Pulmonary ultrasound and dialysis

Alexandre SEIDOWSKY

and

Ziad A. MASSY

Ambroise Paré Hospital

University Hospitals Paris Ile de France West, UVSQ

Boulogne Billancourt (Paris), France

INSERM U-1018, CESP, Villejuif(Paris), France

Conflicts of interest

Dr. A. Seidowsky and Prof. Z.A. Massy are

investigators of the LUST trial

CARE HOSPITALS

Quote of the day

Never go to a doctor whose office plants have died.

— Erma Bombeck

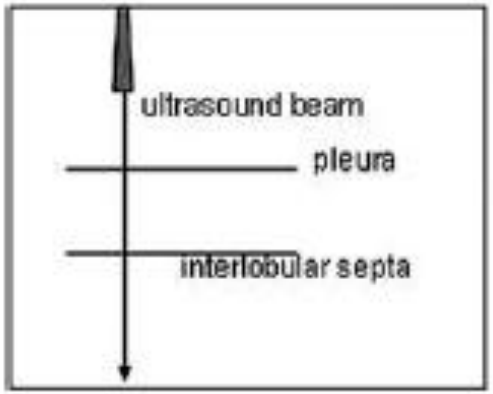

GE Healthcare
Menu
Vscan

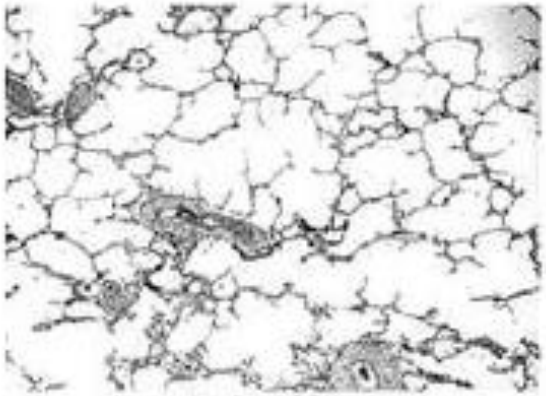
- Formation of images in pulmonary ultrasound
- Pulmonary ultrasound in emergencies and intensive care unit
- Pulmonary ultrasound for the detection of heart failure
- Detection of subclinical pulmonary congestion in chronic kidney disease
- Pathophysiology of pulmonary congestion in chronic kidney disease
- Impact of the use of pulmonary ultrasonography on morbidity and mortality in hemodialysis patients
- Comparison and Combination of Pulmonary Ultrasound with Other Methods
- Conclusions

- **Formation of images in pulmonary ultrasound**
- Pulmonary ultrasound in emergencies and intensive care unit
- Pulmonary ultrasound for the detection of heart failure
- Detection of subclinical pulmonary congestion in chronic kidney disease
- Pathophysiology of pulmonary congestion in chronic kidney disease
- Impact of the use of pulmonary ultrasonography on morbidity and mortality in hemodialysis patients
- Comparison and Combination of Pulmonary Ultrasound with Other Methods
- Conclusions

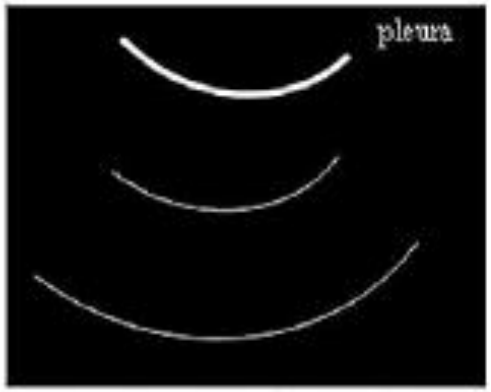
Ultrasound Lung Comets: A Clinically Useful Sign of Extravascular Lung Water

Eugenio Picano, MD, PhD, Francesca Frassi, MD, Eustachio Agricola, MD, Suzana Gligorova, MD, Luna Gargani, and Gaetano Mottola, MD, *Pisa, Milan, and Mercogliano, Italy*

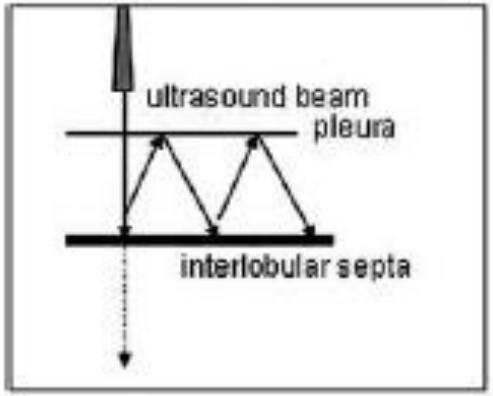


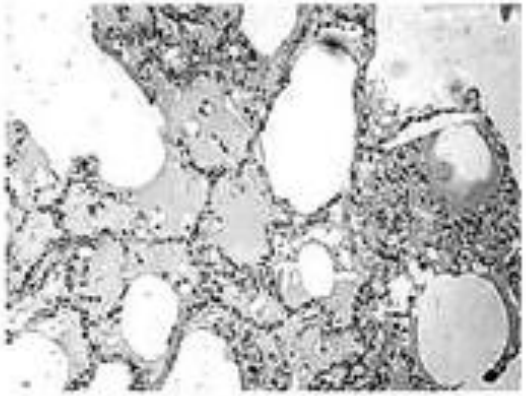


normal lung

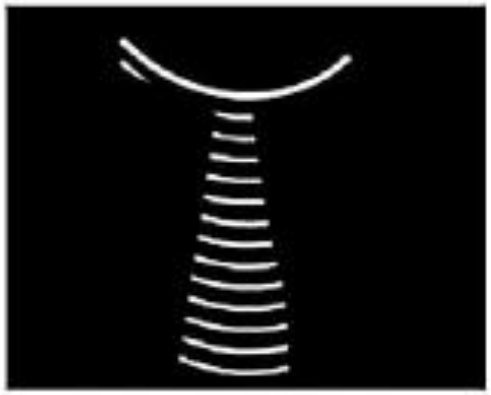


"ring-down" artifacts

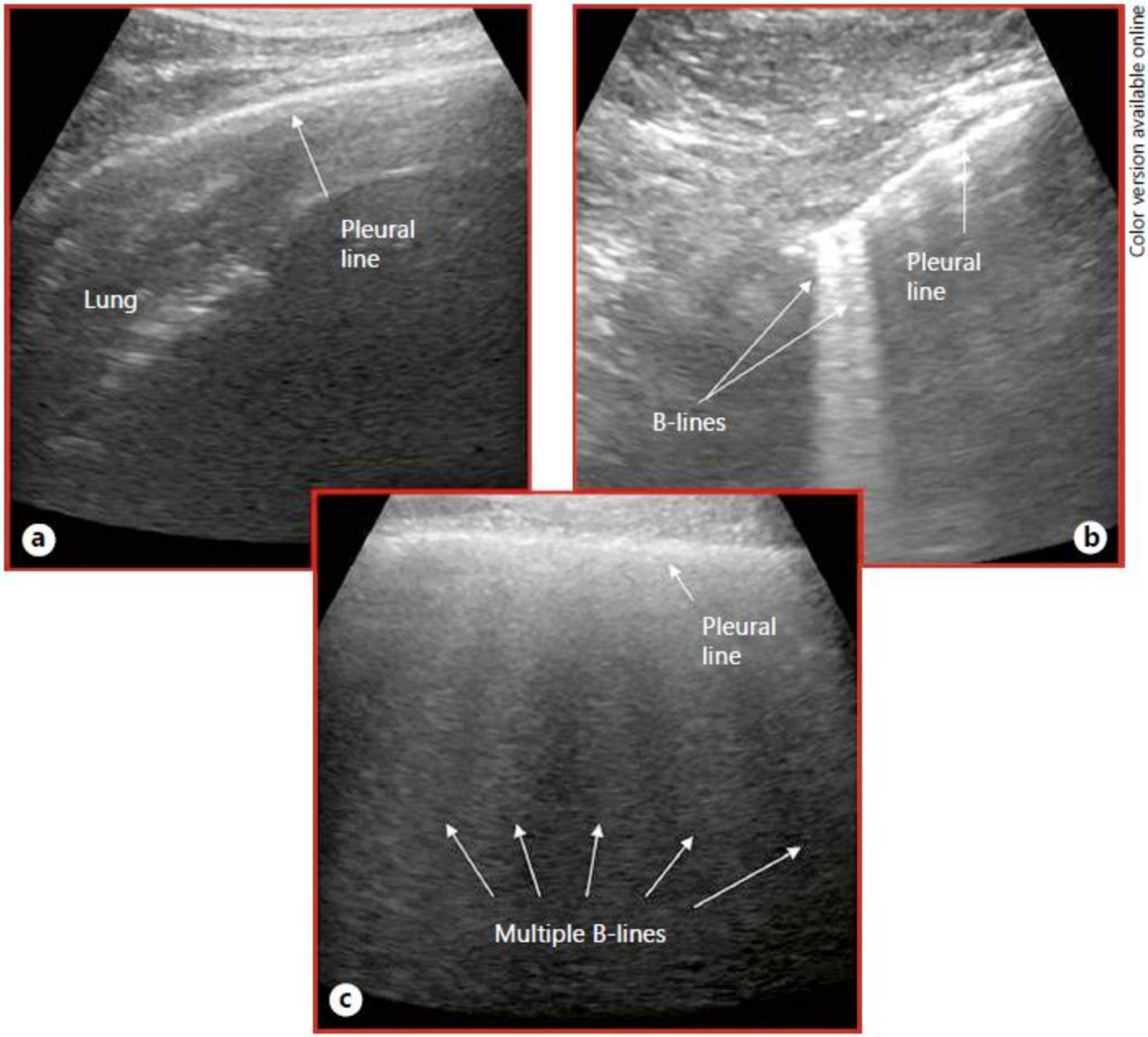




pulmonary edema



"comet-tail" artifact



Color version available online


esaote MyLab
IFC-FGM Pisa
A----------
20 SET 2008 17:47
0:00:00.30
B F G G 37%
TEI P 25 cm XV 1
PRC 7-3-B PRS M
PST 2
FACTORY PA240

The Comet Tail Artifact

Marvin C. Ziskin, MD, David I. Thickman, MD, Nancy Jacobs Goldenberg, MD,
Marc S. Lapayowker, MD, Joseph M. Becker, MD

J Ultrasound Med 1.1-7, Jan-Feb 1982

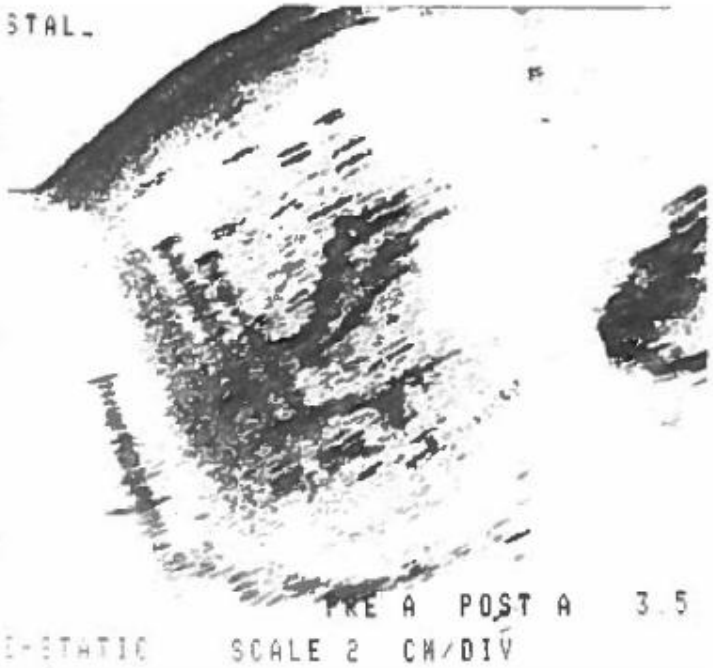
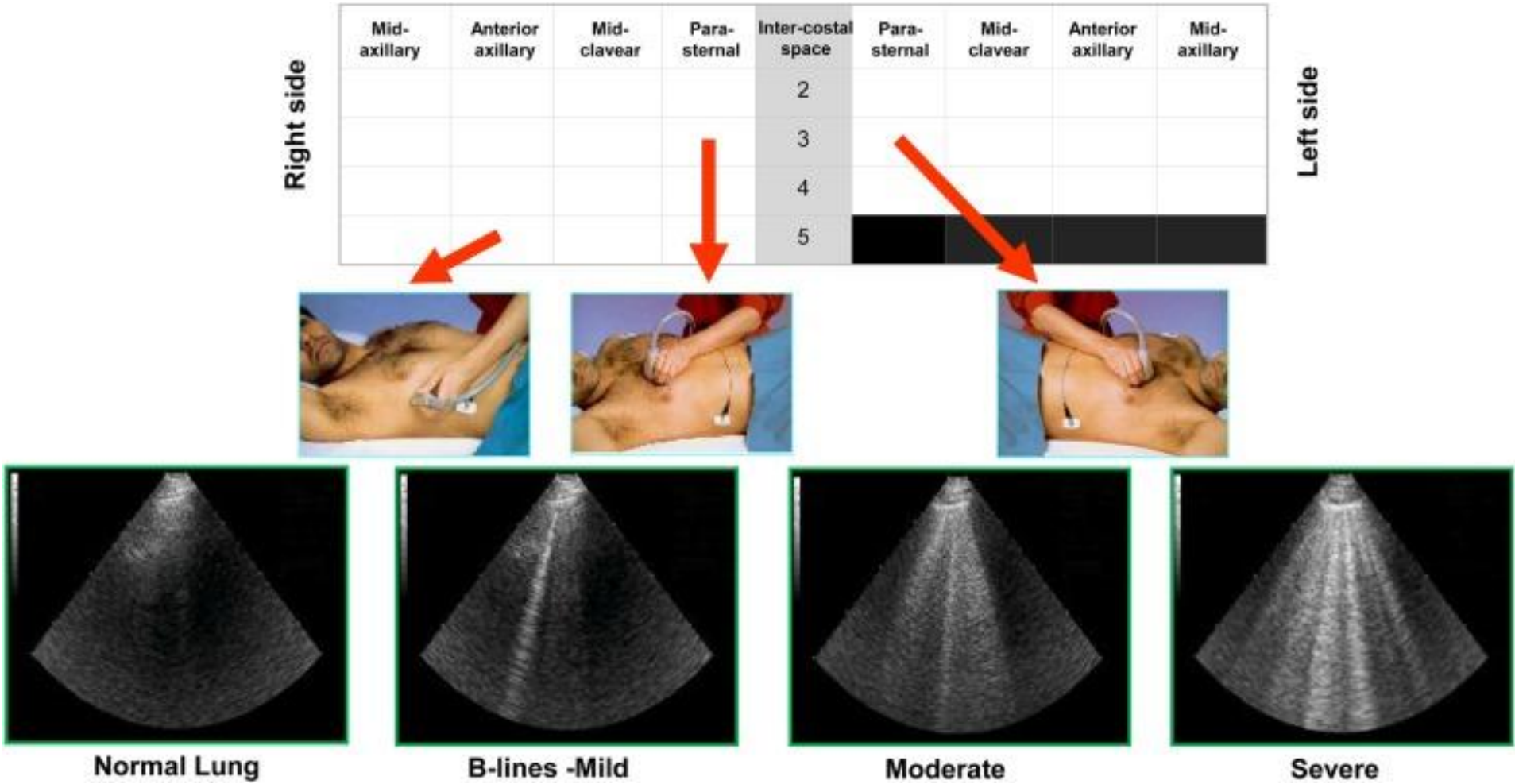


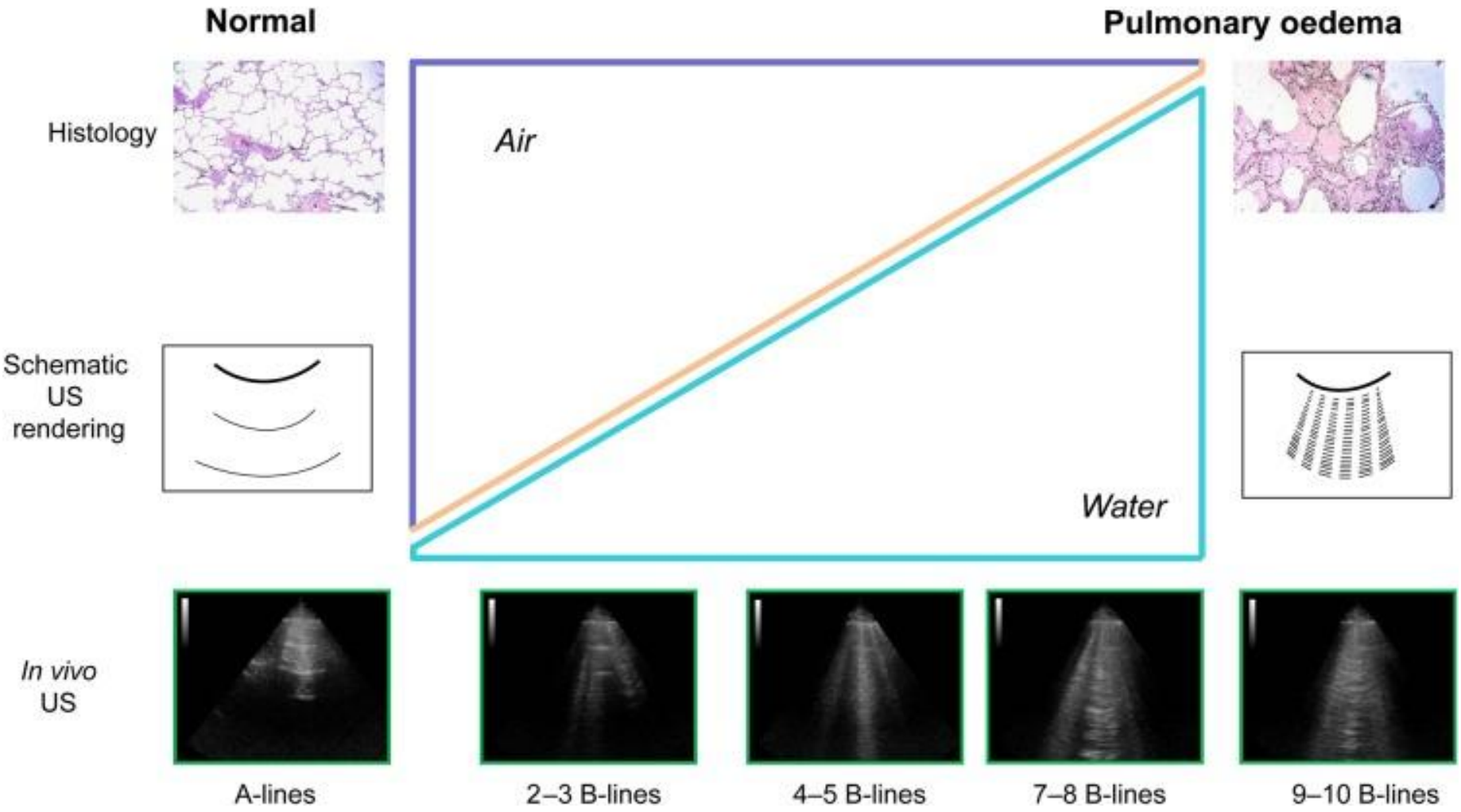
Figure 1. Patient with shotgun wound of abdomen. *Left*, abdominal roentgenogram showing multiple lead pellets scattered throughout abdomen. *Above*, B-scan of right upper quadrant showing prominent comet tail patterns beyond three pellets.

Ultrasound of extravascular lung water: a new standard for pulmonary congestion

European Heart Journal (2016) **37**, 2097–2104

Eugenio Picano[1]* and Patricia A. Pellikka[2]

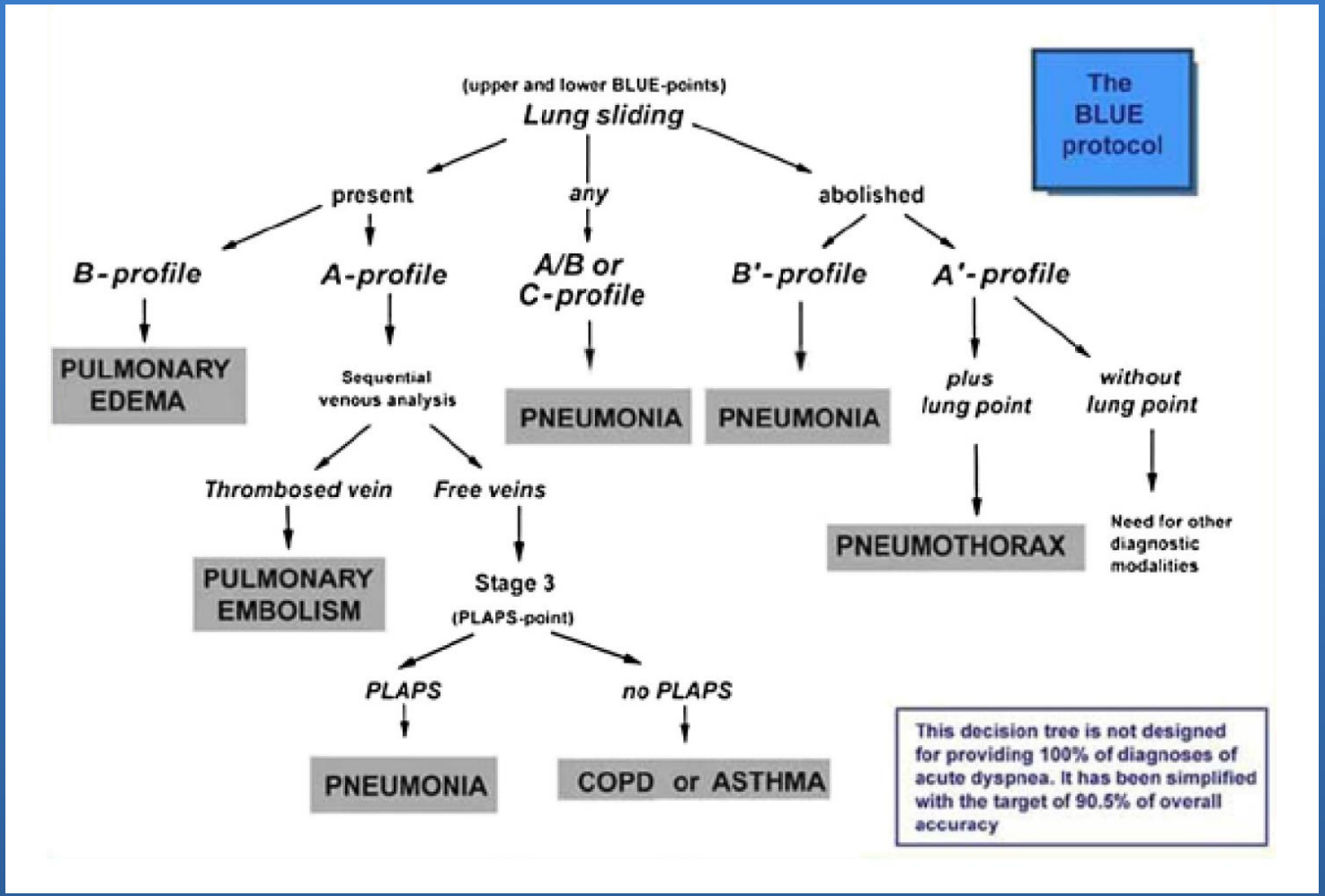



Normal
Pulmonary oedema
Histology
Air
Water
Schematic US rendering
In vivo US
A-lines
2–3 B-lines
4–5 B-lines
7–8 B-lines
9–10 B-lines

- Formation of images in pulmonary ultrasound
- **Pulmonary ultrasound in emergencies and intensive care unit**
- Pulmonary ultrasound for the detection of heart failure
- Detection of subclinical pulmonary congestion in chronic kidney disease
- Pathophysiology of pulmonary congestion in chronic kidney disease
- Impact of the use of pulmonary ultrasonography on morbidity and mortality in hemodialysis patients
- Comparison and Combination of Pulmonary Ultrasound with Other Methods
- Conclusions

Lung ultrasound in the critically ill

Daniel A Lichenstein *Lichenstein annals of Intensive Care 2014, 4;1*



B-lines score on lung ultrasound as a direct measure of respiratory dysfunction in ICU patients with acute kidney injury

Adi Ciumanghel[1] · Ianis Siriopol[1] · Mihaela Blaj[1] · Dimitrie Siriopol[2] · Cristina Gavrilovici[3] · Adrian Covic[2]

Int Urol Nephrol (2018) 50:113–119

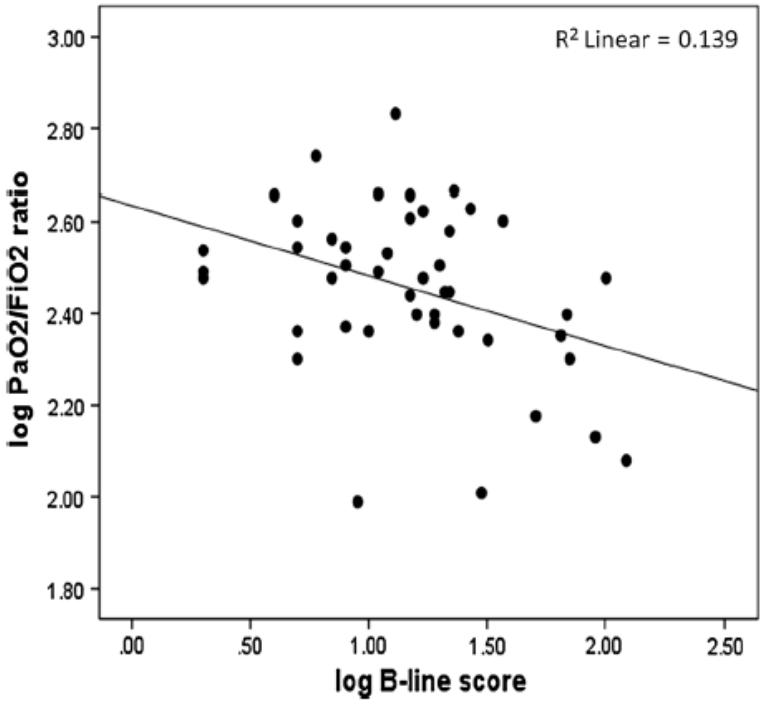


Fig. 1 Correlation between log B-line score and log PaO_2/FiO_2 levels

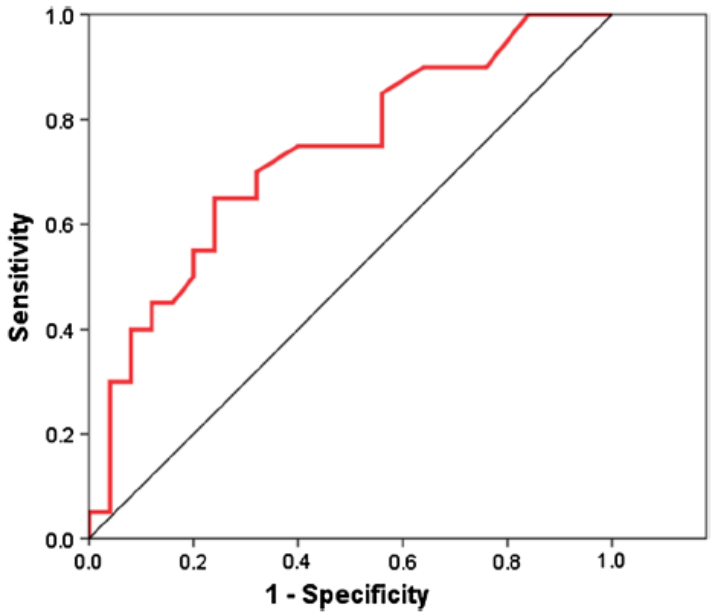


Fig. 2 B-line score's area under the receiver operating characteristics for predicting $PaO_2/FiO_2 < 300$

- Formation of images in pulmonary ultrasound
- Pulmonary ultrasound in emergencies and intensive care unit
- **Pulmonary ultrasound for the detection of heart failure**
- Detection of subclinical pulmonary congestion in chronic kidney disease
- Pathophysiology of pulmonary congestion in chronic kidney disease
- Impact of the use of pulmonary ultrasonography on morbidity and mortality in hemodialysis patients
- Comparison and Combination of Pulmonary Ultrasound with Other Methods
- Conclusions

The Comet-tail Artifact

An Ultrasound Sign of Alveolar-Interstitial Syndrome

DANIEL LICHTENSTEIN, GILBERT MÉZIÈRE, PHILIPPE BIDERMAN, AGNÈS GEPNER, and OLIVIER BARRÉ

Service de Réanimation Médicale and Service de Radiologie, Hôpital Ambroise-Paré, Boulogne (Paris), and Service de Réanimation Polyvalente, Centre Hospitalier Général, Saint-Cloud (Paris), France

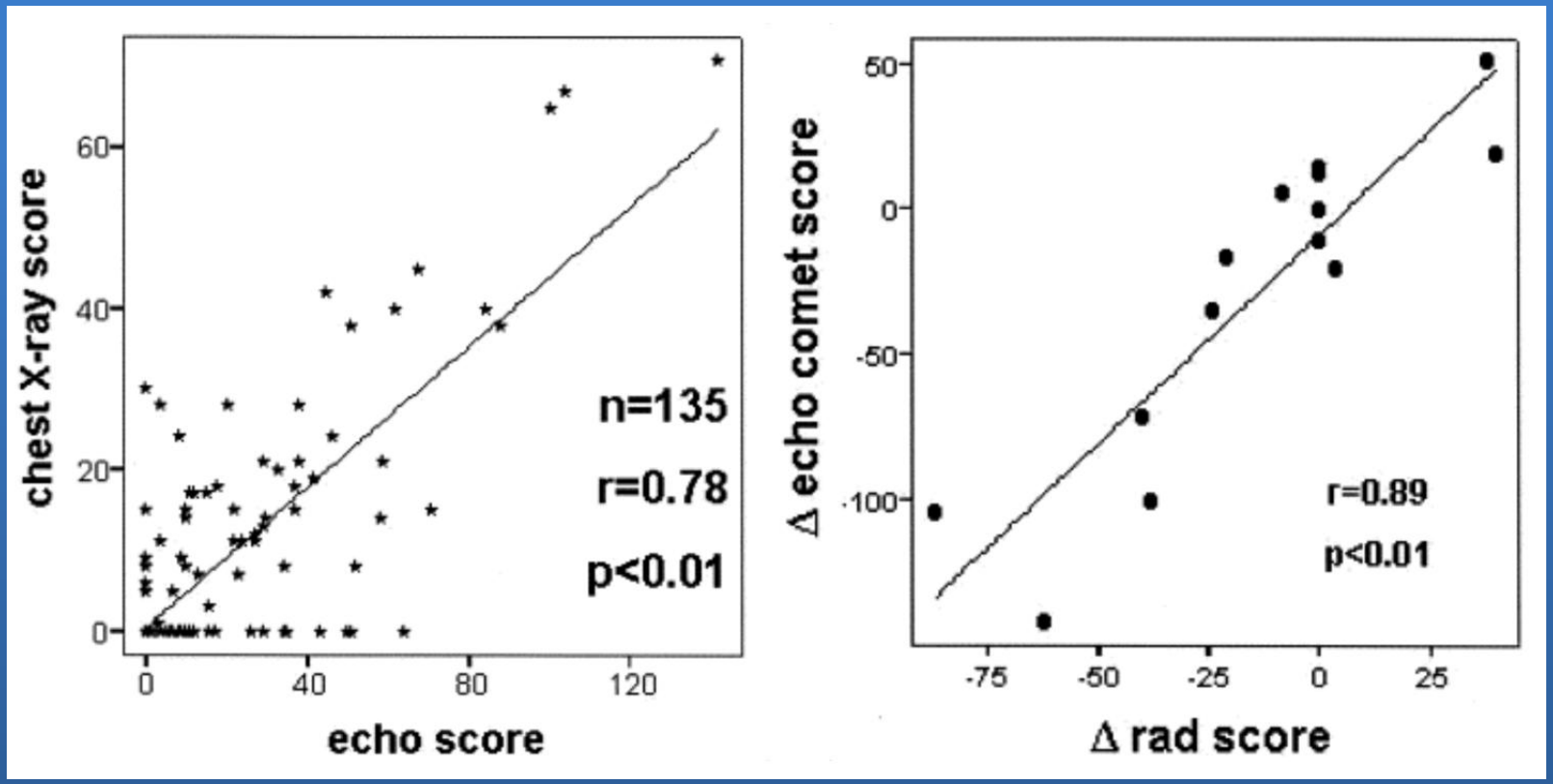
AM J RESPIR CRIT CARE MED 1997;156:1640–1646.

CORRELATION BETWEEN RADIOLOGIC AND SONOGRAPHIC PATTERNS

	Artifact Extending Beyond the Last Intercostal Space	Artifact Confined to the Last Intercostal Space	Absence of Artifact	Total
Diffuse alveolar-interstitial syndrome	86	3	3	92
Localized alveolar-interstitial syndrome	19	4	6	29
Absence of alveolar-interstitial syndrome	9	36	84	129
Total	114	43	93	250

Usefulness of ultrasound lung comets as a nonradiologic sign of extravascular lung water

Zoltan Jambrik et al. *The American Journal of Cardiology, 2004*

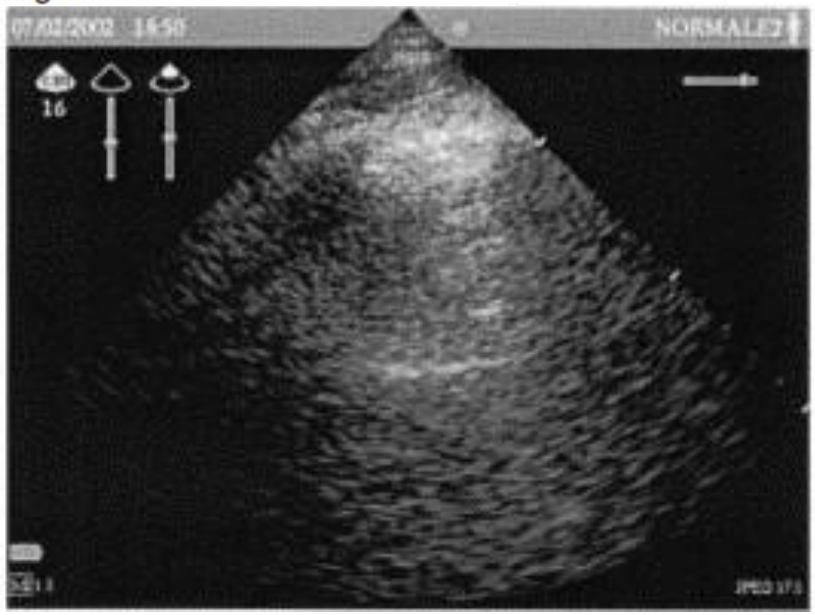


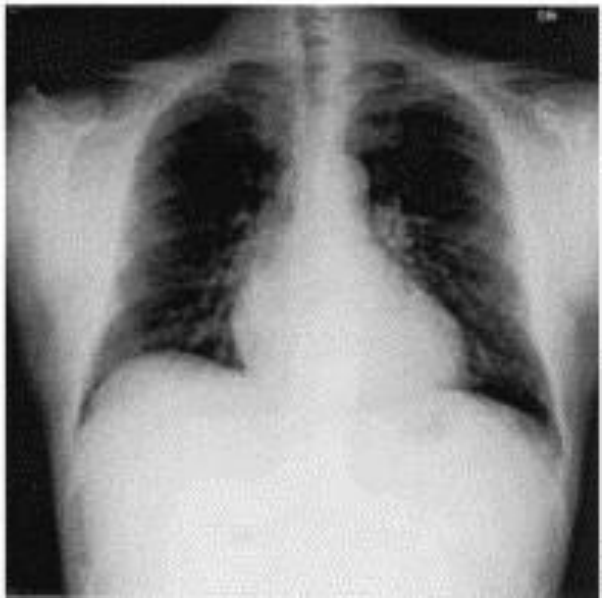
"Ultrasound Comet-Tail Images": A Marker Of Pulmonary Edema*

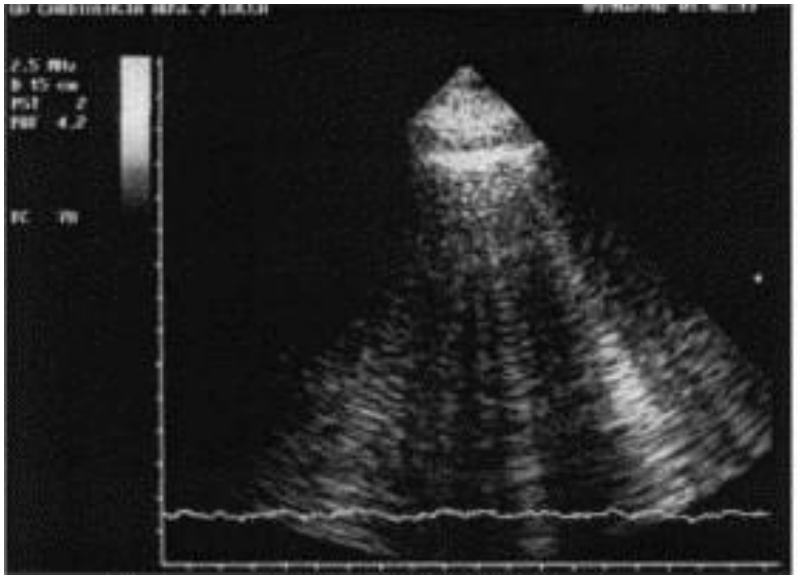
A Comparative Study With Wedge Pressure And Extravascular Lung Water

Eustachio Agricola, MD; Tiziana Bove, MD; Michele Oppizzi, MD; Giovanni Marino, MD; Alberto Zangrillo, MD; Alberto Margonato, MD; and Eugenio Picano, MD

CHEST / 127 / 5 / MAY, 2005

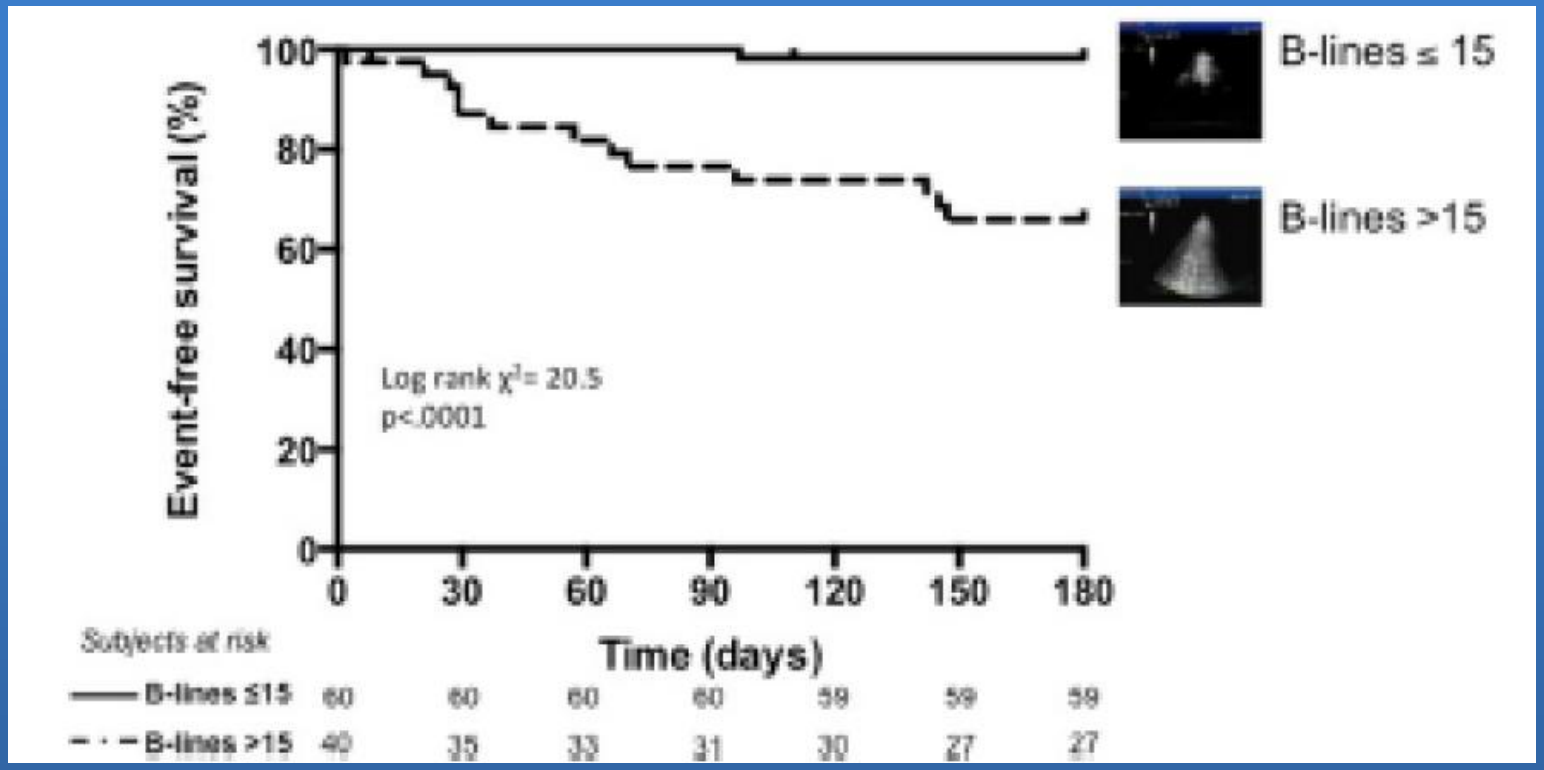






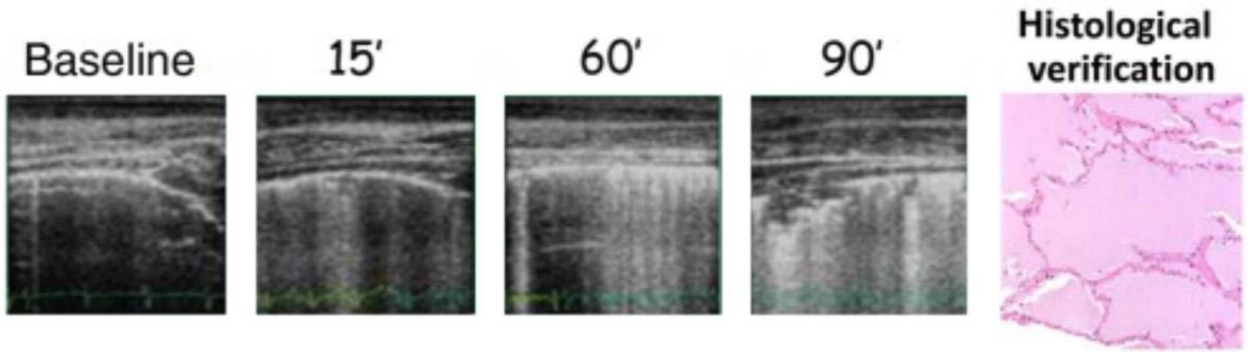
Persistent pulmonary congestion before discharge predicts rehospitalization in heart

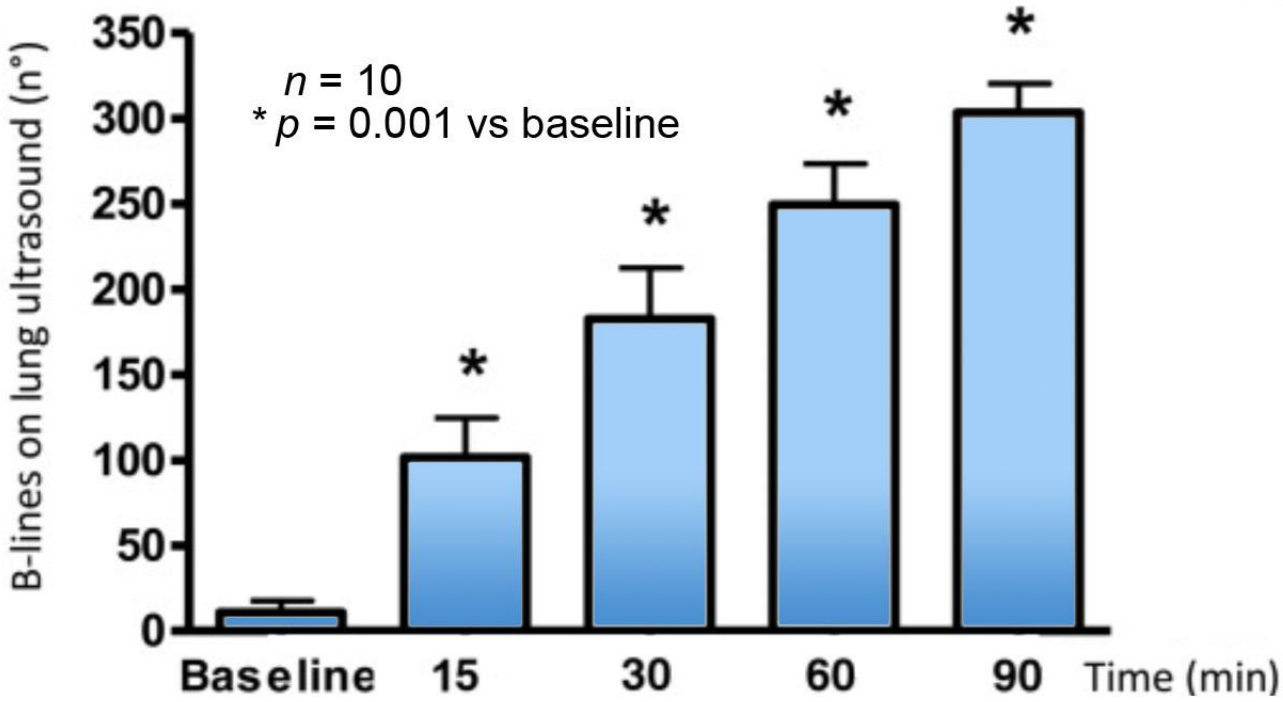
Gargani et al. *Cardiovascular Ultrasound (2015) 13:40*



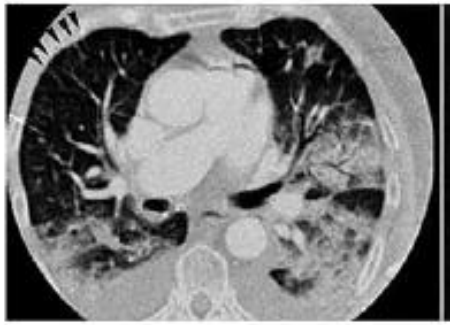
Kaplan Meier survival curves in HF patients stratified according to the number of ß lines before discharge, at 6 months follow-up

Acute respiratory distress syndrome and Acute lung injury have B-lines

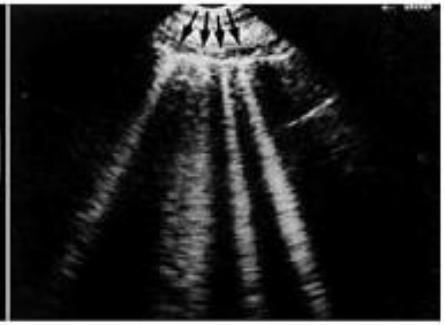




Acute pulmonary edema



Chest Computerized Tomography



Chest Ultrasound

Diffuse interstitial fibrosis

Chest Computerized Tomography

Chest Ultrasound

- Formation of images in pulmonary ultrasound
- Pulmonary ultrasound in emergencies and intensive care unit
- Pulmonary ultrasound for the detection of heart failure
- **Detection of subclinical pulmonary congestion in chronic kidney disease**
- Pathophysiology of pulmonary congestion in chronic kidney disease
- Impact of the use of pulmonary ultrasonography on morbidity and mortality in hemodialysis patients
- Comparison and Combination of Pulmonary Ultrasound with Other Methods
- Conclusions

Chest ultrasound and hidden lung congestion in peritoneal dialysis patients

Nephrol Dial Transplant (2012) 27: 3601–3605 Vincenzo Panuccio

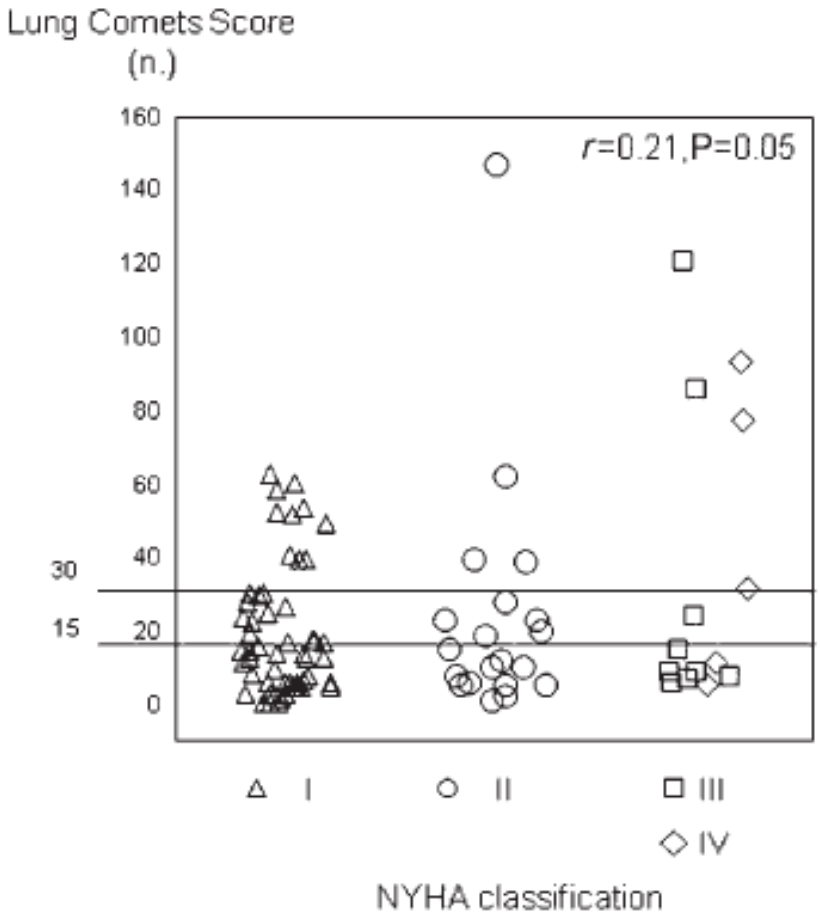
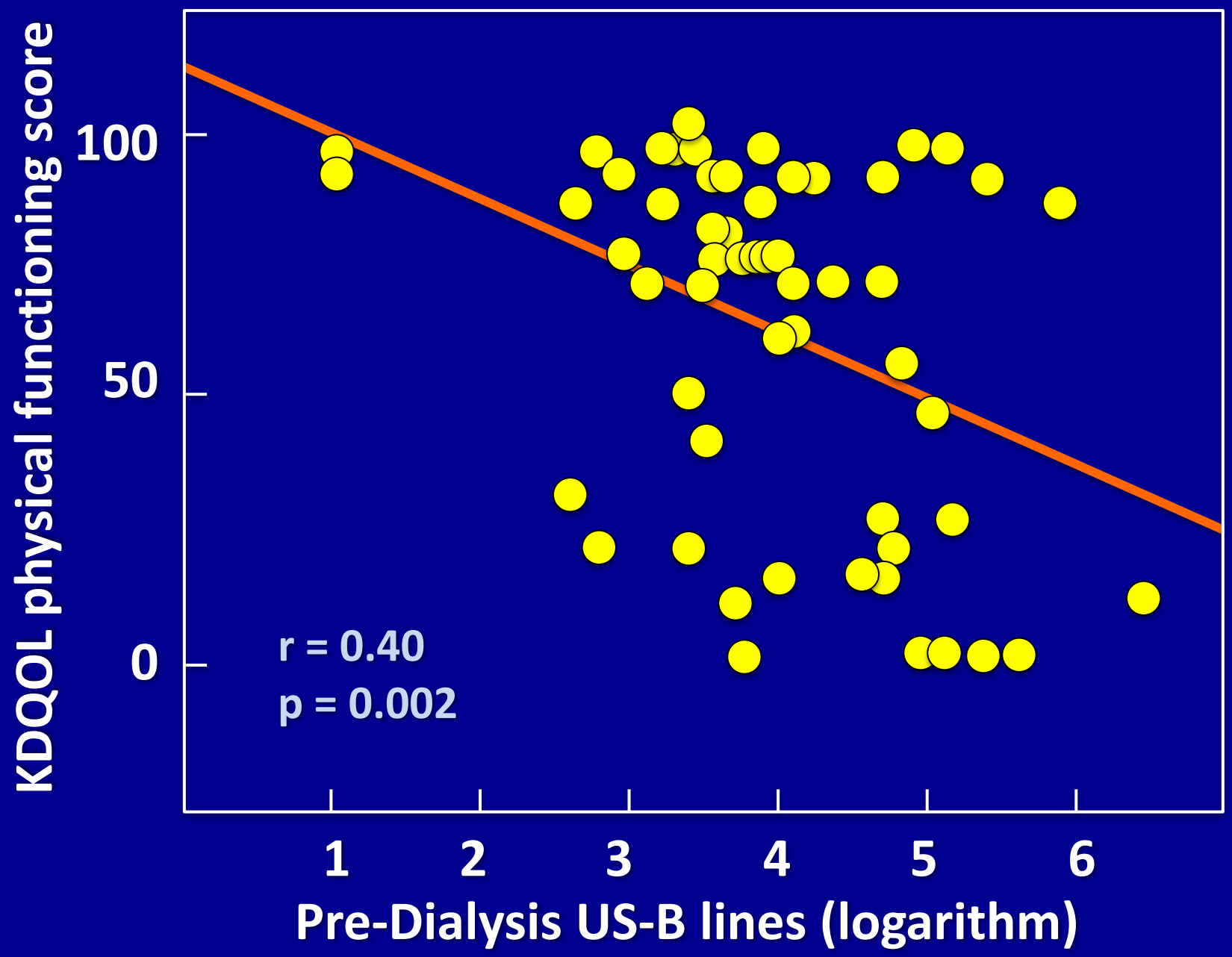


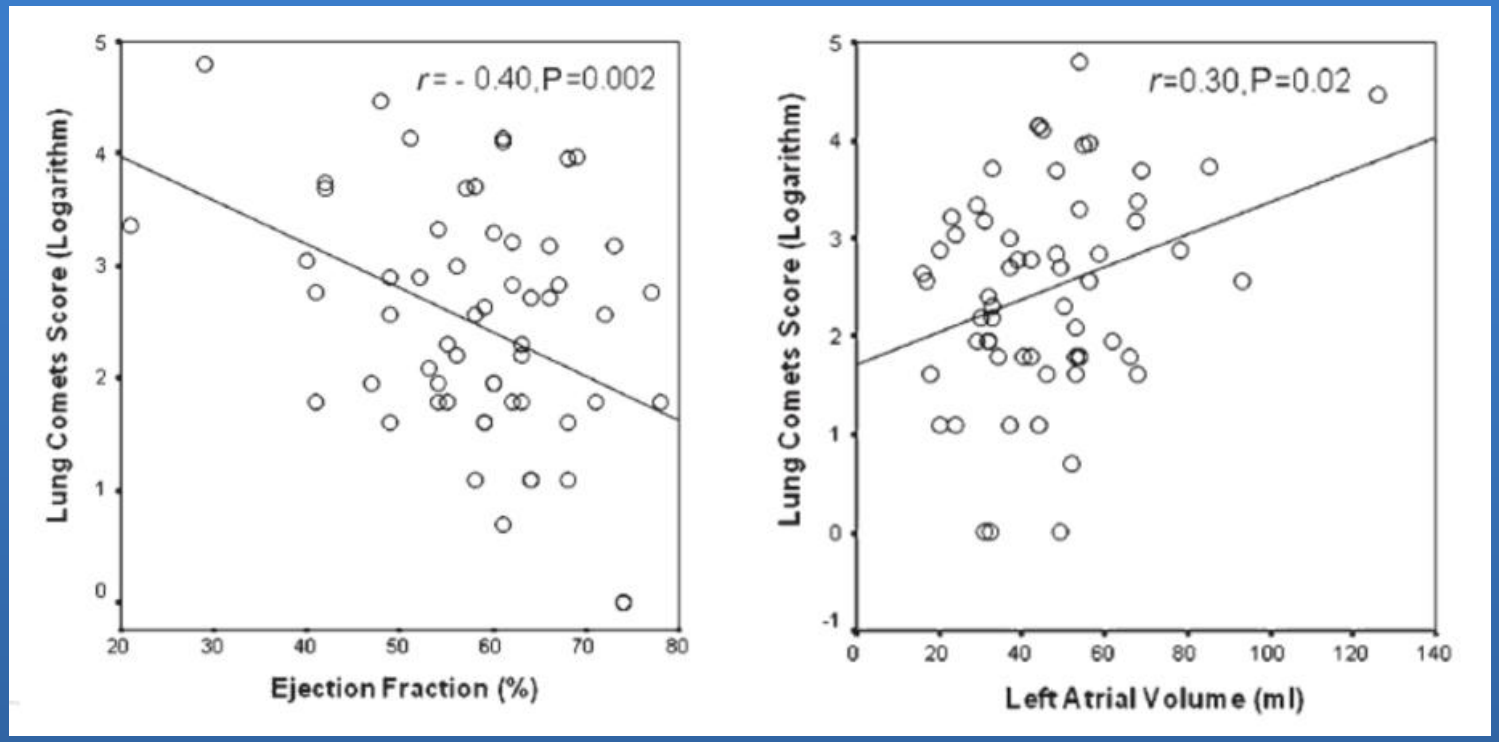
Fig. 2. Patients' distribution according to the Lung Comets Score and NYHA class.


KDQOL physical functioning score
100
50
0
r = 0.40
p = 0.002
1
2
3
4
5
6
Pre-Dialysis US-B lines (logarithm)

- Formation of images in pulmonary ultrasound
- Pulmonary ultrasound in emergencies and intensive care unit
- Pulmonary ultrasound for the detection of heart failure
- Detection of subclinical pulmonary congestion in chronic kidney disease
- **Pathophysiology of pulmonary congestion in chronic kidney disease**
- Impact of the use of pulmonary ultrasonography on morbidity and mortality in hemodialysis patients
- Comparison and Combination of Pulmonary Ultrasound with Other Methods
- Conclusions

Chest ultrasound and hidden lung congestion in peritoneal dialysis patients

Vincenzo Panuccio, Giuseppe Enia, Rocco Tripepi, Claudia Torino, Maurizio Garozzo, Giovanni Giorgio Battaglia, Carmelia Marcantoni, Lorena Infantone, Guido Giordano, Maria Loreta De Giorgi, Mario Lupia, Vincenzo Bruzzese and Carmine Zoccali



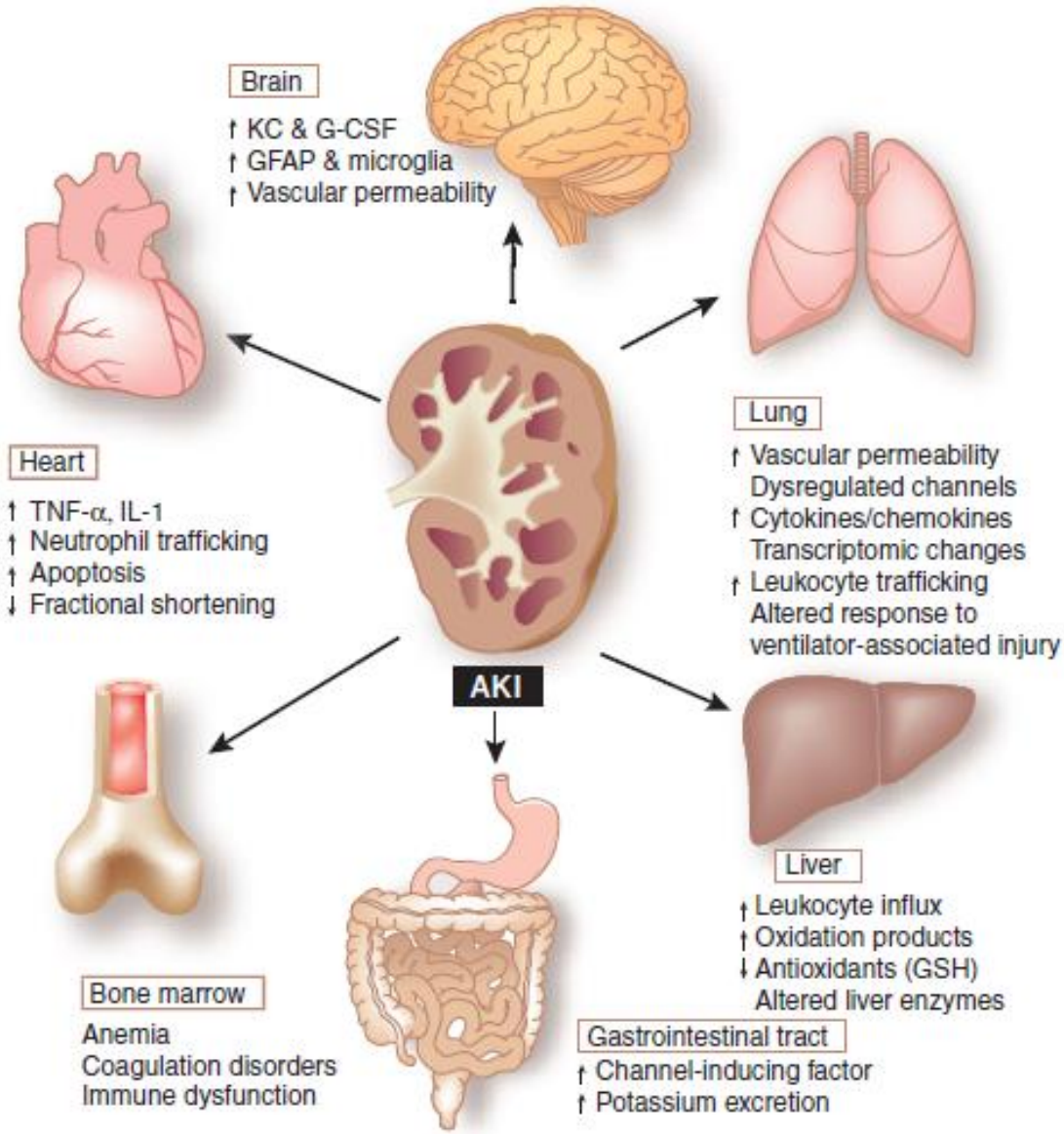
Relationship of lung comets score with ejection fraction

Relationship of lung comets score with left atrial volume

Uremic lung: new insights into a forgotten condition

Kidney International (2008) **74**, 849–851. doi:10.1038/ki.2008.390

Paul J. Scheel[1], Manchang Liu[1] and Hamid Rabb[1]



- Formation of images in pulmonary ultrasound
- Pulmonary ultrasound in emergencies and intensive care unit
- Pulmonary ultrasound for the detection of heart failure
- Detection of subclinical pulmonary congestion in chronic kidney disease
- Pathophysiology of pulmonary congestion in chronic kidney disease
- **Impact of the use of pulmonary ultrasonography on morbidity and mortality in hemodialysis patients**
- Comparison and Combination of Pulmonary Ultrasound with Other Methods
- Conclusions

Pulmonary Congestion Predicts Cardiac Events and Mortality in ESRD

Carmine Zoccali,* Claudia Torino,* Rocco Tripepi,* Giovanni Tripepi,* Graziella D'Arrigo,* Maurizio Postorino,* Luna Gargani,† Rosa Sicari,† Eugenio Picano,† and Francesca Mallamaci,* on behalf of the Lung US in CKD Working Group

J Am Soc Nephrol **24**: 639–646, 2013

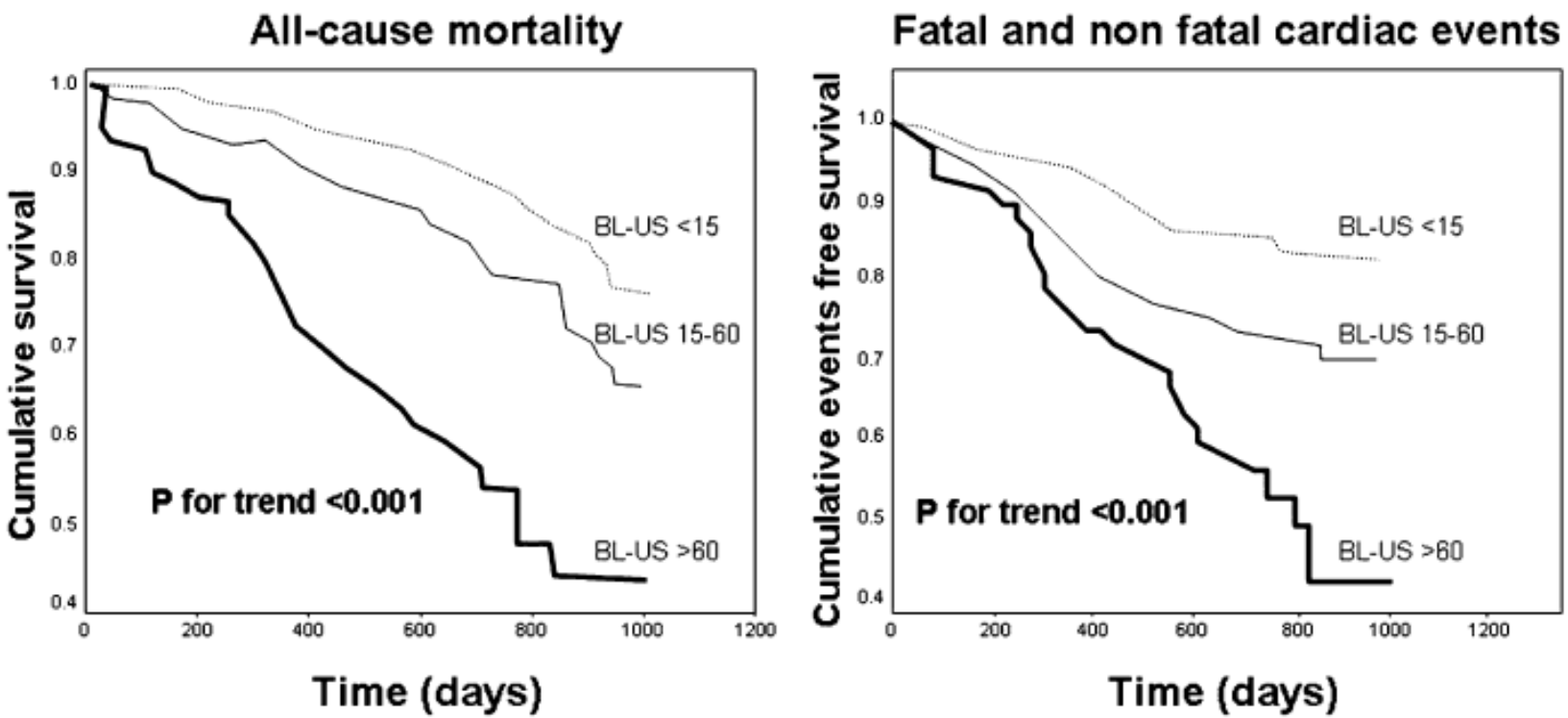
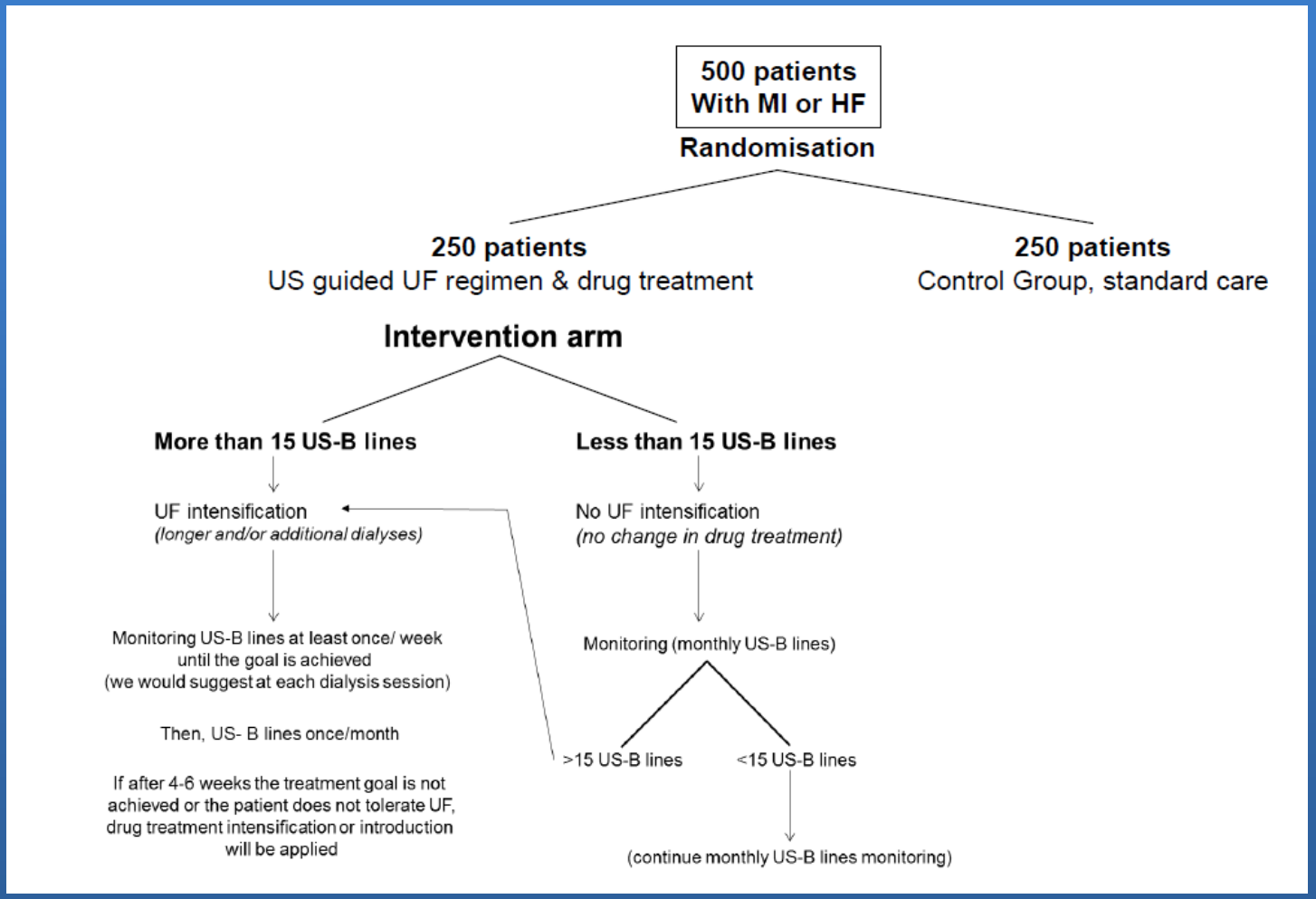


Figure 1. Kaplan–Meier survival analyses of all-cause mortality and fatal and nonfatal cardiac events according to the BL-US.

Lung Water by Ultra-sound Guided treatment to Prevent Death and Cardiovascular Complications in High risk End Stage Renal Disease (ESRD) Patients With Cardiomyopathy (LUST)



- Formation of images in pulmonary ultrasound
- Pulmonary ultrasound in emergencies and intensive care unit
- Pulmonary ultrasound for the detection of heart failure
- Detection of subclinical pulmonary congestion in chronic kidney disease
- Pathophysiology of pulmonary congestion in chronic kidney disease
- Impact of the use of pulmonary ultrasonography on morbidity and mortality in hemodialysis patients
- **Comparison and Combination of Pulmonary Ultrasound with Other Methods**
- Conclusions

The Agreement between Auscultation and Lung Ultrasound in Hemodialysis Patients: The LUST Study

Clin J Am Soc Nephrol 11: 2005–2011, 2016. doi: 10.2215/CJN.03890416

Table 2. Ultrasound B lines number across lung crackles strata of increasing severity

Crackles Category	Ultrasound B Lines No.				Total
	<5	≥5 to <15	≥15 to ≤30	>30	
0	370	388	88	60	906
1	13	35	7	6	61
2	6	26	24	37	93
3	1	3	3	4	11
4	1	14	9	11	35
Total	391	466	131	118	1106

4.1%

22.5 %

The Agreement between Auscultation and Lung Ultrasound in Hemodialysis Patients: The LUST Study

Clin J Am Soc Nephrol 11: 2005–2011, 2016. doi: 10.2215/CJN.03890416

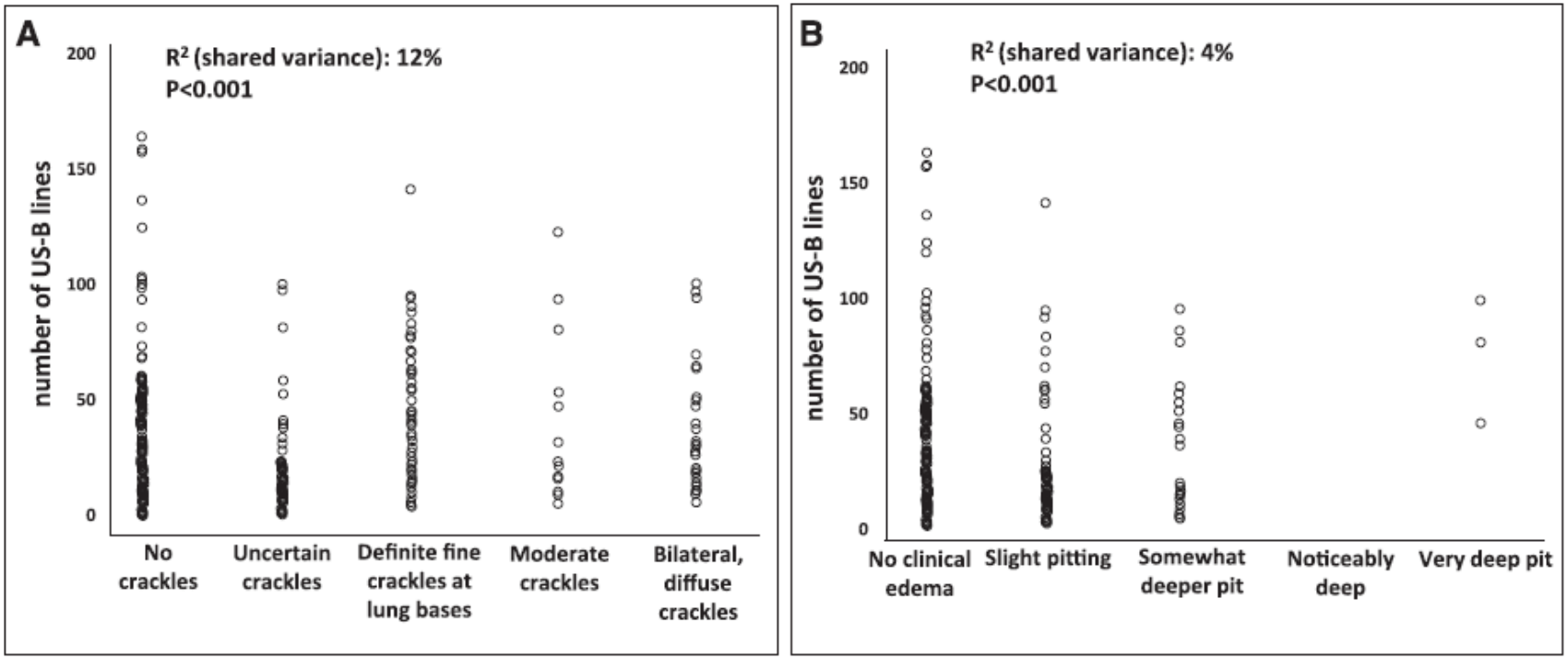


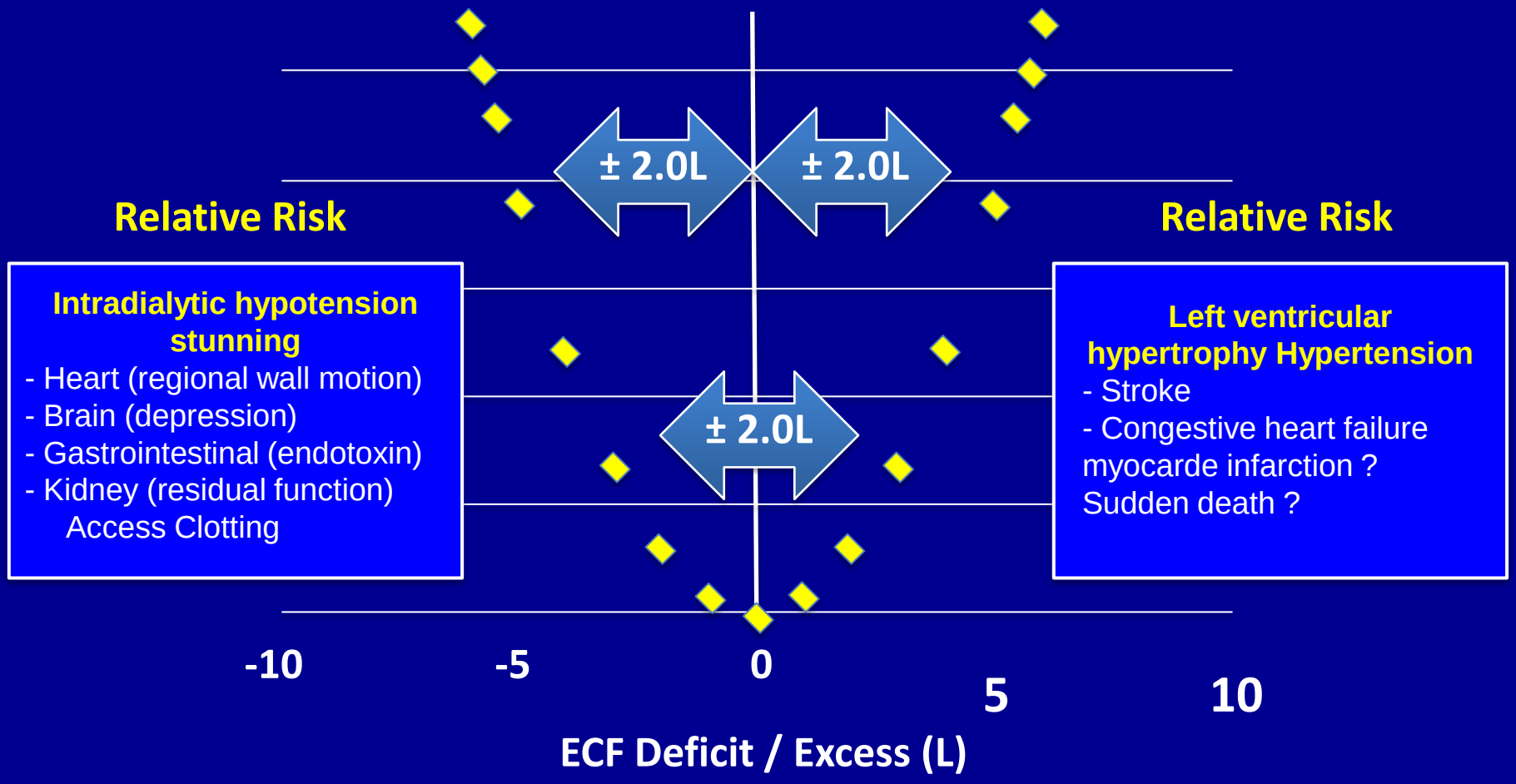
Figure 1. | Poor correlation between ultrasound (US) B lines and clinical signs of lung congestion. Correlation between the severity of lung congestion as detected by US-B lines with (A) pulmonary crackles and (B) peripheral edema.

Table 4. Diagnostic value of pulmonary crackles and peripheral edema for the diagnosis of moderate and severe lung congestion in the 1106 paired measurements (in 79 patients) of these clinical signs and simultaneous ultrasound B lines

Diagnostic Value	Pulmonary Crackles			Peripheral Edema			Crackles and Edema		
	Mild Lung Congestion	Moderate Lung Congestion	Severe Lung Congestion	Mild Lung Congestion	Moderate Lung Congestion	Severe Lung Congestion	Mild Lung Congestion	Moderate Lung Congestion	Severe Lung Congestion
Sensitivity	172/644 (27%)	27/249 (11%)	11/118 (9%)	67/644 (10%)	3/249 (1%)	3/118 (3%)	200/644 (31%)	44/249 (18%)	15/118 (13%)
False positive rate	28/462 (6%)	19/857 (2%)	24/988 (2%)	39/462 (8%)	0/857 (0%)	0/988 (0%)	54/462 (12%)	25/857 (3%)	31/988 (3%)
Specificity	434/462 (94%)	838/857 (98%)	964/988 (98%)	423/462 (92%)	857/857 (100%)	988/988 (100%)	408/462 (88%)	832/857 (97%)	957/988 (97%)
False negative rate	472/644 (73%)	222/249 (89%)	107/118 (91%)	577/644 (90%)	246/249 (99%)	115/118 (97%)	444/644 (69%)	205/249 (82%)	103/118 (87%)
Positive predictive value	172/200 (86%)	27/46 (59%)	11/35 (31%)	67/106 (63%)	3/3 (100%)	3/3 (100%)	200/254 (79%)	44/69 (64%)	15/46 (33%)
Negative predictive value	434/906 (48%)	838/1060 (79%)	964/1071 (90%)	423/1000 (42%)	857/1103 (78%)	988/1103 (90%)	408/852 (48%)	832/1037 (80%)	957/1060 (90%)
Positive likelihood ratio	4.41	4.89	3.84	1.23	—	—	2.66	6.06	4.05
Negative likelihood ratio	0.78	0.91	0.93	0.98	0.99	0.97	0.78	0.85	0.90

The positive likelihood ratio (*i.e.*, sensitivity-to-false positive rate ratio) of peripheral edema could not be calculated, because the corresponding false positive rates were zero. —, value cannot be calculated.

Biodependance Technology and Optimal Fluid Management



American Journal of Kidney Diseases 2013 61, 861-864DOI: (10.1053/j.ajkd.2013.03.004)

Overhydration, Cardiac Function and Survival in Hemodialysis Patients

Mihai Onofriescu[1☯], Dimitrie Siriopol[1☯], Luminita Voroneanu[1], Simona Hogas[1], Ionut Nistor[1], Mugurel Apetrii[1], Laura Florea[1], Gabriel Veisa[1], Irina Mititiuc[1], Mehmet Kanbay[3], Radu Sascau[2], Adrian Covic[1]*

Table 2. Survival analysis using the predefined cut-off of RFO (15%).

	All-cause mortality		Cardiovascular events	
	HR[a]	95% CI	HR[a]	95% CI
Unadjusted	2.12	1.30–3.47	2.46	1.56–3.87
Adjusted[b]	1.87	1.12–3.13	2.31	1.42–3.77

a. The group of patients with a RFO≤15% was used as reference.

b. Adjusted for: age, gender, dialysis vintage, diabetes, cardiovascular comorbidities, and hypertension.

Effect of Fluid Management Guided by Bioimpedance Spectroscopy on Cardiovascular Parameters in Hemodialysis Patients: A Randomized Controlled Trial

Ender Hur, MD,[1] Mehmet Usta, MD,[2] Huseyin Toz, MD,[1] Gulay Asci, MD,[1] Peter Wabel, PhD,[3] Serdar Kahvecioglu, MD,[4] Meral Kayikcioglu, MD,[5] Meltem Sezis Demirci, MD,[1] Mehmet Ozkahya, MD,[1] Soner Duman, MD,[1] and Ercan Ok, MD[1]

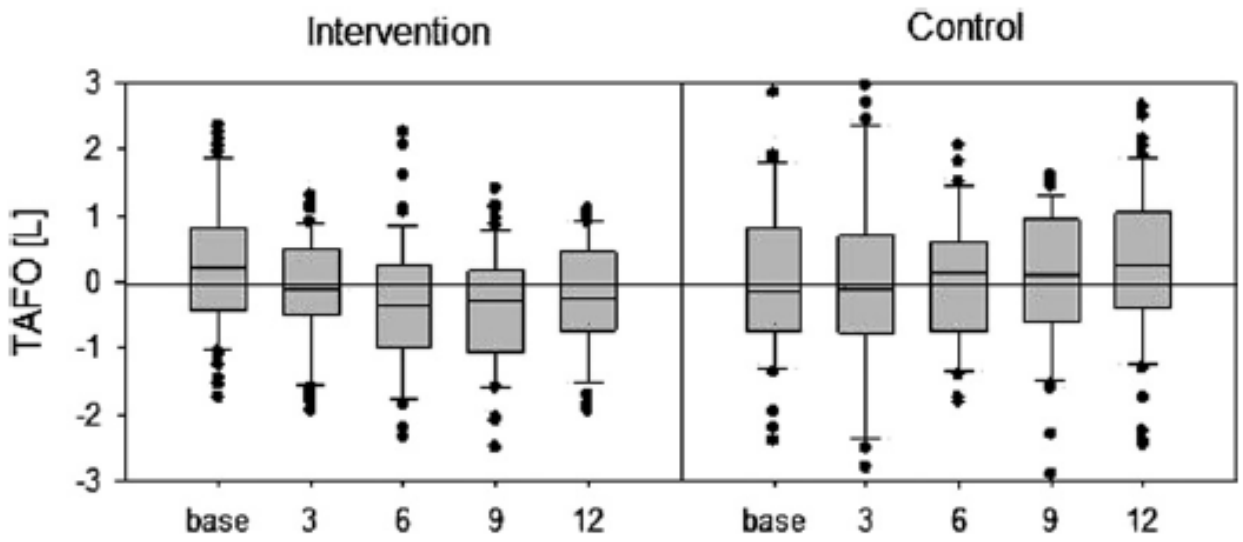
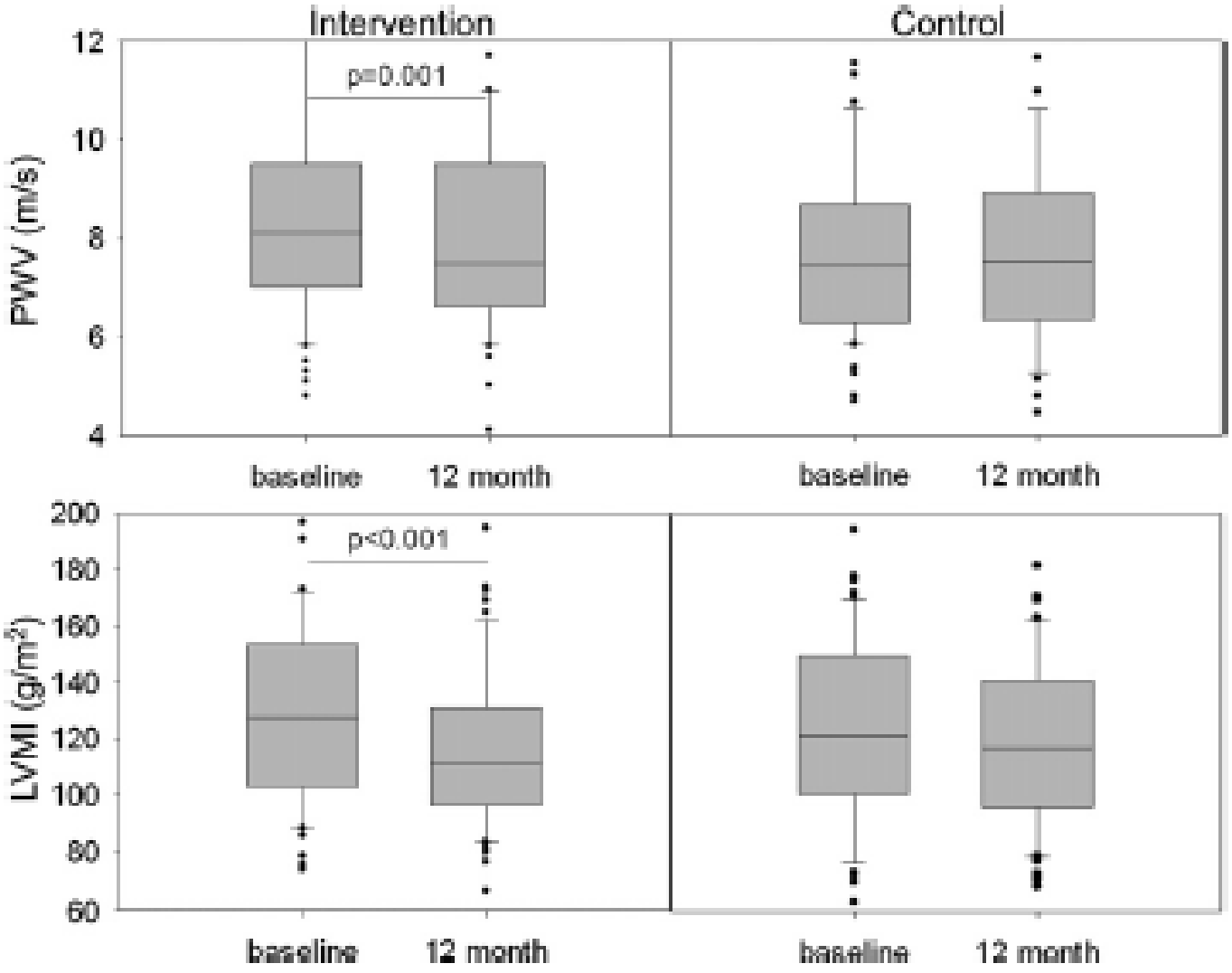


Figure 2. Changes in time-averaged fluid overload (TAFO) in the intervention and control groups over the 12-month study period ($P < 0.001$ to baseline; $P < 0.001$ to 3 month; $P = 0.04$ between 12-month measurements).

Figure 3. Intervention and control groups: changes between baseline and 12-month follow-up measurements of pulse wave velocity (PWV) and left ventricular mass index (LVMI).



Value of bioimpedance analysis estimated "dry weight" in maintenance dialysis patients: a systematic review and meta-analysis

Adrian Covic[1] · Adi-Ionut Ciumanghel[1] · Dimitrie Siriopol[1] · Mehmet Kanbay[2] · Raluca Dumea[1] · Cristina Gavrilovici[3] · Ionut Nistor[1,4]

Study or Subgroup	Bioimpedance Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Huan-Sheng 2016	1.49	1.04	148	1.64	1.4	150	34.9%	-0.15 [-0.43, 0.13]
Hur 2013	0.87	0.88	64	1.41	1.46	62	24.3%	-0.54 [-0.96, -0.12]
Luo 2011	1.72	1.51	78	2.52	1.83	82	19.0%	-0.80 [-1.32, -0.28]
Ponce 2014	2.92	1.47	101	3.36	1.75	88	21.8%	-0.44 [-0.90, 0.02]
Total (95% CI)			**391**			**382**	**100.0%**	**-0.43 [-0.71, -0.15]**

Heterogeneity: Tau² = 0.04; Chi² = 5.72, df = 3 (P = 0.13); I² = 48%
Test for overall effect: Z = 2.99 (P = 0.003)

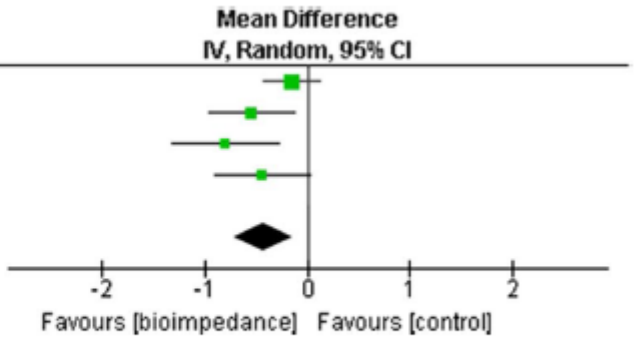


Fig. 4 Forest plot for change in overhydration (L)

Study or Subgroup	Bioimpedance Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Hur 2013	8.1	2.3	64	8.3	1.62	62	51.0%	-0.20 [-0.89, 0.49]
Onofriescu 2014	6.68	1.89	62	8.88	3.23	69	49.0%	-2.20 [-3.10, -1.30]
Total (95% CI)			**126**			**131**	**100.0%**	**-1.18 [-3.14, 0.78]**

Heterogeneity: Tau² = 1.83; Chi² = 11.98, df = 1 (P = 0.0005); I² = 92%
Test for overall effect: Z = 1.18 (P = 0.24)

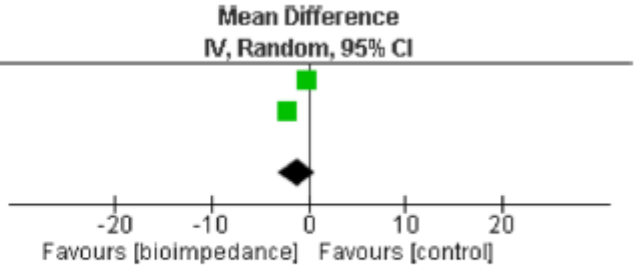


Fig. 7 Forest plot the effect on arterial stiffness (pulse wave velocity in m/s)

Study or Subgroup	Bioimpedance Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Darlan 2010	135	19.4	34	141	23.3	36	5.1%	-6.00 [-16.02, 4.02]
Huan-Sheng 2016	136	23	148	136	22	150	19.7%	0.00 [-5.11, 5.11]
Hur 2013	120	19	64	125	19	62	11.7%	-5.00 [-11.64, 1.64]
Luo 2011	132.9	19.47	78	139.07	22.4	82	12.2%	-6.17 [-12.66, 0.32]
Onofriescu 2014	138.9	14.7	62	140.5	11.4	69	25.0%	-1.60 [-6.14, 2.94]
Ponce 2014	134.6	27.3	101	136.5	24.7	88	9.4%	-1.90 [-9.31, 5.51]
Tan 2016	130	21	39	135	18.4	36	6.5%	-5.00 [-13.92, 3.92]
Tan 2016	136	20	40	140	20	54	7.7%	-4.00 [-12.18, 4.18]
Tan 2016	128	26	29	123	27	25	2.6%	5.00 [-9.20, 19.20]
Total (95% CI)			**595**			**602**	**100.0%**	**-2.73 [-5.00, -0.46]**

Heterogeneity: Tau² = 0.00; Chi² = 4.80, df = 8 (P = 0.78); I² = 0%
Test for overall effect: Z = 2.36 (P = 0.02)

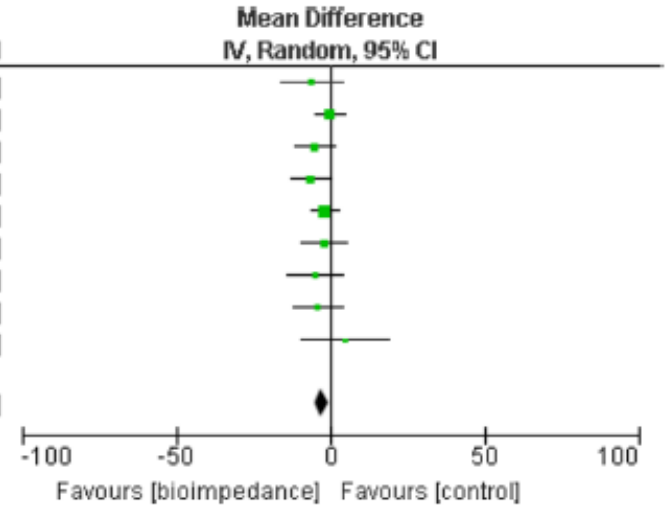


Fig. 6 Forest plot for systolic blood pressure control

Study or Subgroup	[Bioimpedance] Events	Total	[Control] Events	Total	Weight	Risk Ratio M-H, Random, 95% CI
Darlan 2010	1	34	2	36	4.0%	0.53 [0.05, 5.57]
Huan-Sheng 2016	6	148	7	150	19.5%	0.87 [0.30, 2.52]
Hur 2013	2	78	4	78	8.0%	0.50 [0.09, 2.65]
Onofriescu 2014	1	62	8	69	5.3%	0.14 [0.02, 1.08]
Ponce 2014	12	101	8	88	30.8%	1.31 [0.56, 3.05]
Tan 2016	10	149	11	159	32.4%	0.97 [0.42, 2.22]
Total (95% CI)		**572**		**580**	**100.0%**	**0.87 [0.54, 1.39]**
Total events	32		40			

Heterogeneity: Tau² = 0.00; Chi² = 4.75, df = 5 (P = 0.45); I² = 0%
Test for overall effect: Z = 0.58 (P = 0.56)

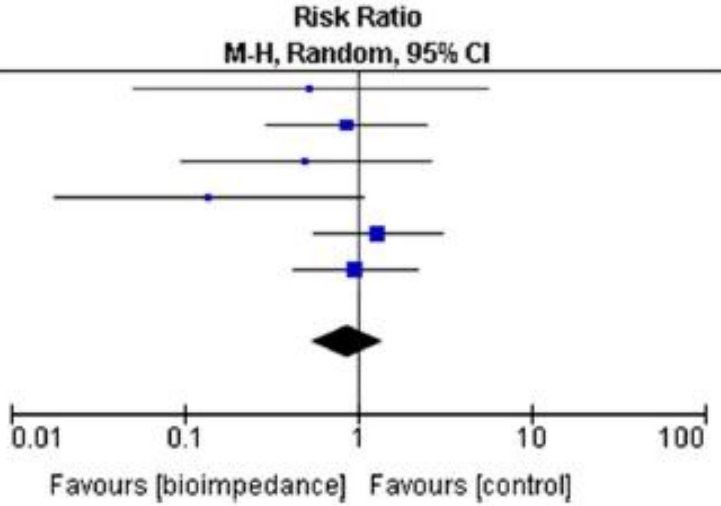


Fig. 3 Forest plot for all-cause mortality

Bioimpedance analysis versus lung ultrasonography for optimal risk prediction in hemodialysis patients

Dimitrie Siriopol[1,2] · Luminita Voroneanu[1,2] · Simona Hogas[1,2] · Mugurel Apetrii[1,2] · Angelica Gramaticu[1,2] · Raluca Dumea[1,2] · Alexandru Burlacu[1,3] · Radu Sascau[1,3] · Mehmet Kanbay[4] · Adrian Covic[1,2]

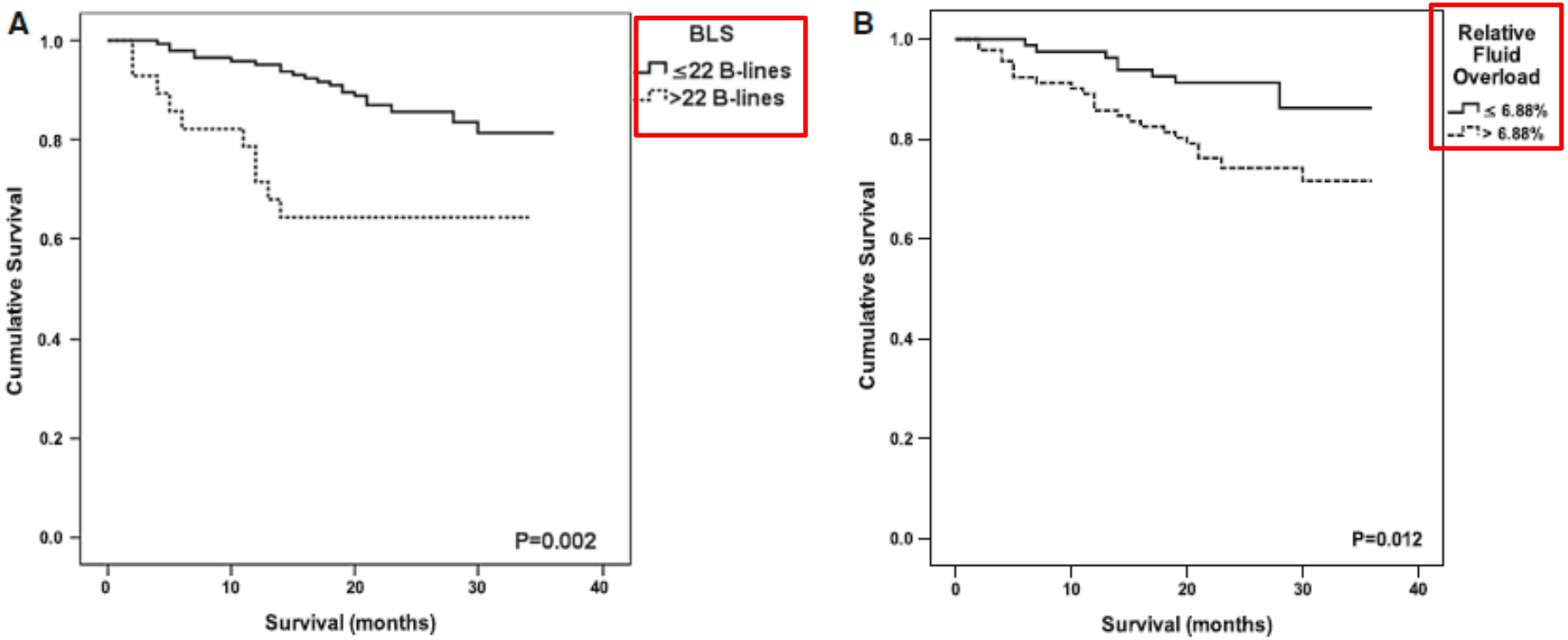


Fig. 1 Kaplan–Meier analysis for all-cause mortality according to B-lines score (**a**) and relative fluid overload (**b**) cut-offs

Table 5 Lung congestion and relative fluid overload association with all-cause mortality

	ULC		RFO	
	HR[a]	95 % CI	HR[b]	95 % CI
Unadjusted	3.08	1.45–6.54	2.68	1.20–6.03
Adjusted	2.72	1.19–6.16	2.93	1.30–6.58

Adjusted for: severity of NYHA class (0—NYHA class 1, 2; 1—NYHA class 3, 4), diabetes, hs-CRP, and left ventricular mass index

[a] The group with ≤22 ULC was used as reference

[b] The group with ≤6.88 RFO was used as reference

Table 6 Performance of the models

	Model 1	Model 2	Model 3
Discrimination[a]			
ΔC statistics, 95 % CI	Reference	0.017 (−0.060–0.094)	0.058 (0.003–0.114)
Calibration			
AIC	299.69	299.53	293.88
BIC	305.42	306.71	301.05
H–L	$\chi^2 = 8.25$	$\chi^2 = 13.91$	$\chi^2 = 13.61$
	$p = 0.41$	$p = 0.08$	$p = 0.09$
Reclasification[a]			
IDI, 95 % CI	Reference	0.036 (−0.005–0.141)	0.036 (0.000–0.096)
NRI, 95 % CI	Reference	0.125 (−0.188–0.350)	0.248 (0.021–0.112)

C statistic with only conventional predictors was 0.728

Model 1—severity of NYHA class, diabetes, hs-CRP, and left ventricular mass index

Model 2—Model 1 + LogULC score

Model 3—Model 1 + RFO

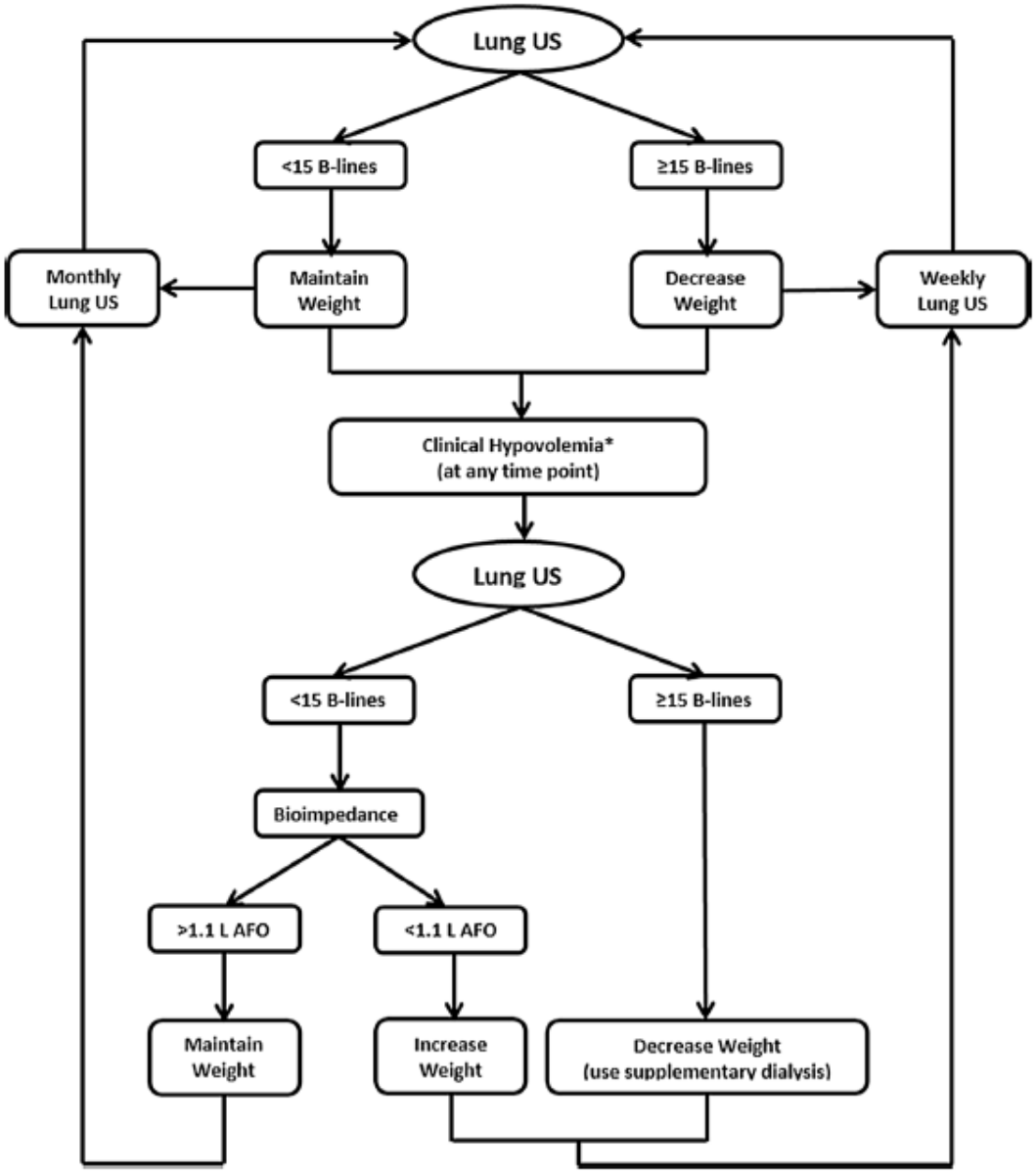
[a] Comparison with model 1

- Formation of images in pulmonary ultrasound
- Pulmonary ultrasound in emergencies and intensive care unit
- Pulmonary ultrasound for the detection of heart failure
- Detection of subclinical pulmonary congestion in chronic kidney disease
- Pathophysiology of pulmonary congestion in chronic kidney disease
- Impact of the use of pulmonary ultrasonography on morbidity and mortality in hemodialysis patients
- Comparison and **Combination of Pulmonary Ultrasound with Other Methods**
- **Conclusions**

Dry weight assessment by combined ultrasound and bioimpedance monitoring in low cardiovascular risk hemodialysis patients: a randomized controlled trial

Int Urol Nephrol (2017) 49:143–153

Dimitrie Siriopol[1]



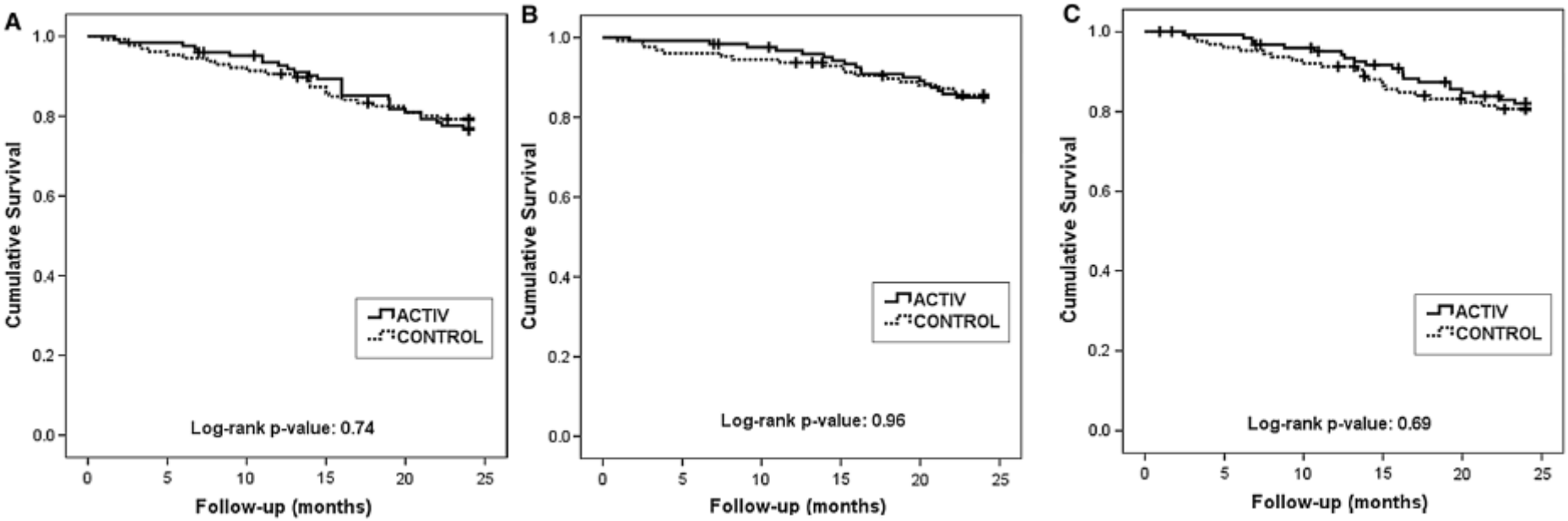


Fig. 3 Kaplan–Meier curves comparing the two groups for the time to the first primary composite outcome (Panel **a**), all-cause mortality (Panel **b**), and cardiovascular events (Panel **c**)

Table 4 Secondary outcome data for the entire cohort

	Control group ($N = 127$) (236.3 Patient-years at risk)		Active group ($N = 123$) (232.3 Patient-years at risk)		Rate ratio (95% CI)
	No. of events	No. of events/100 patient-years	No. of events	No. of events/100 patient-years	
Intradialytic hypotension	1035	438.1	1104	475.3	1.08 (0.99–1.18)
Intradialytic cramps	1056	446.9	1313	565.2	1.26 (1.16–1.37)
Pre-dialytic dyspnea	302	127.8	240	103.3	0.81 (0.68–0.96)
Hospitalizations	89	37.7	103	44.3	1.18 (0.88–1.58)
Vascular access thrombosis	13	5.5	20	8.6	1.56 (0.74–3.42)

Table 5 Biomarker levels and arterial stiffness outcomes

	Length of follow-up			p^*	$p^\dagger$
	Baseline	12 months	24 months		
NT-proBNP (pg/ml)					
Control	8722.2 (6478.5–10,965.8)	9123.6 (6387.6–11,859.6)	12,186.4 (9256.6–15,115.6)	0.09	0.72
Active	8896.3 (6944.8–10,847.8)	9428.4 (6642.8–12,213.9)	10,728.6 (7775.4–13,680.7)		
$p^\ddagger$	–	0.88	0.49		
Hs-cTnT (ng/l)					
Control	42.9 (37.9–47.8)	45.4 (40.1–50.7)	44.6 (38.9–50.2)	0.14	0.65
Active	44.0 (38.7–49.3)	49.4 (43.9–54.7)	45.0 (39.4–50.7)		
$p^\ddagger$	–	0.30	0.91		
PWV (m/s)					
Control	10.3 (9.8–10.9)	11.0 (10.0–12.1)	12.3 (11.1–13.6)	<0.001	0.32
Active	9.7 (9.1–10.4)	11.5 (10.8–12.3)	12.6 (11.7–13.5)		
$p^\ddagger$	–	0.45	0.77		

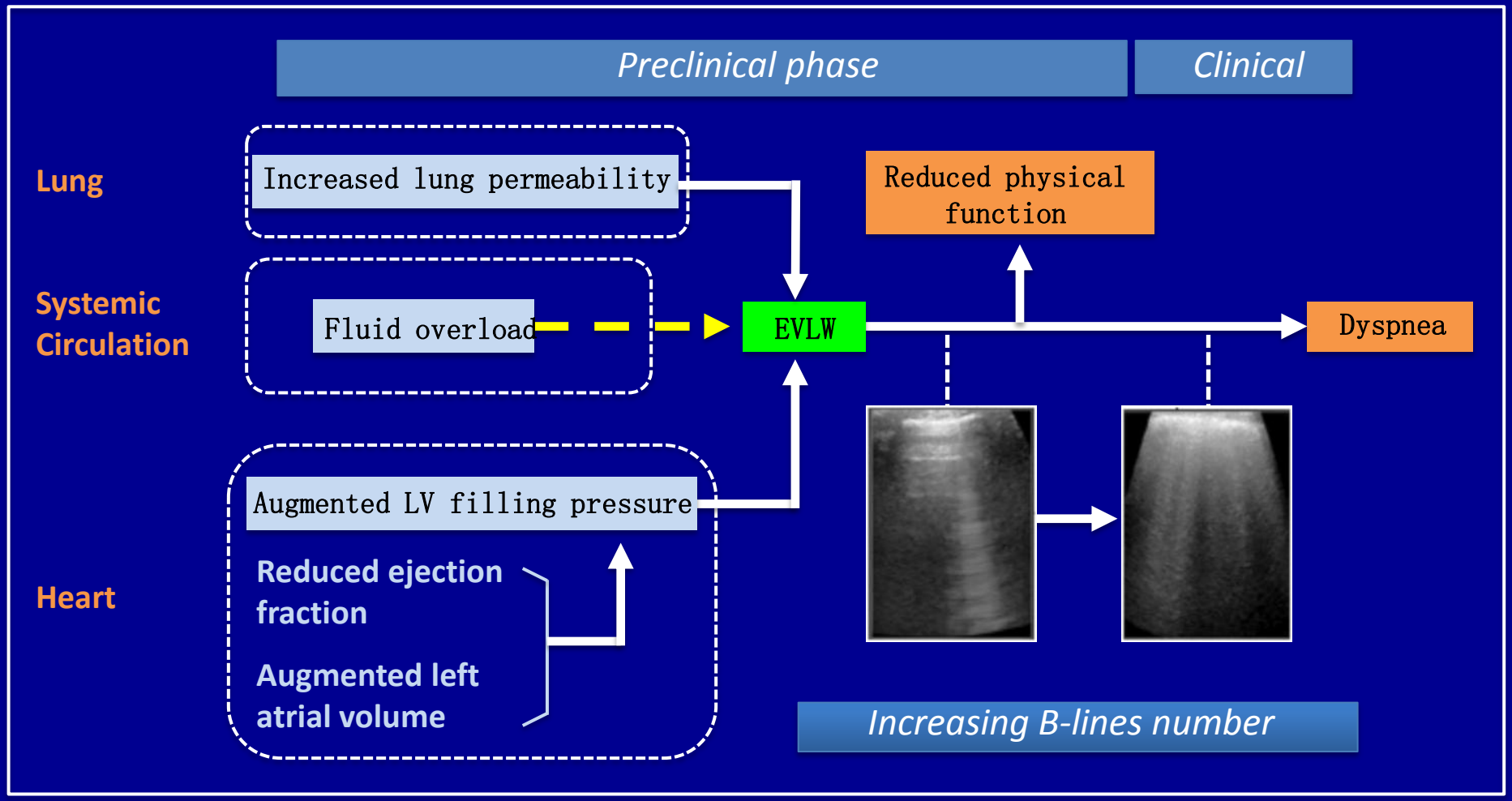
- Formation of images in pulmonary ultrasound
- Pulmonary ultrasound in emergencies and intensive care unit
- Pulmonary ultrasound for the detection of heart failure
- Detection of subclinical pulmonary congestion in chronic kidney disease
- Pathophysiology of pulmonary congestion in chronic kidney disease
- Impact of the use of pulmonary ultrasonography on morbidity and mortality in hemodialysis patients
- Comparison and Combination of Pulmonary Ultrasound with Other Methods
- **Conclusions**

Lung Ultrasound in Hemodialysis : A Card to be Played

Pierpaopolo Di Nicolo[a], Giace Magnoni[b], Antonio Granata[c]

Nephrology and Dialysis Unit, [a]S. Maria Delle Scaletta, Hospital Imola,

[b]Sondrio Civil Hospital Sondrio and [c]S. Giovanni di Dio Hospital Agrigento, Italy



Detection of Pulmonary Congestion by Chest Ultrasound in Dialysis Patients

Francesca Mallamaci, MD,*† Francesco A. Benedetto, MD,‡ Rocco Tripepi,† Stefania Rastelli, MD,§ Pietro Castellino, MD Prof.,§ Giovanni Tripepi, Stat. Dr.,† Eugenio Picano, MD Prof.,‖ Carmine Zoccali, MD Prof.*†

Reggio Calabria, Catania, and Pisa, Italy

JACC: CARDIOVASCULAR IMAGING, VOL. 3, NO. 6, 2010
JUNE 2010:586–94

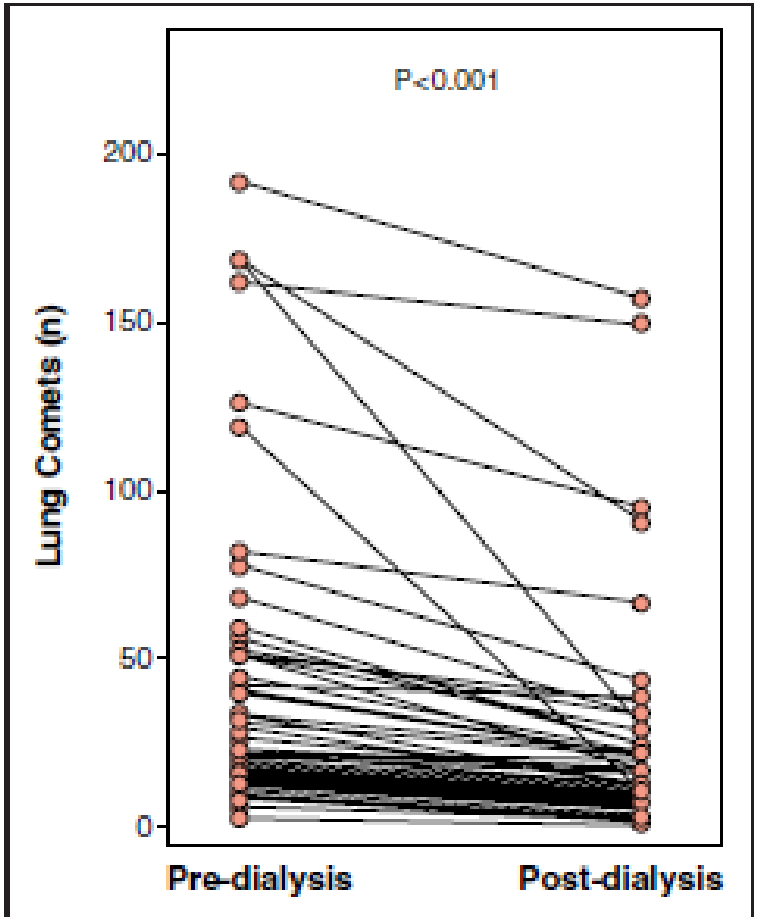


Figure 2. Individuals Pre- and Post-Dialysis Lung Comets Score

Among patients, comparison was made by using the Wilcoxon signed ranks test (see the Statistical Analysis section for details).