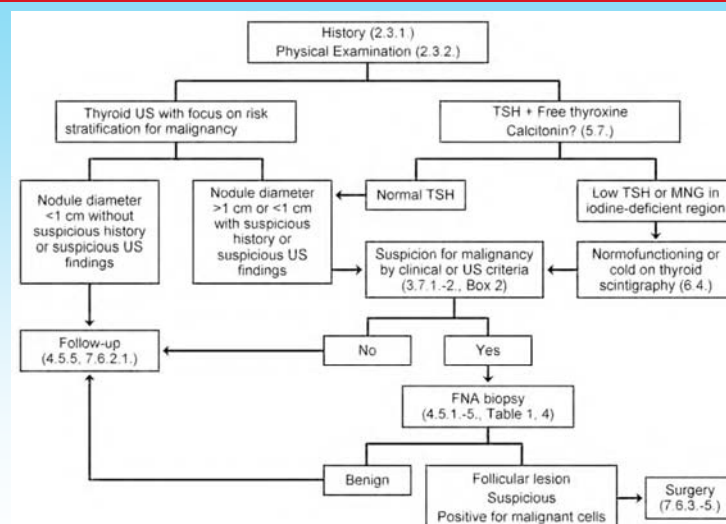


Sono-Elastographie der Schilddrüse

Prof. Dr. Jörg Bojunga
Medizinische Klinik I
Johann Wolfgang Goethe-Universität
Frankfurt am Main

Diagnostischer Algorithmus



AACE/AME/ETA Thyroid Nodule Guidelines, 2010

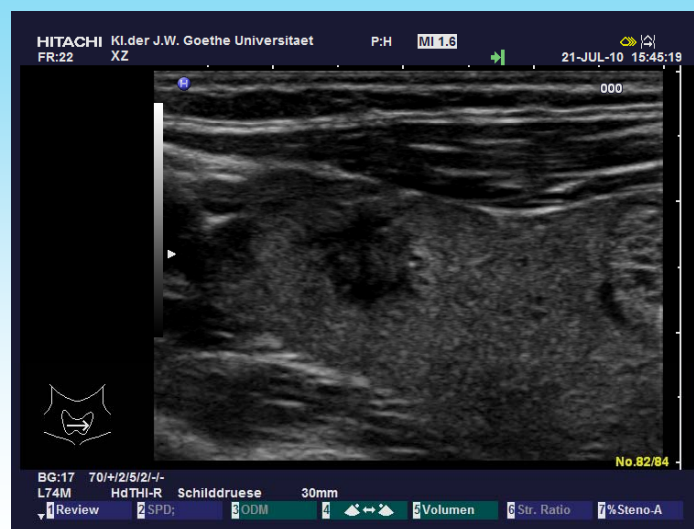
Sonographische Kriterien

Sonographische Charakteristika	Sensitivität (%)	Spezifität (%)
Mikrokalzifikationen	26–59	86–95
Hypoechoogenität	27–87	43–94
unregelmäßige Begrenzung oder kein Halo	17–78	39–85
Solider Knoten	69–75	53–56
Intranoduläre Vaskularisierung	54–74	79–81

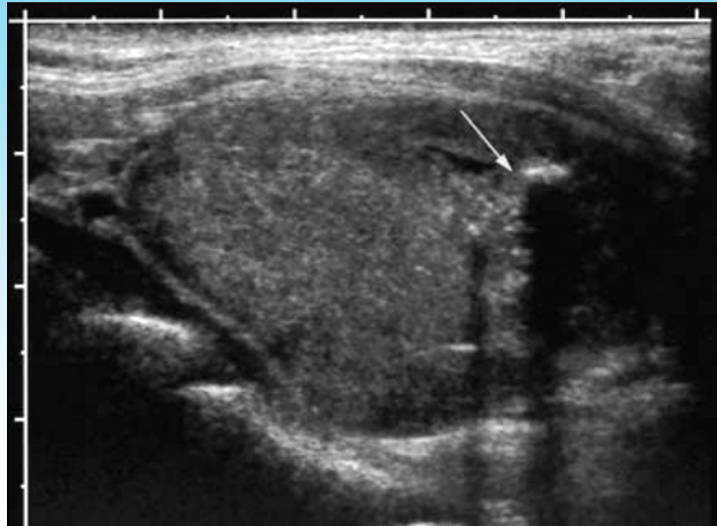
Diese einzelnen Kriterien haben keine ausreichende Sensitivität oder Spezifität zur Prädiktion von Malignität [9]. Aber die Kombination mehrerer Kriterien ist mit deutlich erhöhten Malignitätsraten assoziiert. So beträgt zum Beispiel das Malignitätsrisiko eines solitären soliden Knotens mit punktförmigen Mikrokalzifikationen bei einem Mann 48 % [11].

Paschke Dtsch Med Wochenschr 2009;134: 2498

Sonographische Kriterien



Sonographische Kriterien



TIRADS sinnvoll ?

TIRADS-Kategorien

1: normale Schilddrüse

2: gutartig (Malignitätsrate 0%)

- Anechoisch mit hypoechogenen Punkten, nicht vaskularisiert
- Keine Kapsel, gemischtes Echomuster, vaskularisiert, schwammartig
- Keine Kapsel, gemischte Echogenität mit solidem Anteil, isoechogen, vaskularisiert, hypoechogene Punkte

3: wahrscheinlich gutartig (Malignitätsrate < 5%)

- hyper-, iso- oder hypoechogen, teilweise mit Kapsel, peripher vaskularisiert, bei Hashimoto-Thyreoiditis

4: verdächtig (Malignitätsrate 5–80%)

4a (Malignitätsrate 5–10%):

- Solide oder gemischter iso- oder hypoechogener Knoten mit dünner Kapsel

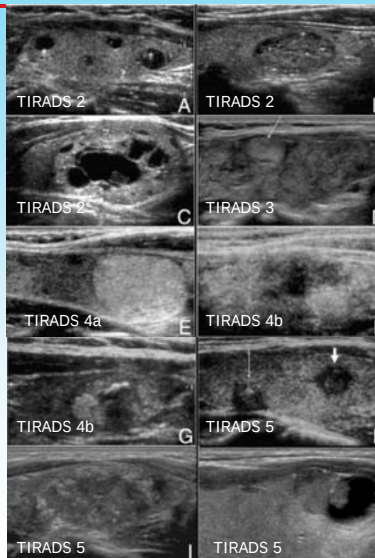
4b (Malignitätsrate 10–80%):

- Hypoechogene Läsion mit schlecht definierbaren Grenzen ohne Kalzifizierungen
- Hyper-, iso- oder hypoechogener Knoten mit dicker Kapsel und scholligen oder Mikro-Kalzifizierungen

5: Wahrscheinlich maligne (Malignitätsrate > 80%)

- **Muster A:** hypoechogener Knoten ohne Kapsel, mit irregulärer Form und Grenzen, penetrierende Gefäße, mit oder ohne Kalzifizierungen
- **Muster B:** iso- oder hypoechogener Knoten ohne Kapsel mit multiplen Mikrokalzifizierungen und Hypervaskularisierung
- **Muster C:** isoechogener Knoten ohne Kapsel, gemischte Hypervaskularisierung mit oder ohne Kalzifizierungen, ohne hyperechogene Punkte

6: Feinnadelaspirationszytologie maligne



Paschke Dtsch Med Wochenschr 2009;134: 2498

Horvath et al., J Clin Endocrinol Metab 2009; 94: 1748

TIRADS sinnvoll ?

FNAZ	TIRADS2	TIRADS3	TIRADS4	TIRADS5
gutartig	100%	85,9%	55%	10,4%
follikuläre Läsion/ Neoplasie	0%	10,7%	31%	3,1%
Karzinom	0%	3,4%	14%	86,5%

Nach Horvath et al., J Clin Endocrinol Metab 2009; 94: 1748

TIRADS - vereinfacht

Association between Thyroid Malignancy and Various US Features

Parameter	No. of Malignant Nodules (n = 275)*	No. of Benign Nodules (n = 1383)*	Univariate Analysis		Multivariate Analysis		
			Odds Ratio [‡]	P Value [‡]	Odds Ratio [‡]	P Value [§]	
Composition							
Solid (n = 1060)	255 (24.1)	805 (75.9)	9.155 (5.745, 14.587)	<.001	1.796 (1.063, 3.031)	.029	
Mixed (n = 598)	20 (3.3)	578 (96.7)	1	...	1	...	
Echogenicity							
Hyper/isoechoogenicity (n = 900)	43 (4.8)	857 (95.2)	1	<.001	1	...	
Hypoechoogenicity (n = 677)	169 (25.0)	508 (75.0)	6.630 (4.635, 9.486)	...	1.955 (1.264, 3.023)	.003	
Marked hypoechoogenicity (n = 81)	63 (77.8)	18 (22.2)	69.756 (37.216, 130.747)	...	3.828 (1.627, 9.010)	.002	
Margins							
Well circumscribed (n = 1330)	68 (5.1)	1262 (94.9)	1	<.001	1	...	
Microlobulated (n = 221)	115 (52.0)	106 (48.0)	20.135 (14.038, 28.880)	...	4.993 (3.061, 8.146)	<.001	
Irregular (n = 107)	92 (86.0)	15 (14.0)	113.828 (60.771, 213.205)	...	15.364 (7.179, 32.883)	<.001	
Calcifications							
Microcalcifications (n = 162)	111 (68.5)	51 (31.5)	25.871 (17.503, 38.240)	<.001	5.908 (3.395, 10.283)	<.001	
Macrocalcifications (n = 246)	67 (27.2)	179 (72.8)	4.449 (3.119, 6.346)	...	1.414 (0.890, 2.247)	.142	
No calcifications (n = 1250)	97 (7.8)	1153 (92.2)	1	...	1	...	
Shape							
Wider than tall (n = 1460)	134 (9.2)	1326 (90.8)	1	<.001	1	...	
Taller than wide (n = 198)	141 (71.2)	57 (28.8)	24.478 (17.152, 34.933)	...	3.662 (2.182, 6.147)	<.001	

* Numbers in parentheses are percentages.

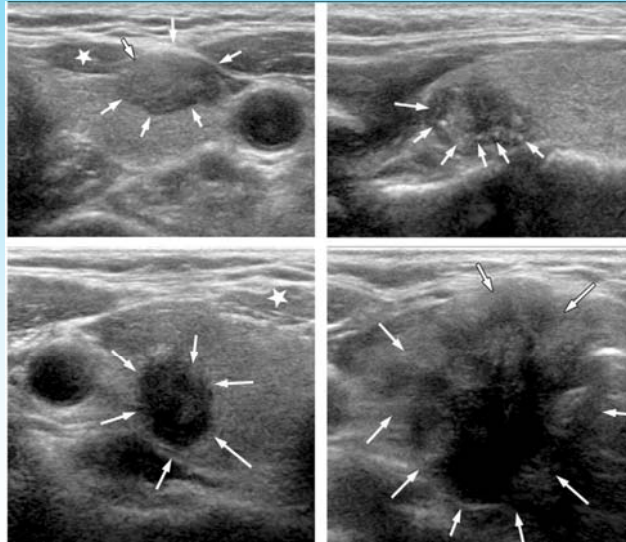
† Numbers in parentheses are 95% confidence intervals.

‡ Determined with the χ^2 test.

§ Determined with logistic regression analysis.

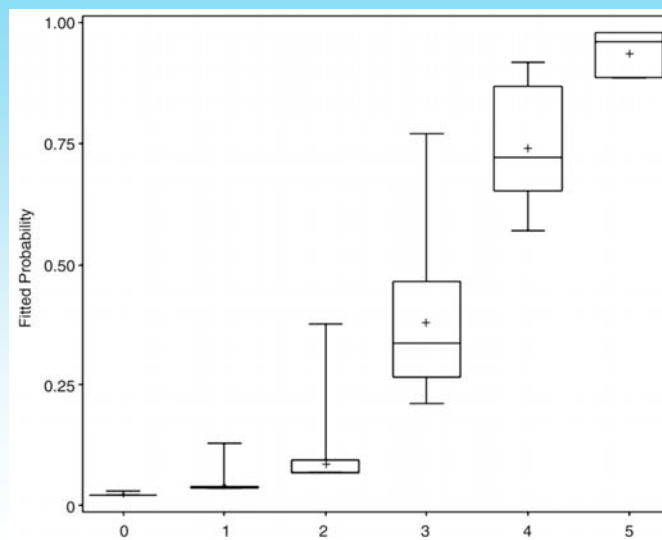
Radiology: Volume 260: Number 3—September 2011

TIRADS - vereinfacht



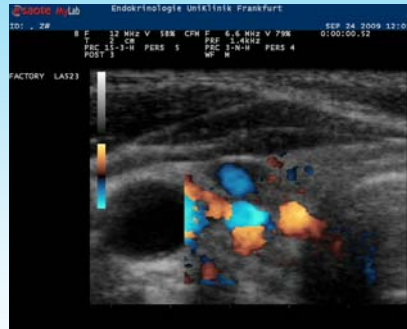
Radiology: Volume 260: Number 3—September 2011

TIRADS - vereinfacht

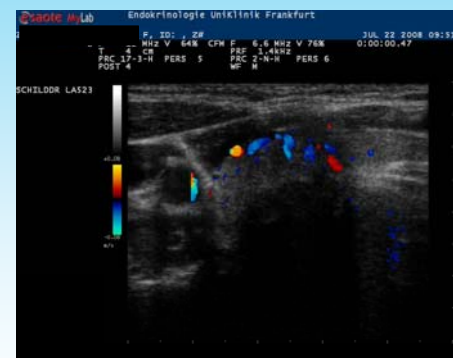


Radiology: Volume 260: Number 3—September 2011

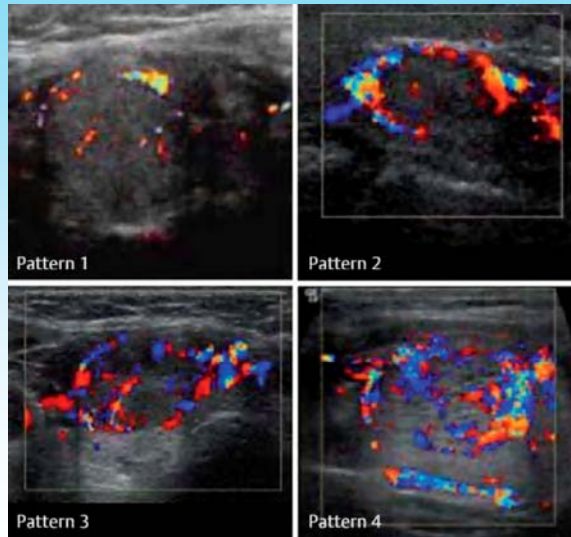
Power-Doppler Sonographie



Power-Doppler Sonographie

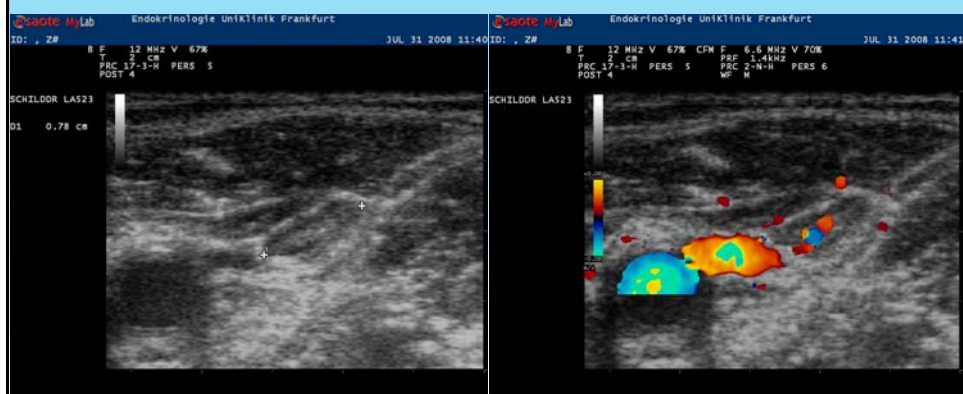


Power-Doppler Sonographie



Ivanac et al., J Ultrasound Med. 2007, 28: 502

Lymphknoten



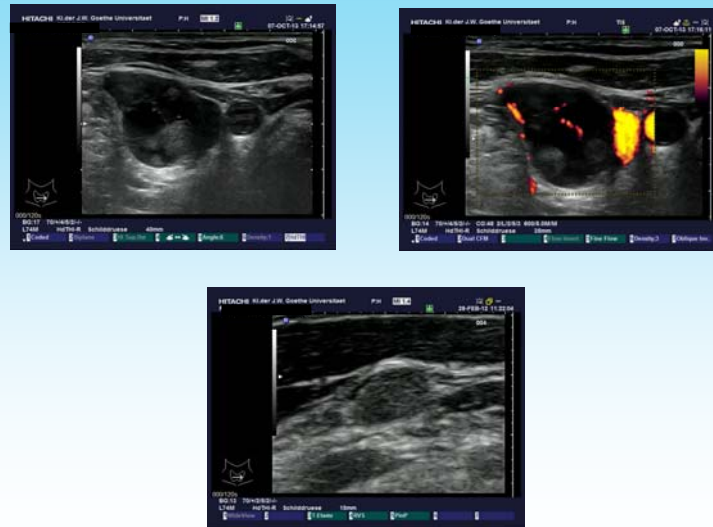
Lymphknoten



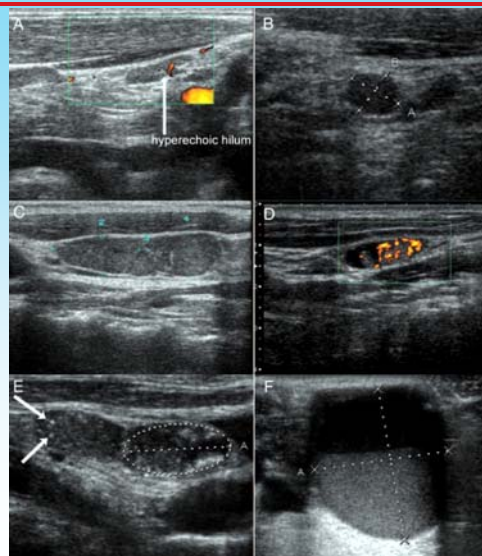
Lymphknoten



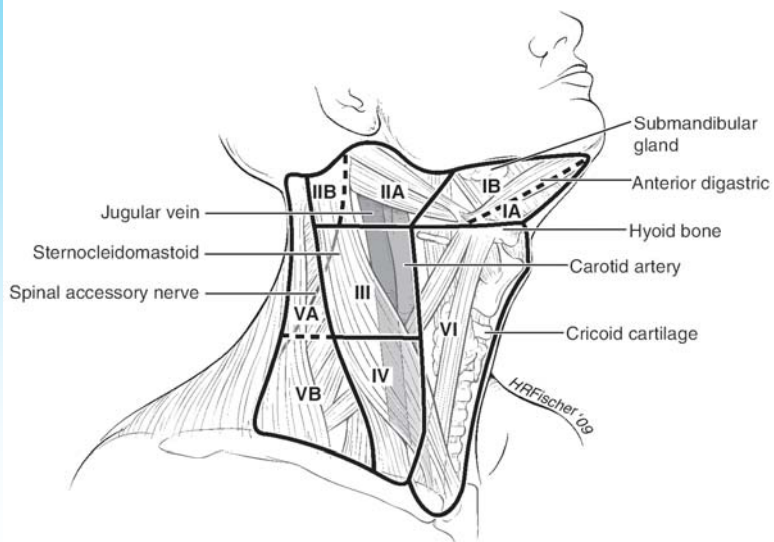
Lymphknoten



Lymphnodes



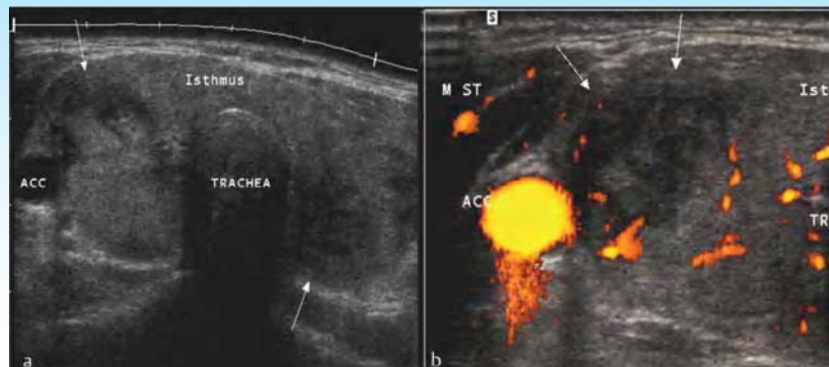
Lymphknotenkompartimente



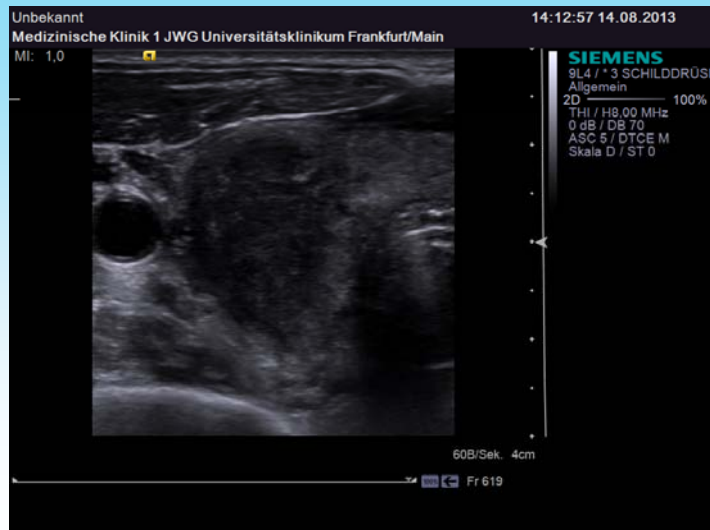
ATA Guidelines 2009

Subakute Thyreoiditis

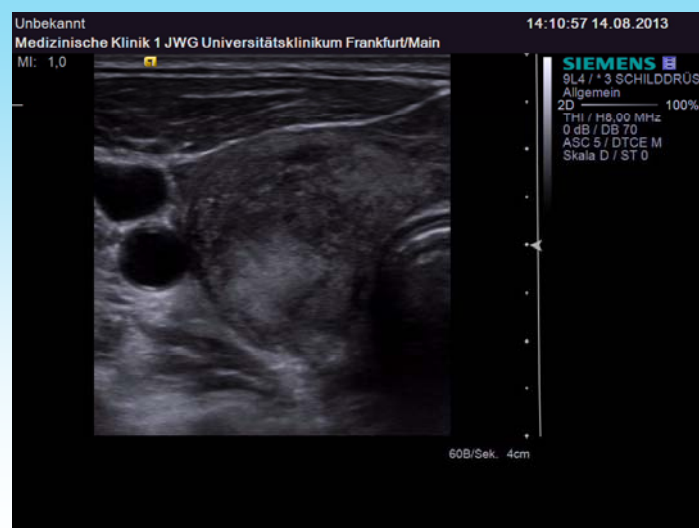
clinical features:	feeling ill, neck pain, tenderness
clinical test parameters:	signs of inflammation, disorder of thyroid function
sonography:	inhomogeneously enlarged organ, hypoechoic areas (dynamic process)
colour Doppler sonography:	reduced/absent vascularisation in the hypoechoic areas, normal vascularisation in the rest of the thyroid
fine needle biopsy:	granulomatous inflammation
scintigraphy:	reduced uptake, inhomogeneous distribution



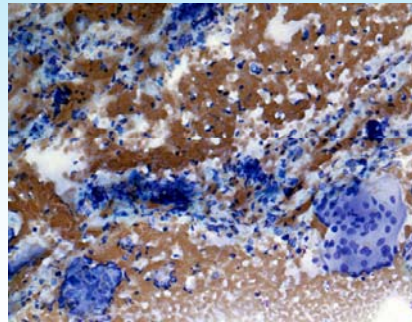
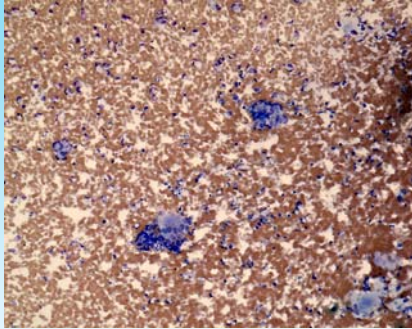
Subakute Thyreoiditis



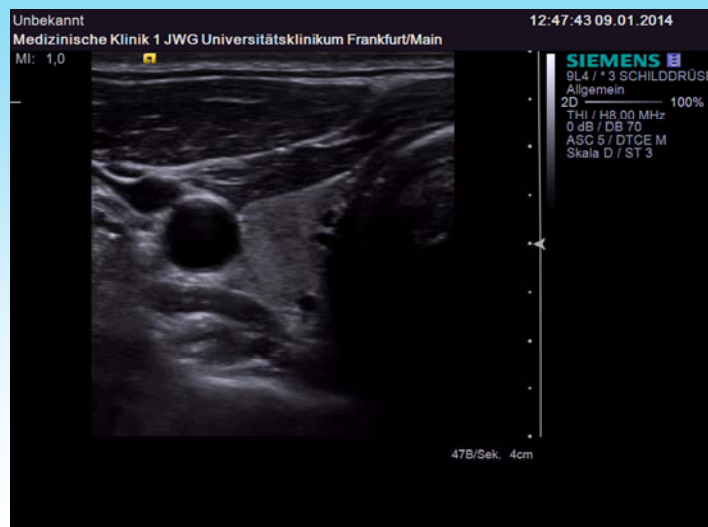
Subakute Thyreoiditis



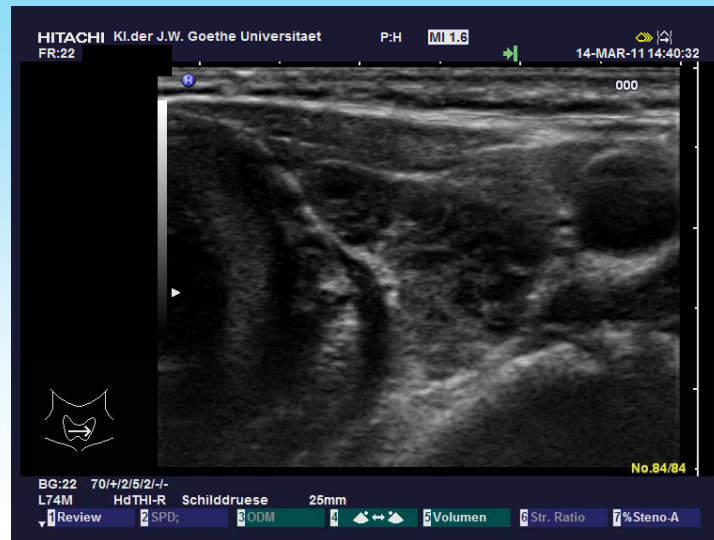
Subakute Thyreoiditis



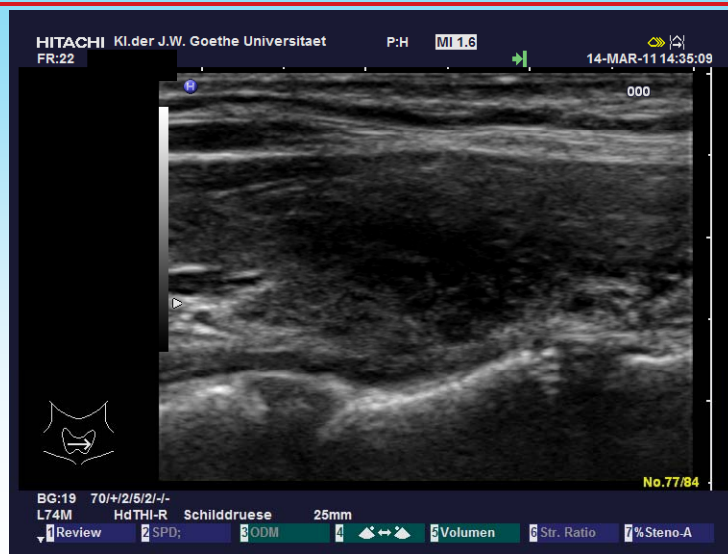
Subakute Thyreoiditis



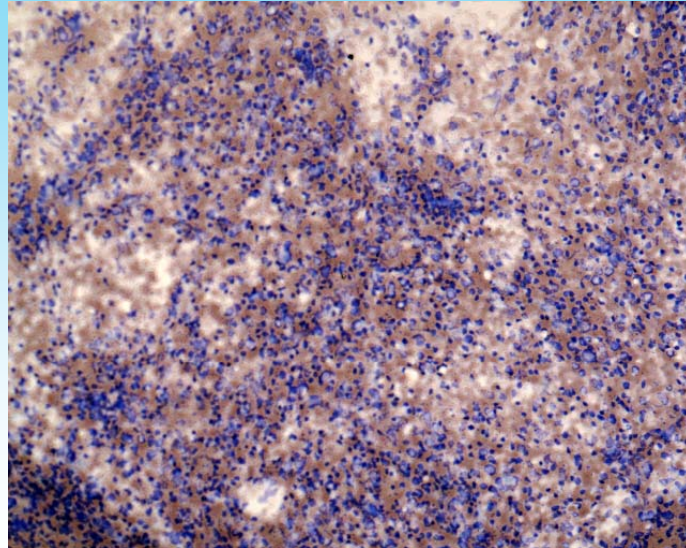
Fokale Thyreoiditis



Fokale Thyreoiditis



Fokale Thyreoiditis

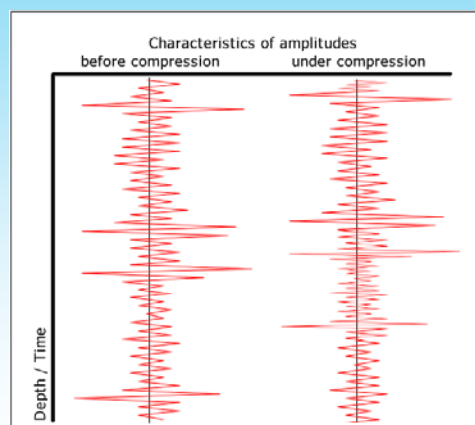


HI-Real-Time Elastographie

vor Kompression



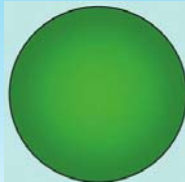
unter Kompression



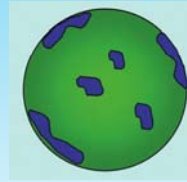
Elastographiemuster

Benigne

ES1

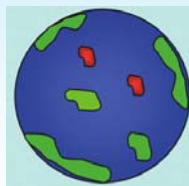


ES 2

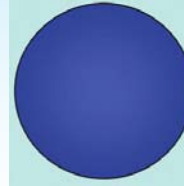


Maligne

ES 3

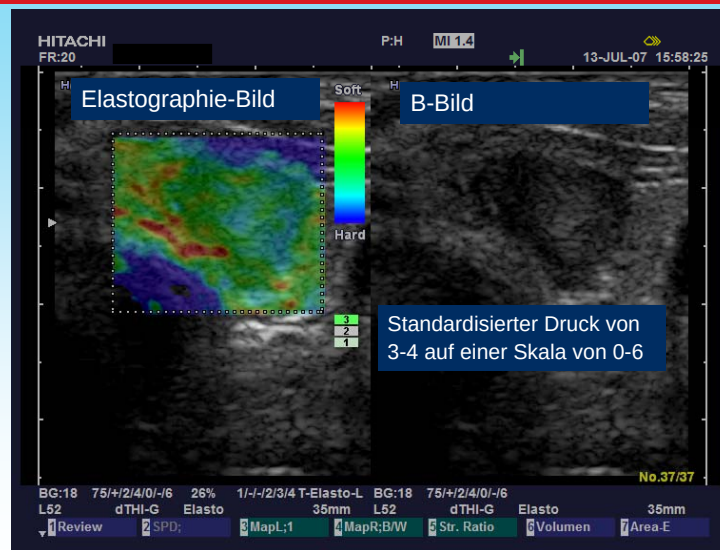


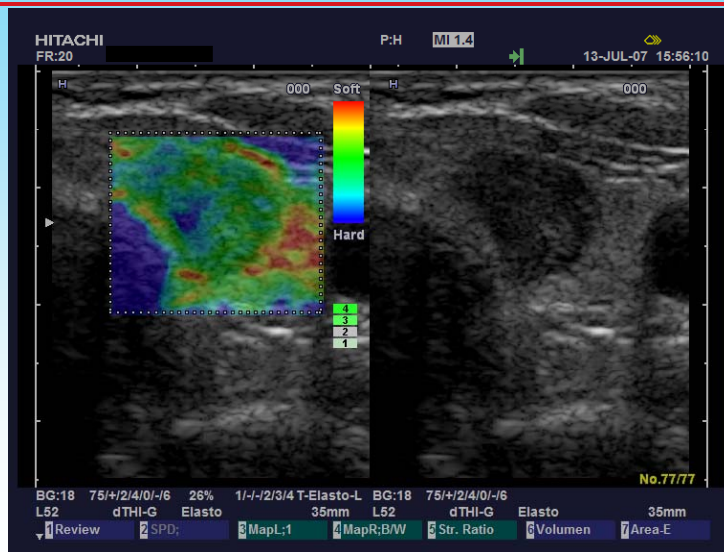
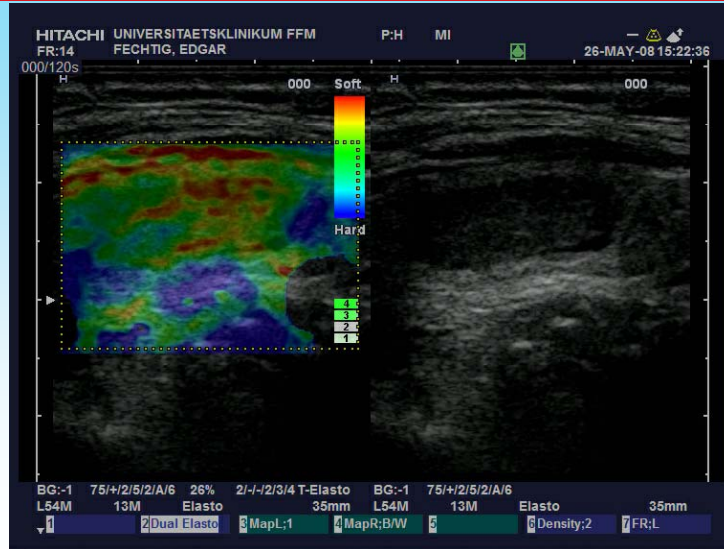
ES 4

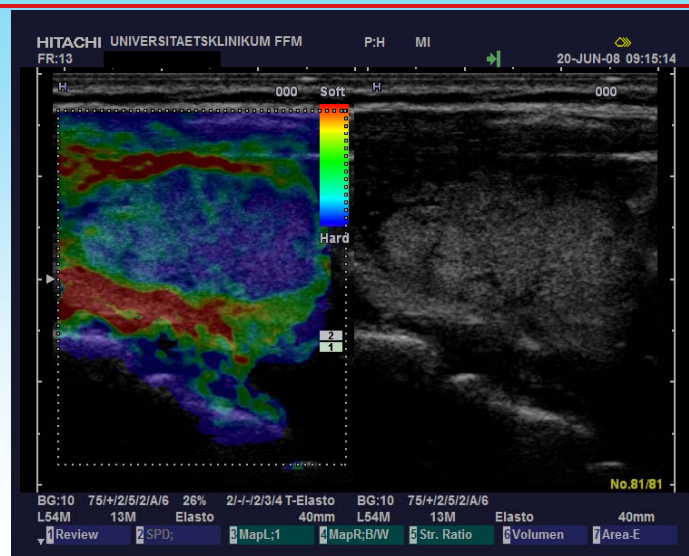
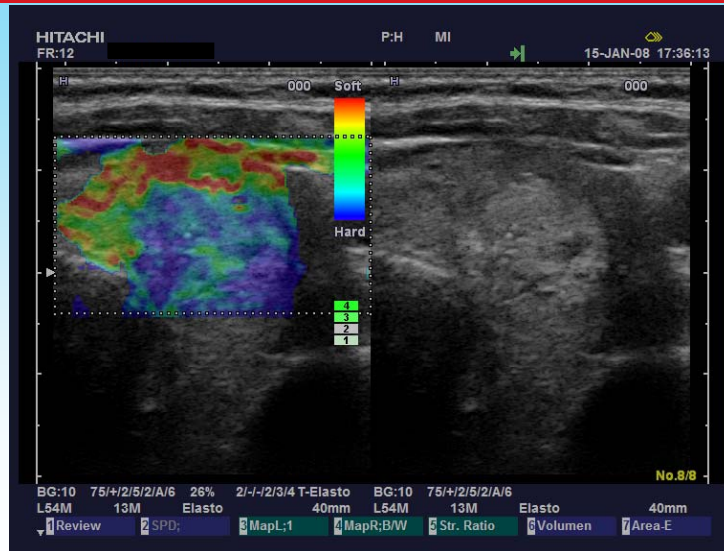


Asteria et al Thyroid 2008

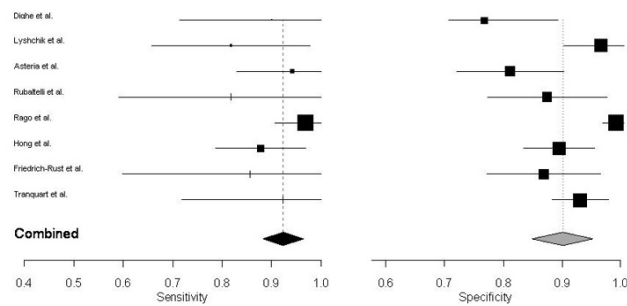
Hitachi EUB-900, 9 MHz Schallkopf





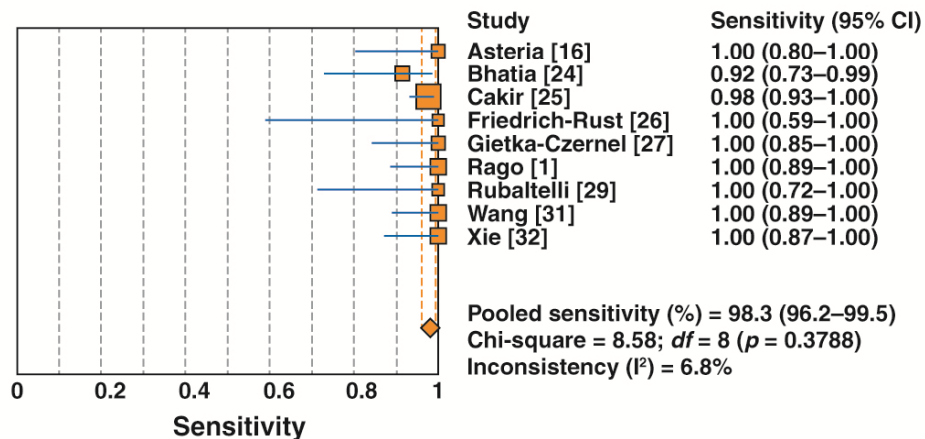


RTE – Meta-Analyse



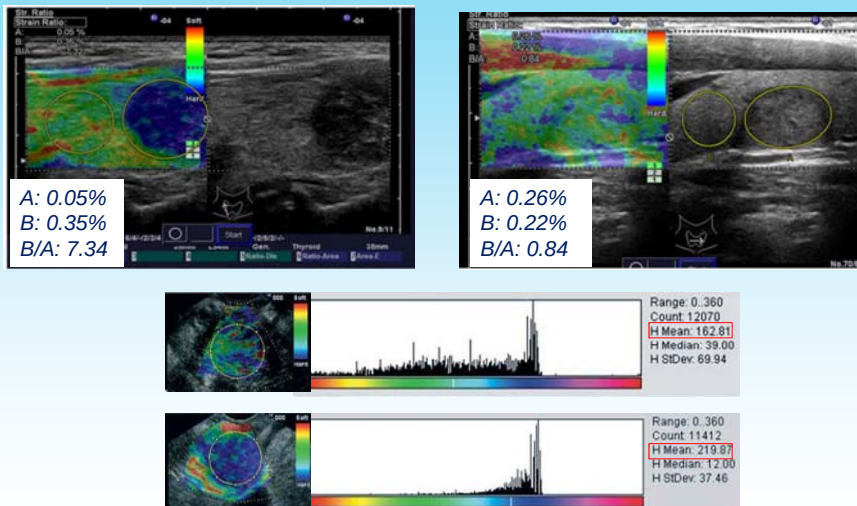
Bojunga et al. Thyroid 2010

S-RTE - Metaanalyse



AJR:202, April 2014

RTE-Quantifizierung: strain value und strain ratio



Ning et al. Eur J Radiol 2010

RTE mittels strain value

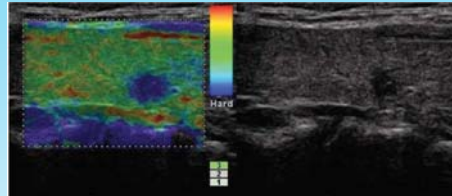
n=309, all referred for surgery
259 benign, 50 malignant nodules (36 papillary, 5 follicular, 9 medullary CA)

	Hard (≤ 0.15)	Intermediate (0.16–0.3)	Soft (≥ 0.31)
Malignant	35	15	0
Benign	46	117	96
Σ	81	132	96
TC (%)	43.2	11.3	0

	Rago et al. [7]	Hong et al. [10]	Rubaltelli et al. [9]	Asteria et al. [8]	≥ 0.31 Bürgerhospital Ffm. 2009
N	92	90	51	67	309
PPV (%)	100	81	64	55.2	43
NPV (%)	98	93	94.5	98.2	100
Colour patterns vs. SV	CP	CP	CP	CP	SV
TC	31 [34%]	49 [54%]	11 [21%]	16 [24%]	50 [16%]
Final histology in all cases	+	+	–	–	+

Vorländer et al. Langenbecks Arch Surg 2010

Schilddrüsenknoten < 10 mm



	Benign n = 19	Malignant n = 32	Statistical significance	Sensitivity (%)	Specificity (%)	Accuracy (%)
Irregular margin on conventional ultrasound						
Present	11	24	$P = 0.052$ (NS)	75.00	42.11	62.75
Absent	8	8				
Microcalcifications on conventional ultrasound						
Present	5	21	$P < 0.0001$	65.63	73.68	68.63
Absent	14	11				
Intranodular blood flow on conventional ultrasound						
Present	10	25	NS	78.13	47.37	66.67
Absent	9	7				
Real-time USE scores of 1 – 3	17	3	$P < 0.0001$	90.63	89.47	90.20
Real-time USE scores of 4 – 5	2	29				

Wang et al. J Int Med Res 2010

TIRADS sinnvoll ?

TIRADS-Kategorien

1: normale Schilddrüse

2: gutartig (Malignitätsrate 0%)

- Anechoisch mit hypoechogenen Punkten, nicht vaskularisiert
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- Keine Kapsel, gemischte Echogenität mit solidem Anteil, isoechogen, vaskularisiert, hypoechogene Punkte

3: wahrscheinlich gutartig (Malignitätsrate < 5%)

- hyper-, iso- oder hypoechogen, teilweise mit Kapsel, peripher vaskularisiert, bei Hashimoto-Thyreoiditis

4: verdächtig (Malignitätsrate 5–80%)

4a (Malignitätsrate 5–10%):

- Solide oder gemischter iso- oder hypoechogener Knoten mit dünner Kapsel

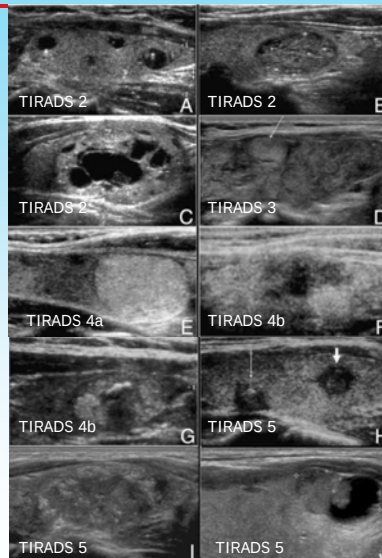
4b (Malignitätsrate 10–80%):

- Hypoechogene Läsion mit schlecht definierbaren Grenzen ohne Kalzifizierungen
- Hyper-, iso- oder hypoechogener Knoten mit dicker Kapsel und scholligen oder Mikro-Kalzifizierungen

5: Wahrscheinlich maligne (Malignitätsrate > 80%)

- **Muster A:** hypoechogener Knoten ohne Kapsel, mit irregulärer Form und Grenzen, penetrierende Gefäße, mit oder ohne Kalzifizierungen
- **Muster B:** iso- oder hypoechogener Knoten ohne Kapsel mit multiplen Mikrokalzifizierungen und Hypervaskularisierung
- **Muster C:** isoechogener Knoten ohne Kapsel, gemischte Hypervaskularisierung mit oder ohne Kalzifizierungen, ohne hyperechogene Punkte

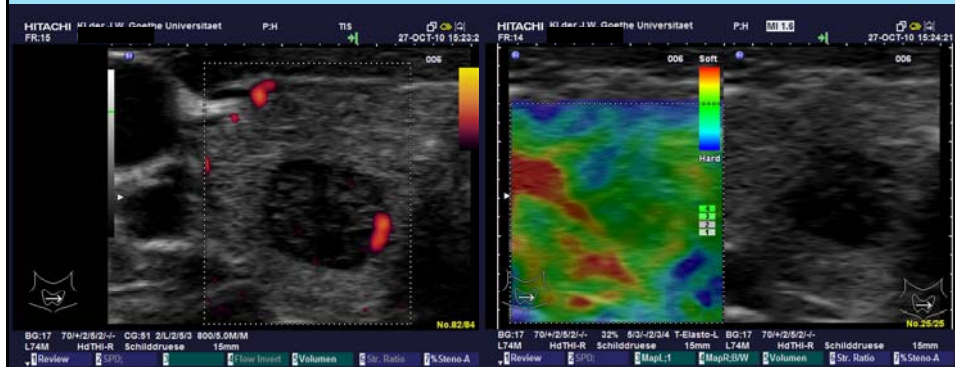
6: Feinnadelaspirationszytologie maligne



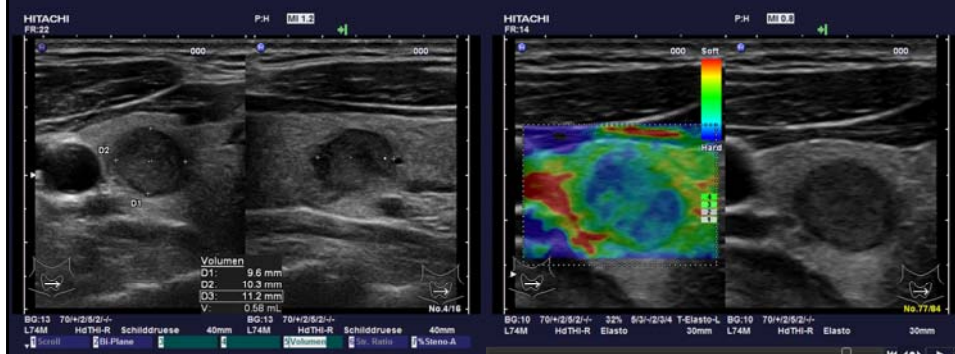
Paschke Dtsch Med Wochenschr 2009;134: 2498

Horvath et al., J Clin Endocrinol Metab 2009; 94: 1748

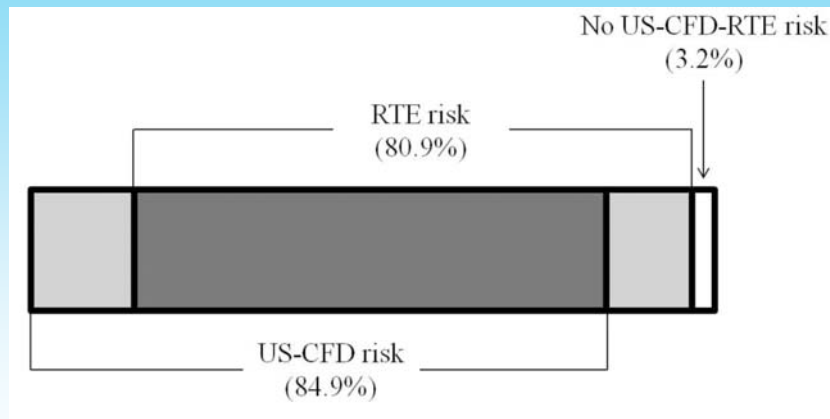
RTE – eine Zusatzinformation zum B-Bild ?



RTE – eine Zusatzinformation zum B-Bild ?



RTE – eine Zusatzinformation zum B-Bild ?



Trimboli JCEM 2012

RTE – TIRADS im Vergleich

	Observer		Benigne (n = 99)	Cancer (n = 15)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	+LR
TIRADS 4-5	1	yes, no	51, 48	15, 0	100 (78;100)	48.5 (38;59)	23 (13;35)	100 (93;100)	1.941 (1.60;2.35)
	2	yes, no	88, 11	14, 1	93 (68;99.8)	11 (6;19)	14 (8;22)	92 (62;99.8)	1.050 (0.90;1.22)
	3	yes, no	76, 23	14, 1	93 (68;99.8)	23 (15;33)	16 (9;25)	96 (79;99.9)	1.216 (1.02;1.45)
SE 3-4	1	yes, no	34, 65	13, 2	87 (60; 98)	66 (55; 75)	28 (16;43)	97 (90;99.6)	2.524 (1.80;3.54)
	2	yes, no	32, 67	14, 1	93 (68;99.8)	68 (58;77)	30 (23;42)	98.5 (92;99.9)	2.887 (2.11;3.96)
	3	yes, no	34, 65	12, 3	80 (52;96)	66 (55;75)	26 (14;41)	96 (88;99)	2.329 (1.61;3.38)

TIRADS

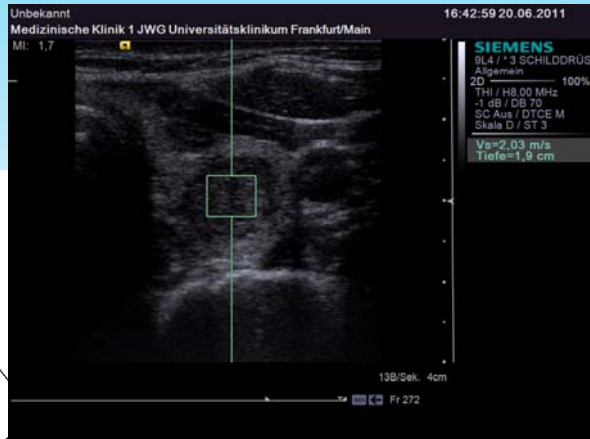
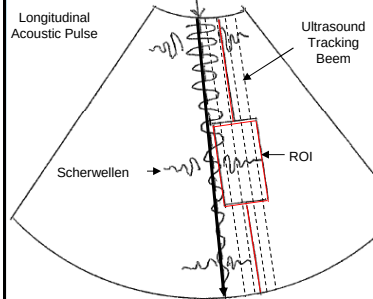
- Cohen's kappa = 0.27 (weak, $p = 0.000001$) for TIRADS 2-5
- $C_k = 0.25$ (weak, $p = 0.0020$) for TIRADS categories 2/3 vs. 4/5

SE

- $C_k = 0.66$ (substantial, $p < 0.000001$) for RTE scores 1-4
- $C_k = 0.81$, (good, $p < 0.000001$) for RTE scores 1/2 vs. 3/4

Friedrich-Rust, Bojunga, PlosONE 2013

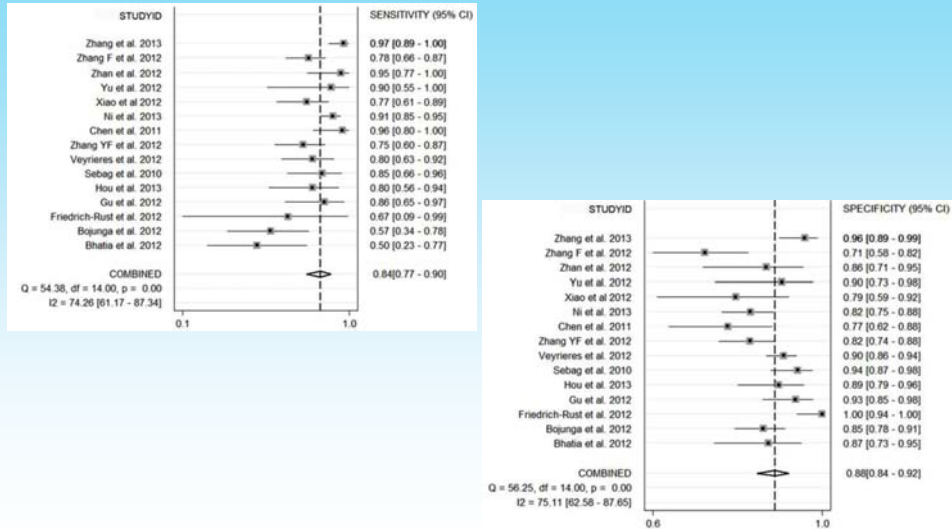
Acoustic Radiation Force Impulse Imaging (Siemens ACUSON S2000, Virtual Touch™ tissue quantification)



ARFI und SD-Knoten



ARFI – Meta-Analyse



Eur Radiol 2014 in press

EFSUMB Guidelines and Recommendations on the Clinical Use of Ultrasound Elastography.

Part 2: Clinical Applications

Ultrasound Med 2013

Authors

D. Cosgrove¹, F. Piscaglia², J. Bamber³, J. Bojunga⁴, J.-M. Correas⁵, O. H. Gilja⁶, A. S. Klauser⁷, I. Sporea⁸, F. Calliada⁹, V. Cantisani¹⁰, M. D'Onofrio¹¹, E. E. Drakonaki¹², M. Fink¹³, M. Friedrich-Rust¹⁴, J. Fromageau¹⁵, R. F. Havre¹⁵, C. Ijssens¹⁶, R. Ohlhofer¹⁷, A. Siftoiu¹⁸, F. Schaefer¹⁹, C. F. Dietrich²⁰

Recommendations

- Elastography is an additional tool for thyroid lesion differentiation.
- Based on expert opinion, elastography may be used to guide follow up of lesions negative for malignancy at FNA.

EFSUMB Guidelines and Recommendations on the Clinical Use of Ultrasound Elastography.

Part 2: Clinical Applications

Ultrasound Med 2013

Authors

D. Cosgrove¹, F. Piscaglia², J. Bamber³, J. Bojunga⁴, J.-M. Correia⁵, O. H. Gilja⁶, A. S. Klausner⁷, I. Sporea⁸, F. Calliada⁹, V. Cantiani¹⁰, M. D'Onofrio¹¹, E. E. Drakonaki¹², M. Fink¹³, M. Friedrich-Rust¹⁴, J. Fromageau¹⁵, R. F. Havre¹⁵, C. Janssen¹⁶, R. Ohlhofer¹⁷, A. Saitou¹⁸, F. Schaefer¹⁹, C. F. Dietrich²⁰

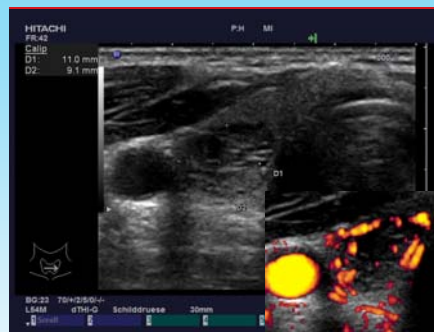
Limitations

Intralesional calcifications are common and may bias the stiffness of the lesion, as has been shown for peripheral calcifications [109 – 111].

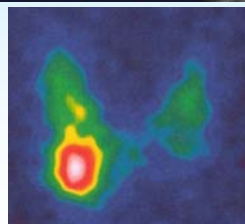
Strain elastography should be interpreted with caution in extensive cystic areas since this may cause artefacts.

Elastography shows high sensitivity, specificity and NPV for the diagnosis of papillary carcinoma: however, the evaluations were performed in highly specialised centres with high incidences of carcinoma.

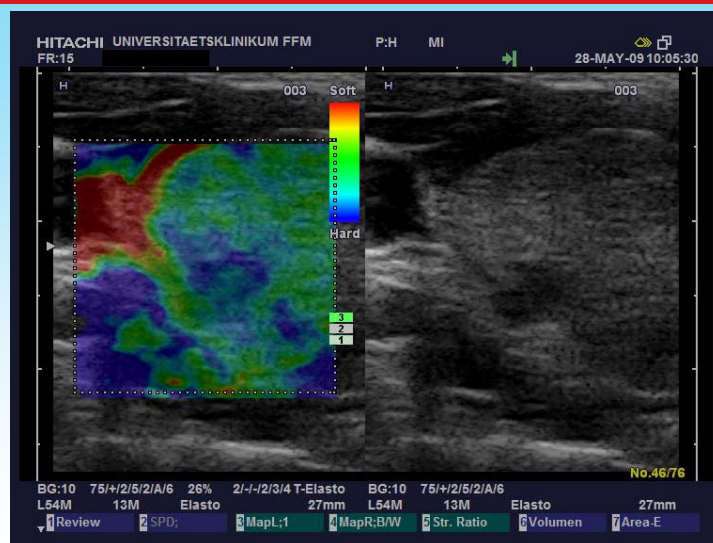
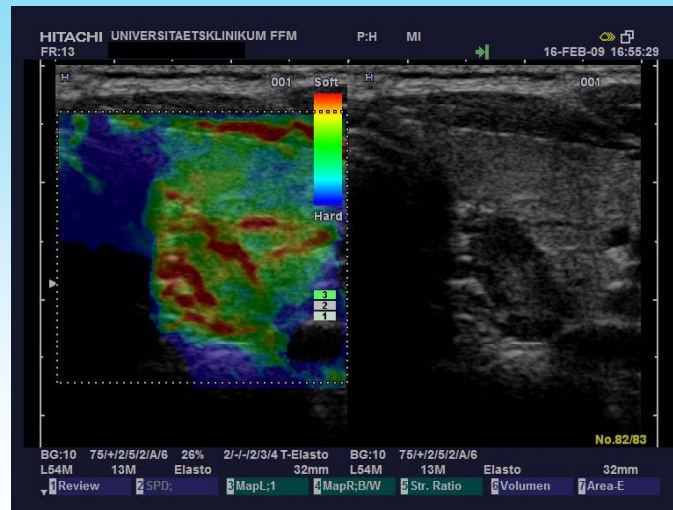
Fallbeispiel 1



TSH 2.2 µU/ml
CT 2 pg/ml



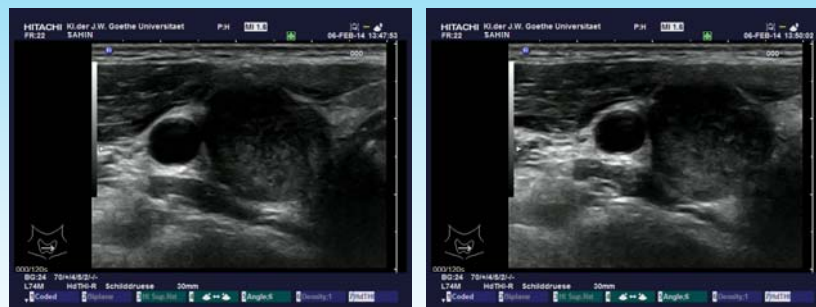
Fallbeispiel 2



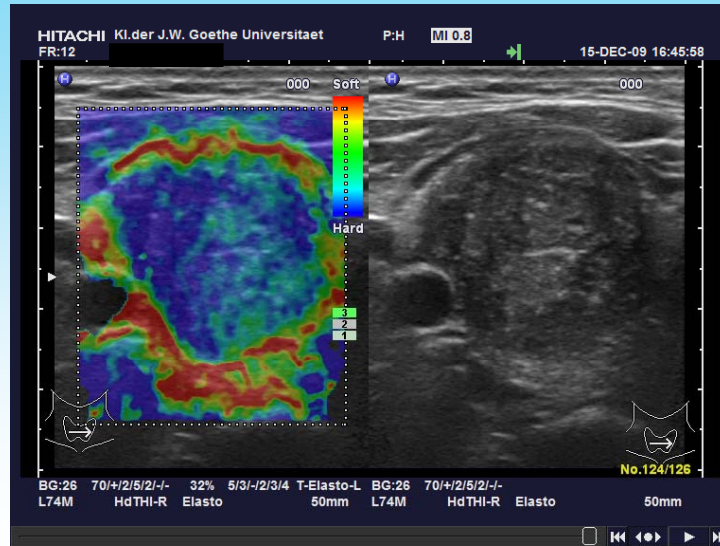
Fallbeispiel 6



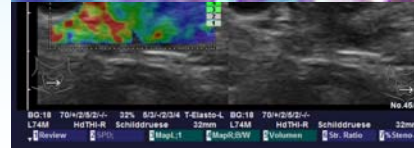
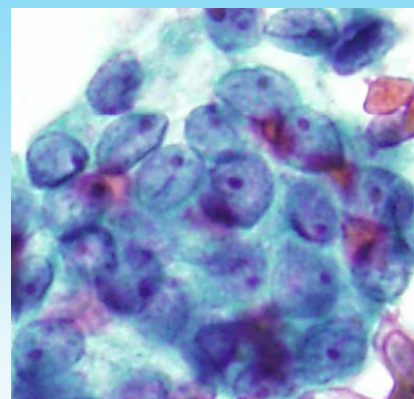
Fallbeispiel 7



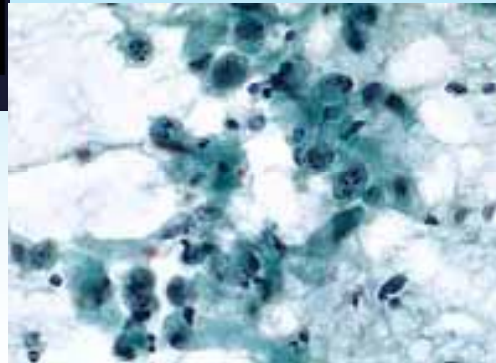
Fallbeispiel 2



Fallbeispiel 4



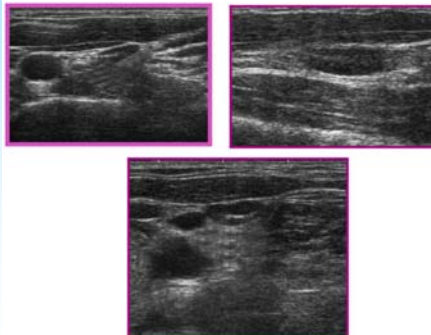
Fallbeispiel 8



Lymphnodes

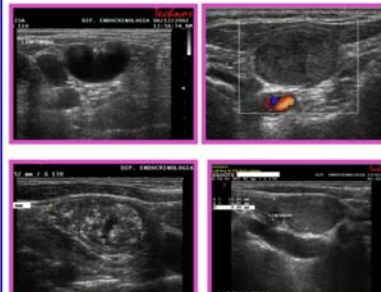
Inflammatory (typical) lymph node

Solid
Hypoechoic
Ellipsoid shape
Central hyperechoic line (hilus)



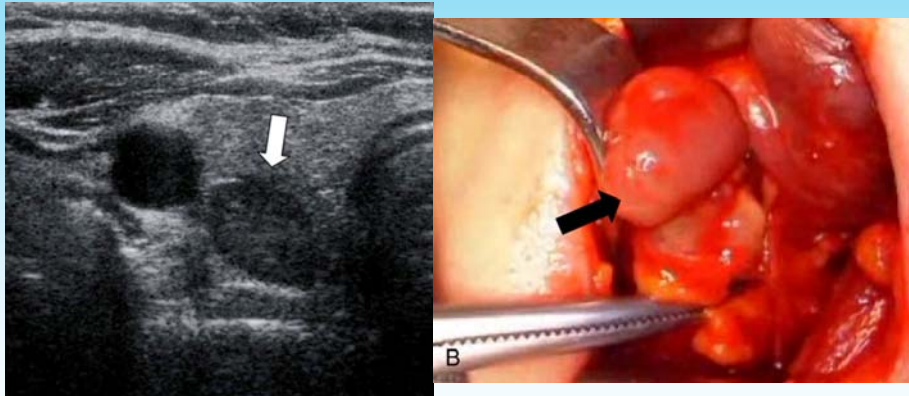
Suspicious (atypical) lymph node

Solid, mixed/cystic
Hypoechoic
Round shape
Central hyperechoic line (hilus): absent



Rago et al.: Best Practice Endocrinol 22:913, 2008

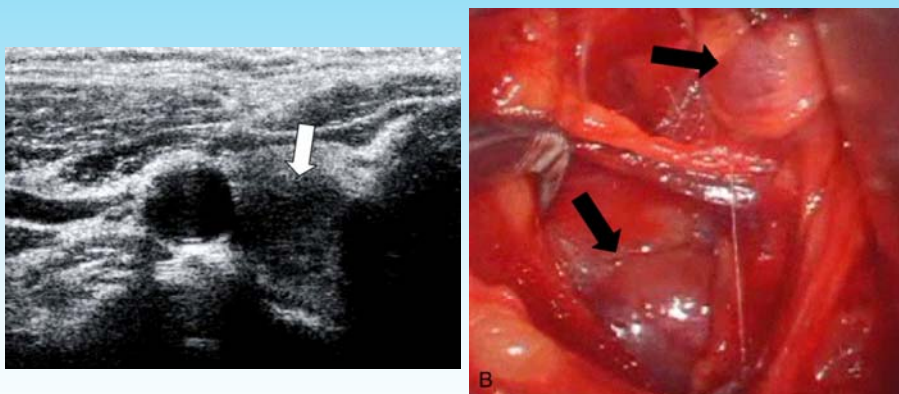
Befunddemonstration



Diagnose: NSD-Adenom

Barbaros et al.: Am J Otolaryng 30:239, 2009

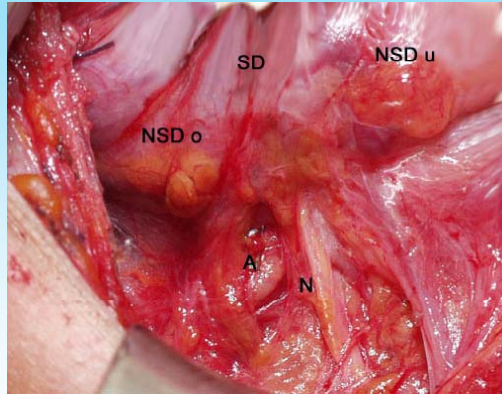
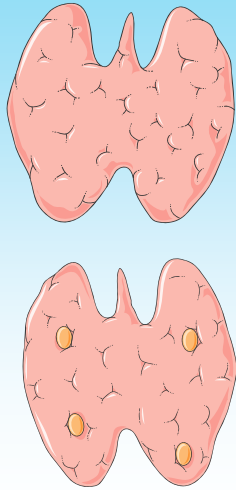
Befunddemonstration



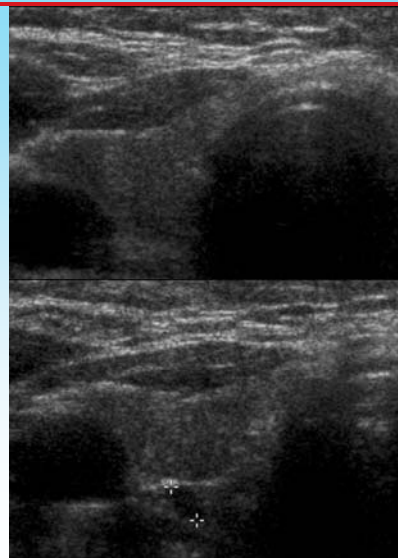
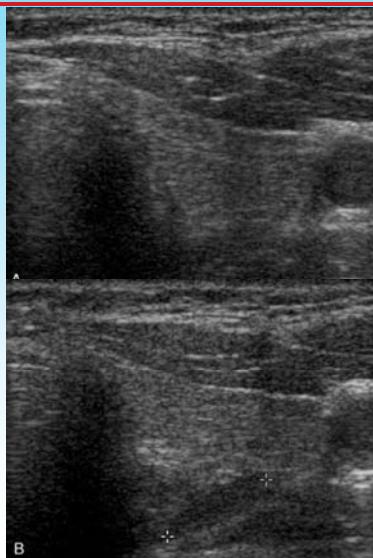
Diagnose: Schilddrüsenknoten

Barbaros et al.: Am J Otolaryng 30:239, 2009

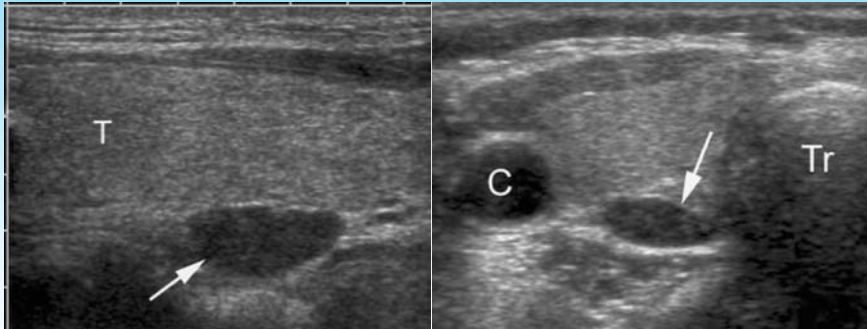
Anatomie der Nebenschilddrüsen



Verbesserte Darstellung durch Kompression



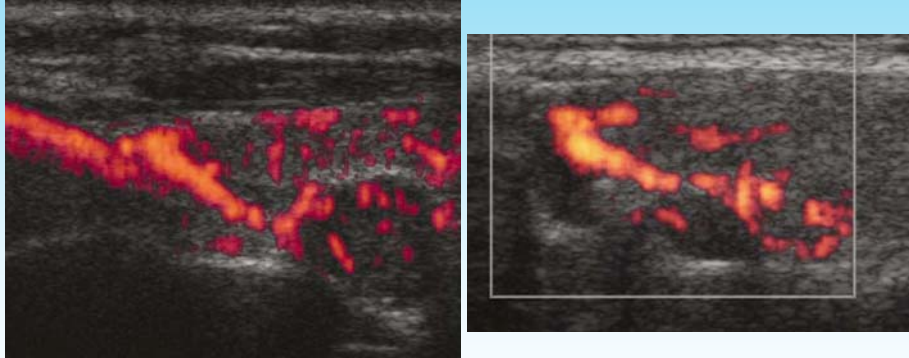
Nebenschilddrüsenadenome



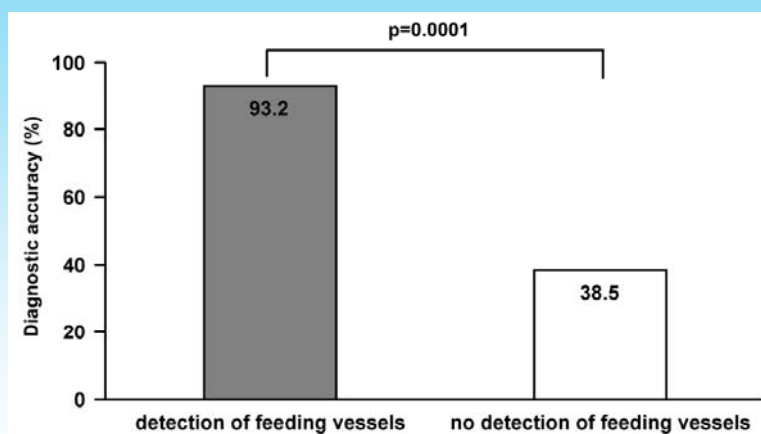
Nebenschilddrüsenadenome



Power-Doppler: typische Vaskularisation



Polgefäß: prädiktiver Wert



Rickes et al.: Ultraschall in Med 24:85, 2003

Differential colour doppler features

Table 1. Color Doppler US patterns of parathyroid lesions, thyroid nodules, and cervical lymph nodes. Pattern I, absence of flow; pattern II, focal peripheral flow ("vascular pole") with arterial Doppler spectrum; pattern III, peripheral flow; pattern IV, internal flow ("parenchymal pattern"); pattern V, peripheral and intranodular flow

	Color Doppler US pattern				
	I	II	III	IV	V
Parathyroid lesions (n = 56)	8	25	1	22	–
Thyroid lesions (n = 72)	12	1	21	–	38
Lymph nodes (n = 20)	18	–	–	2	–
Total	38 (26 %)	26 (18 %)	22 (15 %)	24 (16 %)	38 (26 %)

Mazzeo et al.: Eur Radiol 7:90, 1997

Sono-Elastographie der Schilddrüse

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