

Kopsu UH

Millest räägime?

- Ultraheli artefaktid
- eFAST ja pneumotooraks
- Kopsuhaiguste diagnostika võimalused UH-ga
- UH täpsus ja nõrgad kohad

Mida saab vaadata?

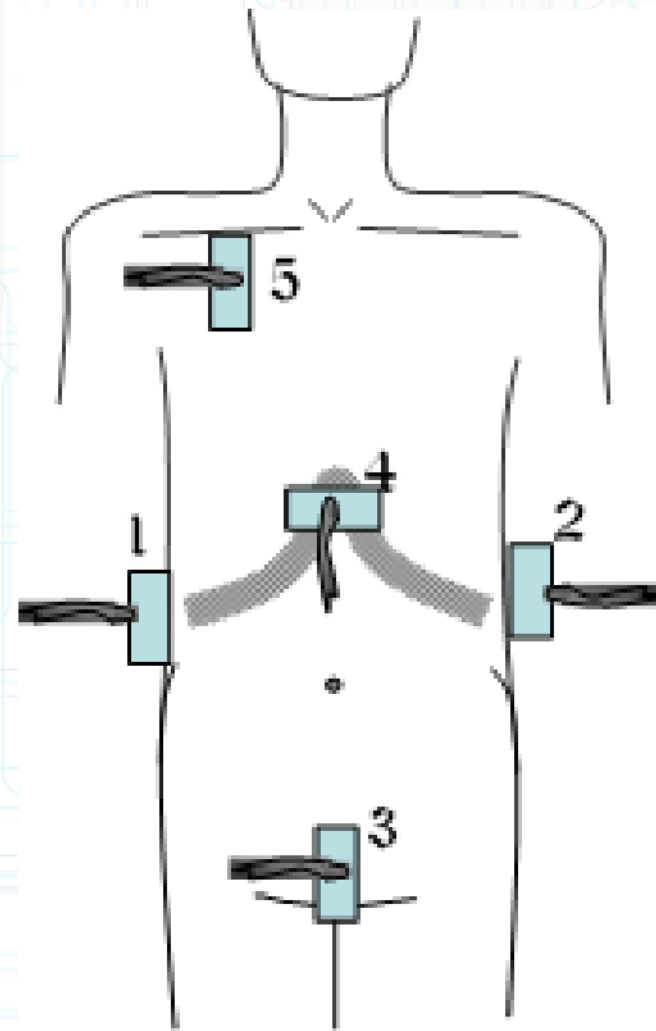
- Eeldus on, et leid ulatub vähemalt vistseraalse pleurani
 - » Vedelik
 - » Konsolidatsioon
 - » Pehmekoeline kolle
 - » Kopsuturse (k.a. Interstitsiaalne turse)
 - » Pneumotooraks

Trauma

- eFAST – extended focused assessment with sonography for trauma
- Kõhust ja perikardiõõnest vaatame vedelikku
- Lisaks rindkerest vedelikku ja õhku

eFAST

- 1 – Morrisoni tasku (maksa ja neeru vaheline peritoneumi sopis) ja parem hemidiafragma
- 2 – Põrna ümbrus ja vasak hemidiafragma
- 3 – Vaagen, nii piki kui ristisuunas
- 4 - Perikard
- 5 – **Mõlemad pleuraõõned õhule**



Tömp trauma

Variant 1: Major blunt trauma. Hemodynamically unstable. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography trauma series	Usually Appropriate	⦿⦿⦿
US FAST scan chest abdomen pelvis	Usually Appropriate	○
CT whole body with IV contrast	May Be Appropriate	⦿⦿⦿⦿
CT whole body without IV contrast	May Be Appropriate	⦿⦿⦿⦿
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	○
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	○

Variant 2: Major blunt trauma. Hemodynamically stable. Not otherwise specified. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
CT whole body with IV contrast	Usually Appropriate	⦿⦿⦿⦿
Radiography trauma series	Usually Appropriate	⦿⦿⦿
US FAST scan chest abdomen pelvis	Usually Appropriate	○
CT whole body without IV contrast	May Be Appropriate	⦿⦿⦿⦿
Fluoroscopy retrograde urethrography	Usually Not Appropriate	⦿⦿⦿
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	○
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	○

Eraldi rindkere trauma

Clinical Condition: Blunt Chest Trauma

Variant 1: First-line evaluation. High-energy mechanism.

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9	Chest x-ray and CT/CTA are complementary examinations.	☢
CT chest with IV contrast	9	Ideally, this procedure should be performed with CTA. Chest x-ray and CT/CTA are complementary examinations.	☢ ☢ ☢
CTA chest with IV contrast	9	Chest x-ray and CT/CTA are complementary examinations.	☢ ☢ ☢
CT chest without IV contrast	5		☢ ☢ ☢
US chest	5		○
CT chest without and with IV contrast	2		☢ ☢ ☢
MRI chest without and with IV contrast	2		○
MRI chest without IV contrast	1		○
<u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Pneumotooraks

- UH on täpsem kui lamades röntgen
 - » Tundlikkus 43% - 48,8% vs 11 – 20,9%
 - » Ühes uuringus UH tundlikkus 77%

Focused Assessment with Sonography in Trauma (FAST) in 2017: What Radiologists Can Learn

John R. Richards, John P. McGahan ✉

✓ **Author Affiliations**

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- Nägemata jäänud pneumotooraksid on väiksemad ning vajavad vähema tõenäosusega ravi
 - Üldine tundlikkus 59%; ravivajavatel 81%

Metaanalüüs

- Tundlikkus 78,6% (95% CI, 68,1 – 98,1)
- Spetsiifilisus 98,4% (95% CI, 97,3 – 99,5)

Alrajab, S., Youssef, A.M., Akkus, N.I. et al. Pleural ultrasonography versus chest radiography for the diagnosis of pneumothorax: review of the literature and meta-analysis. Crit Care 17, R208 (2013). <https://doi.org/10.1186/cc13016>

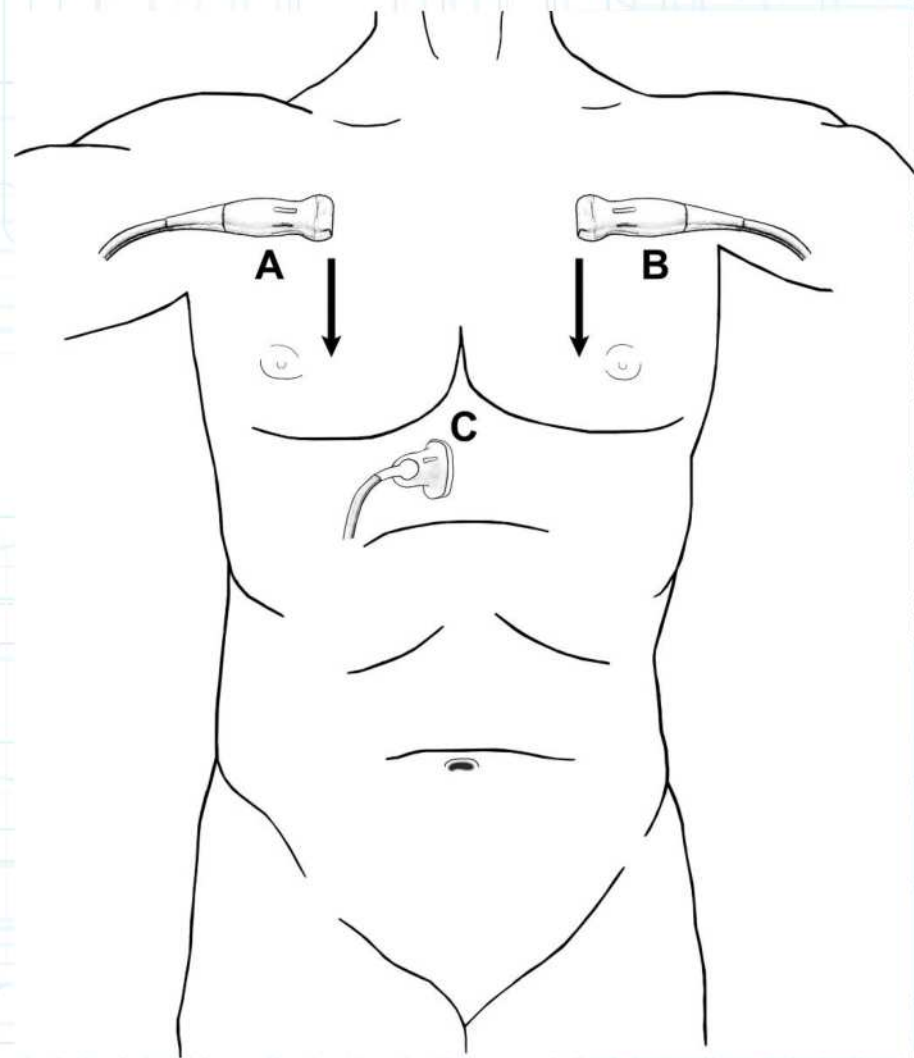
- Tundlikkus 87% (95% CI, 81 – 92)
- Spetsiifilisus 99% (95% CI, 98 – 99)

Ebrahimi A, Yousefifard M, Mohammad Kazemi H, et al. Diagnostic Accuracy of Chest Ultrasonography versus Chest Radiography for Identification of Pneumothorax: A Systematic Review and Meta-Analysis. Tanaffos. 2014;13(4):29–40.

- Ultraheli osas uuringutes heterogeensed tulemused, kuid on läbivalt tundlikum, kui röntgen
- Kuldstandardiks enamasti KT

Protokoll

- Eelistatult lineaarne >5 MHz kõrgesageduslik andur, kuid võib kasutada ka kõhu konveksandurit – tagab eFAST kiire sooritamise
- Sagitaalvaated keskmisel klavikulaarjoonel alates 2. või 3. roidevahemikust liikudes inferioorsemale
- Võib vaadata ka põikisuunas roietevahemikus, et korruga haarata suuremat osa kopsust

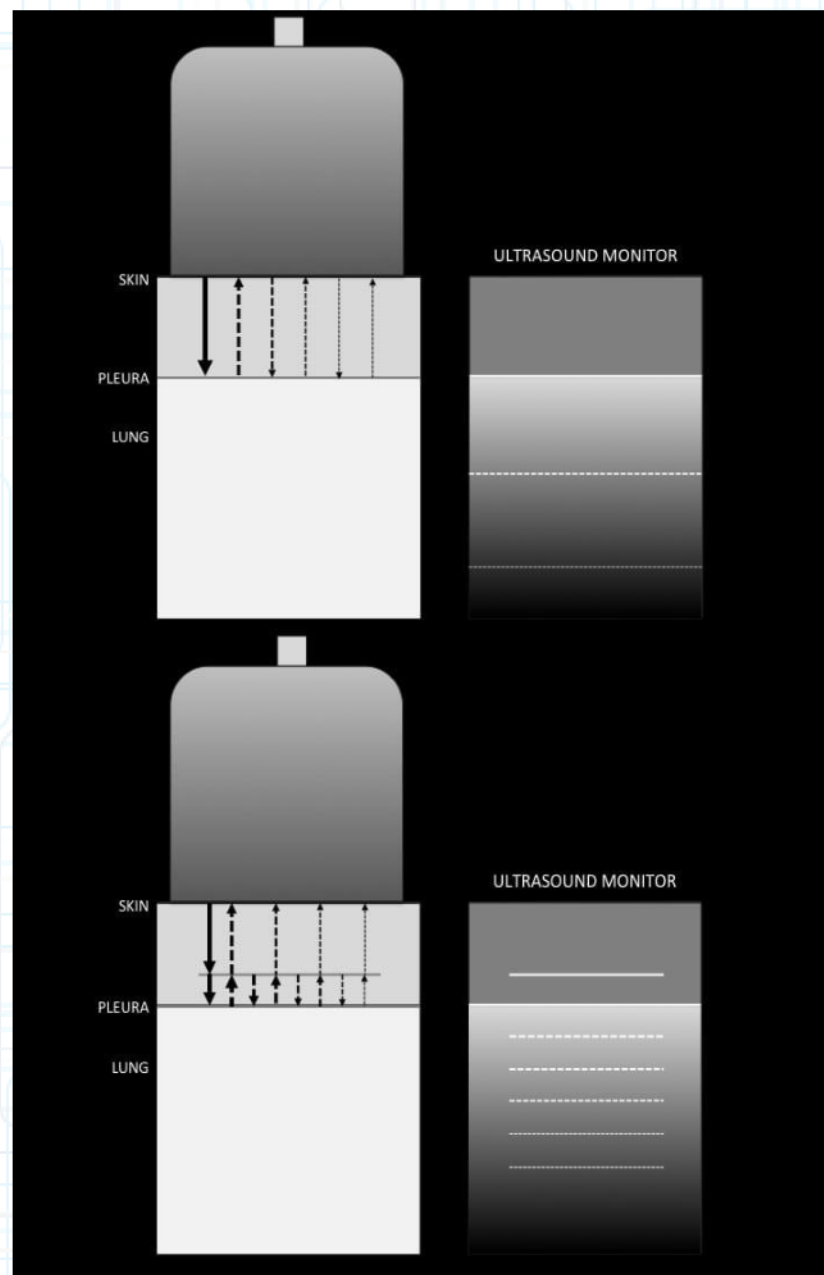


Artefaktid

- Reverberatsioon (reverberation)
- Komeedisaba (comet-tail)
- Ring down

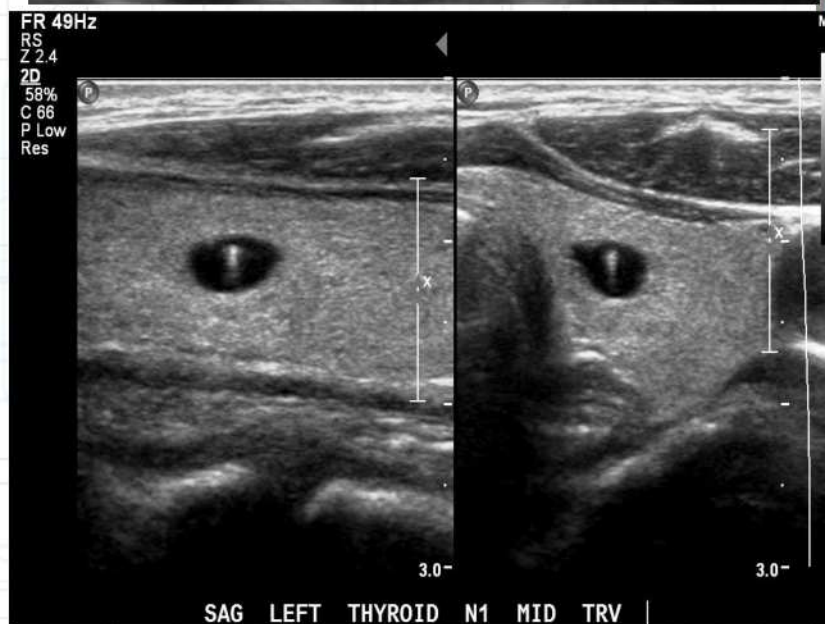
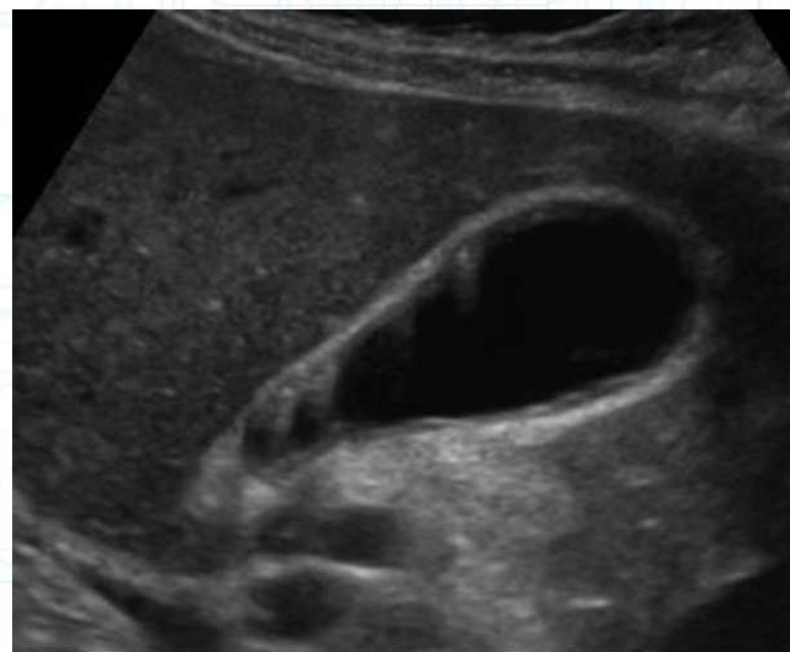
Reverberatsioon

- Järelkõla ehk reverberatsioon (ingl. keeles reverberation)
- Anduri poolt väljasaadetud kajad jäävad kahe paralleelse tugeva reflektori vahele edasi-tagasi liikuma ja jõuavad andurini hiljem



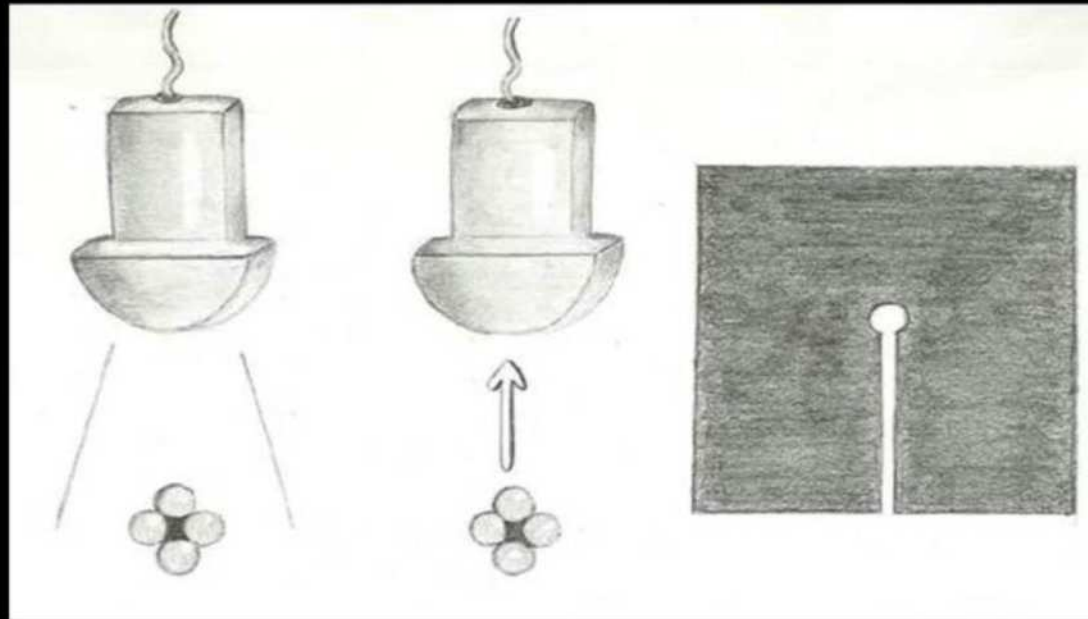
Komeedisaba artefakt

- Samuti reverberatsiooniar artefakt
- Heli põrkub väikeste vahemaade vahel, nimetatakse ka lühimaa reverberatsiooniks (ingl keeles short path reverberation)
- Pinnad ei ole paralleelsed või heli osaliselt neeldub põrkuvate pindade vahel – signaal langeb kiiresti
- Esineb metallobjektidega (õmblused, nõelad, võõrkehad), kaltsifikatsioonidega, sapipõie adenomüomatoosiga, pleura fibrootiliste muutustega jne



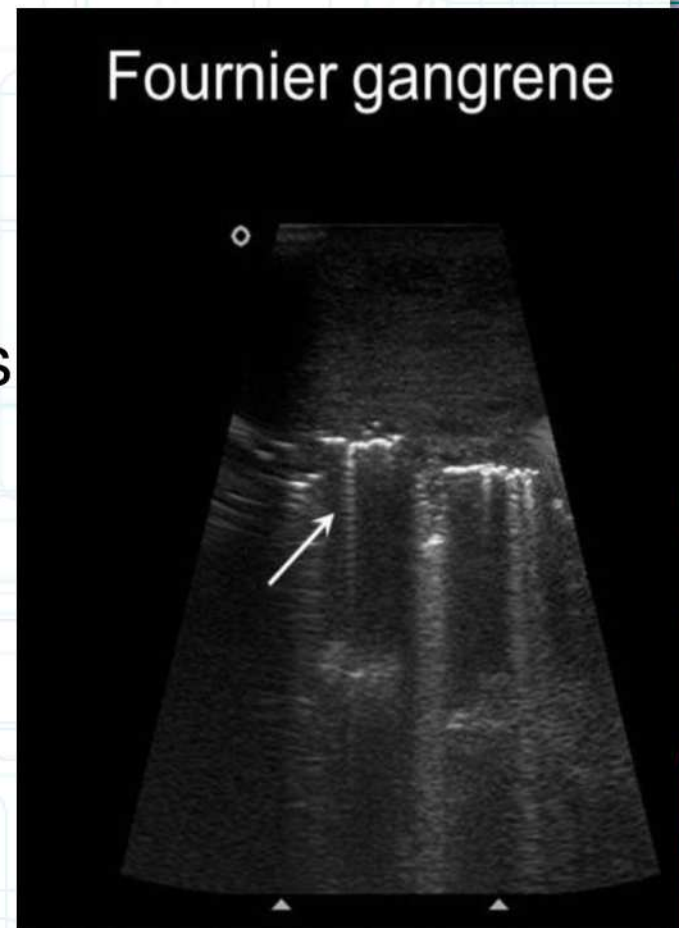
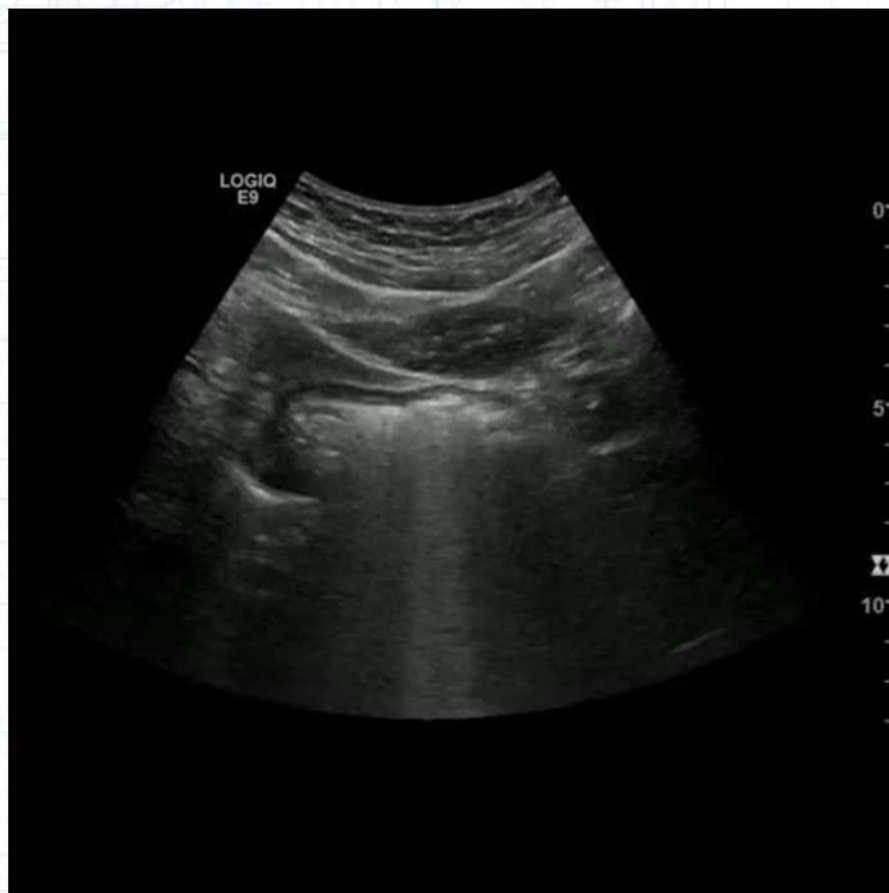
Ring down artefakt

Physical basis of Ring-Down artifact



When the ultrasound beam reaches the gas bubbles, it is capable of exciting the liquid trapped between the bubbles, which causes the liquid resonates. These vibrations create a continuous soundwave which is transmitted back to the receiver. This phenomenon is shown as a line or series of bands extending parallel after the image corresponding to gas.

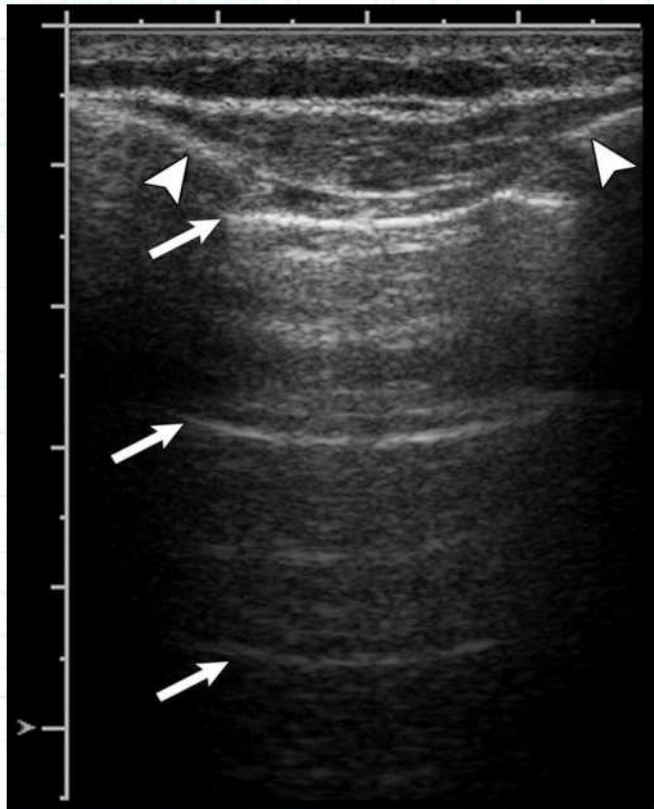
- Ring down on sarnane komeedisaba artefakte, nende eristamine tihti keeruline
- Nimetatakse ka rämpaseks varjuks (ingl. keeles *dirty shadow*)
- Alati seotud gaasiga



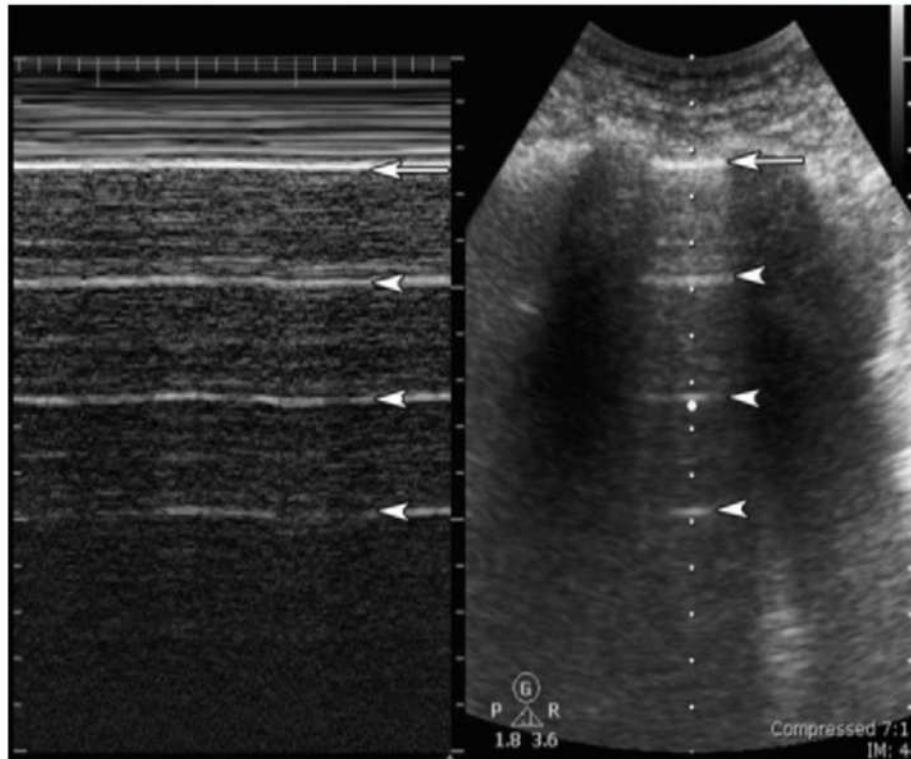
Talegón Meléndez, A. (2013). Ring-Down versus Comet Tail: Two artifacts uncovered. European Congress of Radiology.
<https://doi.org/10.1594/ECR2013/C-2288>

A-jooned

- Horisontaalsed võrdsel kaugusel olevad reverberatsiooniarartefaktid, mis enamasti vastavad pleura ja naha vahelisele kaugusele



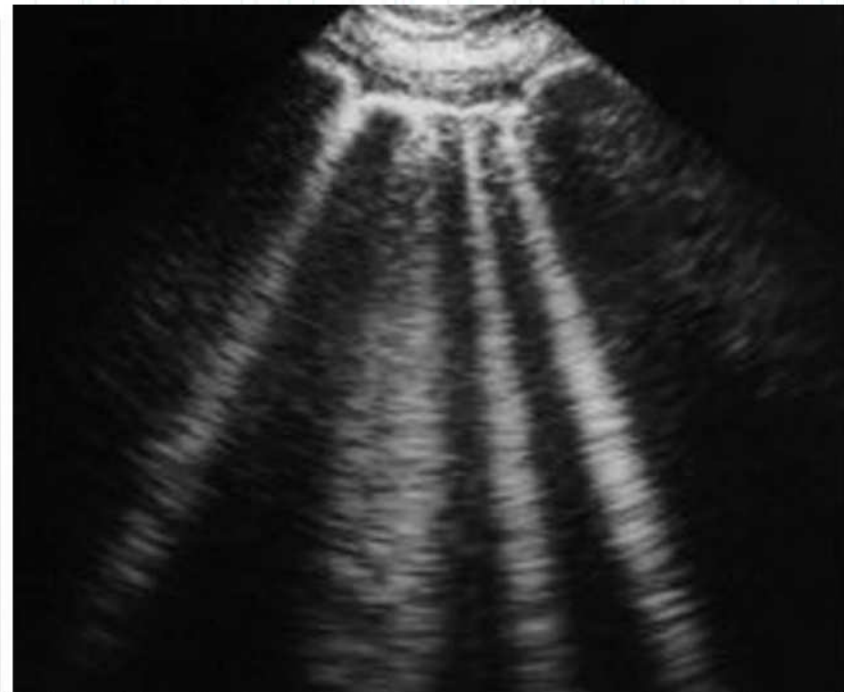
Noolepeaga tähistatud roided. Pindmisem nool tähistab pleuraalset joont. Sügavamal tuhmuvad A-jooned.



Vasakul M-mode ultraheli, paremal tavaline B-mode. Nooltega tähistatud pleuraalsed jooned, sügavamal noolepeadega tuhmuvad A-jooned.

B-jooned

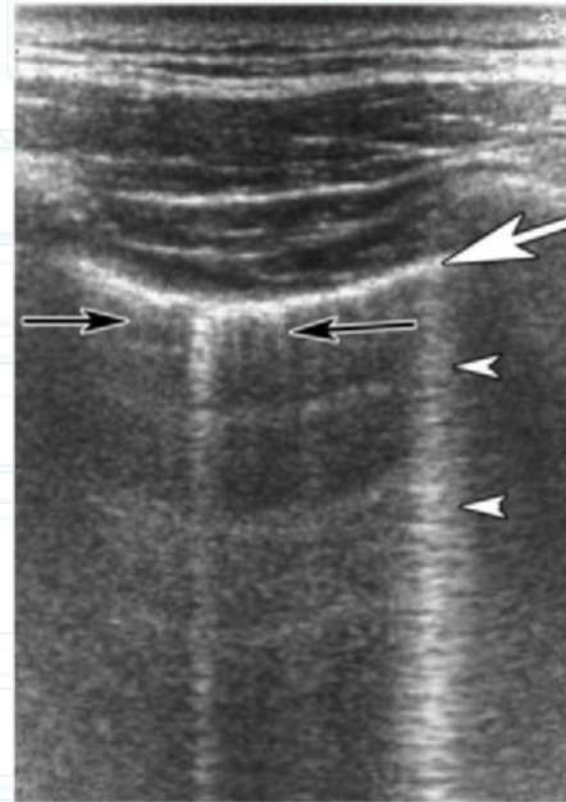
- Ring down artefakt
- Alates pleuraalsest joonest pildi servani kulgevad vertikaalsed hüperehhogeensed suhteliselt teravalt piirdunud jooned, mis korreleeruvad interlobulaarseptide või matt-klaasjate aladega, nimetatakse ka kopsurakettideks
- Varjutavad A-jooni, liiguvad hingamisega
- Üksikud B-jooned võivad normis esineda kopsude basaalosades!



Noolega tähistatud pleuraalne joon, noolepead tähistavad B-joont

Z-jooned

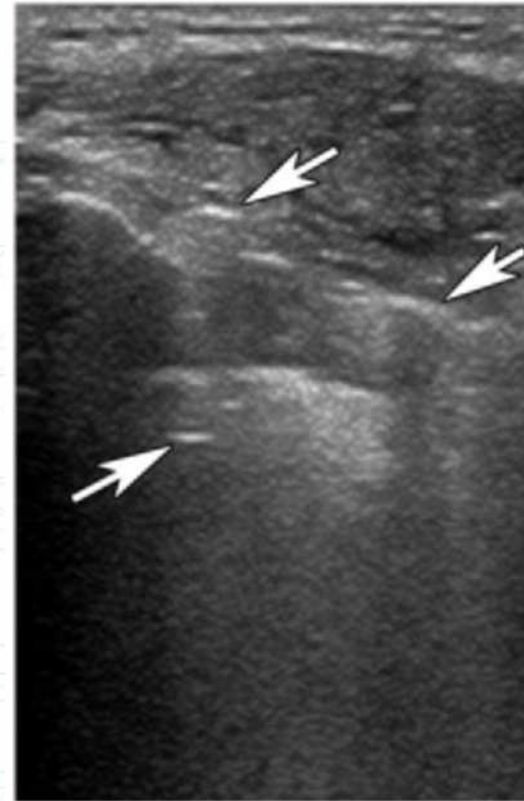
- Komeedisaba artefakt
- Lühikesed vertikaalsed artefaktid, mis saavad alguse pleuraalsest joonest
- Ei varja A-jooni, ei ulatu UH-pildi servani ning ei liigu hingamise rütmis



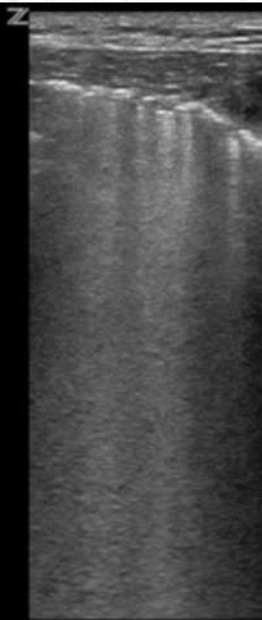
Valge nool – pleurajoon.
Mustad nooled – z-jooned
Valged noolepead – B-joon
Lisaks on näha õrnu A-jooni

E-jooned

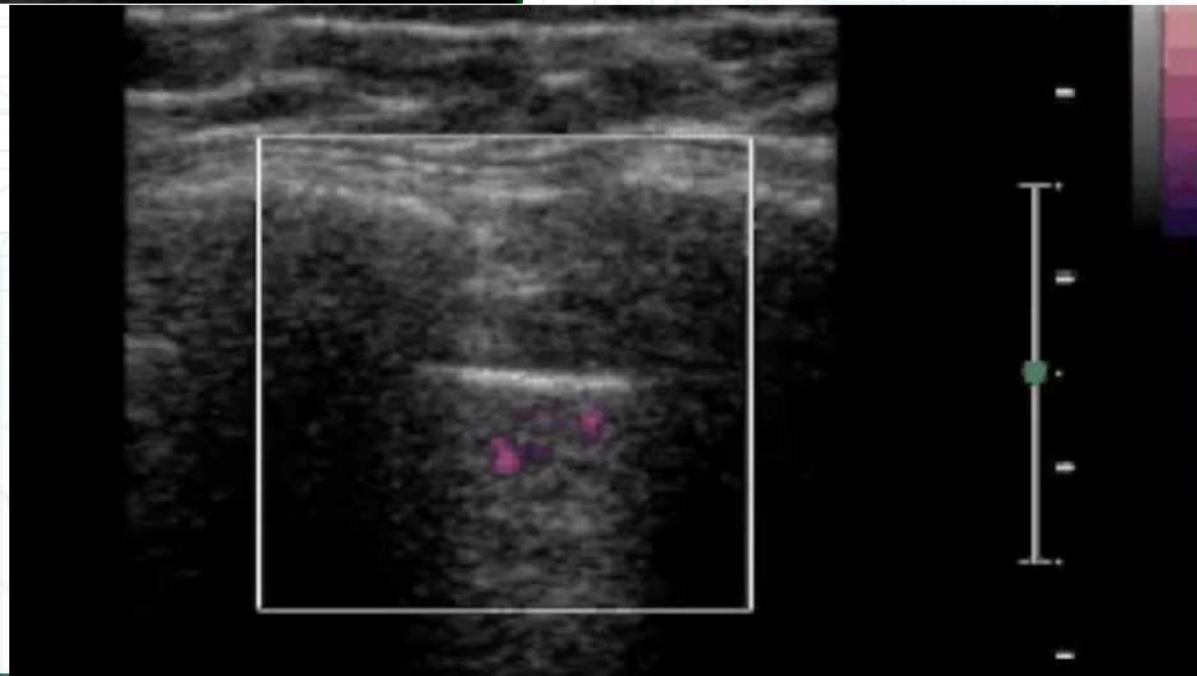
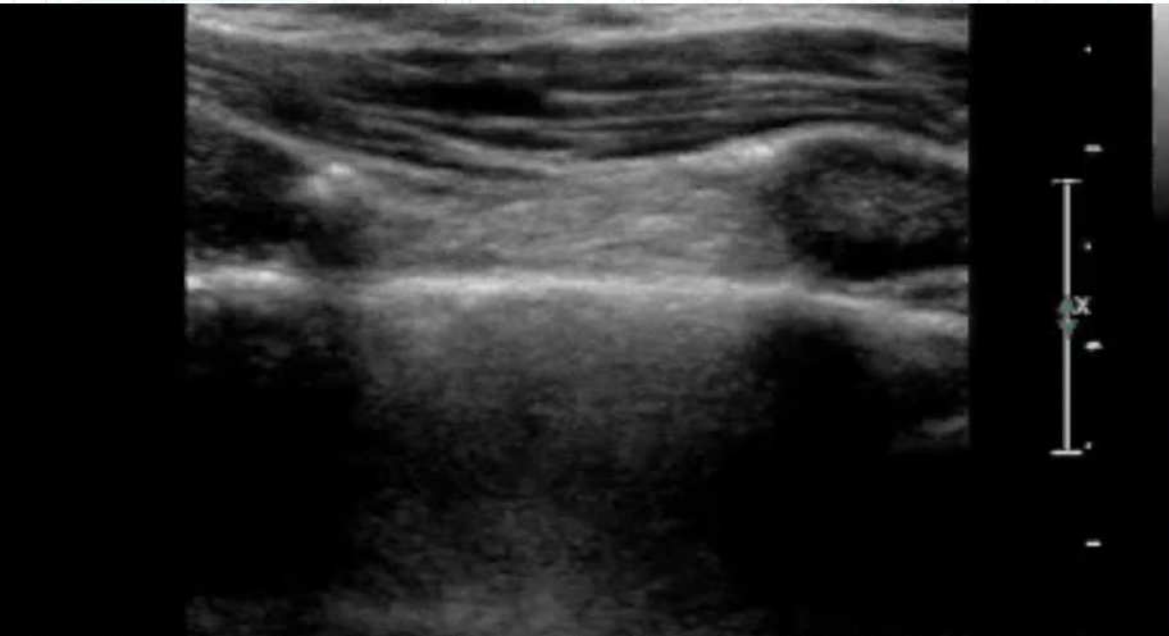
- Nahaaluskoest alguse saavad pleuraalset joont varjutavad artefaktid (ring down ja komeedisaba)
- Varjutavad ka A-jooni ning kulgevad tihti ekraani servani
- E nagu nahaalune õhk **E**mfüseem

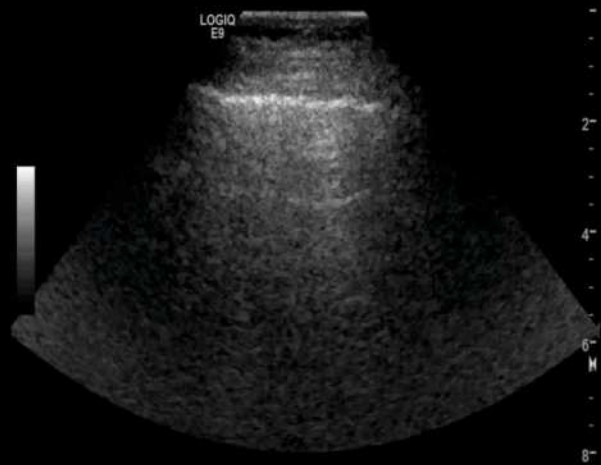


Noolega tähistatud gaasimullid nahaaluses koes, perifeersele ulatuvad õrnad hüperrehogeensed jooned tähistavad E-jooni.



Normipärane kops





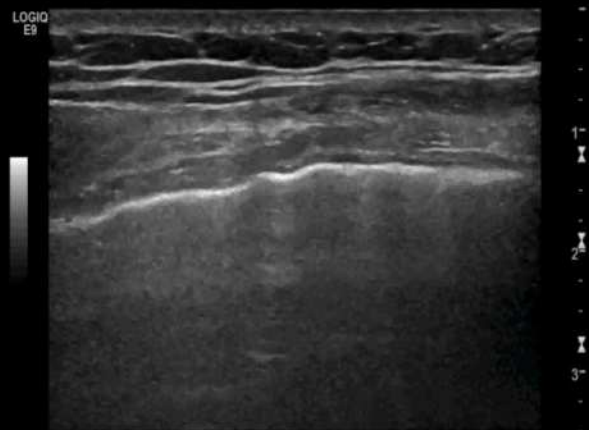
FR16 CH: Freq5.0 Gn40 S/A:0/0 Map:F/0 D3.0 DR60 AO%/100

F



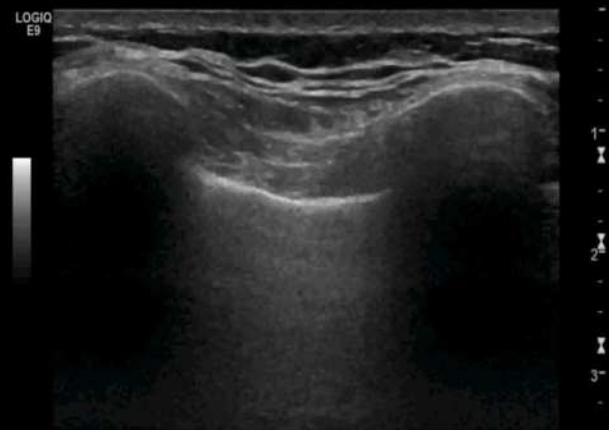
FR16 CH: Freq5.0 Gn40 S/A:0/0 Map:F/0 D3.0 DR60 AO%/100

F



FR25 B: Freq13.0 Gn43 S/A:2/1 Map:A/0 D3.5 DR66 AO%/100

F



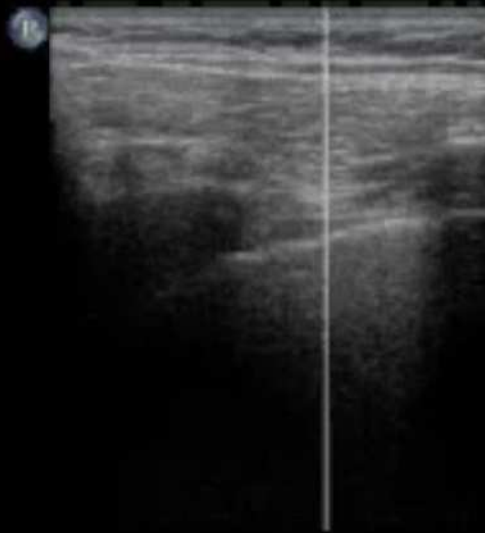
FR25 B: Freq13.0 Gn43 S/A:2/1 Map:A/0 D3.5 DR66 AO%/100

F

M-mode

FR 31Hz
RS

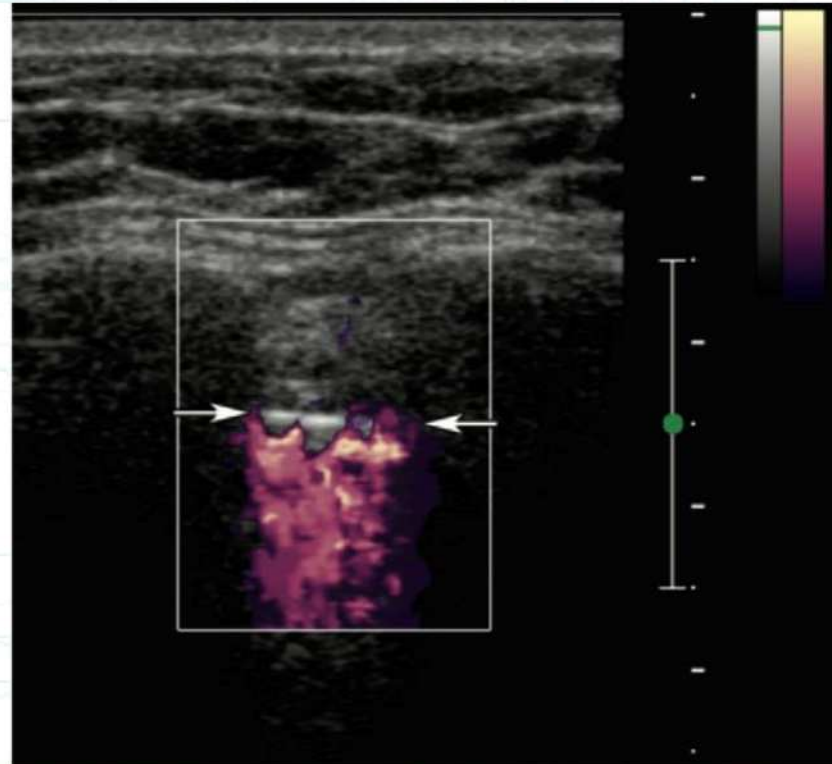
2D / MM
85% 90%
C 61
P Med
Res



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

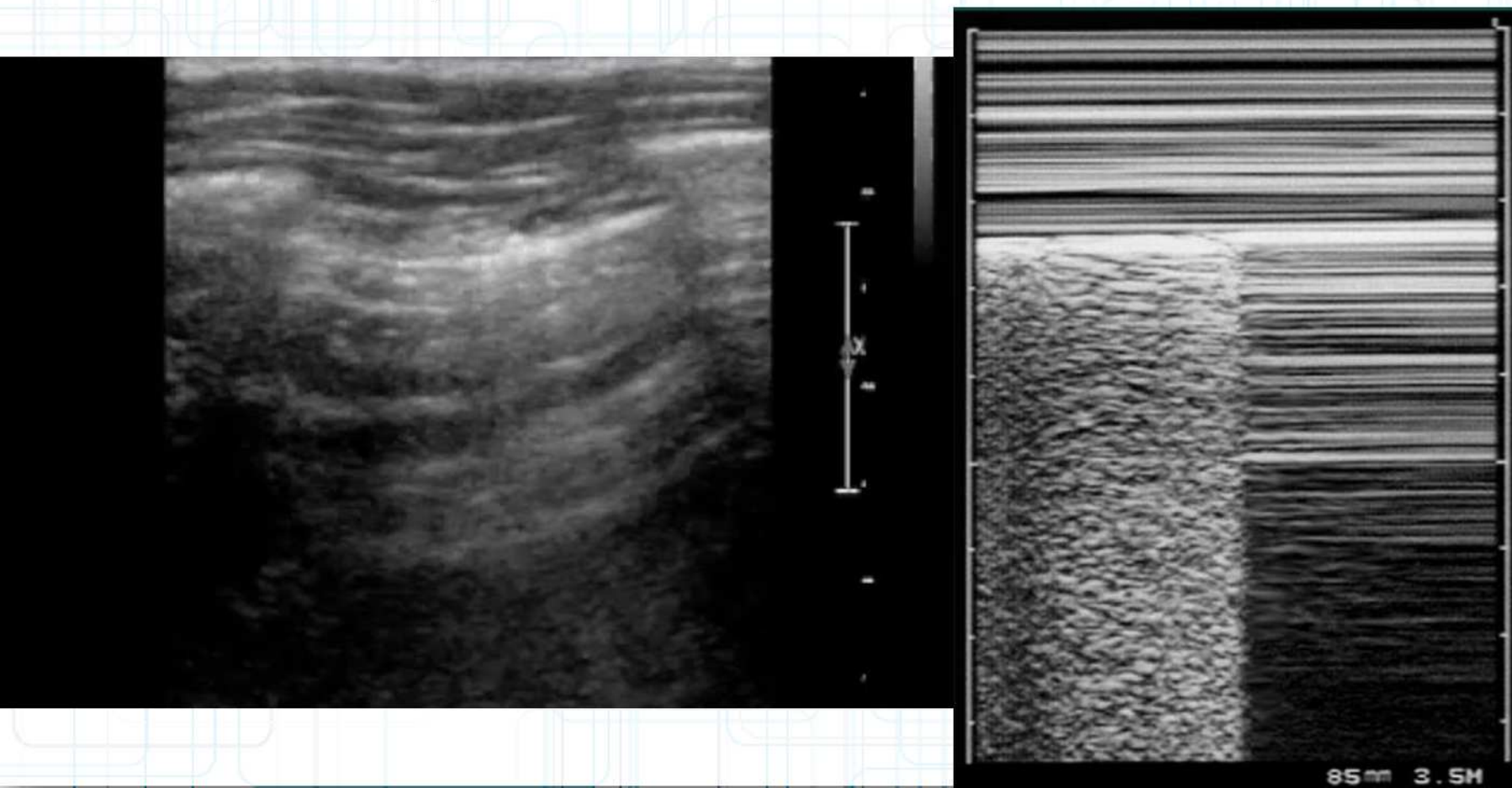
Pneumotooraks

- Kopsu liikumise puudumine
 - Parietaalse pleura alusi ei ole näha libisevat kopsu
 - Dopplersignaali puudumine pleurajoone alusi
- B-jooni ei ole
- A-jooned nähtavad

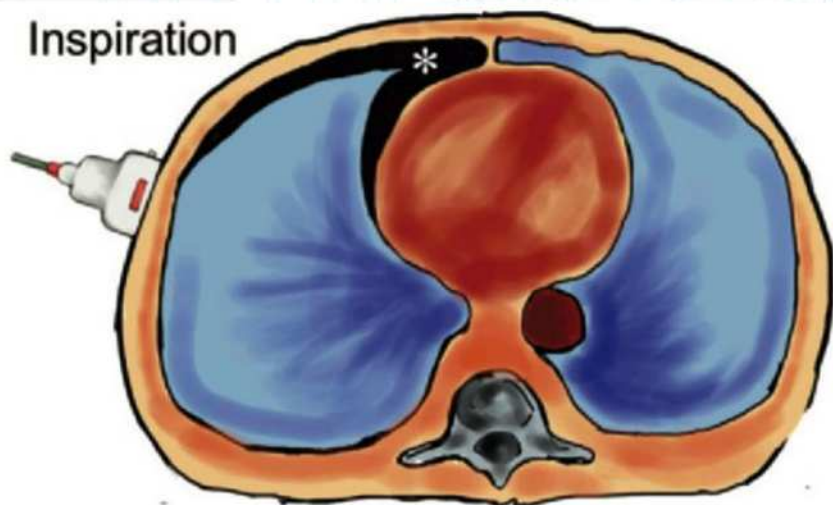


Normipärane dopplersignaali liikuvast kopsust

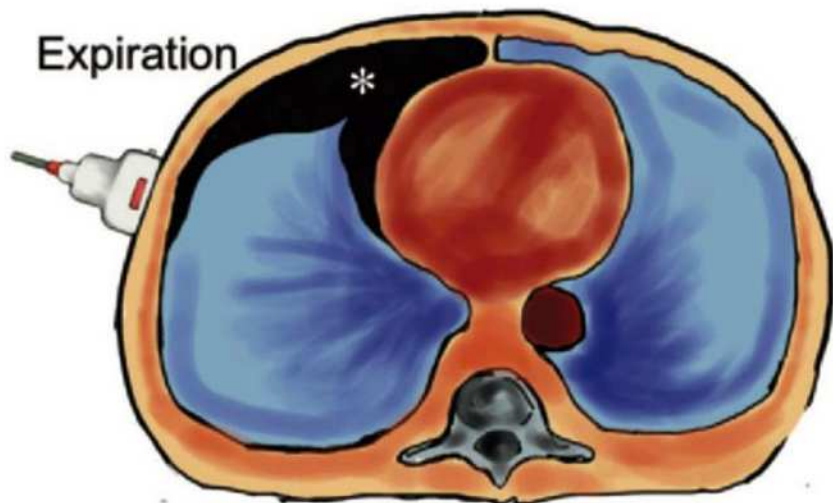
- Kopsupunkt (ingl. keeles lung point) – nähtav liikuva kopsu ja pneumotooraksi üleminekukoht. Kõige spetsiifilisem leid.
- M-mode:
 - Normis mereranna (ingl. keeles seashore) leid
 - Pneumotooraksiga vöötkoodi (ingl. keeles barcode) leid, või stratosfääri leid



Inspiration

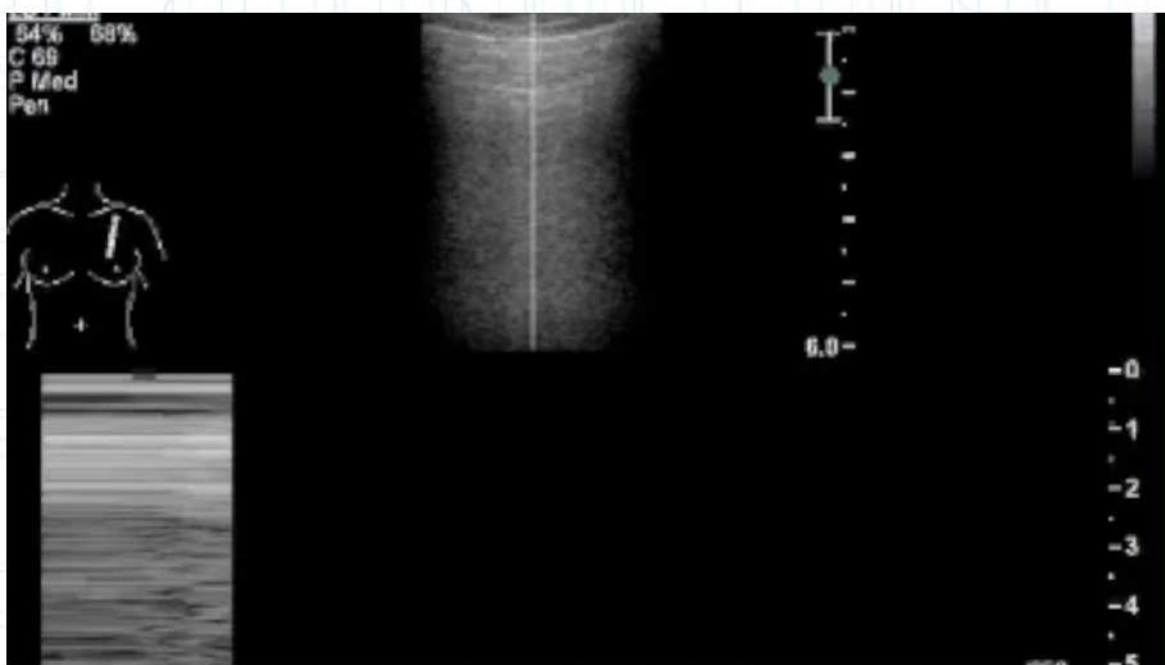


Expiration



Kopsupunkt illustratiivselt. Tärniga on tähistatud õhk pleuraõõnes.

M-mode



Kopsuturse

- Kopsu ultrahelist rääkides kasutatakse terminit äge alveolaar-interstitsiaalne sündroom või interstitsiaalne sündroom
 - Igasugune interstitsiaalne turse kuulub siia alla – ARDS, kardiogeenne kopsuturse, pneumoonia (korreleerub KT-s mattklaasjate kolletega)
 - Erinevused leidude mustrites
- Rohked B-jooned üle mõlema kopsu – difuusne kopsuturse
- Konveksanduriga vähemalt 3 b-joont, lineaariga vähemalt 6 loetakse patoloogiliseks

Kopsuturse dif. dgn

- Interstitsiaalne kopsuhaigus
- Fokaalne:
 - Pneumoonia
 - Fibroos
 - Kontusioon
 - Kopsuinfarkt
 - Lümfangiit

Kardiogeenne kopsuturse

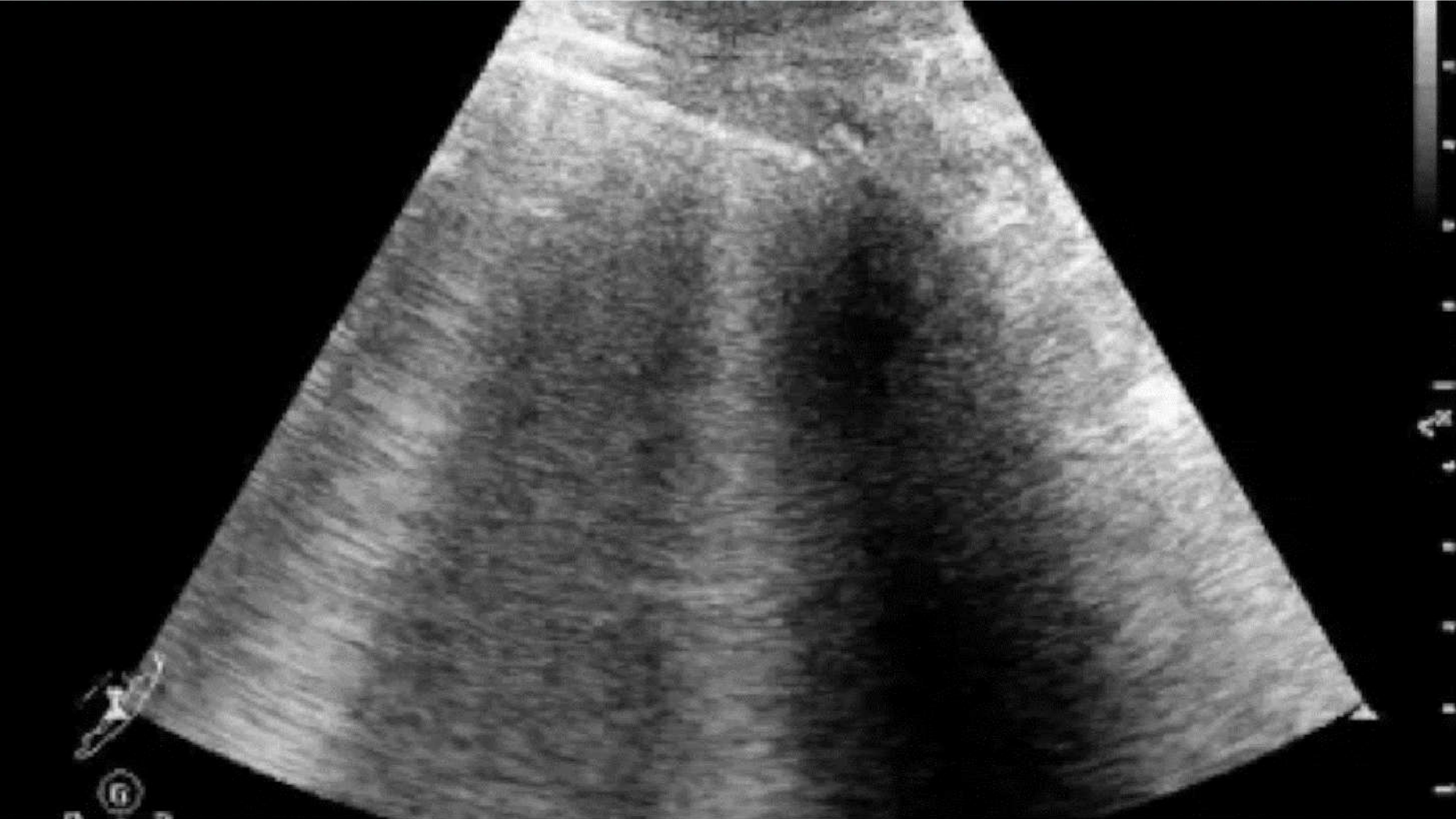
TABLE 4 Diagnostic accuracy of ultrasound (US) in the interstitial syndrome: evidence from systematic reviews

	Number of studies	Population, unit of analysis	US features	Reference standard	Prevalence and number	Sensitivity	Specificity
Acute cardiogenic pulmonary oedema							
AL DEEB 2014 [94]	7 studies	Patients presenting with undifferentiated dyspnoea By patient	US criteria not restricted as long as B-lines were used	5 studies: blinded chart review 2 studies: final diagnosis	45% of 1075 patients	94.1%	92.4%
MARTINDALE 2016 [95]	8 studies	Adults presenting to ED with dyspnoea By patient	At least 3 B-lines in each lung Performed by emergency specialists	Clinical diagnosis by independent reviewers blinded to index test result	45.6% of 1914 patients	85.3%	92.7%

ED: emergency department.

The efficacy of bedside chest ultrasound: from accuracy to outcomes. Mark Hew, Tunn Ren Tay. European Respiratory Review Sep 2016, 25 (141) 230-246; DOI: 10.1183/16000617.0047-2016

- Kõrge uuringueelse tõenäosusega UH täpne
- Madala uuringueelse tõenäosusega sobib turse välistamiseks
- Diferentsiaaldiagnoose ilma muu informatsioonita võimatu eristada



Pneumonia

Variant 1: Acute respiratory illness in immunocompetent patients with negative physical examination, normal vital signs, and no other risk factors. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	⊕
CT chest with IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
CT chest without and with IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
CT chest without IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
MRI chest without and with IV contrast	Usually Not Appropriate	○
MRI chest without IV contrast	Usually Not Appropriate	○
US chest	Usually Not Appropriate	○

Variant 2: Acute respiratory illnesses in immunocompetent patients with positive physical examination, abnormal vital signs, organic brain disease, or other risk factors. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	⊕
US chest	May Be Appropriate	○
CT chest with IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
CT chest without and with IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
CT chest without IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
MRI chest without and with IV contrast	Usually Not Appropriate	○
MRI chest without IV contrast	Usually Not Appropriate	○

Variant 3:

Acute respiratory illness in immunocompetent patients with positive physical examination, abnormal vital signs, organic brain disease, or other risk factors and negative or equivocal initial chest radiograph. Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
CT chest without IV contrast	Usually Appropriate	☼ ☼ ☼
CT chest with IV contrast	May Be Appropriate (Disagreement)	☼ ☼ ☼
US chest	May Be Appropriate	○
CT chest without and with IV contrast	Usually Not Appropriate	☼ ☼ ☼
MRI chest without and with IV contrast	Usually Not Appropriate	○
MRI chest without IV contrast	Usually Not Appropriate	○

Variant 4:

Acute respiratory illnesses in immunocompetent patients with pneumonia complicated by suspected parapneumonic effusion or abscess on initial chest radiograph. Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
CT chest with IV contrast	Usually Appropriate	☼ ☼ ☼
CT chest without IV contrast	Usually Appropriate	☼ ☼ ☼
MRI chest without and with IV contrast	May Be Appropriate (Disagreement)	○
MRI chest without IV contrast	May Be Appropriate (Disagreement)	○
US chest	May Be Appropriate	○
CT chest without and with IV contrast	Usually Not Appropriate	☼ ☼ ☼

Variant 6: **Acute asthma exacerbation in immunocompetent patients, complicated (suspected pneumonia or pneumothorax). Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	⦿
CT chest with IV contrast	May Be Appropriate	⦿ ⦿ ⦿
CT chest without IV contrast	May Be Appropriate	⦿ ⦿ ⦿
US chest	May Be Appropriate	○
CT chest without and with IV contrast	Usually Not Appropriate	⦿ ⦿ ⦿
MRI chest without and with IV contrast	Usually Not Appropriate	○
MRI chest without IV contrast	Usually Not Appropriate	○

Variant 8: **Acute COPD exacerbation in immunocompetent patients with accompanying chest pain, fever, or leukocytosis, or a history of coronary artery disease, or heart failure. Initial imaging.**

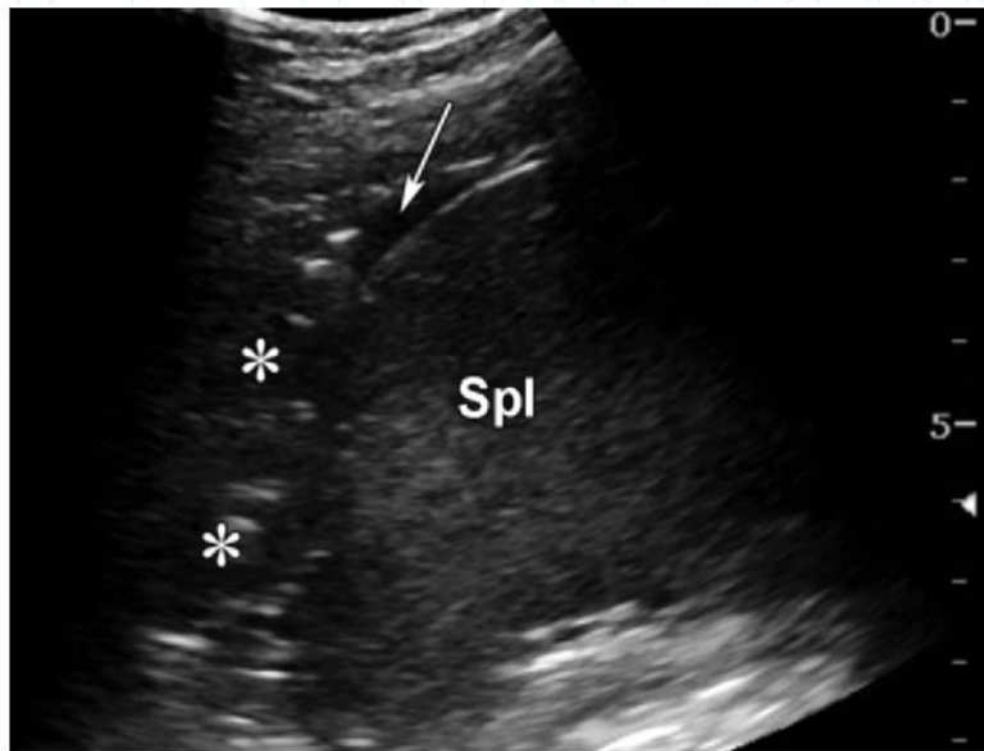
Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	⦿
CT chest without IV contrast	May Be Appropriate	⦿ ⦿ ⦿
CT chest with IV contrast	May Be Appropriate	⦿ ⦿ ⦿
US chest	May Be Appropriate	○
CT chest without and with IV contrast	Usually Not Appropriate	⦿ ⦿ ⦿
MRI chest without and with IV contrast	Usually Not Appropriate	○
MRI chest without IV contrast	Usually Not Appropriate	○

Pneumoonia

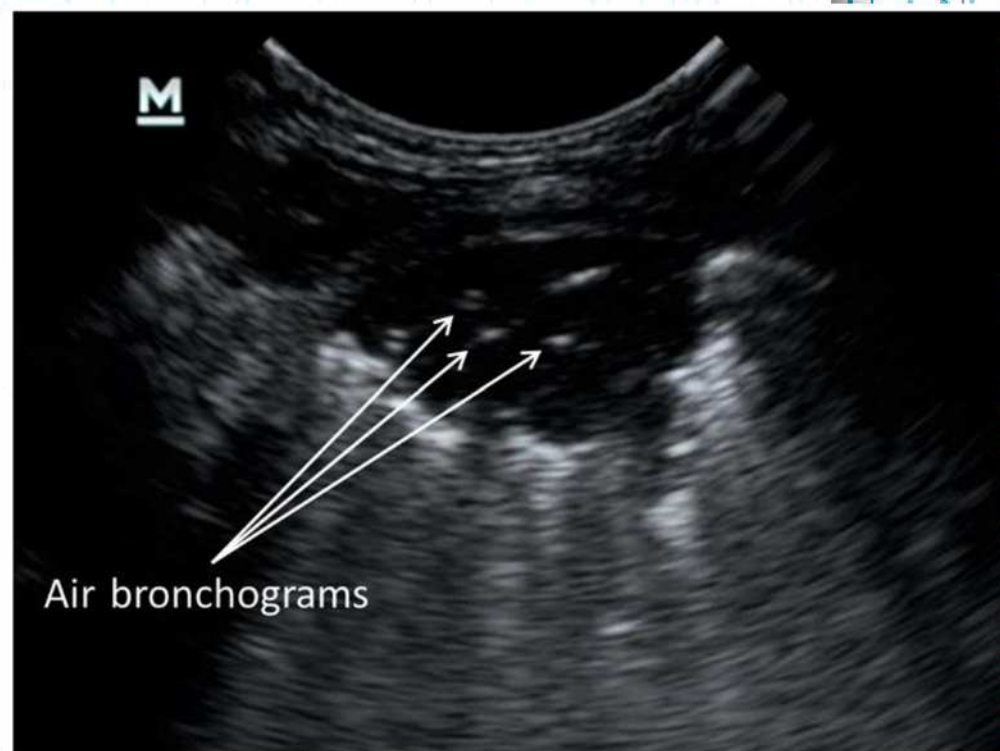
- UH-s on võimalik eristada perifeerset subpleuraalset konsolidatsiooni
- Kops meenutab maksastruktuuri
- Konsolidatsiooni foonil on hüperehhogeensed liikuvad õhk-bronhogrammid – atelektaasi puhul on bronhogramm staatiline*
- Pneumoonia kliinikuga patsient, kellel on fokaalsed B-jooned – samuti kahtlane pneumooniale, KT-s vastaks sellele mattklaasjad alad

Kõik ei ole nõus, et atelektaas ja pnemoonia on hästi eristatavad:

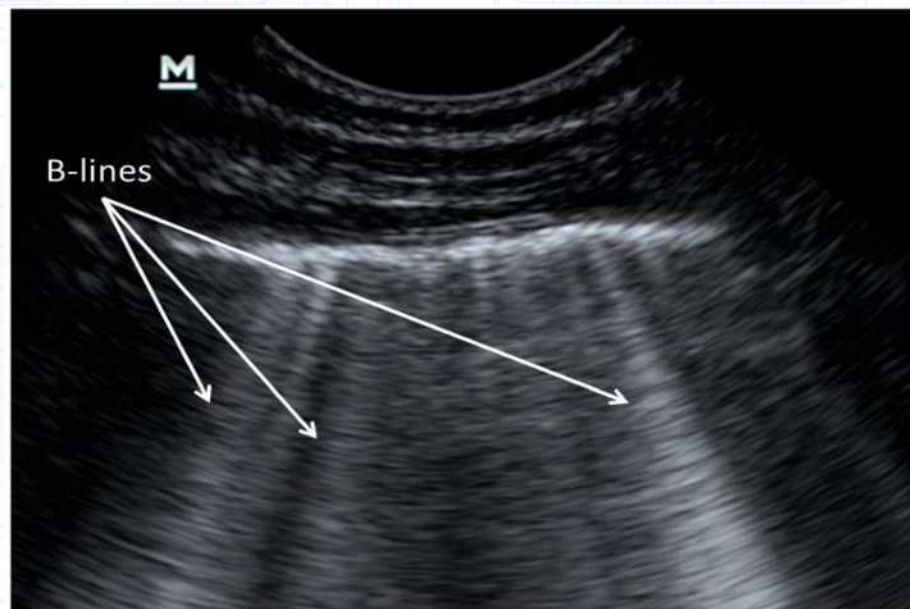
Stadler JAM, Andronikou S, Zar HJ. Lung ultrasound for the diagnosis of community-acquired pneumonia in children. *Pediatr Radiol*. 2017;47(11):1412–1419. doi:10.1007/s00247-017-3910-1



Tärniga tähistatud õhkbronhogrammidega konsolidatsioon. Noolega tähistatud vedeliku pleiuraõõnes. Spl – põrn.



Õhk-bronhogrammidega subpleuraalne konsolidatsioon. Sügavamal konsolidatsiooni piiril B-jooned.



Pneumoonia sümptomatoloogiaga väike poiss – UH-s laatuivad B-jooned

Täpsus

- Konsolidatsiooni leid on mittespetsiifiline, dif dgn:
 - Infektsioosne pneumoonia
 - Organiseeruv pneumoonia
 - ARDS
 - Kopsuinfarkt
 - Atelektaas
- Fokaalsete rohkenenud B-joonte osas samuti dif dgn, mis eristamatud

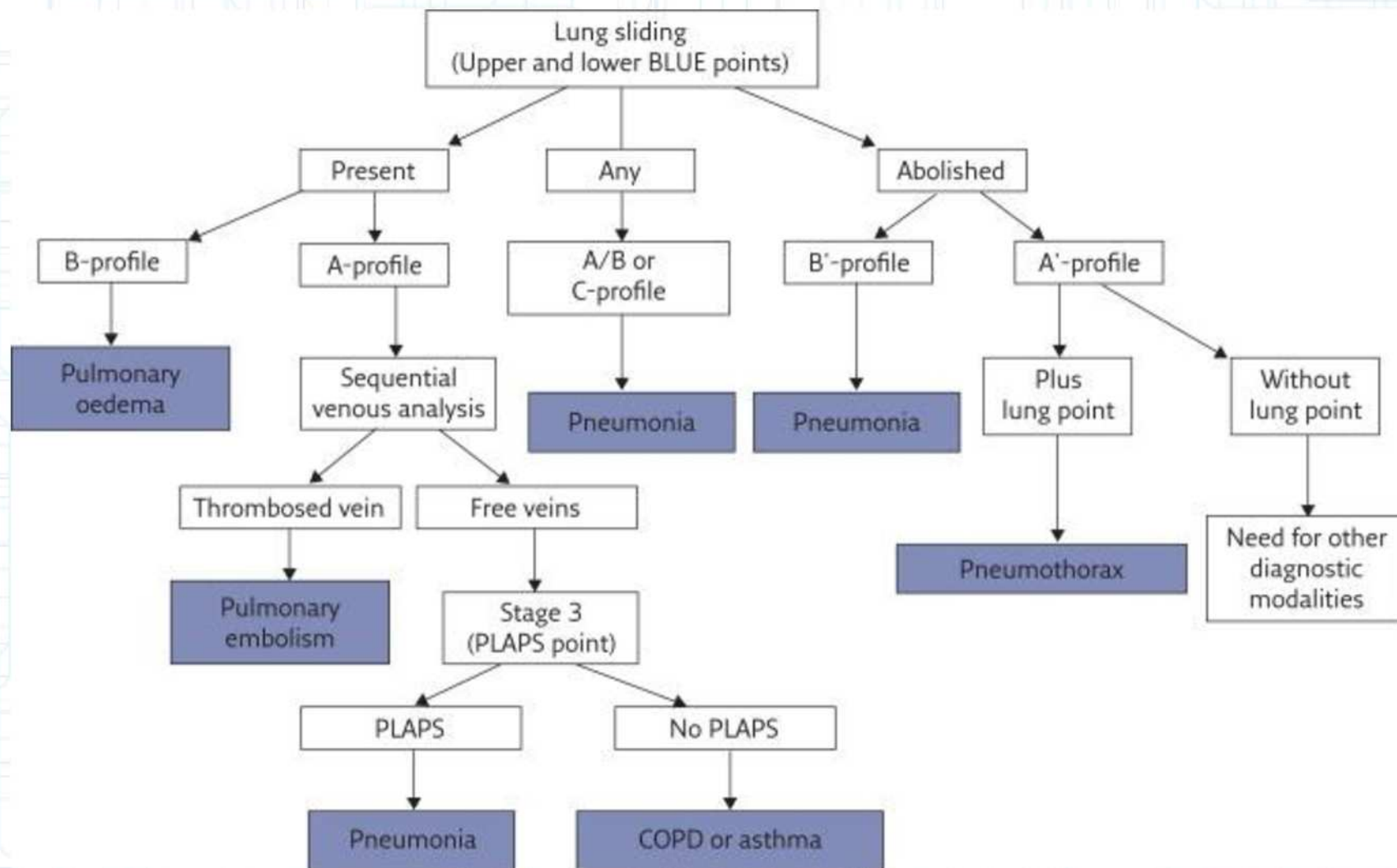
	Number of studies	Population, unit of analysis	US features, comparator	Reference standard	Prevalence and number	Sensitivity	Specificity
Consolidation							
Hew 2015 [32]	4 studies No meta-analysis	Hospitalised adults with acute respiratory failure, By patient, lung or lung region	Consolidation CXR	CT only	Unable to summarise prevalence from heterogeneous units of analysis 224 patients	US: 98–100% CXR: 38–68%	US: 78–100% CXR: 89–95%
Pneumonia							
Hu 2014 [65]	9 studies	Included adults, children, neonates By patient	Unstated	CXR/CT, or CXR only, or clinical diagnoses	62.5% of 1080 patients	US: 97%	US: 94%
CHAVEZ 2014 [66]	10 studies	Adults with clinical suspicion of pneumonia, or acute respiratory failure By patient, lung, or lung region [#]	Consolidation or “alveolar and interstitial”	CT only, or CXR or CT, or clinical diagnosis/CT/CXR	Calculated at 50% of 1098 patients in studies analysed by patient	US: 94%	US: 96%
YE 2015 [67]	5 studies	Clinically suspected pneumonia in adults By patient	Uni/bilateral or focal alveolar–interstitial syndrome, or consolidation with air bronchograms	Hospital discharge diagnosis	67.3% of 742 patients	US: 95% CXR: 77%	US: 90% CXR: 91%

Uuritud erinevaid tulemeid: konsolidatsiooni olemasolu või konkreetset diagnoosi – pneumooniat.

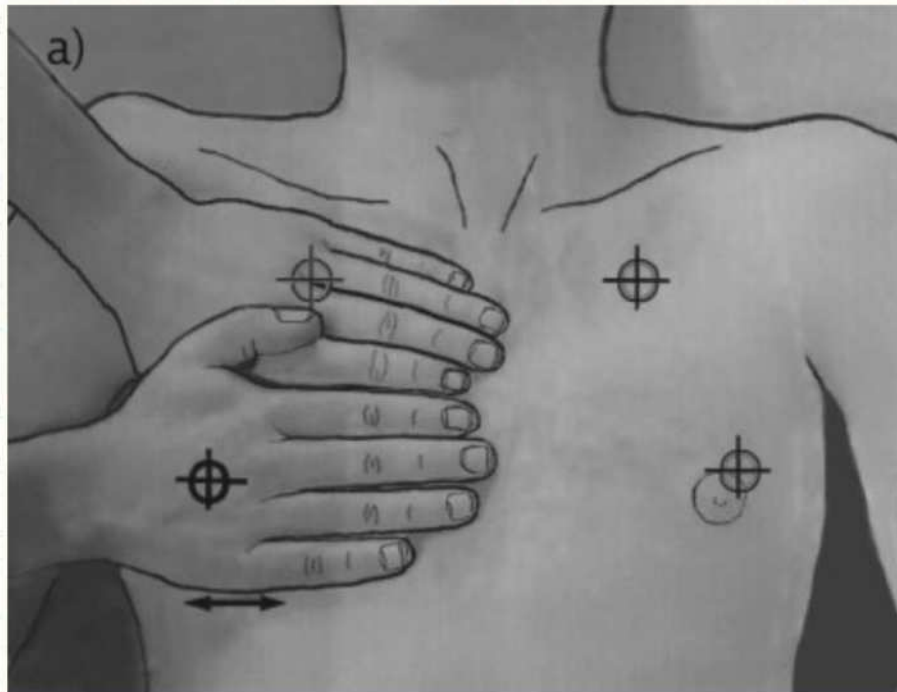
Üldiselt pole uurijad kliinilistele andmetele pimendatud – kõrge tundlikkus ja spetsiifilisus osalt kõrgest uuringueelsest kahtlusest¹²

Tulemused võrreldes röntgeniga siiski paljulubavad.

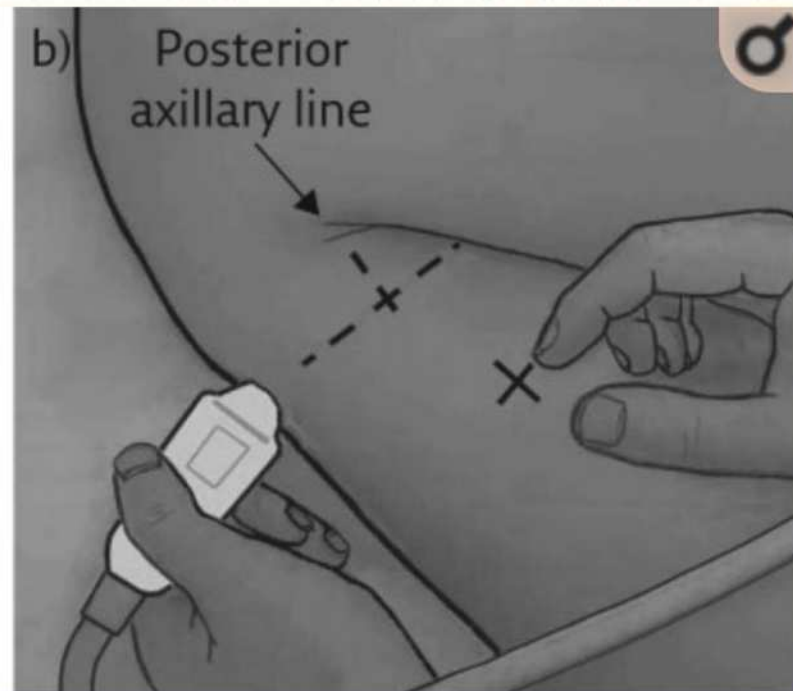
Kriitilise haige uurimise protokoll



- Kriitiliselt haige käsitus – BLUE = bedside lung ultrasound in emergency
- Anduriga vaadatakse rindkere 6 erinevas positsioonis:



a) Käed katavad umbes kopsu ulatuse juhul kui käte suurus on patsiendi omadega sarnane. Sihikutega on tähistatud anduriga uuritavad lokalisatsioonid.



b) pildil a olevast alumisest punktist kujuteldava joone tõmbamisel lateraalsele saab võimalikult posterioorsel PLAPS (posterolateral alveolar or pleural syndromes) punkti – antud pildil on punktiks ristumine tagumise aksillaarjoonega

- Jagab leiud profiilideks, mis omakorda annavad kõige tõenäolisema diagnoosi:
 - A profiil: kopsu libisemine ja A-jooned
 - A' profiil: A-jooned ilma kopsu libisemiseta
 - B profiil: kopsu libisemine ja B-jooned
 - B' profiil: B-jooned ilma kopsu libisemiseta
 - A/B profiil: ühe kopsu osas A-jooned, teisel pool B-jooned
 - C profiil: anterioorne konsolidatsioon

Mechanism of dyspnoea	BLUE protocol profile	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Acute haemodynamic pulmonary oedema	B-profile	97%	95%	87%	99%
Exacerbated COPD or severe acute asthma	Nude profile (A-profile with no DVT and no PLAPS)	89%	97%	93%	95%
Pulmonary embolism	A-profile with DVT	81%	99%	94%	98%
Pneumothorax	A'-profile (with lung point)	88%	100%	100%	99%
Pneumonia	All profiles [#]	89%	94%	88%	95%
	B'-profile	11%	100%	100%	70%
	A/B-profile	14.5%	100%	100%	71.5%
	C-profile	21.5%	99%	90%	73%
	A-V-PLAPS profile	42%	96%	83%	78%

- profiilide tundlikkused kokku liidetud

Probleemid

- Valenegatiivsete põhjused:
 - » KOK haiged (pneumotooraksi miimik)
 - » Ülekaalulisus
 - » Nahaalune õhkemfüseem
 - » Pleurani mitteulatuivad lesioonid

Veel erinevaid probleeme

- Leidudeks on artefaktid
 - Uued masinad vähemate artefaktidega¹⁰
 - Ultraheli seadistused võivad artefakte kaotada või muuta¹⁰
- Praktiliselt kõigi leidudega kaasneb diferentsiaaldiagnostiline rida ja kõrge tundlikkus/spetsiifilisus haiguste osas on ainult koos muu kliiniku ja diagnostikaga
- Dünaamika hindamine erinevatel inimestel?
- Pilt ei ole ülevaatlik, ei saa infot muude rindkere struktuuride kohta – kui tahaks saada, läheks väga kaua aega

Mis jäi katmata

- Igapäevase töö:
 - Pleuraefusioonid
 - Subpleuraalsed massid (tuumor, abstsess)
- Interstitsiaalsed kopsuhaigused
- Kopsu kontusioon

Koju kaasa

- Artefaktid: reverberatsioon, komeedisaba ja *ring down*
- A-jooned, B-jooned, E-jooned, Z-jooned
- Pneumotooraksi kahtlusel lung point'i leidmine on hea spetsiifilisusega leid
- Muud leiud on mittespetsiifilised, koos taustinformatsiooniga spetsiifilisus tõuseb
- UH on oskaja käes erakorralise patsiendi kopsu kiireks uurimiseks hea esmane modaliteet

Kasutatud kirjandus

1. ACR appropriateness criteria
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3. <https://radiopaedia.org/articles/pneumothorax-ultrasound-1?lang=us>
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5. <https://litfl.com>
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