2]
Federico Vázquez[1]
Manuel Puig-Domingo[1,2]

OBJECTIVE. Ultrasound-based stratification of the malignancy risk of thyroid nodules has potential variability. The purpose of this study is to evaluate the diagnostic effectiveness of the first commercially available system for computer-aided diagnosis (CADx) imaging analysis.

MATERIALS AND METHODS. Ultrasound images of 300 thyroid nodules (135 of which were malignant) acquired before surgical treatment were retrospectively reviewed by a thyroid expert, and his classification of each image was then compared with the classification rendered by an image analysis program (AmCAD-UT, AmCAD Biomed). The American Thyroid Association (ATA) classification system, the European Thyroid Imaging Reporting and Data System (EU-TIRADS), and the classification system jointly proposed by American and Italian associations of clinical endocrinologists (the American Association of Clinical Endocrinologists [AACE], the American College of Endocrinology [ACE], and Associazione Medici Endocrinologi [AME]) were used for risk stratification.

RESULTS. The diagnostic performance of the thyroid expert when the ATA system was used was as follows: sensitivity, 87.0%; specificity, 91.2%; positive predictive value, 90.5%; and negative predictive value, 90.9%. Compared with the expert, the CADx program, when used with the three classification systems, had a similar sensitivity but a lower specificity and positive predictive value. Regarding the negative predictive value, the results of the expert did not differ from those of the CADx program when it applied the ATA classification system (90.9% vs 86.3%; $p = 0.07$). The ROC AUC value was 0.88 for the expert clinician and 0.72 for the CADx program when the ATA classification system was used.

CONCLUSION. The CADx ultrasound image analysis program described in the present study is useful for risk stratification of thyroid nodules, but it does not perform better than a sonography expert.

Keywords: computer-aided diagnosis, imaging analysis, malignancy, thyroid nodules, ultrasound

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Received October 8, 2018; accepted after revision February 6, 2019.

AmCAD BioMed Corporation provided a free version of the AmCAD-UT system for use in this study.

[1]Endocrinology and Nutrition Service, Department of

According to ultrasound (US) and autopsy studies, the prevalence of thyroid nodules in the general population is estimated to be between 20% and 60% [1]. Although fewer than 10% of thyroid nodules are malignant, the overall incidence of thyroid cancer has lately

raphy is an imaging modality that is broadly used for diagnostic evaluation of the thyroid gland, because expert examination of the images that sonography yields can serve to stratify the risk of malignancy in thyroid nodules [4] and, in particular, can identify those patients who require fine-needle aspiration [5].

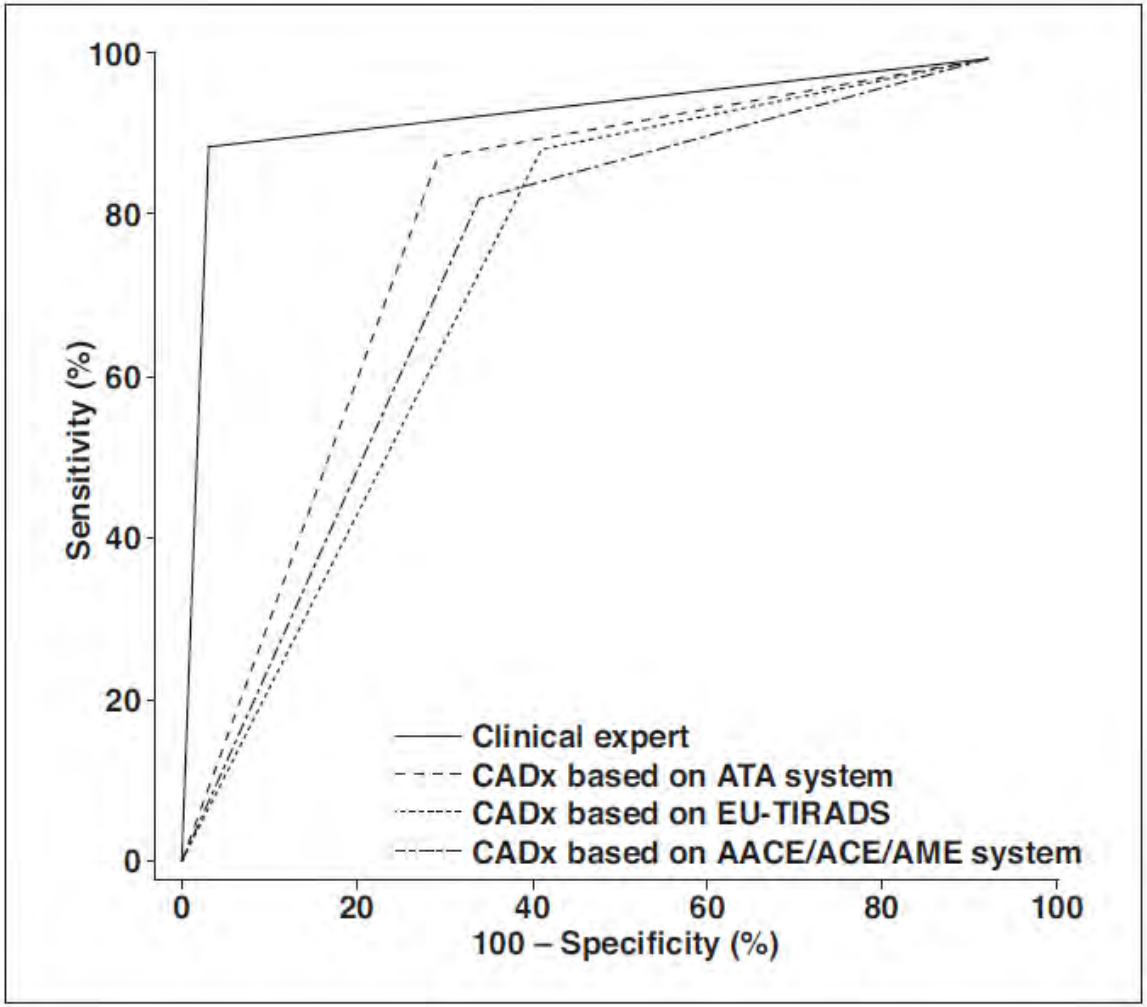
Am CAD -UT. Resultats

TABLE 1: Diagnostic Effectiveness of Evaluation of Ultrasound Images by Clinical Expert and Computer-Aided Diagnosis (CADx) Program Based on Different Classification Systems

Evaluator or Evaluating System	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	AUC Value
Clinical expert using ATA system	87.0	91.2	90.5	90.9	0.88
CADx based on ATA system[a]	87.0	68.8[b]	64.5[b]	86.3	0.72[b]
CADx based on EU-TIRADS[c]	85.2	50.2[b,d]	50.1[b,d]	82.6[b]	0.71[b]
CADx based on AACE/ACE/AME system[e]	81.5	53.2[b,d]	51.8[b,d]	80.8[b]	0.70[b]

Reverter JL. *Am J Roetgen* 2019

Am CAD -UT. Resultats



Reverter JL. *Am J Roetgen* 2019

AmCAD. Resultats

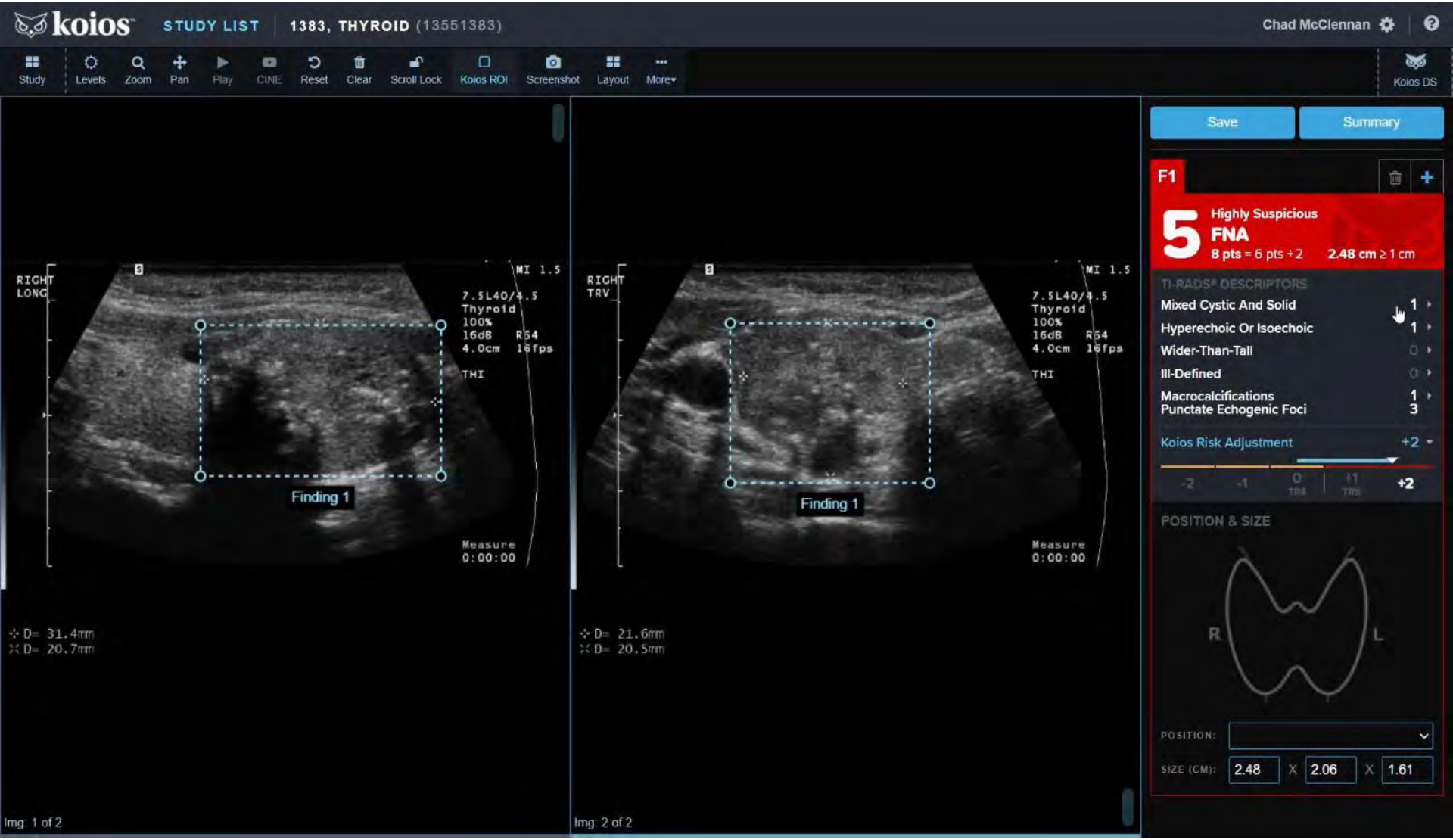
TABLE 2: Publications Describing the Performance of AmCAD-UT (AmCAD Biomed)

First Author [Ref], Study Interpretation	No. of Nodules	Sensitivity		Specificity		PPV		NPV		AUC	
		%	*p*	%	*p*	%	*p*	%	*p*	Value	*p*
Reverter [24]	300										
AmCAD-UT using ATA output		87.0		68.8		64.5		86.3		.72	
Clinical experts		87.0	.76	91.2	< .01	90.5	< .01	90.9	.07	.88	< .05
Wu [26]	265										
Observers with < 10 y experience										.72	
Observers with < 10 y experience and AmCAD-UT										.78	< .01
Observers with ≥ 10 y experience										.74	
Observers with ≥ 10 y experience and AmCAD-UT										.81	≤ .01
Lu [25]	234										
Radiologist		96.1		55.0						.66	
AmCAD-UT		89.0		82.5	< .05					.92	< .05
Radiologist and AmCAD-UT		94.8		85.0	< .05					.93	< .05
Chambara [30]	205										
AmCAD-UT default setting (ACR TI-RADS)		79.6		43.0		56.1		69.7		.72	
AmCAD-UT adjusted setting 1		74.5		48.6		57.0		67.5		.67	
AmCAD-UT adjusted setting 2		61.2		57.9		57.1		62.0		.62	
AmCAD-UT adjusted setting 3		78.5		41.1		55.0		67.7		.67	
Wu [41]	65										
AmCAD-UT		64.0		72.0		54.0		80.0			
Human observer		64.0		67.0		50.0		78.0			

Wildman B. *AJR* 2022

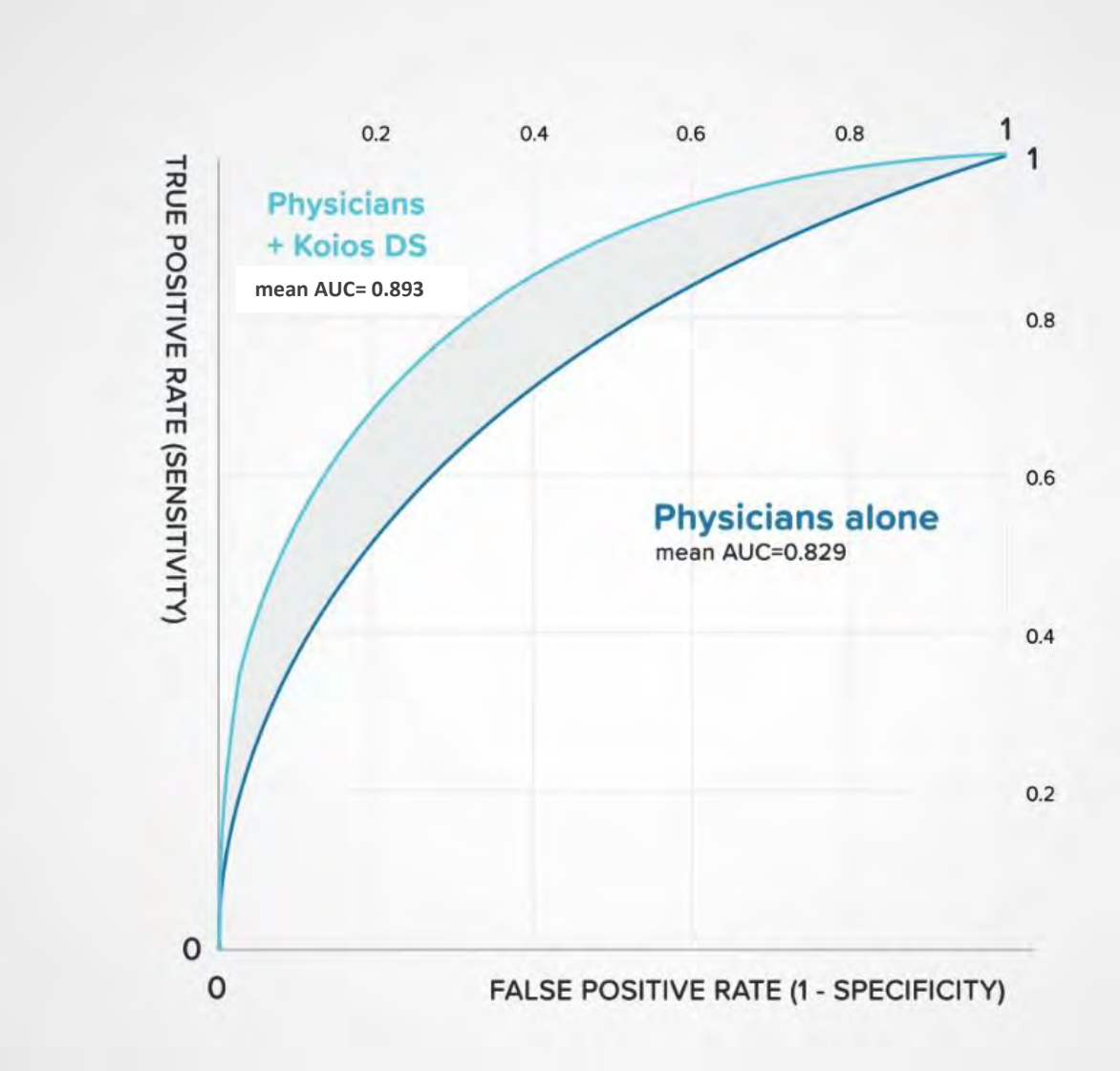
Programes CAD comercials

Programes CAD comercials



Koios DS Thyroid

Koios DS Thyroid



XXVè Congrès de la Societat Catalana d'Endocrinologia i Nutrició
Barcelona, 24 i 25 de novembre 2022

Am CAD -UT.

European Thyroid Journal
Official Journal of the European Thyroid Association

RESEARCH

Reliability of a computer-aided system in the evaluation of indeterminate ultrasound images of thyroid nodules

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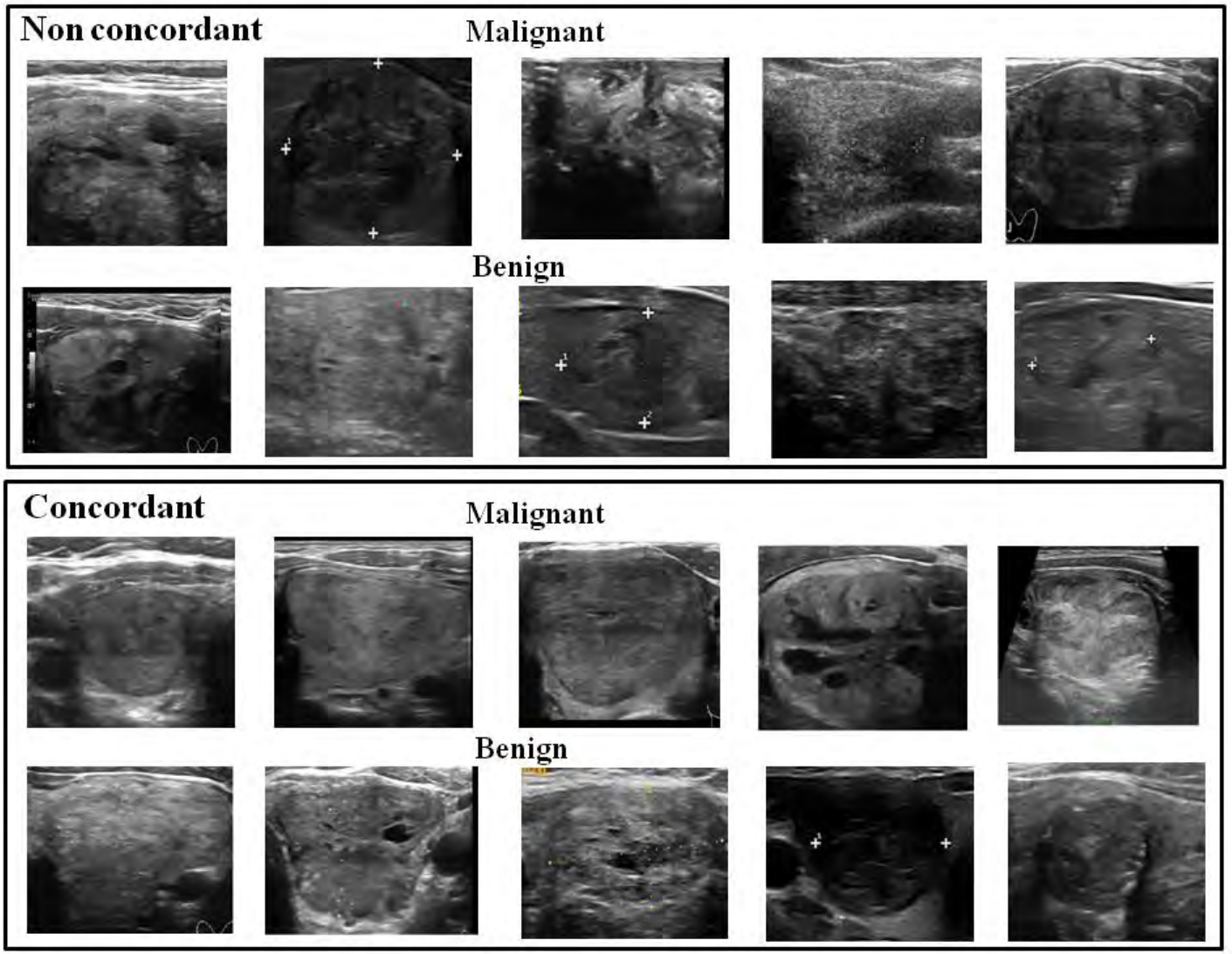
Abstract

Introduction: Computer-aided diagnostic (CAD) programs for malignancy risk stratification from ultrasound (US) imaging of thyroid nodules are being validated both experimentally and in real-world practice. However, they have not been tested for reliability in analyzing difficult or unclear images.
Methods: US images with indeterminate characteristics were evaluated by five observers with different experience in US examination and by a commercial CAD program. The nodules, on which the observers widely agreed, were considered concordant and, if there was little agreement, not concordant or difficult to assess. The diagnostic performance of the readers and the CAD program was calculated and compared in both

Key Words
- thyroid nodules
- CAD system
- risk classification

Germans Trias i Pujol Hospital



Reverter JL, *Eur Thyr J 2019*.

Am CAD -UT.

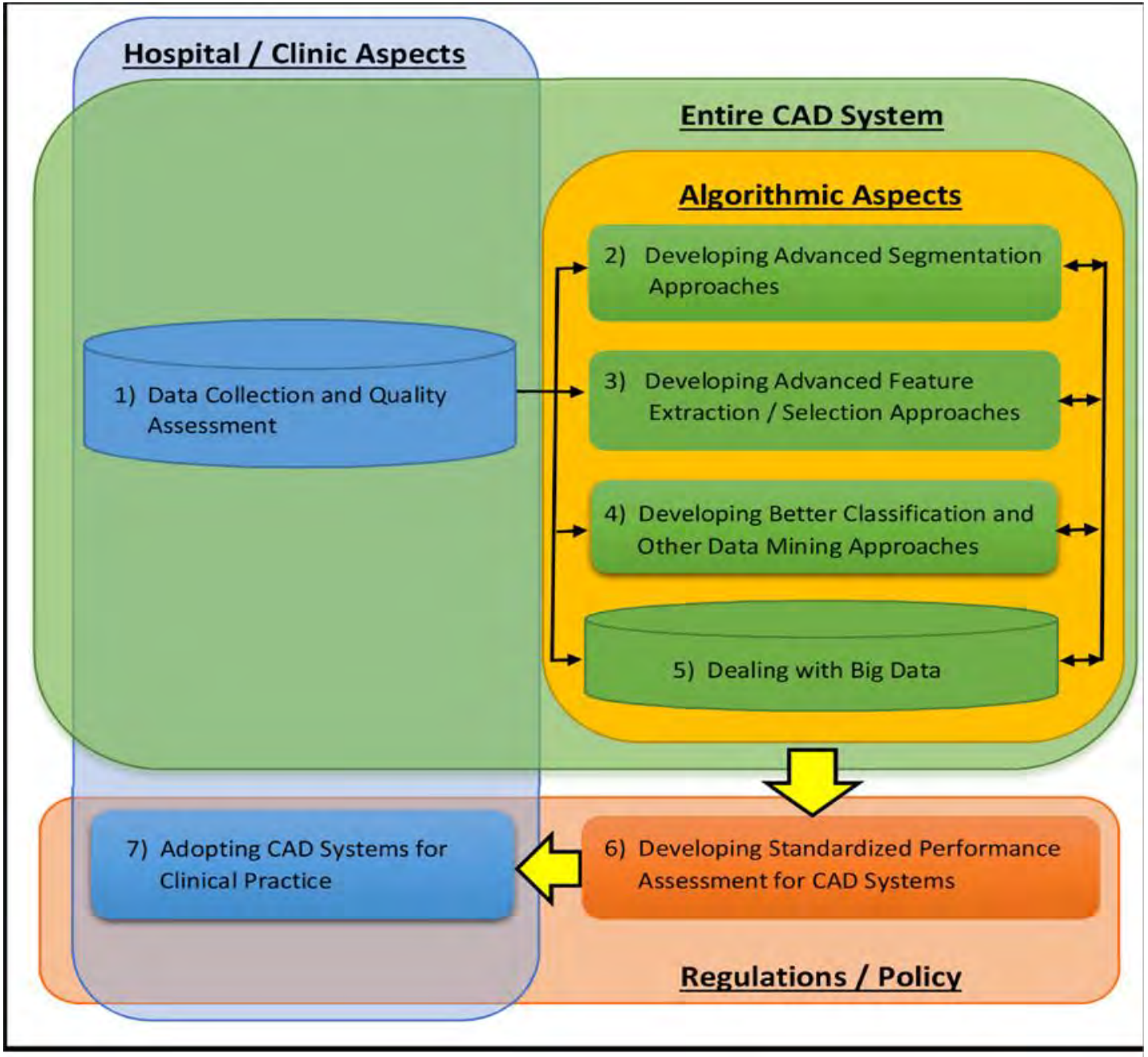
European Thyroid JOURNAL

Table 1 Diagnostic performance of the group of readers and the CAD program in the set of concordant (n = 37) and non-concordant (n = 43) nodules.

	SEN (%)	**SPE** (%)	**PPV** (%)	**NPV** (%)	**Accuracy** (%)
AmCAD					
Concordant	87.5	45.5	77.7	77.7	74.2
Non-concordant	80.7	50.0	71.4	72.4	70.0
Clinical observers					
Concordant	95.0	49.4	75.2	85.6	77.0
Non-concordant	74.0[a]	43.5	46.2[a,b]	66.1	57.1[b]

[a]$P < 0.05$ with respect to concordant; [b]$P < 0.05$ with respect to AmCAD.
CAD, computer-aided diagnostic; NPV, negative predictive value; PPV, positive predictive value; SEN, Sensitivity; SPE, Specificity.

Aplicacions clíniques dels sistemes CAD



CNN-CAD in metastatic lymph node IA mapping

18

Figure legends

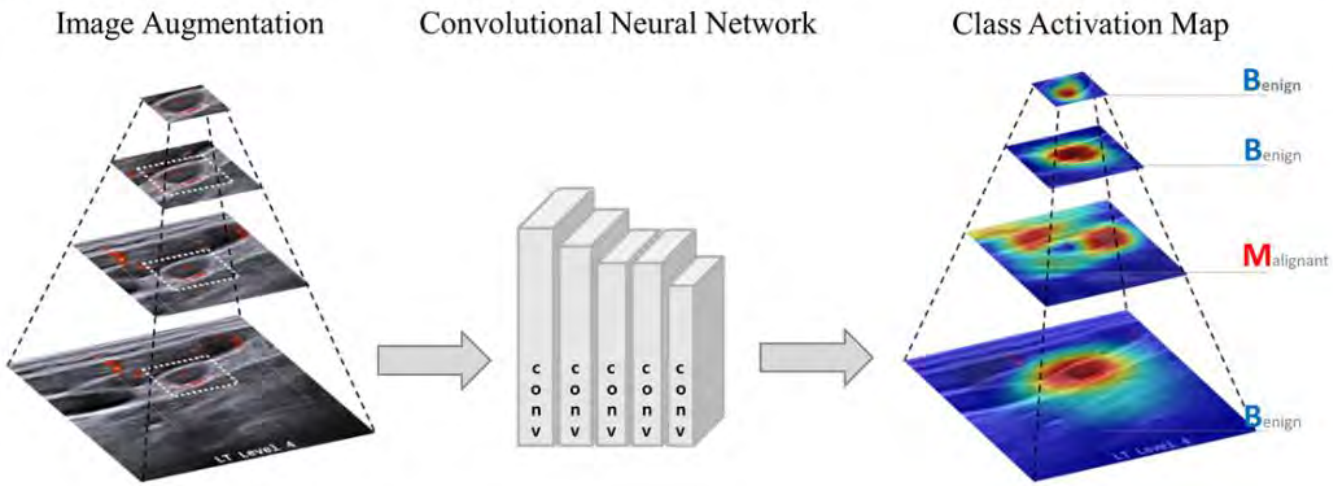


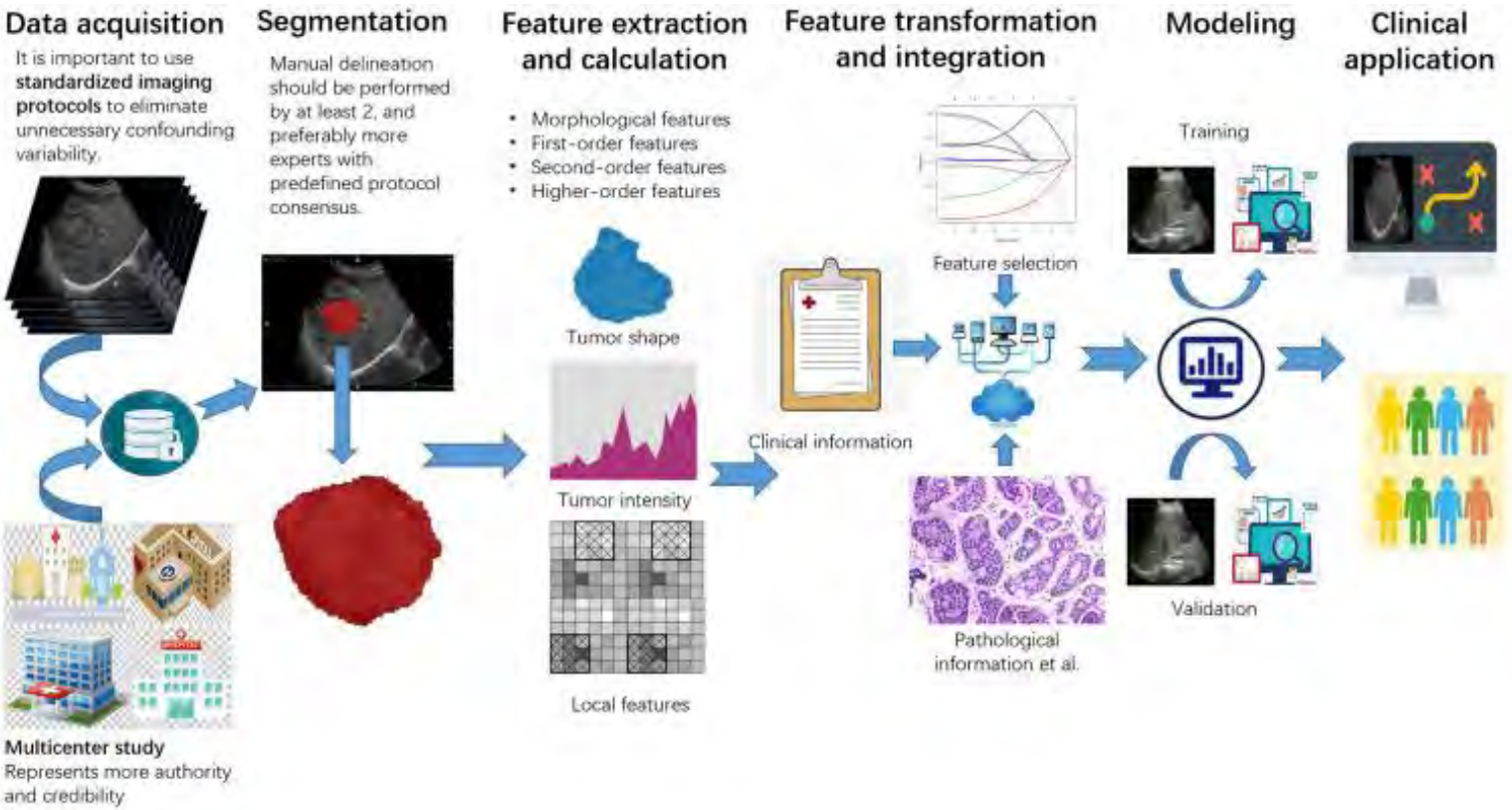
Figure 1. Workflow of data learning.

Lee JH. *Thyroid* 2018

Radiomicsomics in Precision Medicine

Screening, Diagnosis, Classification, and Staging

Individualized Treatment and Survival Prediction



Aplicacions clíniques dels sistemes CAD

Punts clau:

- On implementar el CAD a l'algoritme de diagnòstic ?

- Elevada especificitat o elevada sensibilitat ?

- Necessària validació d'eficàcia i eficiència en clínica

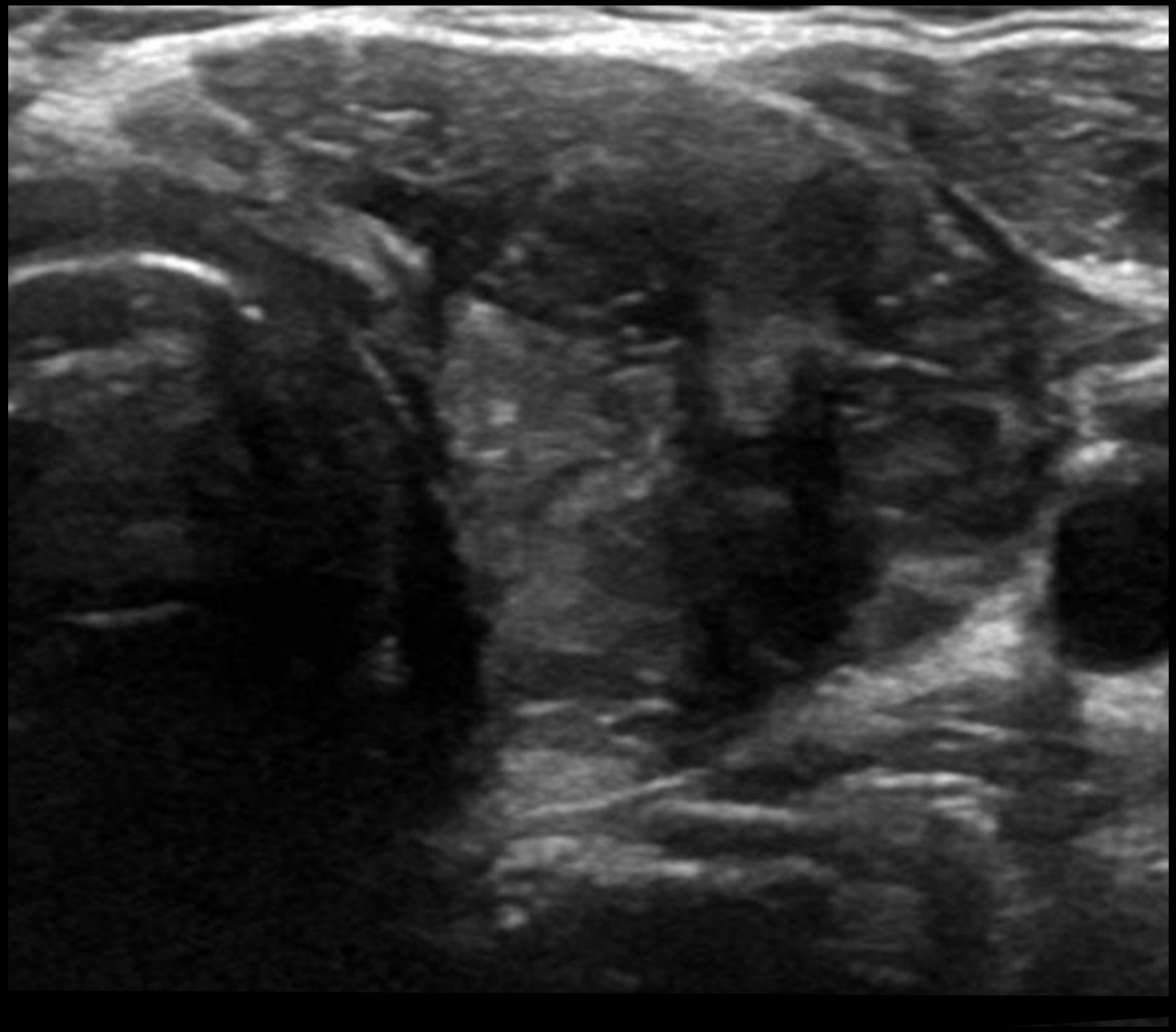
- L'algoritme ha de ser robust i fiable

- Avaluació económica

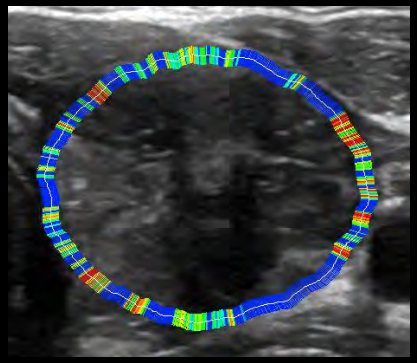
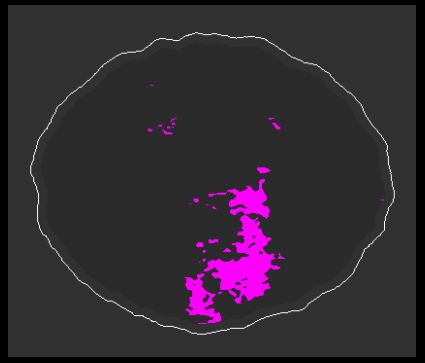
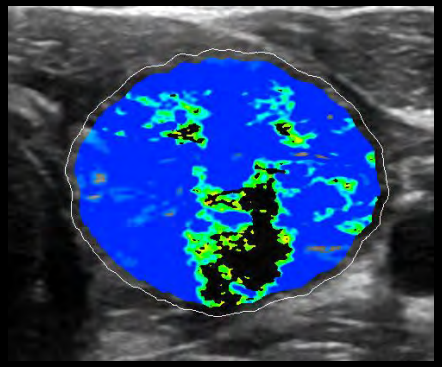
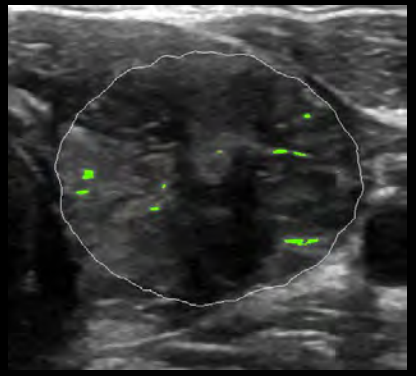
- Sistema d'aprenentatge i formació

- La investigació ha d'explicar els motius en que es basen les prediccions

Classificació de risc TI-RADS ?



Classificació de risc TI-RADS ?

Impression

The nodule tumor, which measures 2,17 (W) x 1,79 (T) cm in size, is a isoechoic and homogeneous nodule with the presence of echogenic foci (likely microcalcifications), anechoic area, and ill-defined margin.

Methodology	Risk of Malignancy
AACE/ACE/AME, 2016	High-risk (50-90%)
ACR, 2017	TI-RADS 4: Moderately Suspicious (3 Points)
ATA, 2015	Not specified
BTA, 2014	U2: Benign
European TiRADS, 2017	EU-TIRADS 5: High risk (26-87%)
Kwak et al., 2011 (Korea)	Category 4B: Intermediate suspicion for malignancy (6.8-37.8%)
KSThR and KSR, 2016	Category 4: Indeterminate suspicion (15-50%)
Seo et al., 2015 (Korea)	Category 3: Indeteminate (> 5%, <= 50%)

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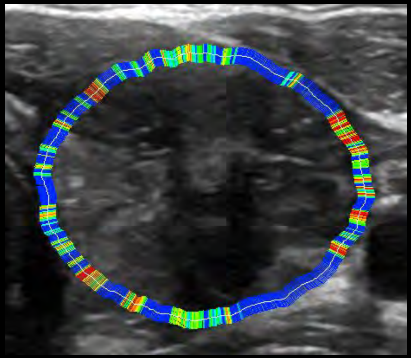
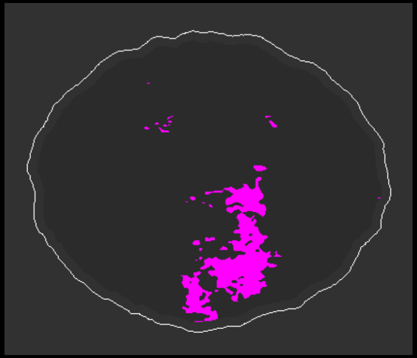
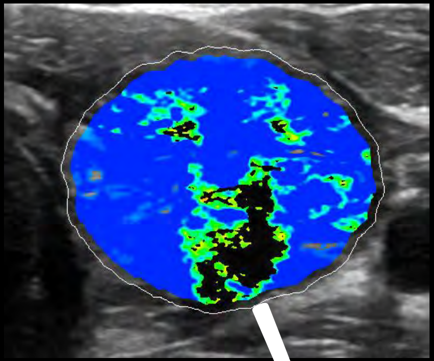
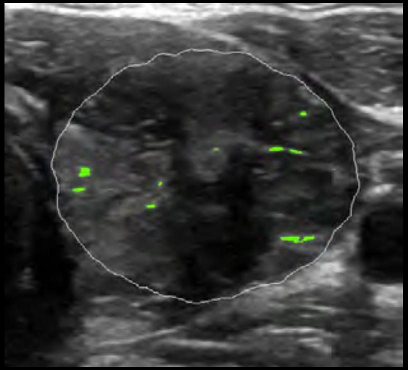
Barcelona, 24 i 25 de novembre 2022

Classificació de risc TI-RADS ?

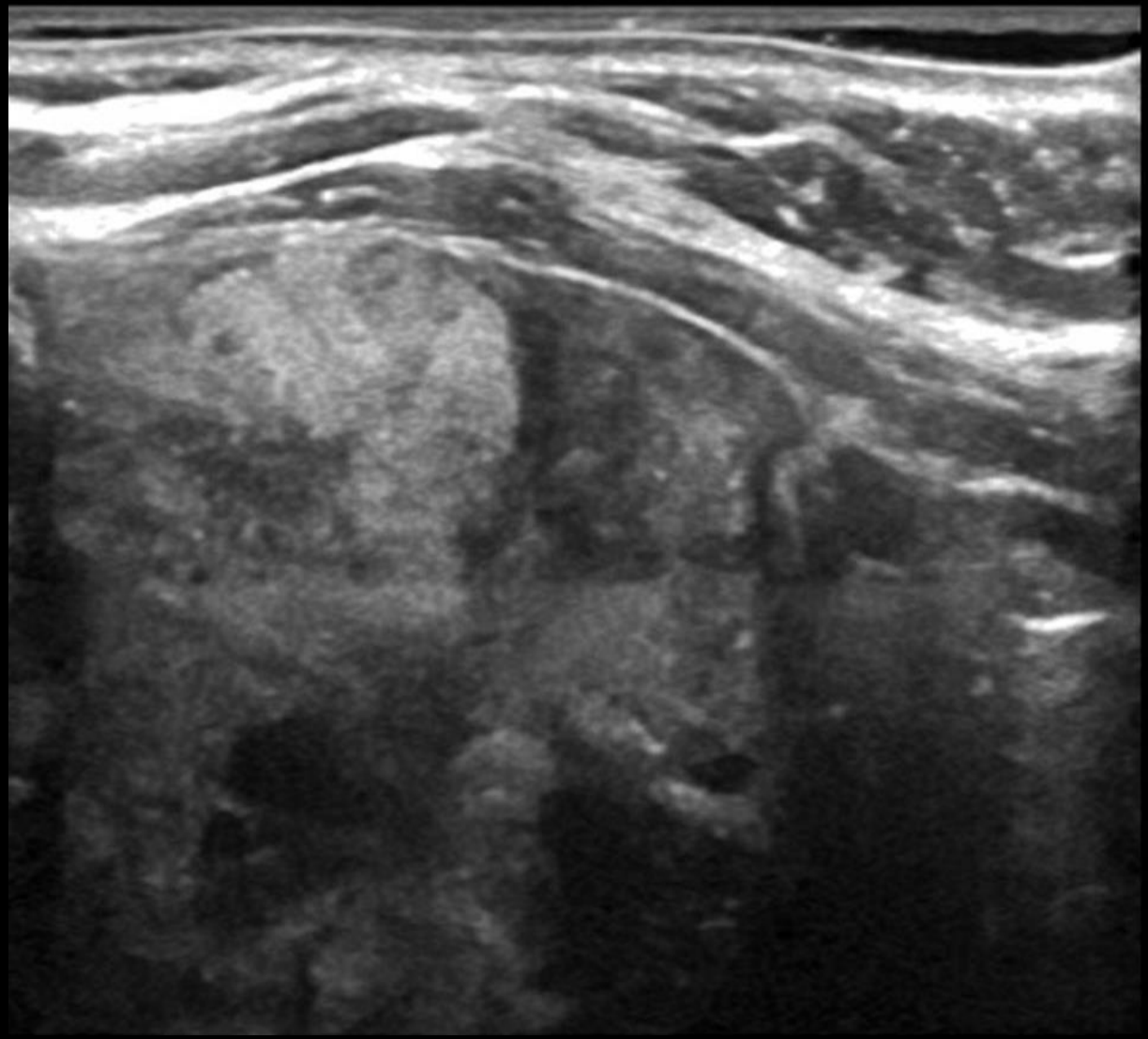
Maligne !

Impression

The nodule tumor, which measures 2,17 (W) x 1,79 (T) cm in size, is a isoechoic and homogeneous nodule with the presence of echogenic foci (likely microcalcifications), anechoic area, and ill-defined margin.

Methodology	Risk of Malignancy
AACE/ACE/AME, 2016	High-risk (50-90%)
ACR, 2017	TI-RADS 4: Moderately Suspicious (5 Points)
ATA, 2015	Not specified
BTA, 2014	U2: Benign
European TiRADS, 2017	EU-TIRADS 5: High risk (26-87%)
Kwak et al., 2011 (Korea)	Category 4B: Intermediate suspicion for malignancy (6.8-37.8%)
KSThR and KSR, 2016	Category 4: Indeterminate suspicion (15-50%)
Seo et al., 2015 (Korea)	Category 3: Indeteminate (> 5%, <= 50%)

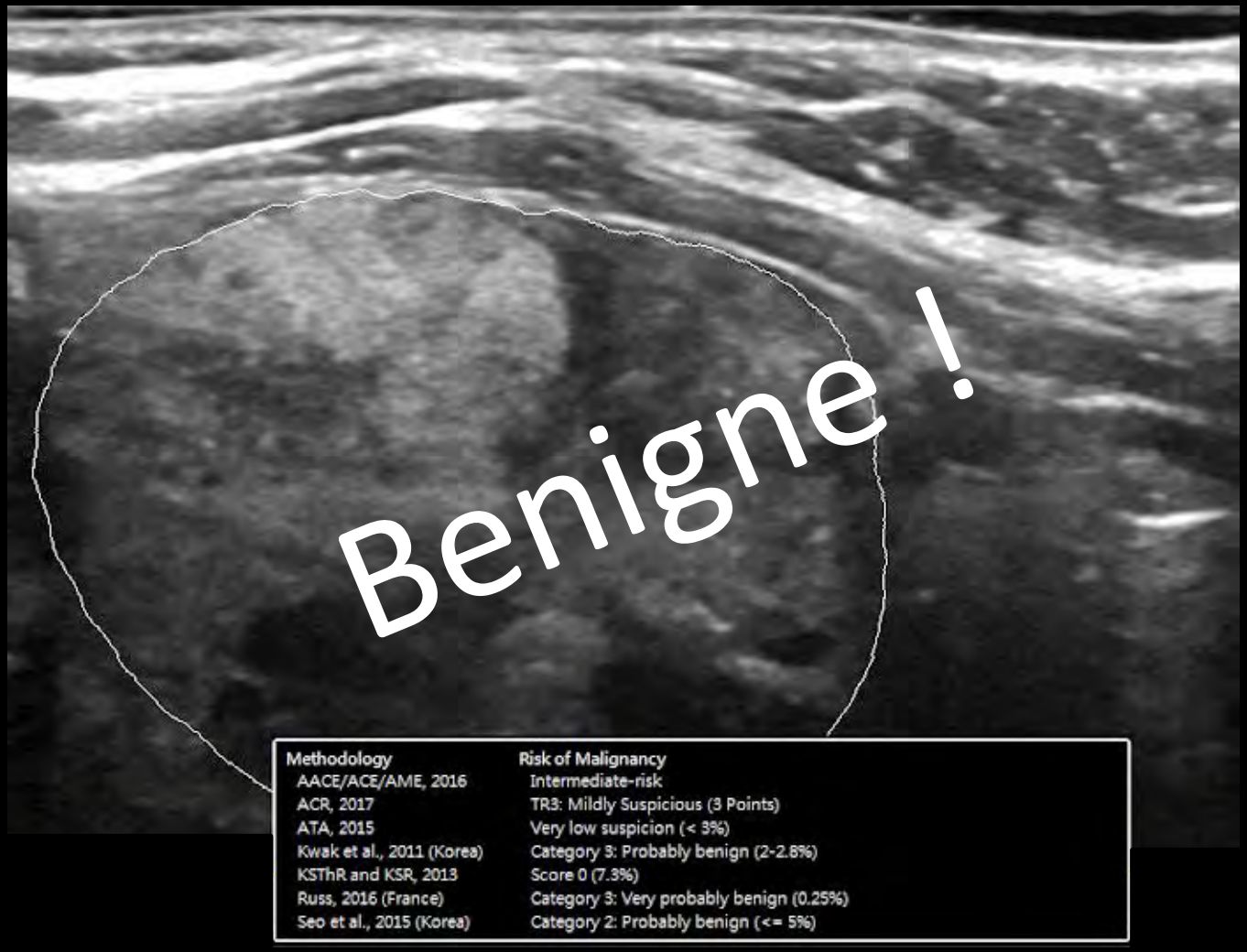
Classificació de risc TI-RADS ?



Classificació de risc TI-RADS ?

Methodology	Risk of Malignancy
AACE/ACE/AME, 2016	Intermediate-risk
ACR, 2017	TR3: Mildly Suspicious (3 Points)
ATA, 2015	Very low suspicion (< 3%)
Kwak et al., 2011 (Korea)	Category 3: Probably benign (2-2.8%)
KSThR and KSR, 2013	Score 0 (7.3%)
Russ, 2016 (France)	Category 3: Very probably benign (0.25%)
Seo et al., 2015 (Korea)	Category 2: Probably benign (<= 5%)

Classificació de risc TI-RADS ?



Methodology	Risk of Malignancy
AACE/ACE/AME, 2016	Intermediate-risk
ACR, 2017	TR3: Mildly Suspicious (3 Points)
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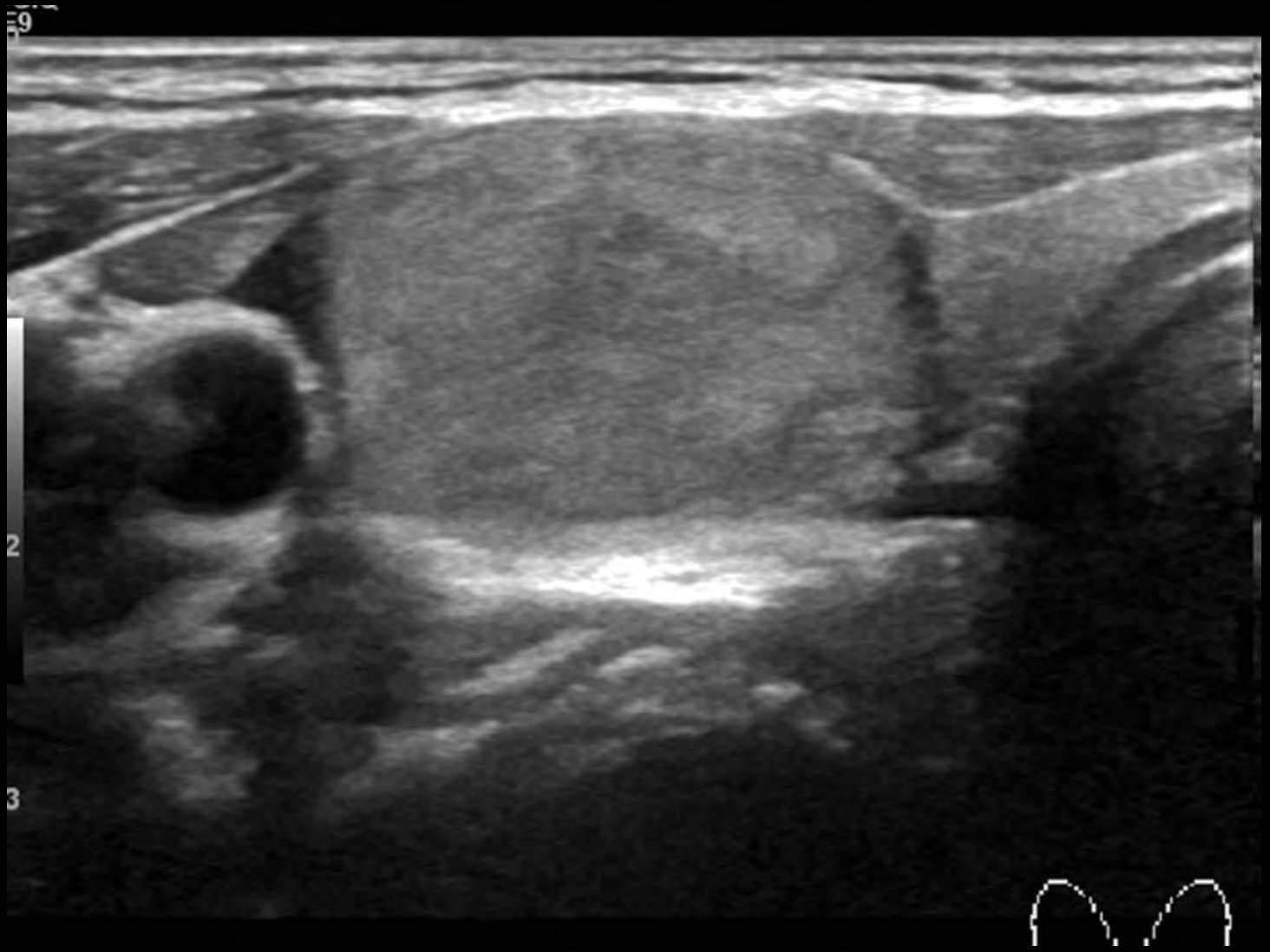
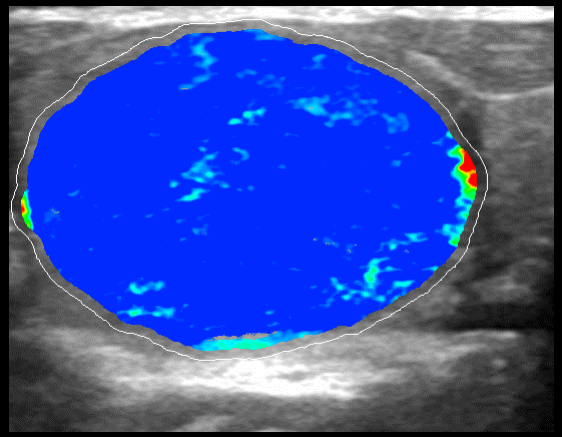
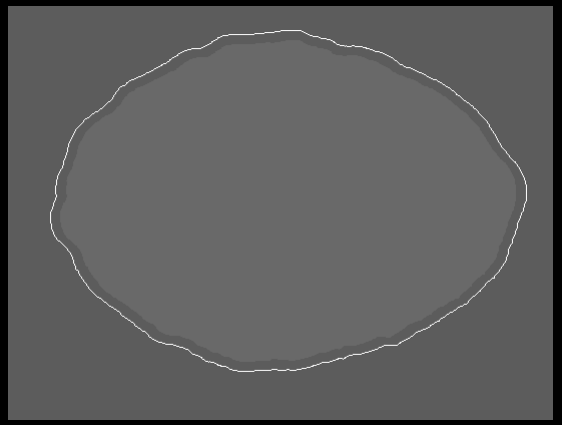
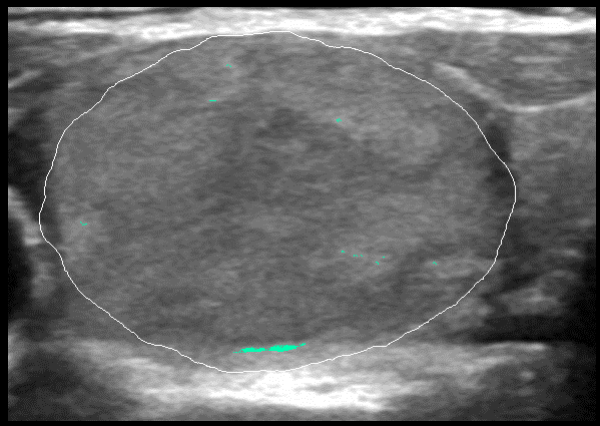
Classificació de risc TI-RADS ?



Classificació de risc TI-RADS ?





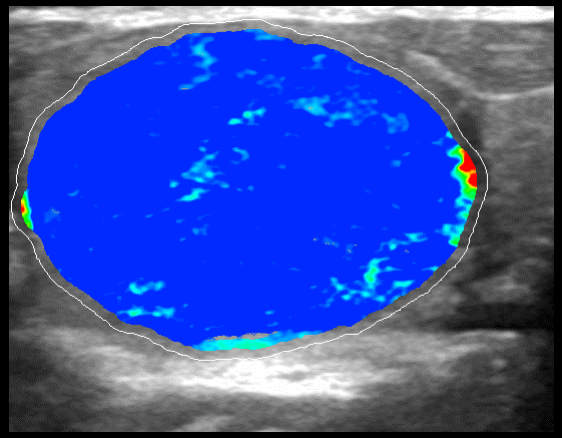


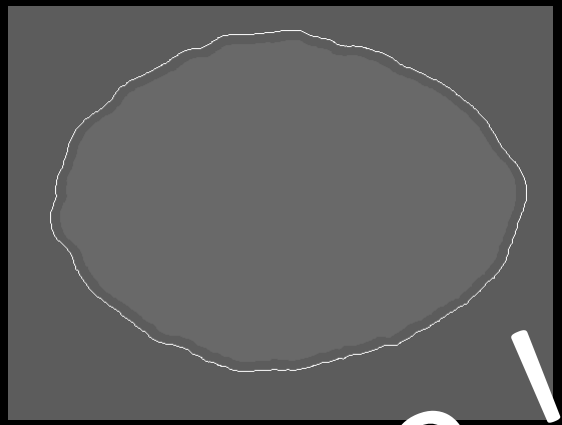
Impression

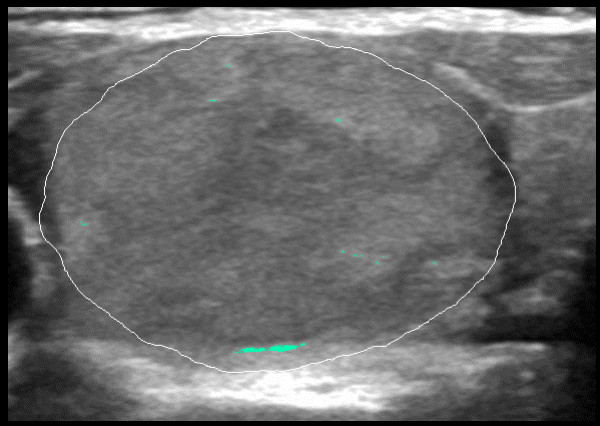
The nodule tumor, which measures 2,41 (W) x 1,72 (T) cm in size, is a hyperechoic and homogeneous nodule.

Methodology	Risk of Malignancy
AACE/ACE/AME, 2016	Not specified
ACR, 2017	TI-RADS 3: Mildly Suspicious (3 Points)
ATA, 2015	Low suspicion (5-10%)
BTA, 2014	U2: Benign
European TiRADS, 2017	EU-TIRADS 3: Low risk (2-4%)
Kwak et al., 2011 (Korea)	Category 4A: Low suspicion for malignancy (3.6-12.7%)
KSThR and KSR, 2016	Category 3: Low suspicion (3-15%)
Seo et al., 2015 (Korea)	Category 2: Probably benign (<= 5%)

Classificació de risc TI-RADS ?







Benigne !

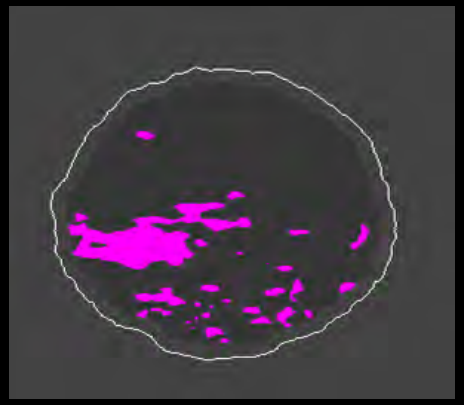
Impression

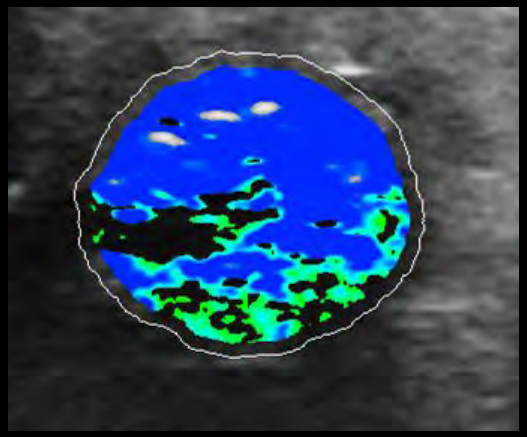
The nodule tumor, which measures 2,4 (M x [illegible]) cm in size, is a hyperechoic and homogeneous nodule

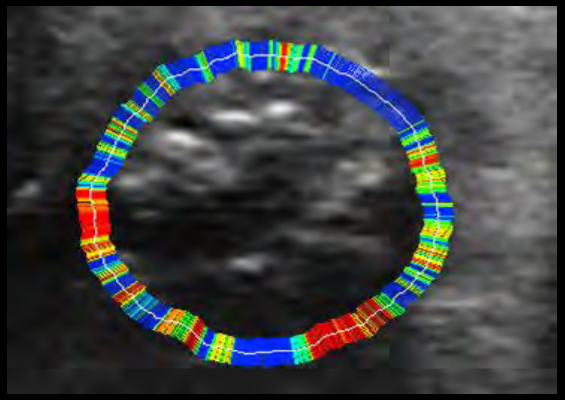
Methodology	Risk of Malignancy
AACE/ACE/AME, 2016	Not specified
ACR, 2017	TI-RADS 3: Mildly Suspicious (3 Points)
ATA, 2015	Low suspicion (5-10%)
BTA, 2014	U2: Benign
European TiRADS, 2017	EU-TIRADS 3: Low risk (2-4%)
Kwak et al., 2011 (Korea)	Category 4A: Low suspicion for malignancy (3.6-12.7%)
KSThR and KSR, 2016	Category 3: Low suspicion (3-15%)
Seo et al., 2015 (Korea)	Category 2: Probably benign (<= 5%)

Classificació de risc TI-RADS ?

Classificació de risc TI-RADS ?





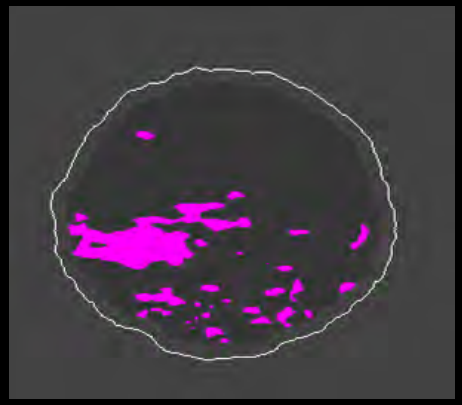


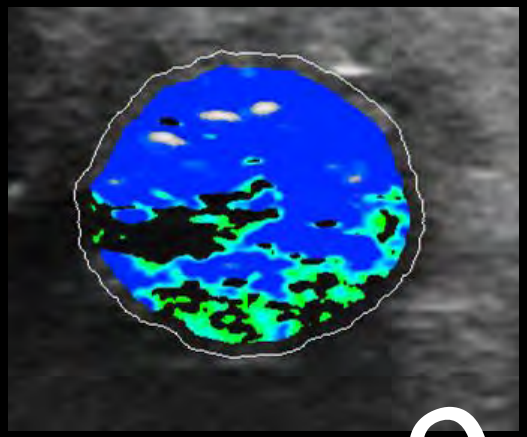
Impression

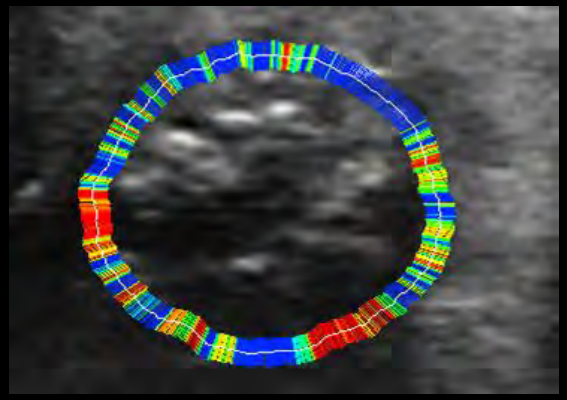
The nodule tumor, which measures 1,34 (W) x 1,22 (T) cm in size, is a hypoechoic and heterogeneous nodule with the presence of echogenic foci (likely microcalcifications), anechoic area, and ill-defined and irregular margin.

Methodology	Risk of Malignancy
AACE/ACE/AME, 2016	High-risk (50-90%)
ACR, 2017	TI-RADS 5: Highly Suspicious (8 Points)
ATA, 2015	High suspicion (> 70-90%)
BTA, 2014	U4: Suspicious
European TiRADS, 2017	EU-TIRADS 5: High risk (26-87%)
Kwak et al., 2011 (Korea)	Category 4C: Moderate concern but not classic for malignancy (21-91.9%)
KSThR and KSR, 2016	Category 4: Indeterminate suspicion (15-50%)
Seo et al., 2015 (Korea)	Category 4: Suspicious malignancy (> 50%)

Classificació de risc TI-RADS ?







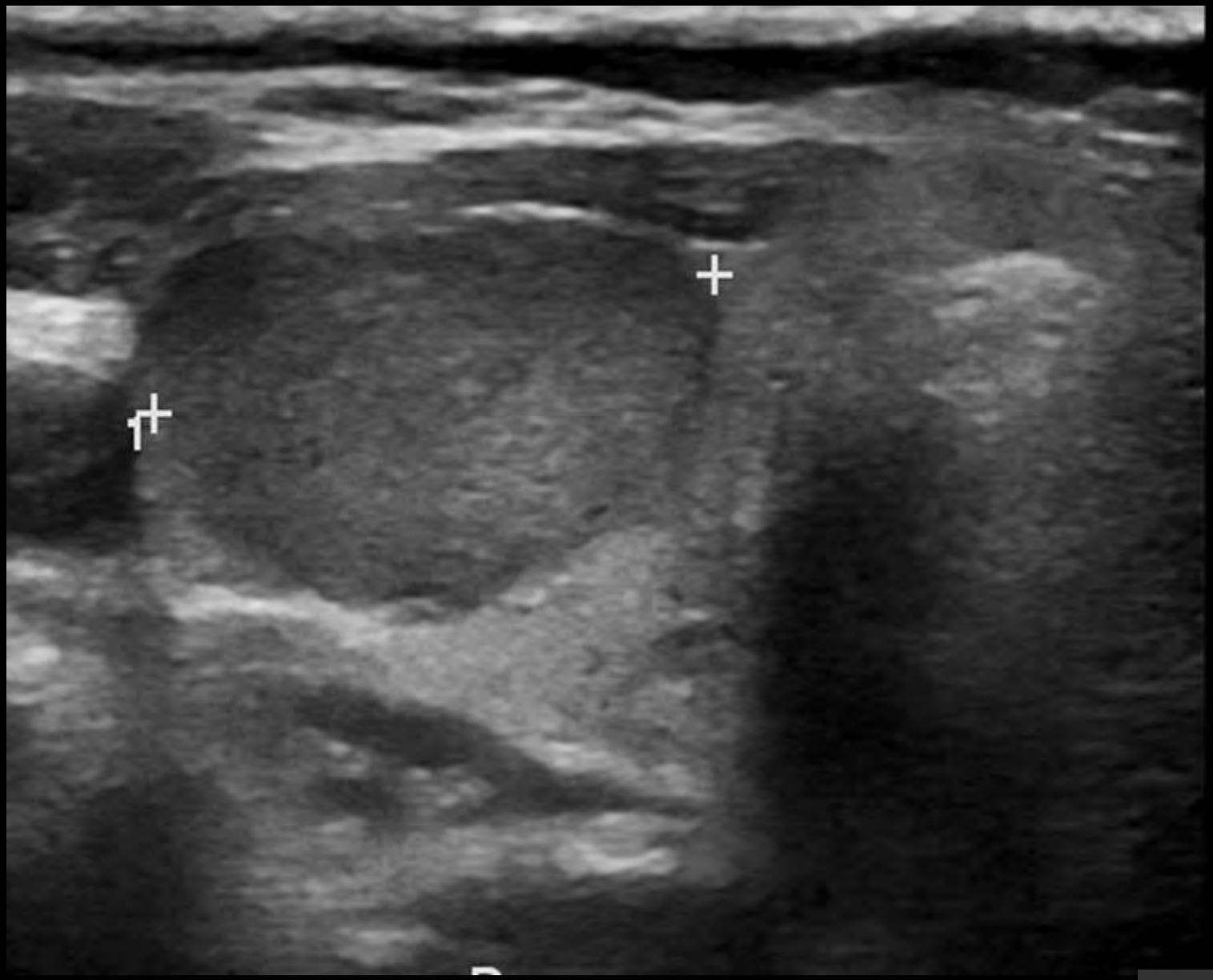
Maligne !

Impression

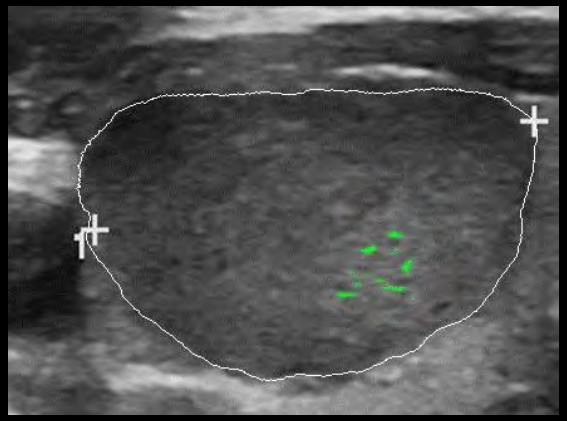
The nodule tumor, which measures 1.24 (W) x 1.32 [illegible] in size, is a hypoechoic and heterogeneous nodule with the presence of echogenic foci (likely microcalcifications), anechoic area, and ill-defined and irregular margin.

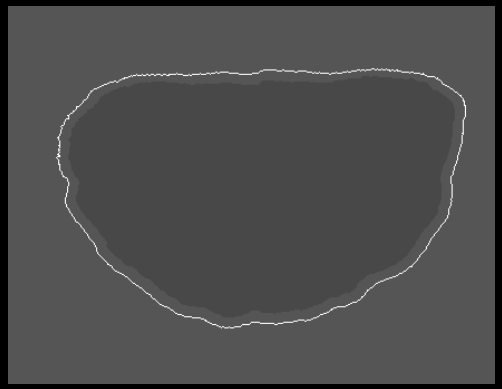
Methodology	Risk of Malignancy
AACE/ACE/AME, 2016	High-risk (50-90%)
ACR, 2017	TI-RADS 5: Highly Suspicious (8 Points)
ATA, 2015	High suspicion (> 70-90%)
BTA, 2014	U4: Suspicious
European TiRADS, 2017	EU-TIRADS 5: High risk (26-87%)
Kwak et al., 2011 (Korea)	Category 4C: Moderate concern but not classic for malignancy (21-91.9%)
KSThR and KSR, 2016	Category 4: Indeterminate suspicion (15-50%)
Seo et al., 2015 (Korea)	Category 4: Suspicious malignancy (> 50%)

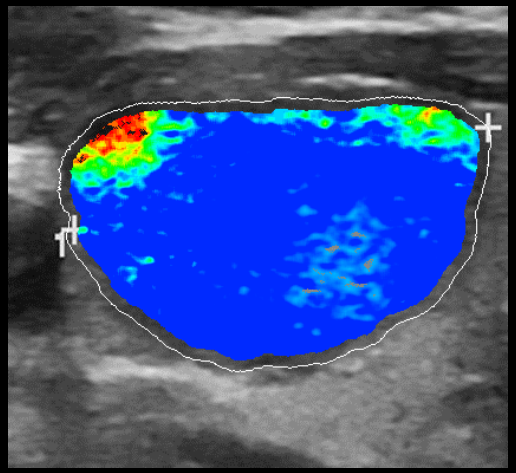
Classificació de risc TI-RADS ?

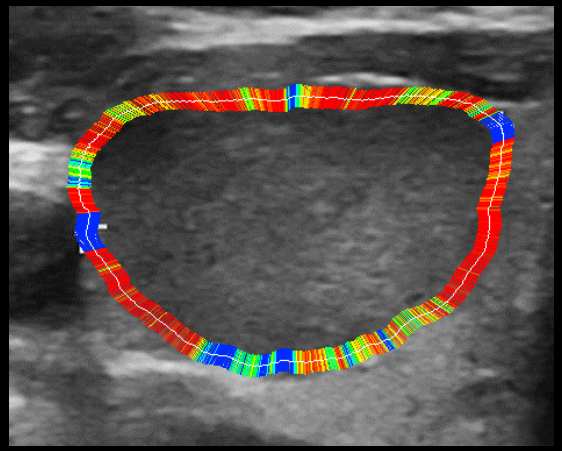


Classificació de risc TI-RADS ?







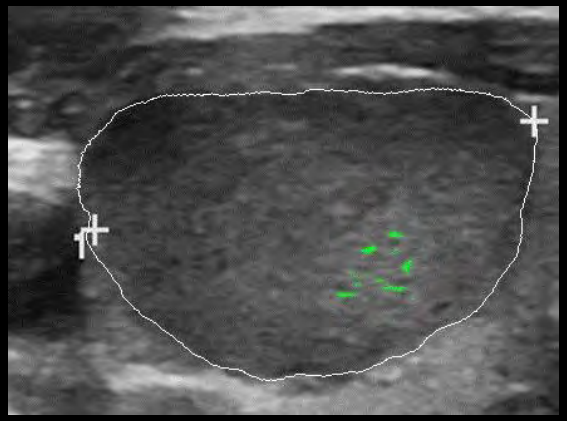


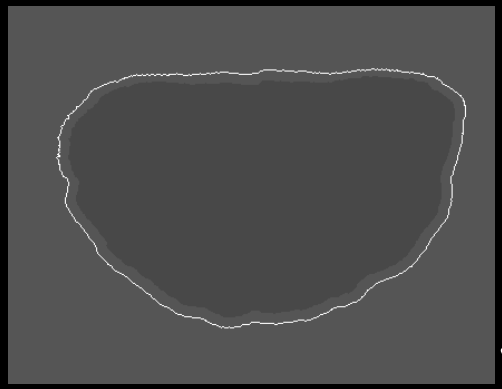
Impression

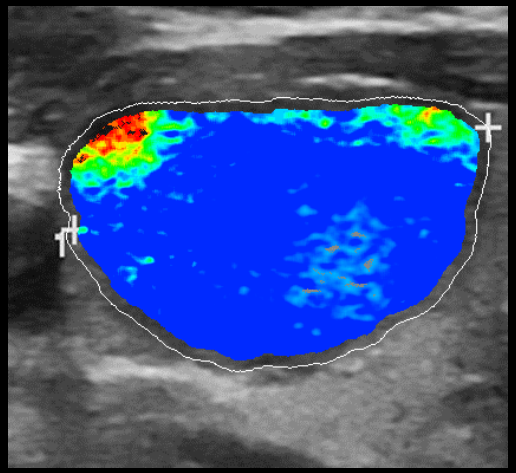
The nodule tumor, which measures 2,00 (W) x 1,35 (T) cm in size, is a hypoechoic and homogeneous nodule with the presence of ill-defined margin and extrathyroidal extension.

Methodology	Risk of Malignancy
AACE/ACE/AME, 2016	High-risk (50-90%)
ACR, 2017	TI-RADS 5: Highly Suspicious (7 Points)
ATA, 2015	High suspicion (> 70-90%)
BTA, 2014	U4: Suspicious
European TiRADS, 2017	EU-TIRADS 4: Intermediate risk (6-17%)
Kwak et al., 2011 (Korea)	Category 4C: Moderate concern but not classic for malignancy (21-91.9%)
KSThR and KSR, 2016	Category 4: Indeterminate suspicion (15-50%)

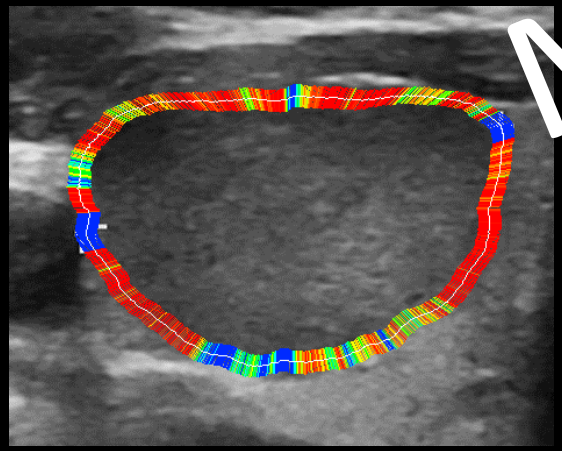
Classificació de risc TI-RADS ?







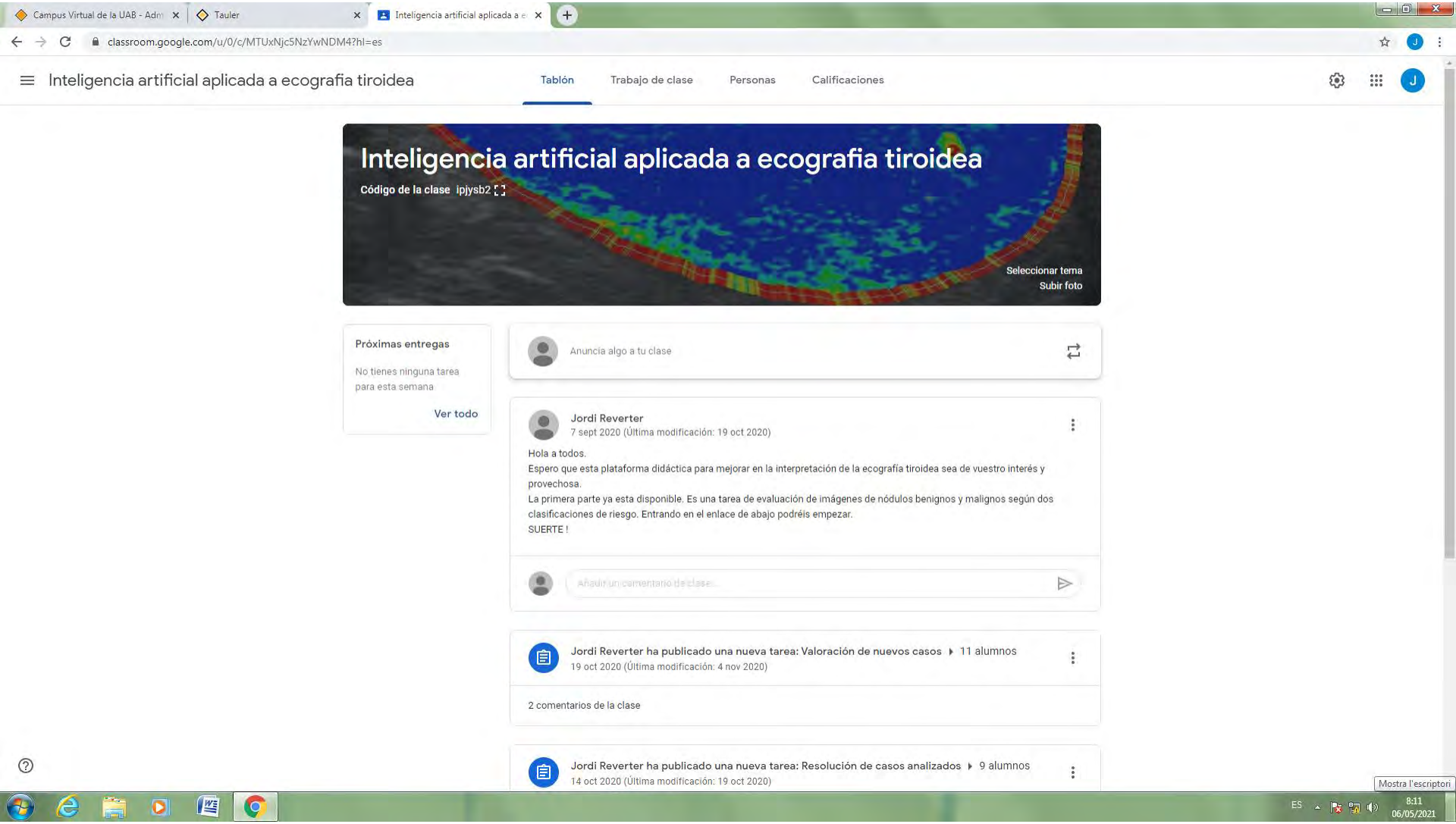
Maligne !



Impression

The nodule tumor, which measures 2,00 (W) x 1,35 (T) cm in size, is a hypoechoic and homogeneous nodule with the presence of ill-defined margin and extrathyroidal extension.

Methodology	Risk of Malignancy
AACE/ACE/AME, 2016	High-risk (50-90%)
ACR, 2017	TI-RADS 5: Highly Suspicious (7 Points)
ATA, 2015	High suspicion (> 70-90%)
BTA, 2014	U4: Suspicious
European TiRADS, 2017	EU-TIRADS 4: Intermediate risk (6-17%)
Kwak et al., 2011 (Korea)	Category 4C: Moderate concern but not classic for malignancy (21-91.9%)
KSThR and KSR, 2016	Category 4: Indeterminate suspicion (15-50%)



Salut/ Germans Trias i Pujol Hospital

Tauler | Trabajo de clase de Inteligencia

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Inteligencia artificial aplicada a ecografia tiroidea

Tablón | Trabajo de clase | Personas | Calificaciones

Crear | Google Calendar | Carpeta de Drive de la clase

Valoración de nuevos casos 2 — Última modificación: 4 nov 2...

Resolución de casos analizados — Última modificación: 19 oct ...

Categorización de nódulos mediante el sist... — Última modificación: 19 oct ...

Sin fecha de entrega ▸ 11 alumnos

Se presenta una serie de los nódulos que habían sido evaluados previamente analizados por el sistema automatizado. Es conveniente hacer una revisión de forma crítica observando en cada nódulo presentado en la primera diapositiva cada una de las características destacadas por el programa. Por último, valorar si se está de acuerdo con la clasificación obtenida.
El alumno debe descargarse el programa Excel donde señalará si disminuye (utilizando valores negativos: -3, -2, -1 ...), coincide (señalar 0) o aumenta (introducir valores positivos: 1, 2, 3 ...) la clasificación ACR ofrecida por el sistema.

7 Han presentado la tarea

4 Asignadas

Estudio IA US alumno. T... Excel

Caso 2.pptx PowerPoint

Caso 3.pptx PowerPoint

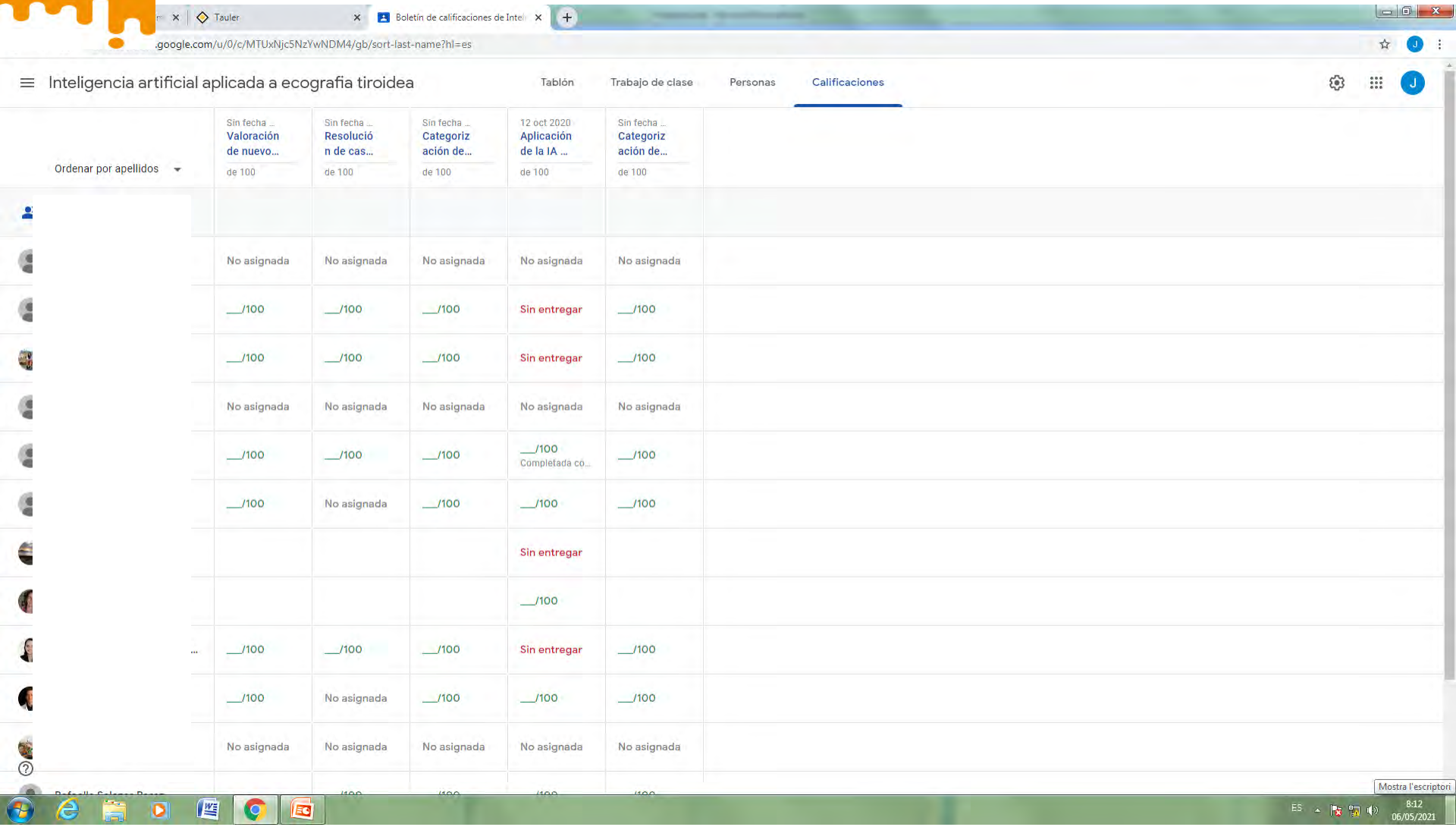
Caso 4.pptx PowerPoint

Ver tarea

Aplicación de la IA en la categorización ... 3 — Fecha de entrega: 12 oct 2020

Categorización de riesgo de nódulos tir... 1 — Última modificación: 19 oct ...

8:12 06/05/2021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.google.com/u/0/c/MTUxNjc5NzYwNDM4/gb/sort-last-name?hl=es
Inteligencia artificial aplicada a ecografia tiroidea
Tablón
Trabajo de clase
Personas
Calificaciones
Ordenar por apellidos
Sin fecha ... Valoración de nuevo... de 100
Sin fecha ... Resolució n de cas... de 100
Sin fecha ... Categoriz ación de... de 100
12 oct 2020 Aplicación de la IA ... de 100
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Gràcies