Gruppo di Ricerca Ecografia Toracica nell'Anziano (GRETA)

CORSO TEORICO-PRATICO DI ECOGRAFIA TORACICA NELL'ANZIANO

Ecografia diaframmatica ed eco muscolare: un complemento all'ecografia toracica

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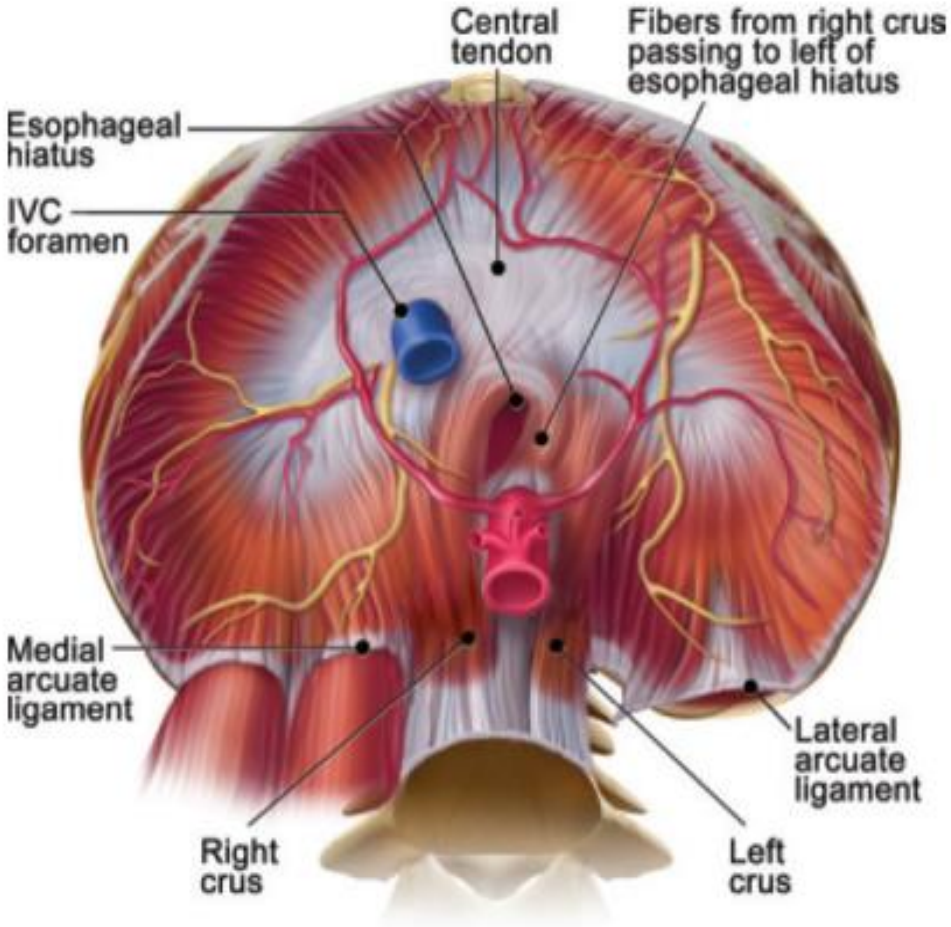
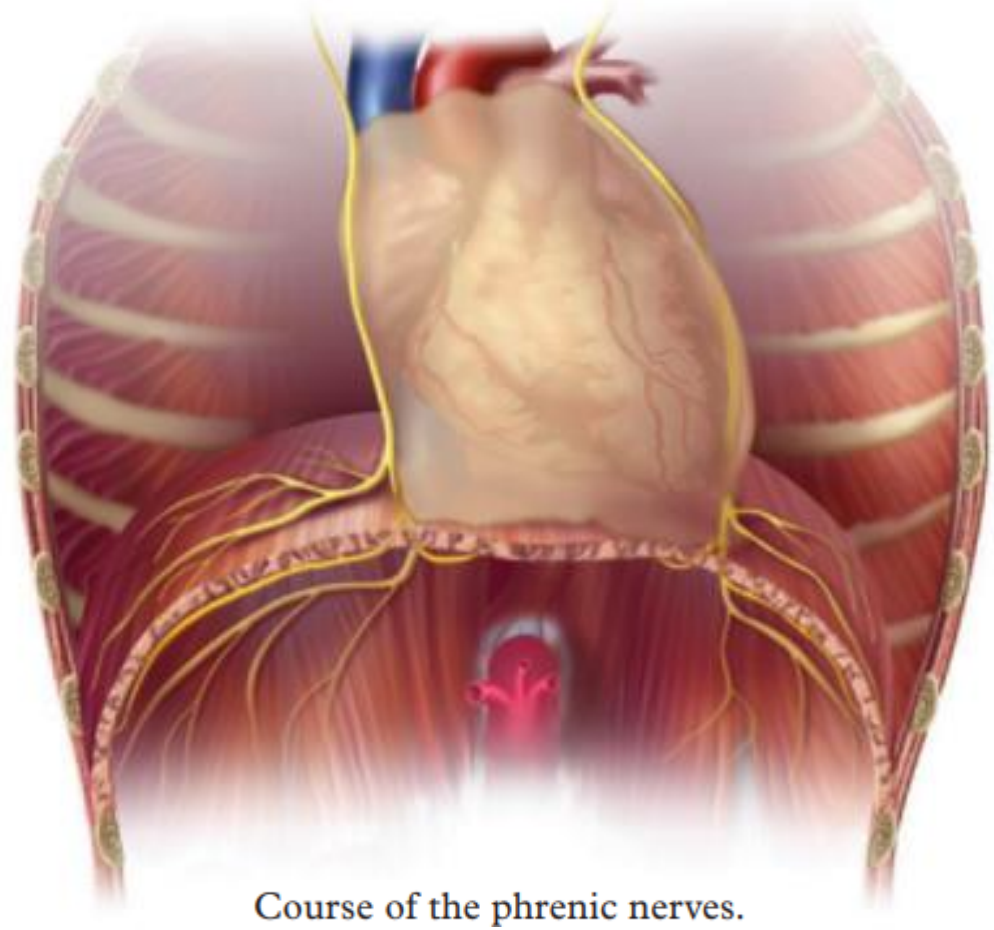
SOCIETÀ ITALIANA DI GERONTOLOGIA E GERIATRIA

Imaging of the Diaphragm: Anatomy and Function[1]





Course of the phrenic nerves.

Diaphragmatic dysfunction

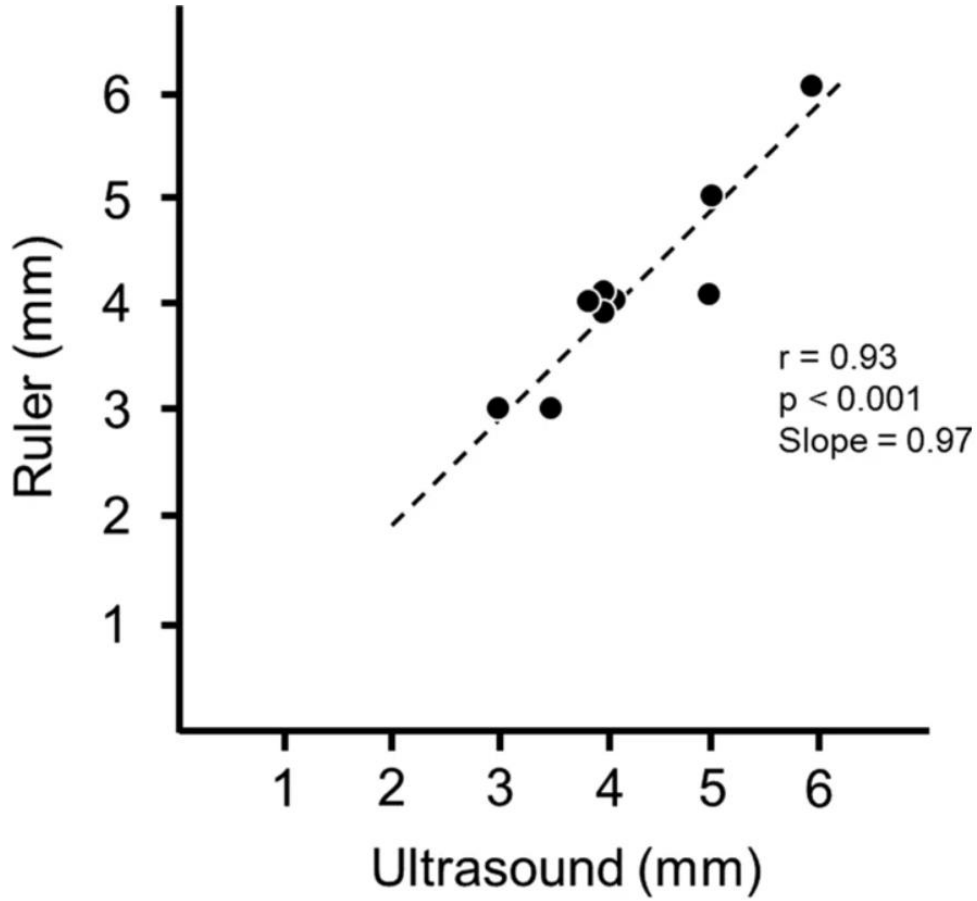
Paralysis and Weakness

Eventration

Eventration is a congenital thinning of the diaphragmatic muscle that causes a focal bulge.

Location of the lesion	Disease	Comment
Phrenic	Trauma[30] Compression/infiltration (mediastinal neoplasms) Guillain-Barré[31] Infection (Herpes-Zoster virus, pneumonias,[32] Lyme disease,[33] HIV infection[34]) Amyotrophic neuralgia (Parsonage-Turner)[35] Thoracic surgeries[36] Others [malnutrition,[37] diabetes,[38] hypothyroidism,[23] benign thyroid hypertrophy,[39] porphyria, vasculitis, Charcot-Marie-Toot[41] disease] Idiopathic[46]	Guillain-Barré disease is the most frequent cause of acute respiratory muscle paralysis. More than 25% of patients will need non-invasive ventilation. Infection with Herpes-Zoster virus produces diaphragmatic paralysis if it affects the cervical territory and is usually ipsilateral and usually permanent. Amyotrophic neuralgia presents pain and flaccid paralysis of the shoulder muscles. It is associated with both uni and bilateral diaphragmatic involvement. In idiopathic causes the paralysis can be unilateral or bilateral.
Lung	Asthma and chronic obstructive pulmonary disease	The existing pulmonary hyperinflation can deteriorate the diaphragmatic function since the diaphragm does not have an optimal length for its normal functioning.[1]
Neuromuscular junction	Myasthenia gravis, botulism,[40] Lambert-Eaton syndrome[20]	During an acute myasthenic crisis there may be acute respiratory failure that will require invasive ventilation.
Muscular	Muscular dystrophies, steroid myopathy,[42] Pompe disease,[43] myositis, mechanical ventilation[45]	In the presence of a diaphragmatic paralysis, acid alfa-glucosidase enzyme levels should be determined to discard late-onset Pompe disease (16.7%) prevalence).[44] Mechanical ventilation, both invasive and non-invasive, can produce atrophy of the diaphragm due to disuse.

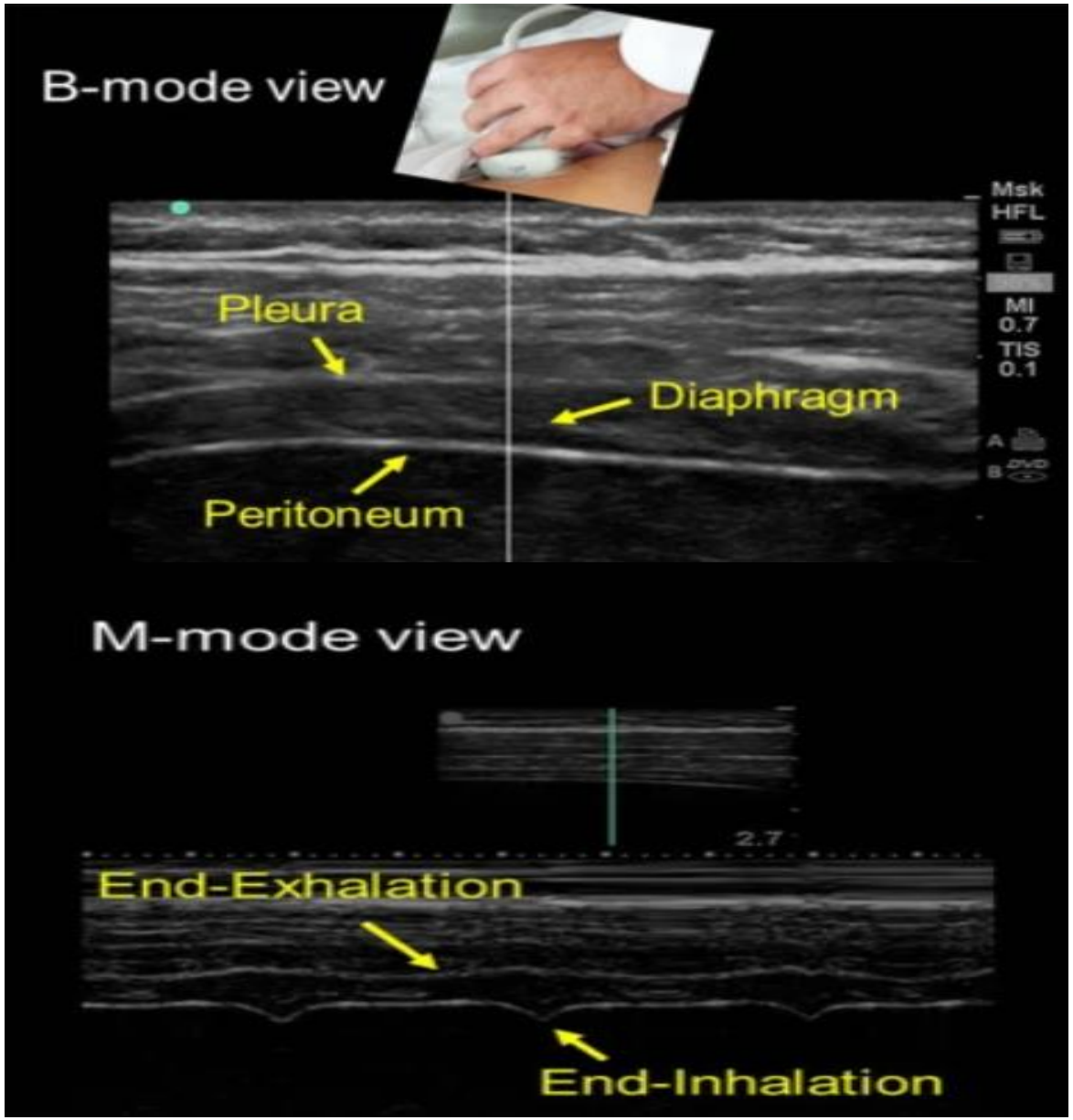
Ultrasound measurement of diaphragm thickness (zone of apposition)



Relationship of diaphragm thickness measured in situ in 10 human cadavers by ultrasound and in vitro by a ruler. Ultrasound measurements of diaphragm thickness in situ are as accurate as measurements in vitro with a ruler.

Ultrasound measurement of diaphragm thickness (zone of apposition)

- Operators use linear ultrasound probes to measure diaphragm thickness. These probes use high frequency ultrasound waves (7–18 Hz) to create high resolution images of structures near the body surface .
- To measure diaphragm thickness, operators place the ultrasound probe longitudinally parallel to the long axis of the body, usually between the eighth to tenth intercostal space, at the anterior axillary line or midway between the anterior- and mid-axillary lines.
- The costo-phrenic sinus is identified as the transition between lung and liver (right) or between lung and spleen (left).
- The zone of apposition, where the diaphragm is opposed to the rib cage, is located caudal to the costo-phrenic sinus.
- To identify the diaphragm, subjects are asked to inhale while operators select B-mode imaging.
- The diaphragm is identified as a three-layer structure (two echogenic layers of peritoneum and pleura sandwiching a more hypoechoic layer of the muscle itself) underneath the intercostal muscles that reappear as lung artifact recedes



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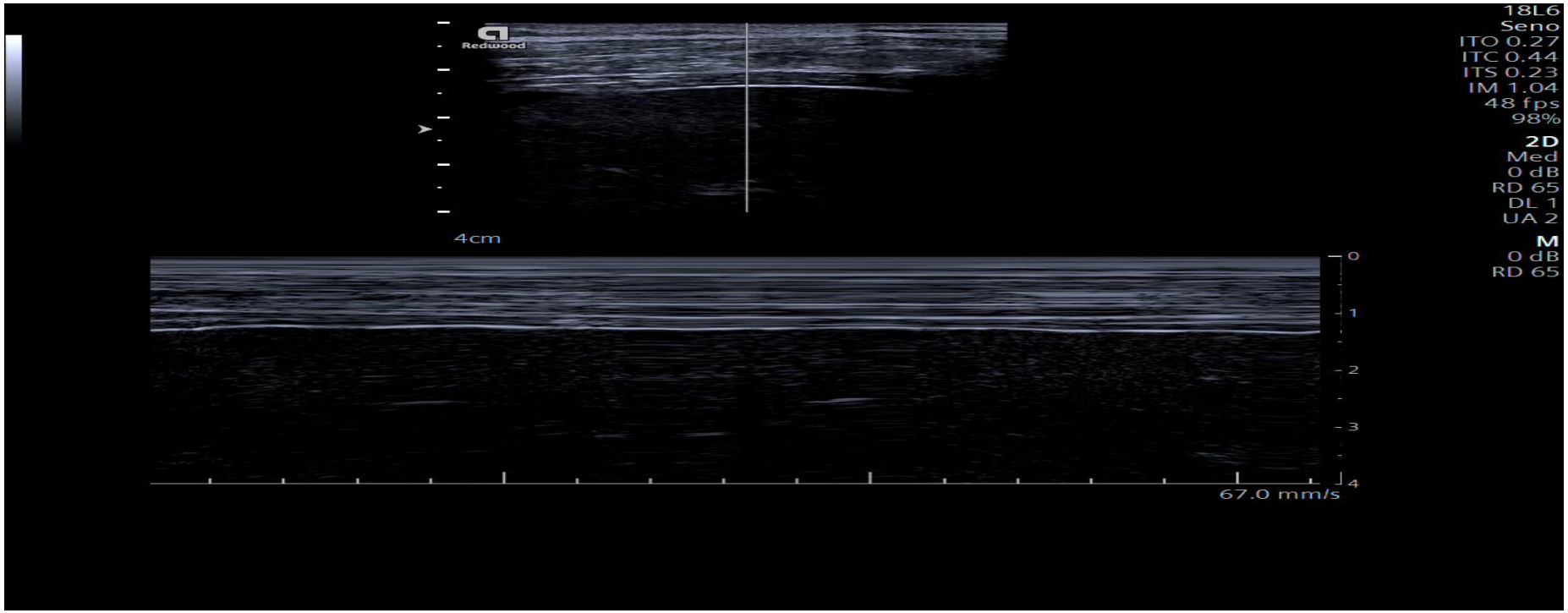

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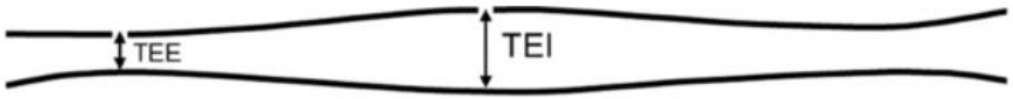
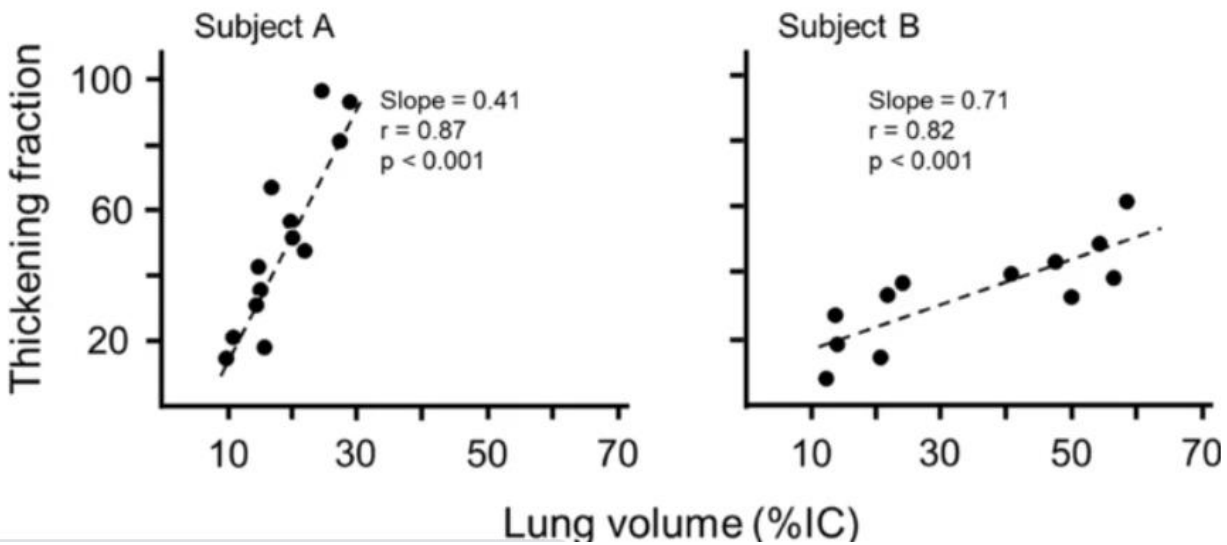
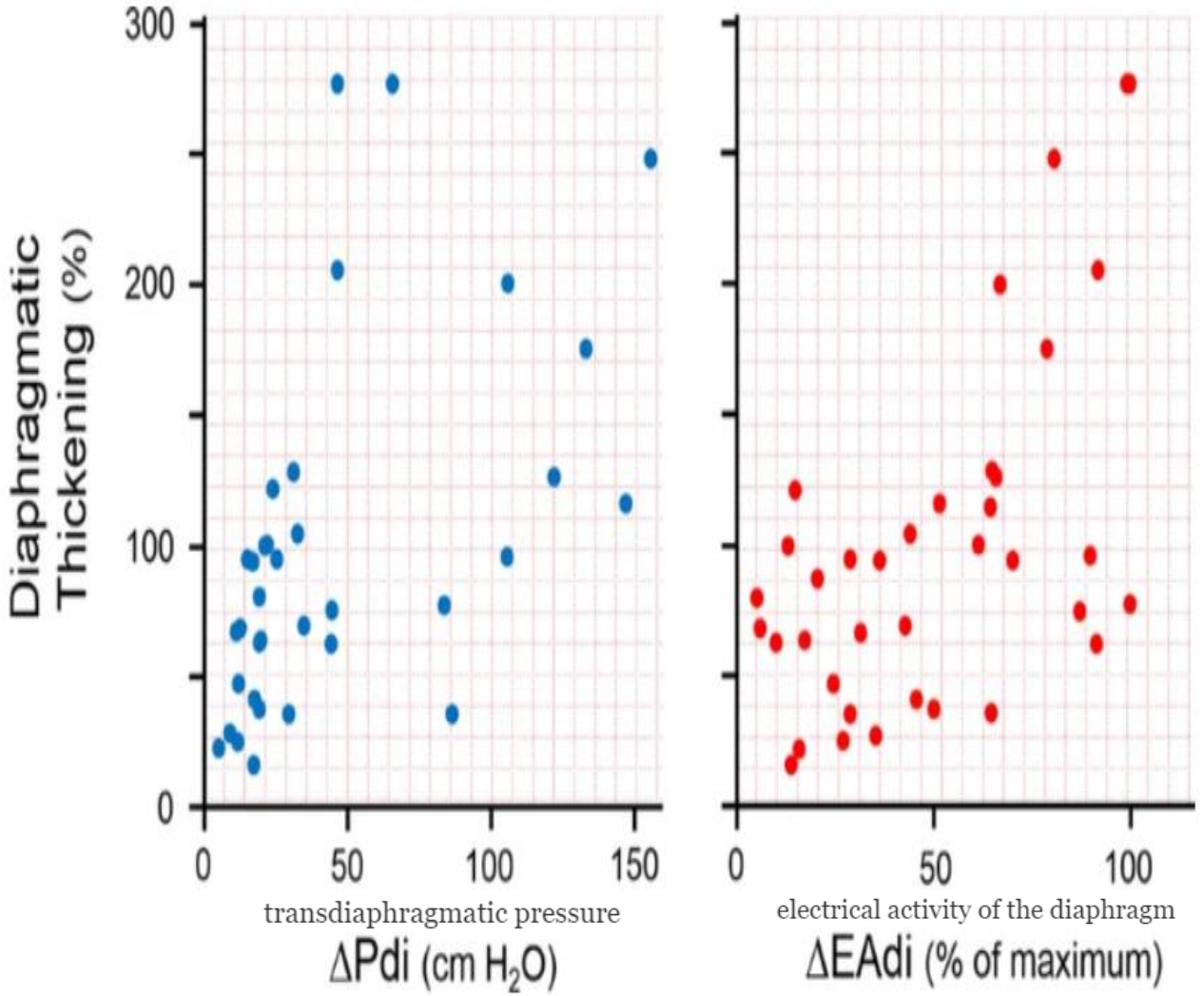
Ultrasound estimation of diaphragm strength and recruitment (zone of apposition)



TEI = Thickness end inhalation
TEE = Thickness end exhalation

$$TF = \frac{(TEI - TEE)}{TEE} \times 100$$





(r^2 = 0.32 and 0.28, respectively, $p < 0.01$).

The course of diaphragm atrophy in ventilated patients assessed with ultrasound: a longitudinal cohort study

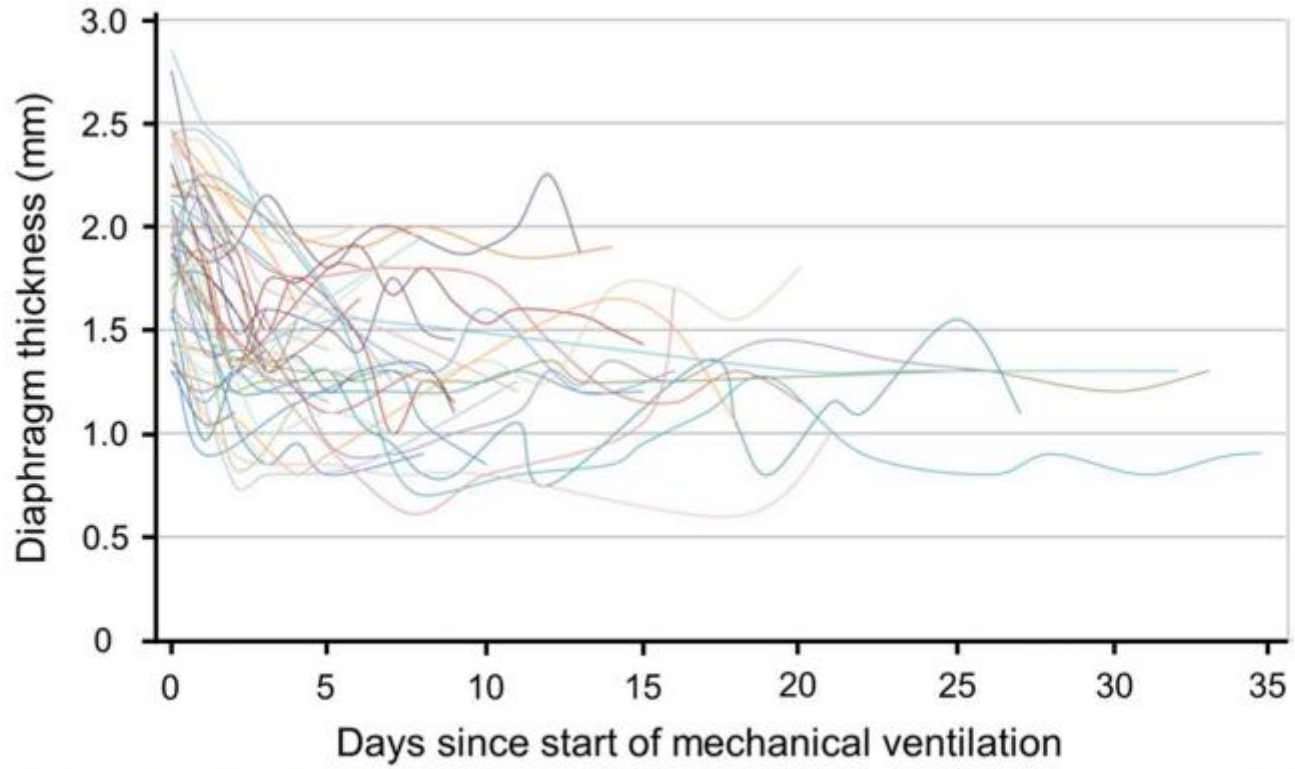


Fig. 15 Ultrasound measurements of diaphragm thickness in critically ill patients requiring mechanical ventilation. Raw values of diaphragm thickness for each day of mechanical ventilation. Lines use a Bézier curve construction (see text for details). Reproduced under Open Access Creative Commons License: Schepens et al. Crit Care 2015;19(1):422

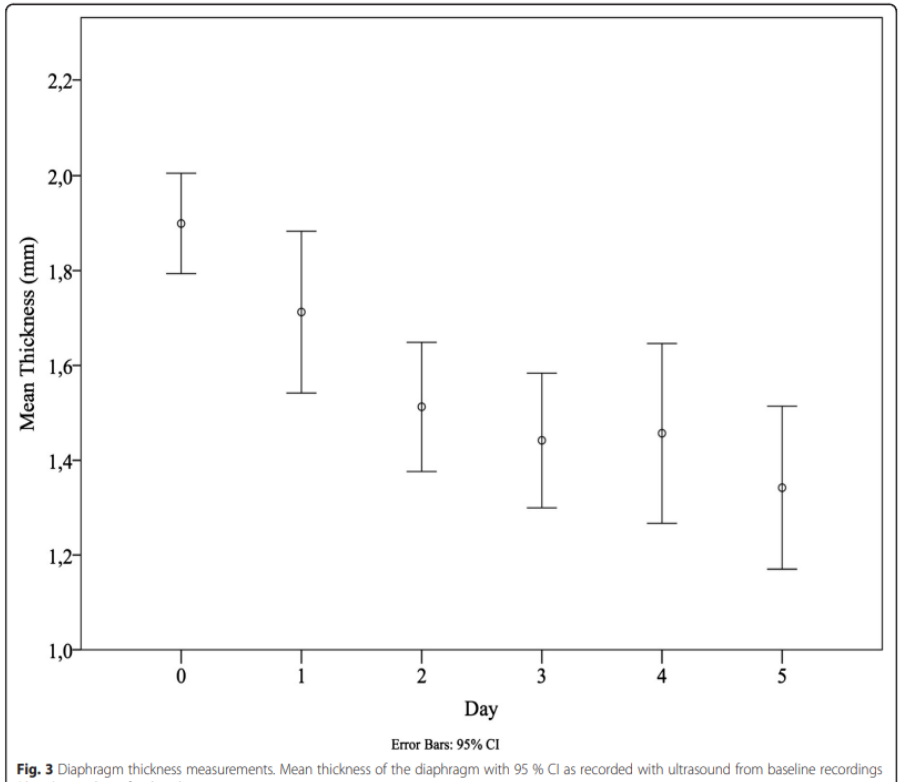


Fig. 3 Diaphragm thickness measurements. Mean thickness of the diaphragm with 95 % CI as recorded with ultrasound from baseline recordings (day 0) to 5 days after baseline

Schepens *et al. Critical Care* (2015) 19:422
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Diaphragmatic muscle thickness in older people with and without sarcopenia

Olgun Deniz[3,1] · Suheyla Coteli[1] · Nur Betul Karatoprak[2] · Mehmet Can Pence[2] · Hacer Dogan Varan[1] · Muhammet Cemal Kizilarslanoglu[1] · Suna Ozhan Oktar[2] · Berna Goker[1]

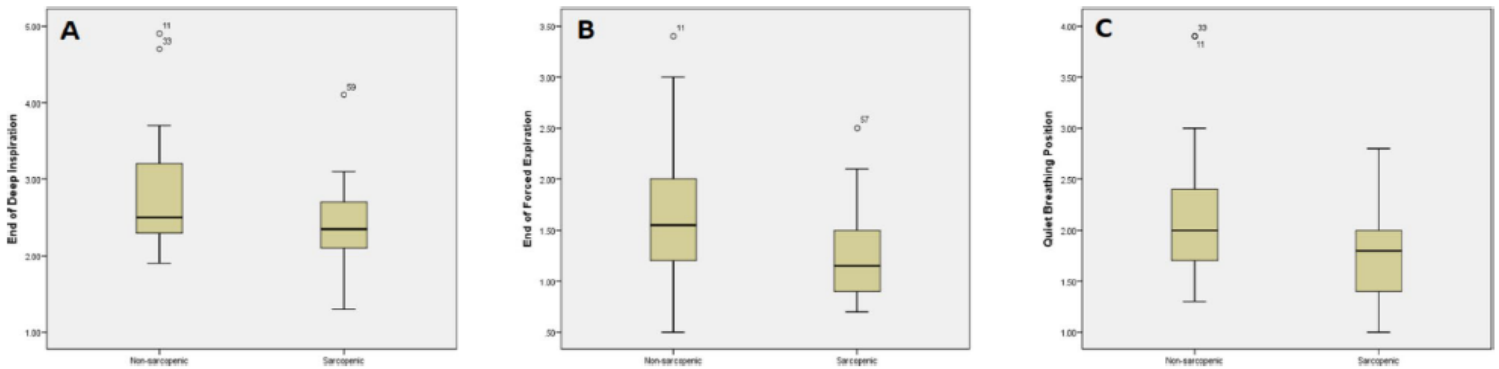


Fig. 2 Comparison of the diaphragmatic muscle thickness in each position. Graphics of the diaphragmatic muscle thickness in three positions in millimeter: **a** end of deep inspiration, **b** end of forced expiration, **c** quiet breathing position

Table 3 Ultrasonographic assessment of diaphragmatic thickness, PEF results, and skeletal muscle index of the participants

	Sarcopenic ($n=30$)	Non-sarcopenic ($n=30$)	p
End of deep inspiration (mm)	2.3 (1.3–4.1)	2.5 (1.9–4.9)	**0.02**
End of forced expiration (mm)	1.1 (0.7–2.5)	1.5 (0.5–3.4)	**<0.01**
Quiet breathing position (mm)	1.8 (1.0–2.8)	2.0 (1.3–3.9)	**0.02**
Peak expiratory flow rate (lt/min)	245 (150–500)	310 (220–610)	**<0.01**
Skeletal muscle mass index (SMI) (kg/m^2)	7.64 ± 0.83	9.22 ± 1.31	**<0.01**

Normally distributed variable was presented as mean ± standard deviation while skew distributed ones presented as median (min–max)

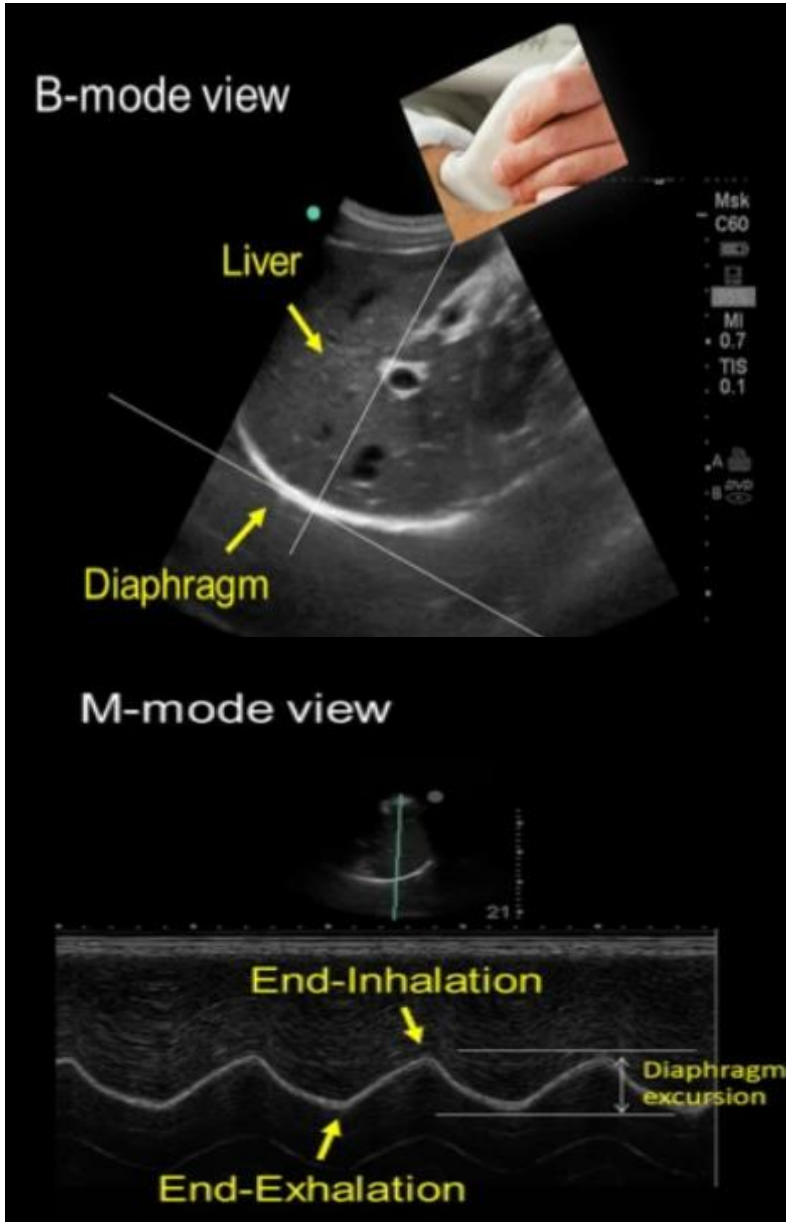
Bold values denote statistical significance at the $p < 0.05$ level

Table 1 Baseline characteristics of the participants

	Sarcopenic ($n=30$)	Non-sarcopenic ($n=30$)	p
Age (years)	79.9 ± 5.6	73.3 ± 5.5	**<0.01**
BMI (kg/m^2)	23.9 ± 3.6	29.4 ± 4.3	**<0.01**
Gender			
Women	16 (53)	19 (63)	0.43
Men	14 (47)	11 (37)	
Diabetes mellitus	8 (26.7)	9 (30.0)	0.39
Hypertension	23 (76.7)	20 (66.7)	0.39
Osteoporosis	10 (34.5)	8 (28.6)	0.63
Coronary artery disease	11 (36.7)	4 (13.3)	**0.04**
Chronic heart failure	2 (6.7)	0 (0)	0.49
Dementia	2 (6.7)	0 (0)	0.49
Depression	2 (6.7)	2 (6.7)	1.00
Smoking	10 (33.4)	10 (33.4)	1.00
Number of medication	6 (0–15)	4 (0–8)	**<0.01**
Katz ADLs	5 (1–6)	6 (5–6)	**<0.01**
Lawton–Brody IADLs	6 (1–8)	8 (5–8)	**<0.01**
MNA-SF	10 (5–14)	13 (11–14)	**<0.01**
MMSE	23.5 (8–30)	28 (22–30)	**<0.01**
GDS	5.5 (0–15)	2 (0–12)	0.05
Gait speed (m/sn)	0.84 (0.17–2)	1.39 (1.03–1.93)	**<0.01**
Hand grip strength (kg)	18.6 ± 6.5	24.5 ± 7.0	**<0.01**
Right calf circumference (cm)	32.6 ± 2.9	37.2 ± 3.2	**<0.01**

Ultrasound measurement of diaphragm motion (dome)

- The cranio-caudal movement of the dome of the diaphragm during quiet breathing and during forceful inspiratory efforts such as sniff maneuvers or maximal inspirations can be monitored using curvilinear ultrasound probes.
- Curvilinear probes use low frequency ultrasound waves (2–6 Hz) that penetrate deeply in the body giving a wide depth of field.
- On the right, operators position the probe longitudinally in the subcostal area between the mid-clavicular and anterior axillary lines using the liver as acoustic window.
- The probe is directed medially, cephalad and dorsally so that the ultrasound beam reaches the right dome of the diaphragm perpendicularly.
- On the left side, operators use the spleen as an acoustic window. (Less often, operators may use the right or left lateral view (midaxillary lines) or the posterior subcostal view or the subxiphoid view).
- Once a good quality B-mode image is obtained, operators adjust the M-mode interrogation line as to be perpendicular to the movement of the hemidiaphragm. With M-mode ultrasonography, the diaphragm appears as a single thick echogenic line.
- During inhalation the contracting diaphragm moves towards the ultrasound probe.



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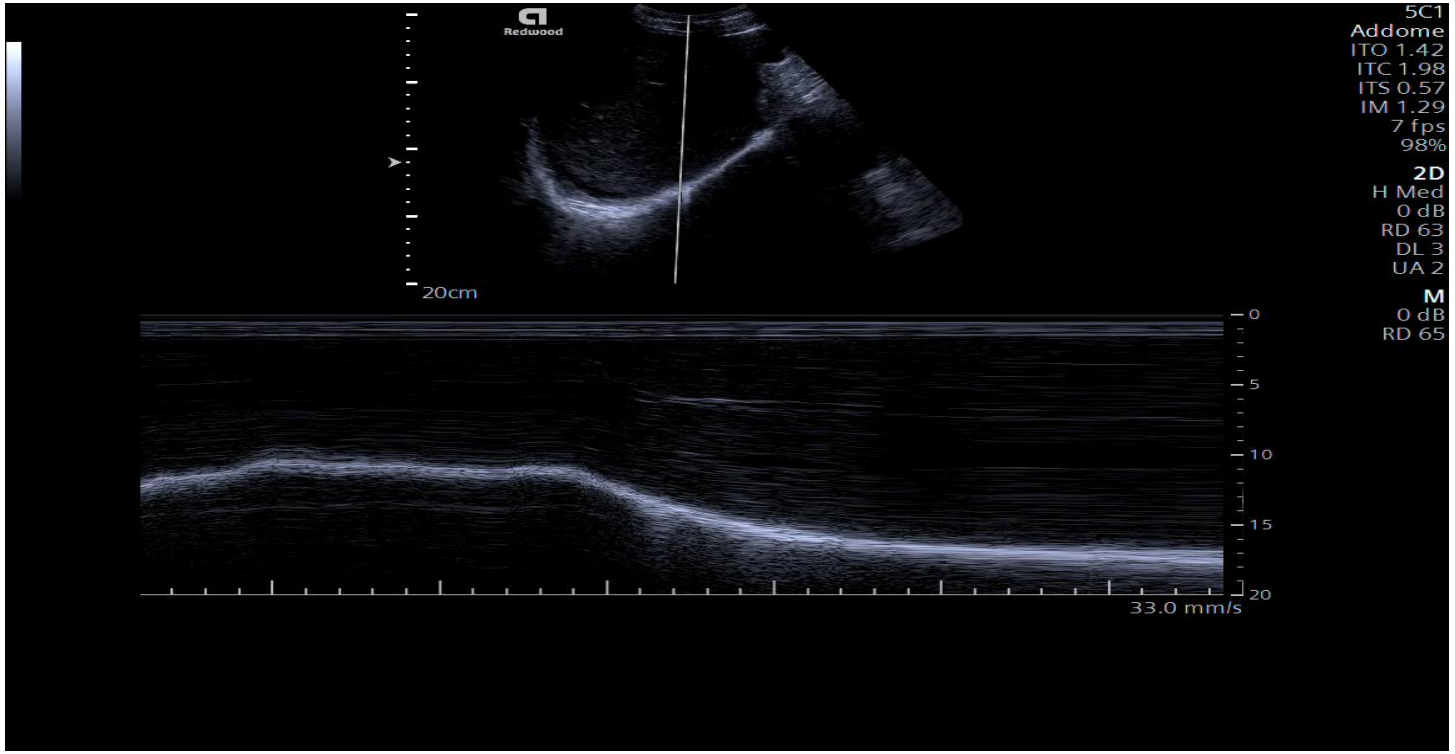

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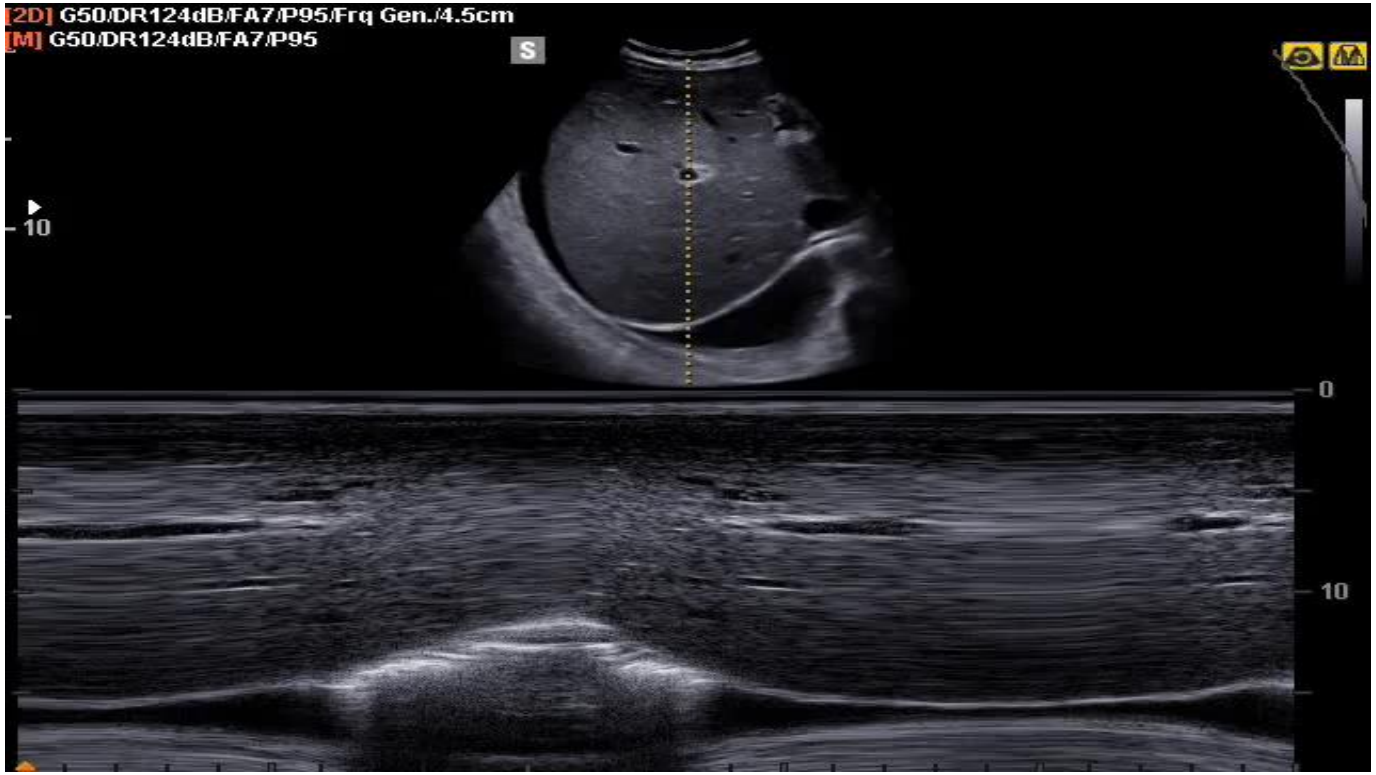

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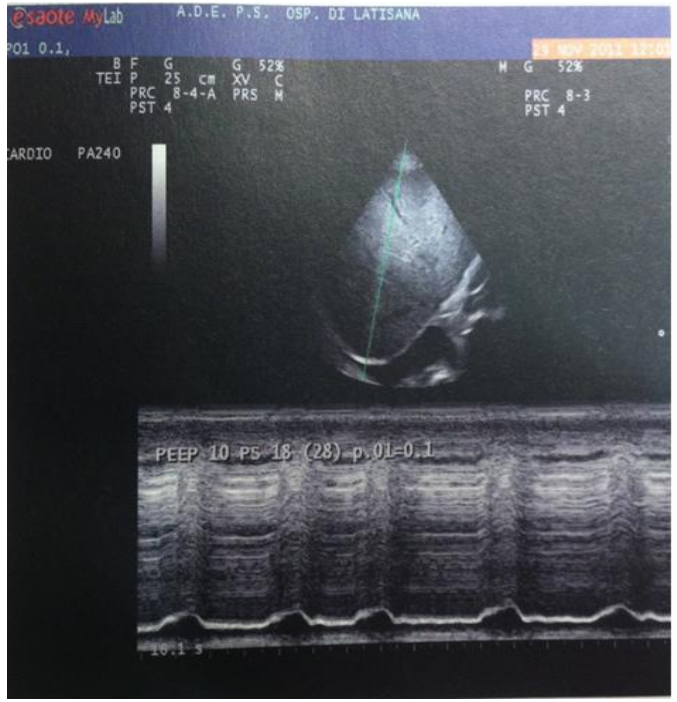
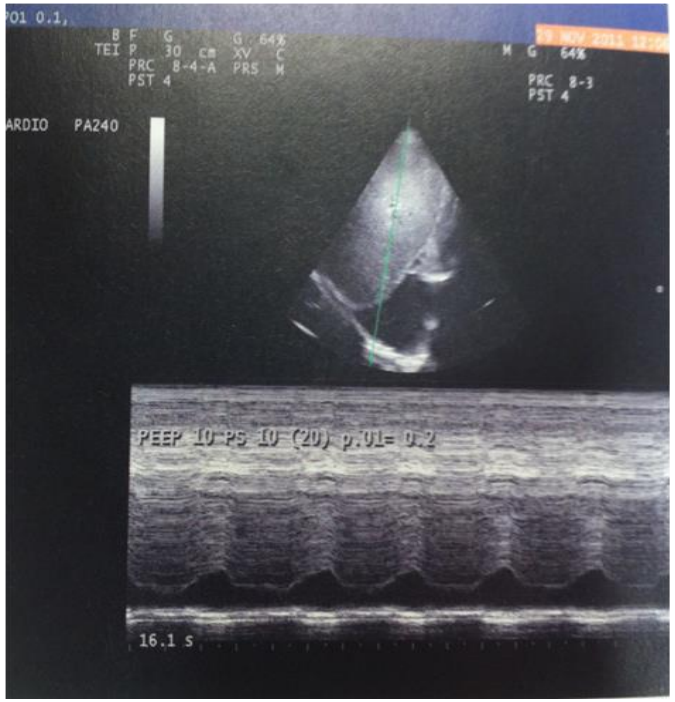
DIAFRAMMA

Lo studio del diaframma in corso di ventilazione meccanica

PEEP
18 cmH2O



PEEP
10 cmH2O



PEEP
6 cmH2O