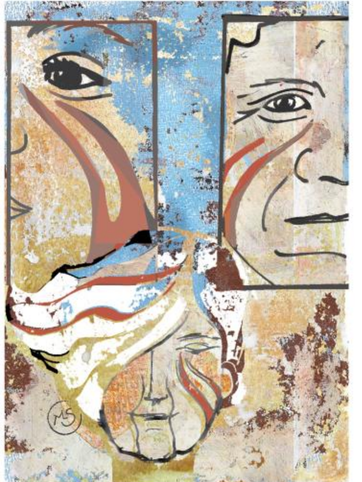
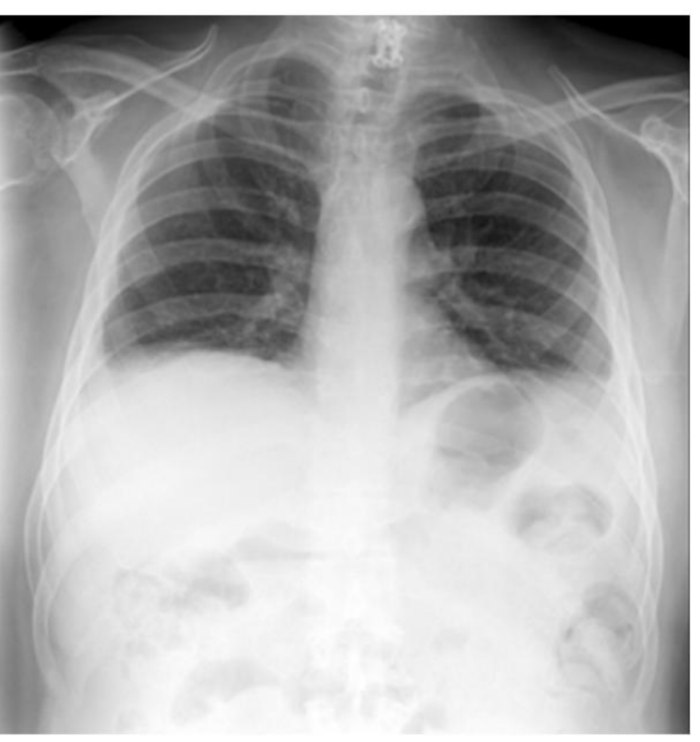


# Ecografia diaframmatica

**Simone Scarlata**
**Fondazione Policlinico Universitario**
**Campus Bio Medico**
**Roma**

# DEA: Uomo 55 anni

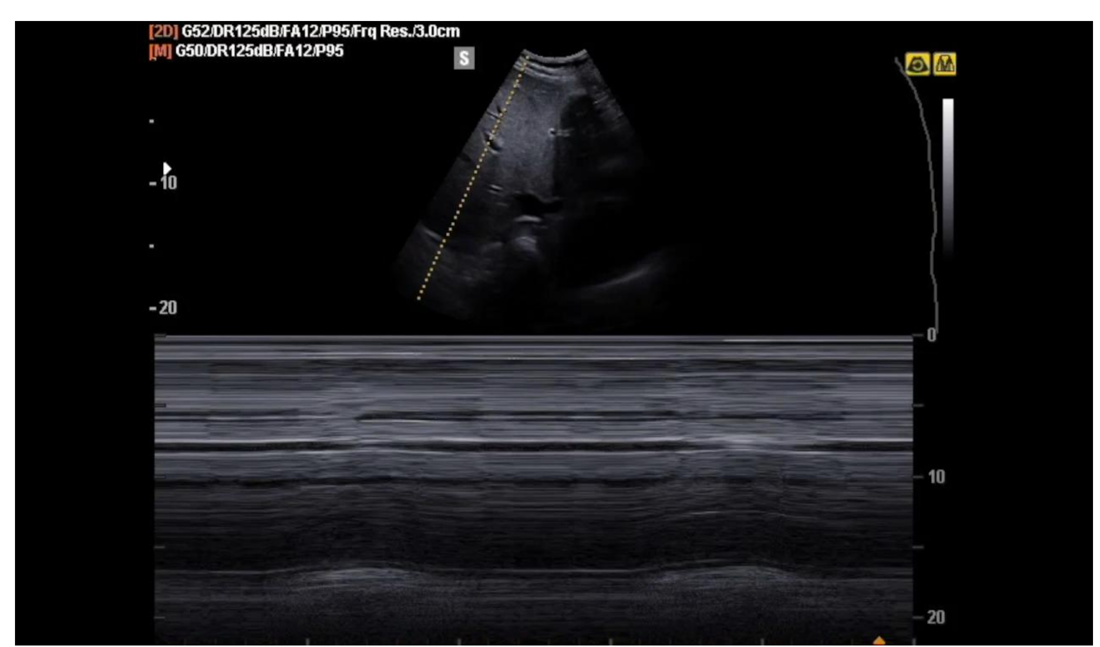
Figure 1.

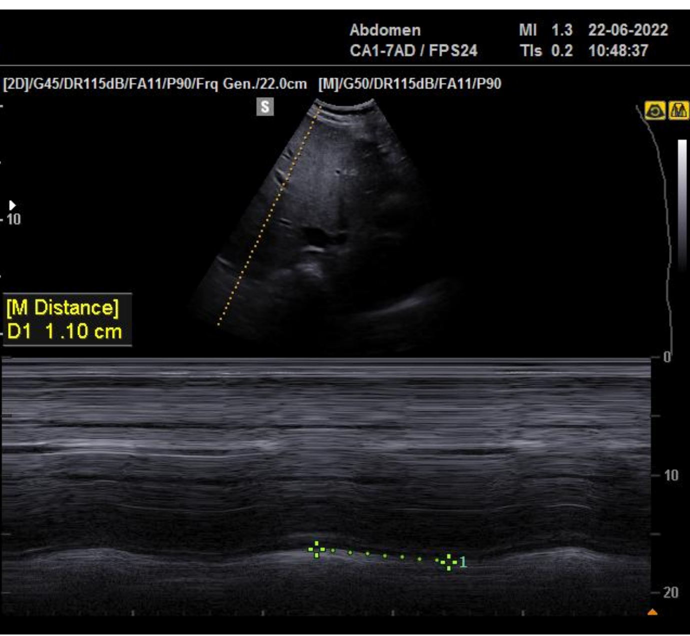


Chest X-ray: opacification of cost-phrenic sinuses in the posteroanterior (PA) projection.

EGA in aria ambiente: pH=7.42; pO2=63 mmHg; pCO2=54 mmHg; HCO3-=40.9 mmol/L; SaO2=88,2%; Lac=0.8 mmol/L

## Controllo US per mancato miglioramento degli scambi




«Severa ipomobilita`del diaframma bilaterale (escursione inspiratoria stimata 1 cm), nelle immagini scansione destra <<<< lesione traumatica monolaterale delle radici del nervo frenico

# Background

- Metodica **rapida** e **riproducibile**
- **Non invasiva**
- Curva di apprendimento **accessibile** a tutti che si basa su due proiezioni addominali eseguibili con strumentazioni di **medio-basso livello**

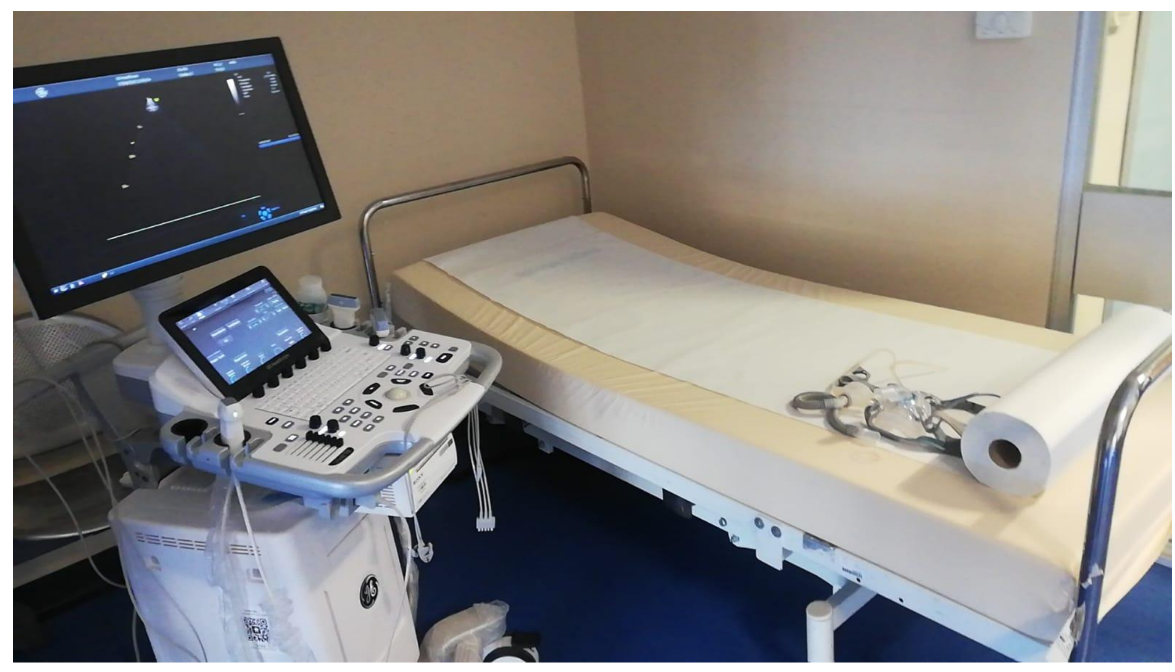
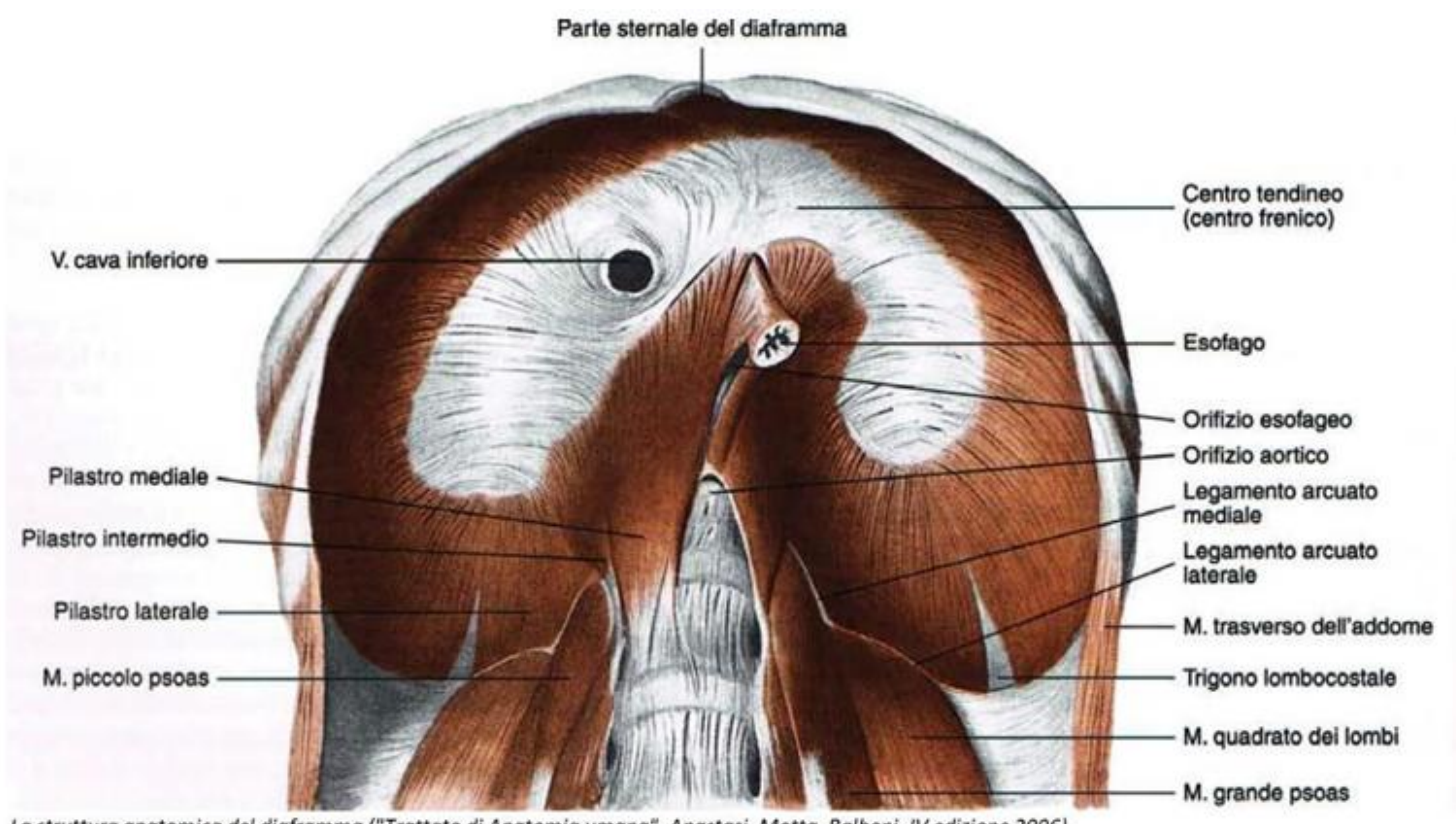


**Exhibit E**, Roriz D, Abreu I, Soares PB, Alves FC. Ultrasound in the evaluation of diaphragm. 2015:1-16. doi:10.1594/ecr2015/C-2402.

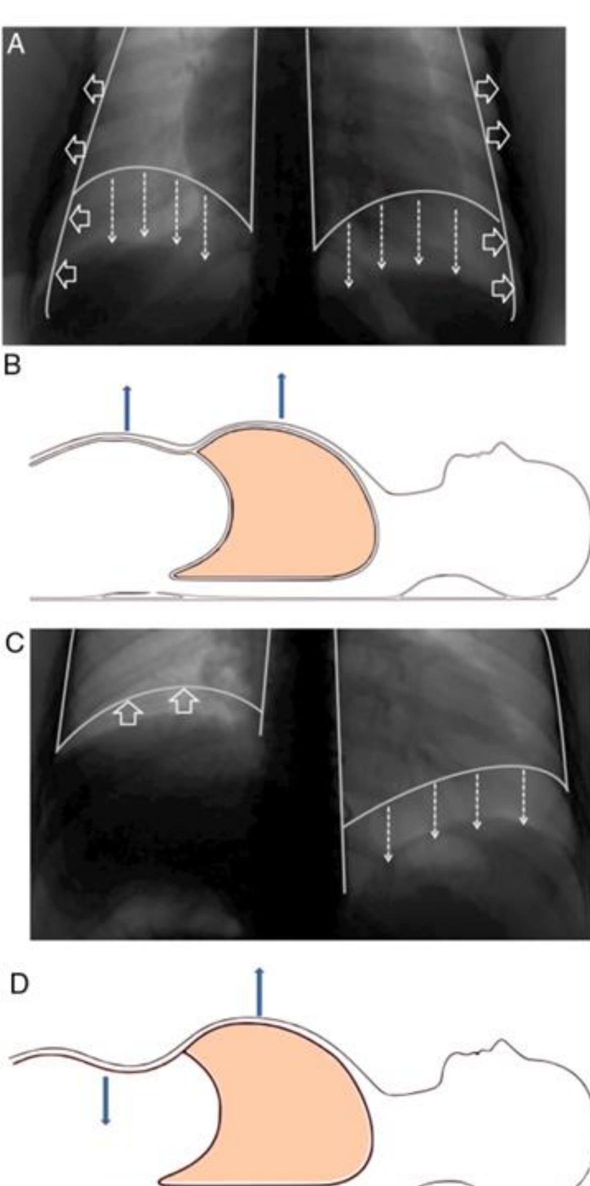
# Anatomia




*La struttura anatomica del diaframma ("Trattato di Anatomia umana", Anastasi, Motta, Balboni, IV edizione 2006)*

# Disfunzione diaframmatica

**Figure 1** (A) Normal contraction of the diaphragm during quiet inspiration: the muscular action causes the diaphragm to move together like a piston in the caudal direction (direction of the arrows), thereby increasing abdominal pressure and decreasing pleural pressure. The latter is transmitted to the lung, causing it to be insufflated. (B) In supine position, it can be seen that both the rib cage and the abdomen move outwards. (C) When there is paralysis of the diaphragm (right side), the negative intrathoracic pressure drags the diaphragm and the abdominal viscera towards the thorax (direction of the arrows), which generates a negative abdominal pressure. (D) In supine position, it is observed how this negative abdominal pressure causes a paradoxical movement during inspiration: the abdomen moves inwards.



# Disfunzione diaframmatica

**Table 1** Causes that can cause diaphragmatic dysfunction.

| Location of the lesion | Disease | Comment |
|---|---|---|
| Cerebral cortex | Vascular accident | The respiratory motor neurons of the pyramidal tract (corticospinal) are scattered throughout a wide area of the cortex, so they rarely affect the diaphragm. |
| Internal capsule | Vascular accident<br>Arnold–Chiari disease | Vascular accidents located in the brain stem can cause hypoventilation due to involvement of the bulbospinal tract, affecting the automatic control of respiration.[1,13] |
| Central nervous system | Multiple sclerosis | Uncommon cause of diaphragmatic involvement. The main implication occurs in the expiratory musculature. It usually appears in patients in very advanced stages with severe alteration of mobility. The initial clinical presentation as isolated diaphragmatic paralysis is rare and is usually bilateral.[14–18] |
| Spinal cord | Traumatic degenerative (severe spondylosis) | If the lesion is at the level of C3–C5, in addition to the diaphragmatic involvement, other major muscles of inspiration may be affected. When the injury affects the C2 level or higher, the need for ventilatory support is almost inevitable and, as we move away from this level, the probability decreases and is rarely needed in lesions below C5.[19–21] |
| Motor neurons | Post-polio syndrome<br>Amyotrophic lateral sclerosis<br>Syringomyelia<br>Paraneoplastic neuropathy associated with antibodies-HU<br>Radiation post-irradiation<br>Spinal muscular atrophy | The post-polio syndrome can manifest itself years after its recovery and affect the same muscle groups as new ones.[1,22]<br>Amyotrophic lateral sclerosis produces secondarily atrophy and weakness of the respiratory muscles. Diaphragmatic involvement may be the first manifestation or develop throughout the disease. It is bilateral and its involvement could be valuable even before the respiratory symptoms begin.[23–25] |
| Brachial plexus | Traumatic<br>Iatrogenic (anaesthetic blockages, obstetric procedures, chiropractic manipulations of the neck, radiotherapy)<br>Idiopathic | All of these can cause diaphragmatic paralysis.[26–29] |

# Disfunzione diaframmatica

| | | |
|---|---|---|
| Phrenic | Trauma[30]<br>Compression/infiltration (mediastinal neoplasms)<br>Guillain–Barré[31]<br>Infection (Herpes–Zoster virus, pneumonias,[32] Lyme disease,[33] HIV infection[34])<br>Amyotrophic neuralgia (Parsonage-Turner)[35]<br>Thoracic surgeries[36]<br>Others [malnutrition,[37] diabetes,[38] hypothyroidism,[23] benign thyroid hypertrophy,[39] porphyria, vasculitis, Charcot-Marie-Toot[41] disease]<br>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.<br>Infection with Herpes–Zoster virus produces diaphragmatic paralysis if it affects the cervical territory and is usually ipsilateral and usually permanent.<br>Amyotrophic neuralgia presents pain and flaccid paralysis of the shoulder muscles. It is associated with both uni and bilateral diaphragmatic involvement.<br>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]<br>Mechanical ventilation, both invasive and non-invasive, can produce atrophy of the diaphragm due to disuse. |

# Anatomia Ecografica: escursione

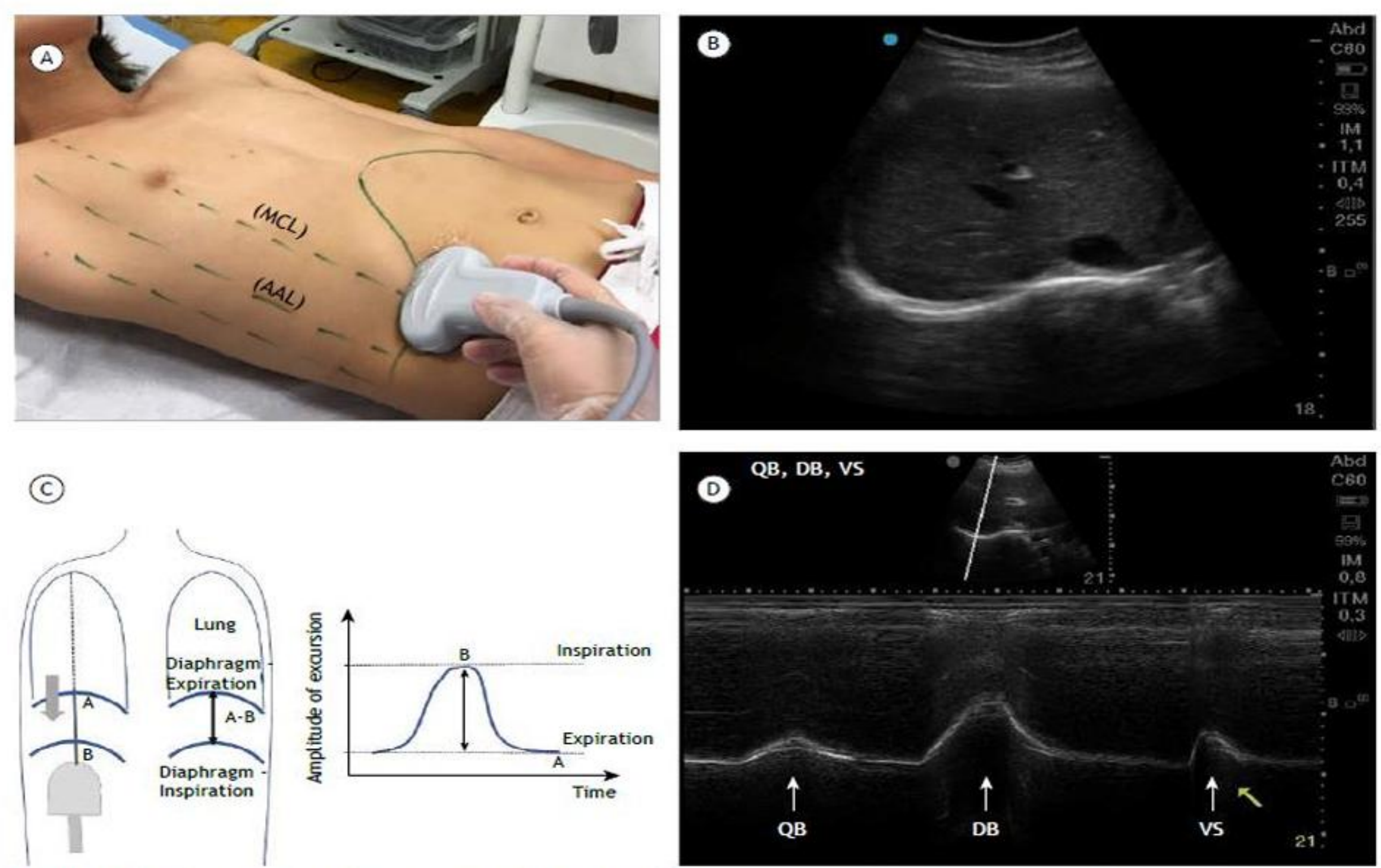
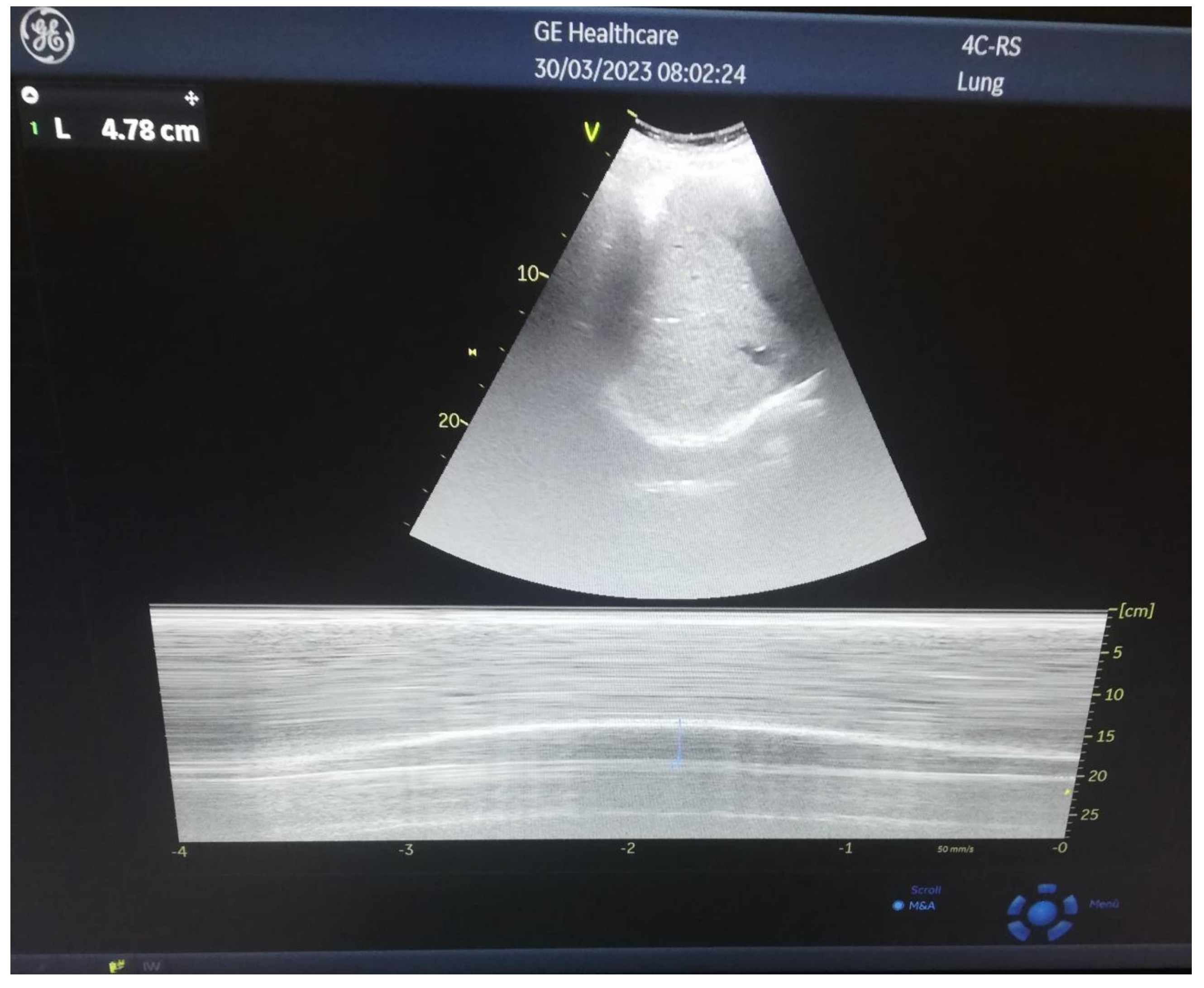


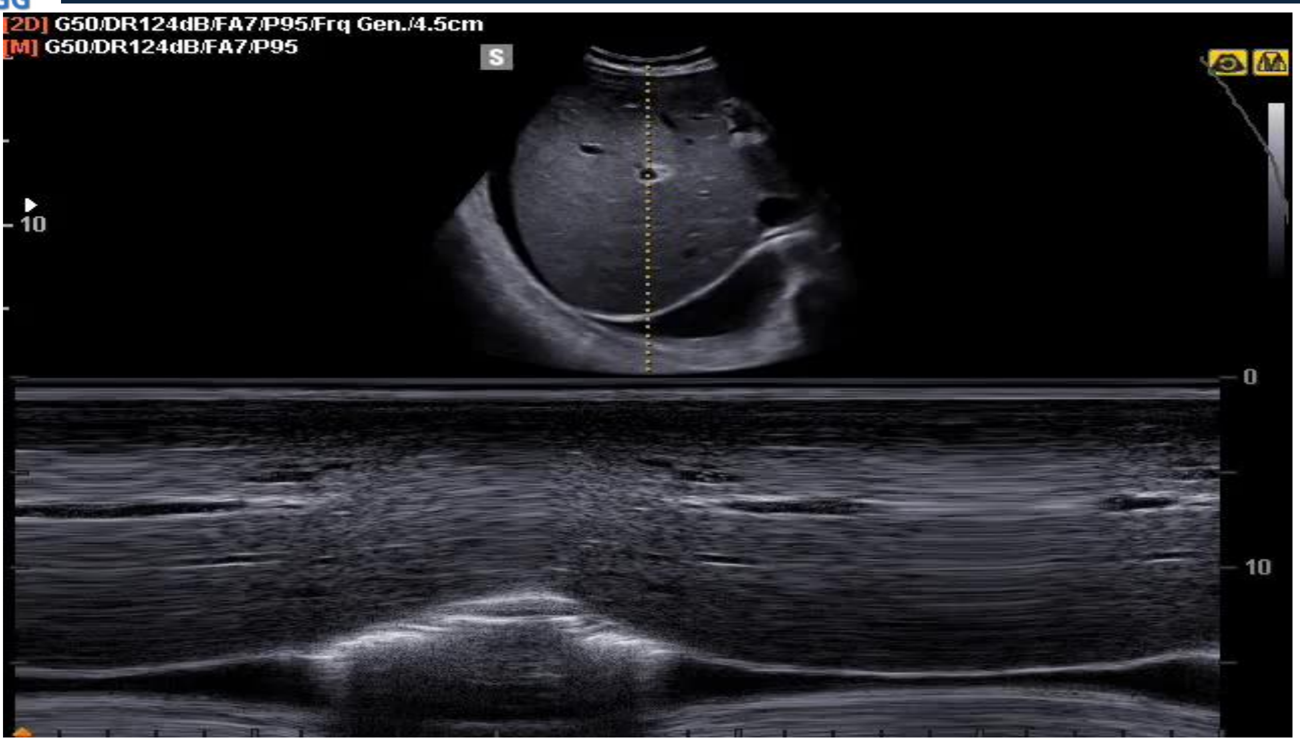

**Figure 2.** In A, measuring the excursion of right hemidiaphragm using the anterior subcostal view with the convex probe positioned below the costal margin between the midclavicular line (MCL) and anterior axillary line (AAL). In B, ultrasound appearance of the right hemidiaphragm in the subcostal region between the MCL and AAL. In C, schematic representation of the measurement of diaphragmatic excursion: on the left, placement of the probe in the subcostal region to display the diaphragm in B mode and placement of the exploratory line demonstrating excursion from expiration to inspiration (points A-B). In D, measurement of diaphragmatic excursion in M mode. The top of the figure depicts the normal right diaphragm in B mode, and the bottom portion depicts M-mode ultrasound of the diaphragmatic excursion during quiet breathing (QB), deep breathing (DB), and voluntary sniff (VS).

# Anatomia Ecografica: escursione



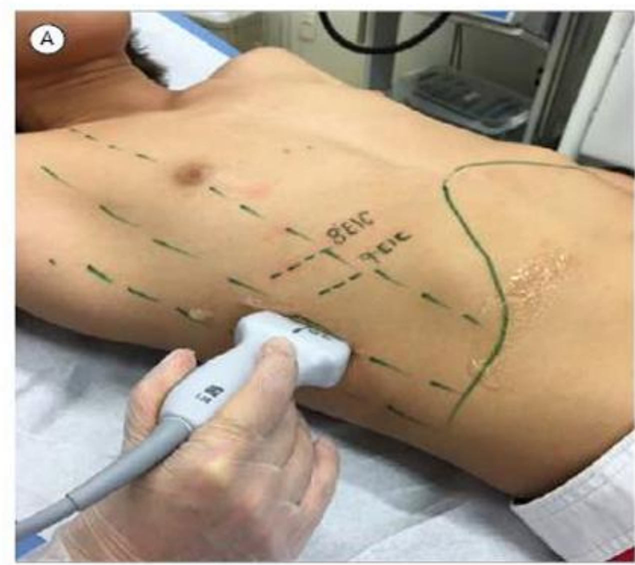

M-Mode Ultrasound Imaging of the diaphragmatic excursion

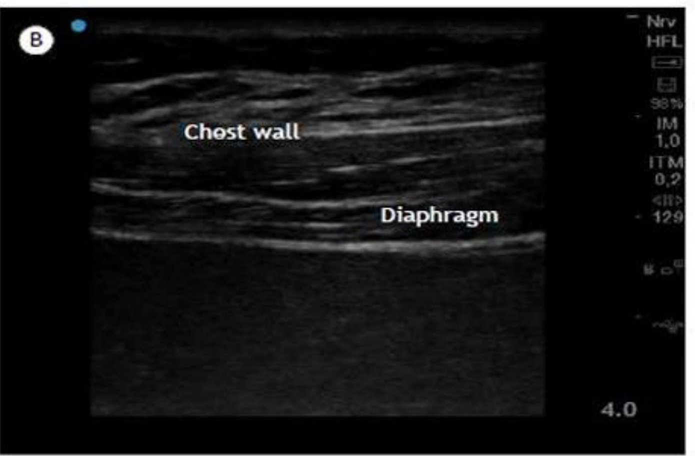
## Ultrasound measurement of diaphragm motion (dome)




- 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.

# Anatomia Ecografica: spessore



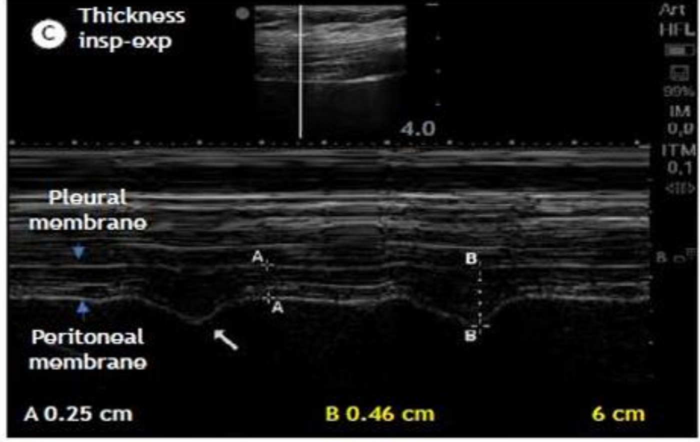
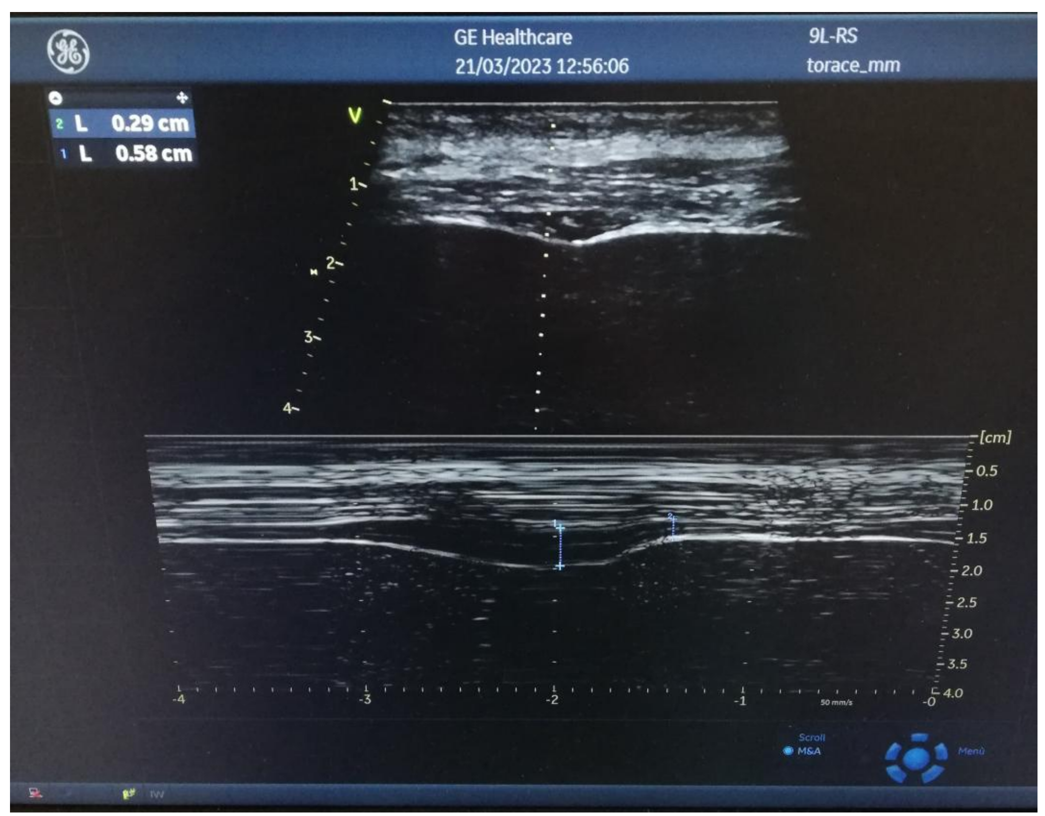




**Figure 4.** In A, measuring the thickness of right hemidiaphragm through the placement of the linear transducer over the zone of apposition (ZOA) at the ninth intercostal space, between the anterior axillary and midaxillary lines. In B, ultrasound appearance of the left hemidiaphragm at the ZOA between the ninth and tenth intercostal spaces, during quiet breathing, at functional residual capacity. In C, measurement of diaphragm thickness: the top of the figure displays the ZOA of a normal diaphragm, in B mode; and the bottom portion shows, in M mode, the diaphragm thickness at end-expiration (exp), or distance A-A, and diaphragm thickness at end-inspiration (insp), or distance B-B.

# Anatomia Ecografica: spessore

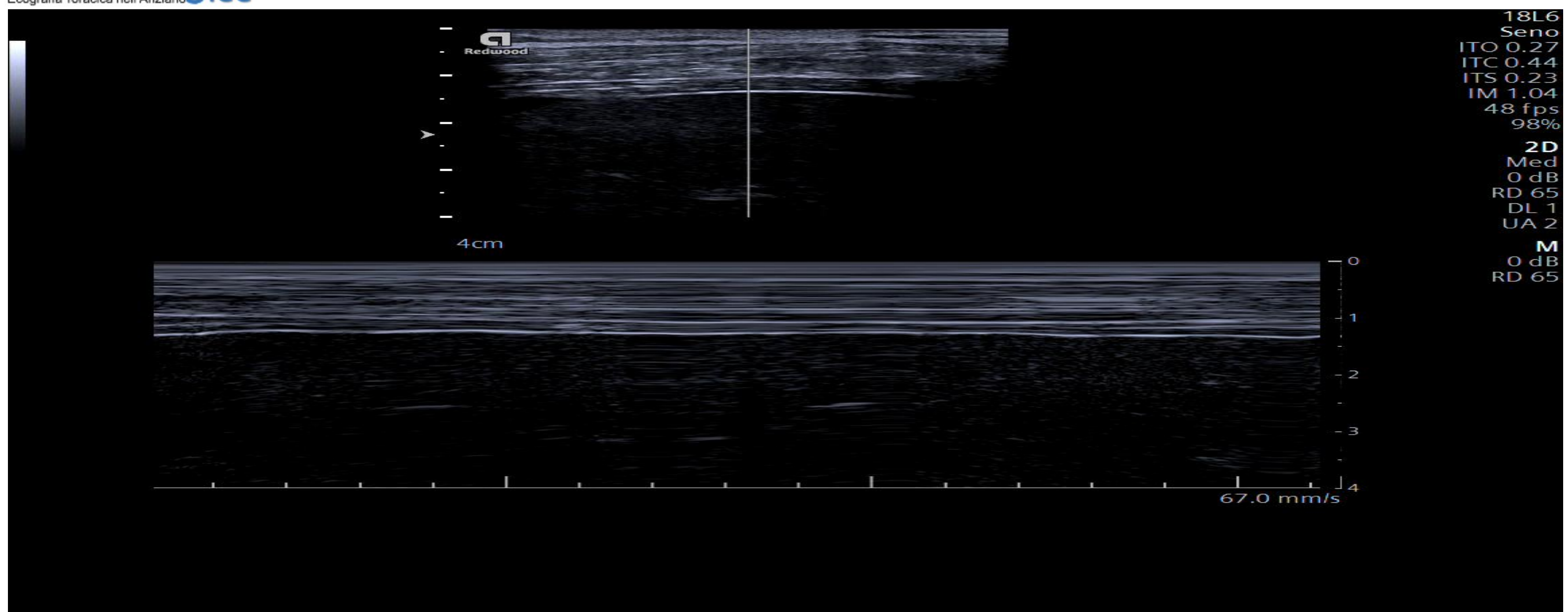
$$\textbf{Escursione di spessore diaframmatico}\ (\Delta DT) = DTi - DTe$$

$$\textbf{Frazione di spessore diaframmatica}\ (TFdia) = \frac{\Delta DT}{DTe}\ x\ 100$$




**M-Mode Ultrasound Imaging of the diaphragmatic thickening**

## 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

# Anatomia Ecografica: valori normali

**Table 3.** Normal and pathologic values for diaphragm US

| Diaphragmatic area | Parameter and test | Mean normal values ± SD | Pathologic values | Reference |
|---|---|---|---|---|
| Zone of apposition | diaphragmatic thickness | 2.7±0.5 mm | <2 mm | Gottesman et al. [26], 1997 |
| | thickening fraction[a] | 37±9% | <20% | |
| Dome | diaphragmatic tidal excursion | women: 16±3 mm<br>men: 18±3 mm | women: <9 mm<br>men: <10 mm | Boussuges et al. [22], 2009 |
| | sniff test | women: 26±5 mm<br>men: 29±6 mm | women: <16 mm<br>men: <18 mm | |
| | deep breath | women: 57±10 mm<br>men: 70±11 mm | women: <37 mm<br>men: <47 mm | |

Diaphragmatic thickness is measured at FRC. SD = Standard deviation. [a] Thickening fraction: ratio of the difference between thickness at TLC and thickness at FRC to thickness at FRC and expressed as percentage.

**Boussuges A**, Gole Y, Blanc P. **Diaphragmatic motion studied by m-mode ultrasonography: methods, reproducibility, and normal values.** Chest. 2009 Feb 1;135(2):391-400.

# Reproducibility and Clinical Correlates of Supine Diaphragmatic Motion Measured by M-Mode Ultrasonography in Healthy Volunteers

Simone Scarlata Damiana Mancini Alice Laudisio Augusto Benigni
Raffaele Antonelli Incalzi

Unit of Respiratory Pathophysiology and Thoracic Endoscopy, Division of Geriatrics, Campus Bio Medico University

**Table 2.** Right diaphragmatic excursion in males and females

| | Overall | 95% CI | Males | 95% CI | Females | 95% CI | *p* value |
|---|---|---|---|---|---|---|---|
| QB, mm | 17.6 (5.4) | 16.0–19.2 | 20.3 (5.7) | 17.7–22.9 | 15.1 (3.7) | 13.5–16.7 | 0.001 |
| DB, mm | 62.0 (15.5) | 57.3–66.7 | 69.3 (14.6) | 62.6–75.9 | 55.4 (13.3) | 49.6–61.2 | <0.001 |

Values are presented as mean (SD).

**Table 3.** Correlation analysis between diaphragmatic excursion and anthropometric data

| | | Spearman's correlation coefficient (R) | *p* value |
|---|---|---|---|
| QB | Age | –0.227 | 0.139 |
| | Height | 0.514 | <0.001 |
| | Weight | 0.314 | 0.038 |
| DB | Age | –0.272 | 0.006 |
| | Height | 0.342 | 0.001 |
| | Weight | 0.225 | 0.024 |

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# Reproducibility of diaphragmatic thickness measured by M-mode ultrasonography in healthy volunteers

Simone Scarlata*, Damiana Mancini, Alice Laudisio, Antonelli Incalzi Raffaele

*Geriatrics, Unit of Respiratory Pathophysiology and Thoracic Endoscopy, Campus Bio Medico University and Teaching Hospital, Rome, Italy*

**Table 4**

Linear regression analysis assessing the association of ultrasonographic measurements with demographic and anthropometric data.

| | Diaphragmatic Motion | Expiratory Thickness | Inspiratory Thickness | Diaphragmatic Ratio | Thickness Difference |
|---|---|---|---|---|---|
| Age | −0.27* | −0.15 | −0.17 | −0.06 | −0.16 |
| Weight | 0.36* | 0.08 | −0.03 | 0.07 | −0.09 |
| Height | 0.35* | −0.03 | −0.03 | 0.08 | −0.01 |
| BMI | 0.11 | 0.23 | 0.14 | −0.04 | −0.04 |
| Sex | | | | | |
| Male | 65.0 (13.0) | 1.87 (0.38) | 2.78 (0.48) | 1.57 (0.04) | 0.91 (0.28) |
| Female | 55.0 (14.1) | 1.67 (0.39) | 2.39 (0.54) | 1.47 (0.04) | 0.72 (0.26) |
| p-value | 0.004 | 0.043 | 0.004 | 0.071 | 0.006 |
| Cigarette smoke exposure | | | | | |
| No | 59.3 (14.8) | 1.77 (0.37) | 2.55 (0.53) | 1.49 (0.23) | 0.78 (0.26) |
| Yes | 60.5 (13.4) | 1.73 (0.47) | 2.61 (0.61) | 1.60 (0.27) | 0.88 (0.34) |
| p-value | 0.760 | 0.717 | 0.734 | 0.123 | 0.243 |
| Sedentary work | | | | | |
| Yes | 57.8 (14.4) | 1.67 (0.36) | 2.46 (0.53) | 1.51 (0.25) | 0.78 (0.28) |
| No | 61.7 (14.3) | 1.87 (0.41) | 2.70 (0.54) | 1.52 (0.23) | 0.84 (0.29) |
| p-value | 0.272 | 0.045 | 0.066 | 0.974 | 0.458 |
| Physically active | | | | | |
| No | 58.5 (13.4) | 1.75 (0.38) | 2.59 (0.55) | 1.56 | 0.83 (0.28) |
| Yes | 60.6 (15.4) | 1.77 (0.41) | 2.55 (0.54) | 1.47 | 0.78 (0.28) |
| p-value | 0.561 | 0.882 | 0.788 | 0.125 | 0.468 |

## Le applicazioni pratiche dell'ecografia diaframmatica[1]

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

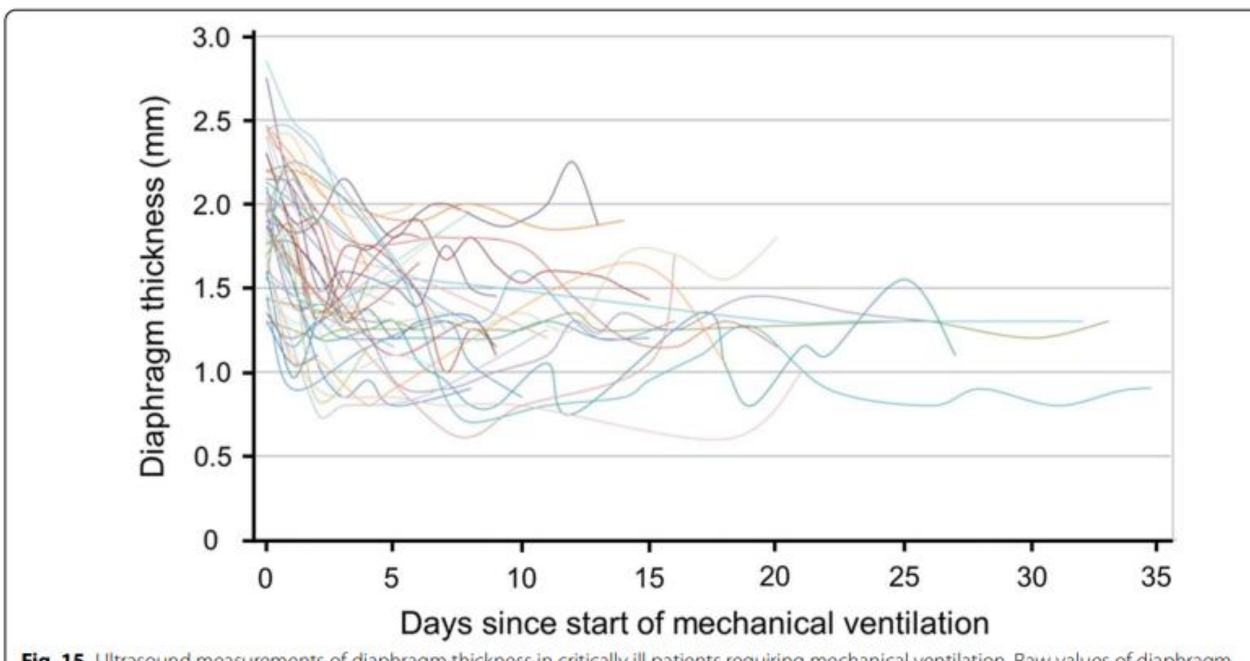


**Fig. 15** Ultrasound measurements of diaphragm thickness in critically ill patients requiring mechanical ventilation. Raw values of diaphragm thickness for each day of mechanical ventilation. Lines use a Bézier curve construction (see text for details). Reproduced under Open Access Creative Commons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

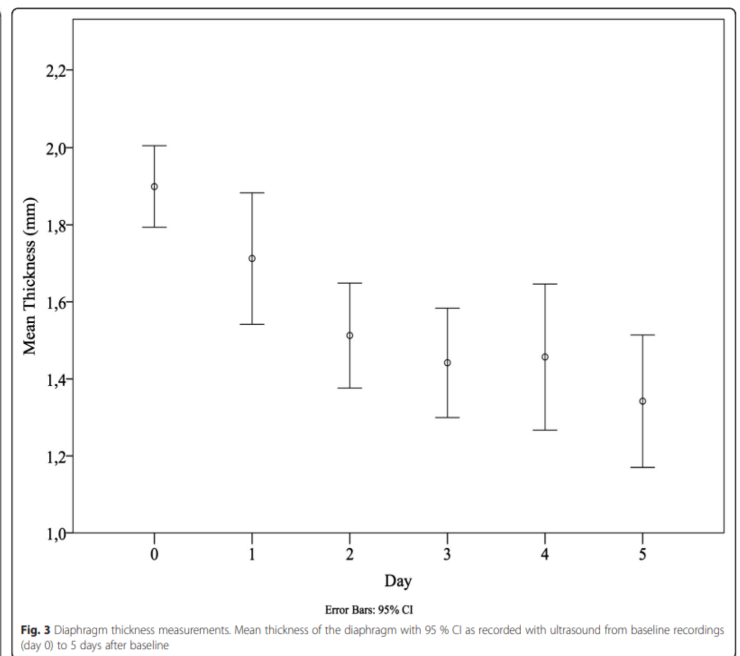


**Fig. 3** Diaphragm thickness measurements. Mean thickness of the diaphragm with 95 % CI as recorded with ultrasound from baseline recordings (day 0) to 5 days after baseline

Schepens *et al. Critical Care* (2015) 19:422
DOI 10.1186/s13054-015-1141-0

# Le applicazioni pratiche dell'ecografia diaframmatica[1]

1. **Terapia Intensiva:** disfunzione diaframmatica ed outcomes avversi come il fallimento dello svezzamento da ventilazione assistita, prolungamento della degenza in cure intensive e mortalità.

**CONCLUSIONS: Diaphragm atrophy** occurs quickly in **mechanically ventilated patients** and can accurately be monitored using ultrasound. Length of MV, as opposed to other variables, is associated with the degree of atrophy

REVIEW
*Journal of Cachexia, Sarcopenia and Muscle* 2016; **7**: 403–412
Published online 9 March 2016 in Wiley Online Library (wileyonlinelibrary.com) **DOI:** 10.1002/jcsm.12108

## Dysfunction of respiratory muscles in critically ill patients on the intensive care unit

David Berger[1], Stefan Bloechlinger[1,2], Stephan von Haehling[3], Wolfram Doehner[4], Jukka Takala[1], Werner J. Z'Graggen[5] & Joerg C. Schefold[1]*

[1]*Department of Intensive Care Medicine, Inselspital, University Hospital of Bern, Bern, Switzerland;* [2]*Department of Clinical Cardiology, Inselspital, University Hospital of Bern, Bern, Switzerland;* [3]*Department of Cardiology and Center for Innovative Clinical Trials, University of Göttingen, Göttingen, Germany;* [4]*Center for Stroke Research Berlin, Charite Universitätsmedizin Berlin, Berlin, Germany;* [5]*Department of Neurosurgery and Dept. of Neurology, Inselspital, University Hospital of Bern, Bern, Switzerland*

SCHEPENS, Tom, et al. The course of diaphragm atrophy in ventilated patients assessed with ultrasound: a longitudinal cohort study. *Critical care*, 2015, 19: 1-8.

# Le applicazioni pratiche dell'ecografia diaframmatica[1]

1. **Terapia Intensiva:** disfunzione diaframmatica ed outcomes avversi come il fallimento dello svezzamento da ventilazione assistita, prolungamento della degenza in cure intensive e mortalità.

**CONCLUSIONS: Diaphragm atrophy** occurs quickly in **mechanically ventilated patients** and can accurately be monitored using ultrasound. Length of MV, as opposed to other variables, is associated with the degree of atrophy.

EXPERT REVIEW OF RESPIRATORY MEDICINE
2022, VOL. 16, NO. 8, 853–855
https://doi.org/10.1080/17476348.2022.2112670

EDITORIAL

## Diaphragmatic ultrasound in weaning ventilated patients: a reliable predictor?

Khalil El Gharib [a], Marc Assaad[a] and Michel Chalhoub[b]

[a]Department of Medicine, Staten Island University Hospital, New York, NY, USA; [b]Department of Pulmonary and Critical Care, Staten Island University Hospital, New York, NY, USA

SCHEPENS, Tom, et al. The course of diaphragm atrophy in ventilated patients assessed with ultrasound: a longitudinal cohort study. *Critical care*, 2015, 19: 1-8.

# Le applicazioni pratiche dell'ecografia diaframmatica[1]

2. **Pneumologia:** spessore diaframmatico (TF < 20%) come fattore prognostico negativo associato a maggiore necessità di steroide-terapia e a fallimento di terapia con NIMV durante la riacutizzazione di BPCO.

Respirology / Volume 22, Issue 2 / p. 338-344

Original Article | Full Access

## Prevalence and outcomes of diaphragmatic dysfunction assessed by ultrasound technology during acute exacerbation of COPD: A pilot study

Federico Antenora, Riccardo Fantini, Andrea Iattoni, Ivana Castaniere, Antonia Sdanganelli, Francesco Livrieri, Roberto Tonelli, Stefano Zona, Marco Monelli, Enrico M. Clini, Alessandro Marchioni

# Le applicazioni pratiche dell'ecografia diaframmatica[1]

**Table 2** Clinical outcomes in the studied population

| | Overall | Diaphragmatic status DD+ | DD– | *P*-value | R-squared |
|---|---|---|---|---|---|
| NIV failure | 15 (36) | 9 | 6 | <0.001 | 0.27 |
| Tracheostomy | 7 (16) | 5 | 2 | 0.006 | 0.20 |
| MV (days) | 9 (5–17) | 18 (13–25) | 6.5 (3–10) | 0.023 | 0.15 |
| ICU stay (days) | 8 (5–12.5) | 17.5 (7–19) | 7 (4–10) | 0.02 | 0.13 |
| Hospital stay (days) | 14 (28) | 17 (8–28) | 13 (10–27) | 0.7 | — |
| ICU death | 8 (19.5) | 4 (40.0) | 4 (12.9) | 0.04 | 0.16 |
| Hospital death | 11 (26.8) | 5 (50.0) | 6 (19.35) | 0.057 | — |
| 90-day death | 15 (46.8) | 6 (66.6) | 9 (39.1) | 0.12 | — |

Values are expressed in numbers of subjects and percentages for dichotomous variables and in median and interquartile range for continue variables.

—, inconclusive results; DD, diaphragmatic dysfunction; ICU, intensive care unit; MV, mechanical ventilation; NIV, non-invasive mechanical ventilation.

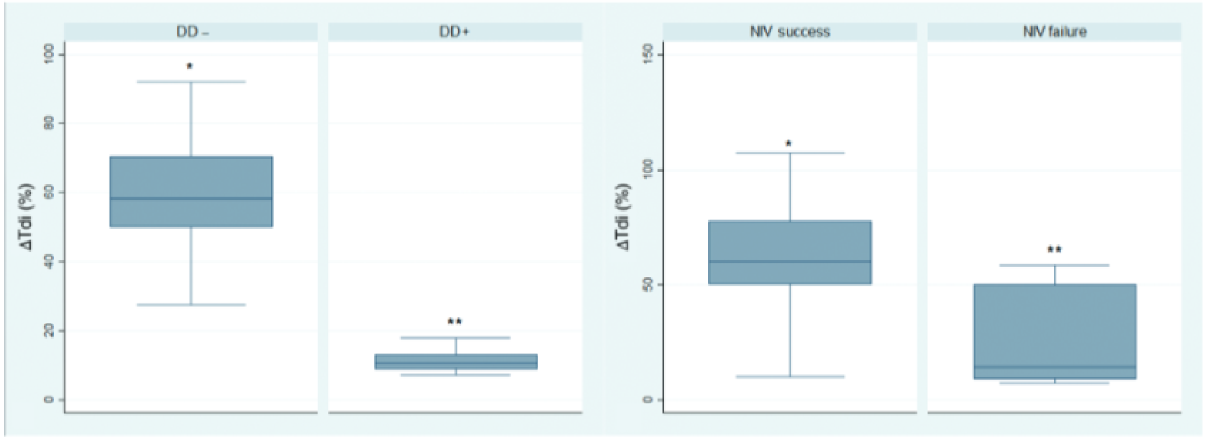


**Figure 3** (A) Change in diaphragm thickness (ΔTdi) values distribution in patients with diaphragmatic dysfunction (DD+) or without (DD–) altered motility of the diaphragm. *, ΔTdi median: 58.8% and **, ΔTdi median: 10.5%. (B) ΔTdi values distribution in the categories of patients with non-invasive mechanical ventilation (NIV) failure or success. *, ΔTdi median: 60.0% and **, ΔTdi median: 14.28%.

# Le applicazioni pratiche dell'ecografia diaframmatica[1]

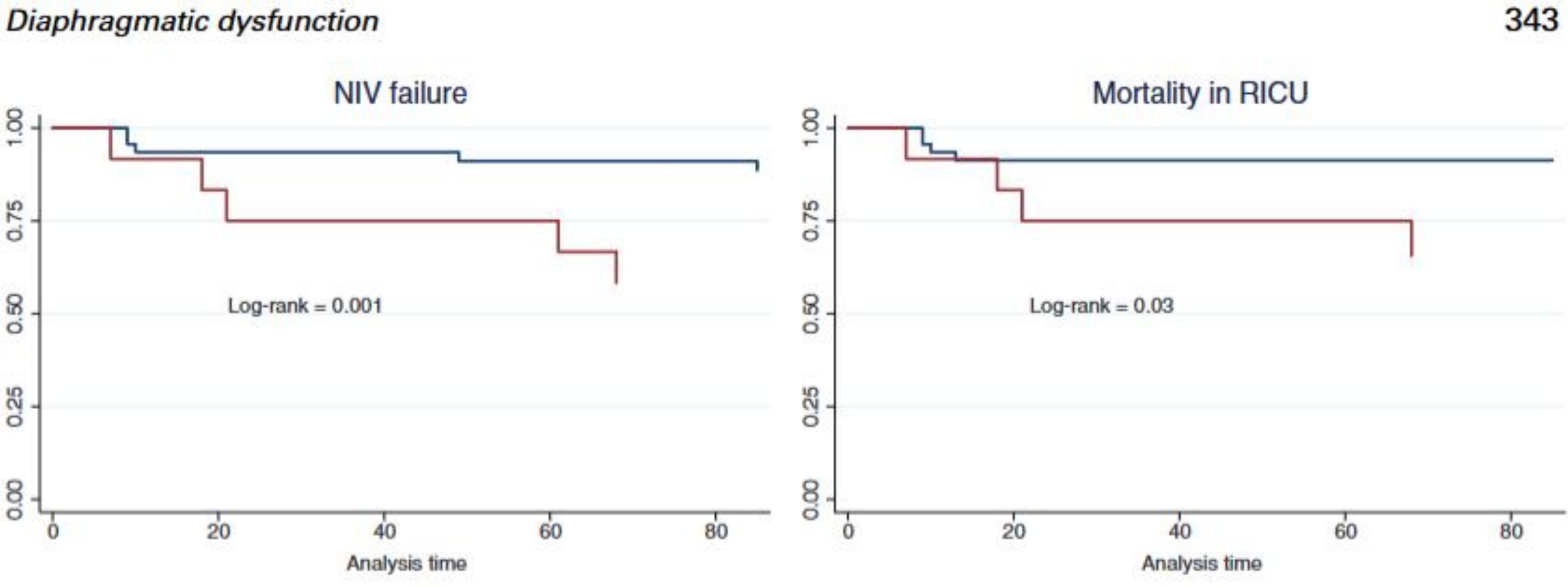


**Figure 4** Kaplan–Meyer curves for non-invasive mechanical ventilation (NIV) failure and intensive care unit (ICU) survival in patients with diaphragmatic dysfunction (DD+, ——) or without (DD–, ——) altered mobility of the diaphragm.

# Le applicazioni pratiche dell'ecografia diaframmatica[1]

2. **Pneumologia:** spessore diaframmatico (TF < 20%) come fattore prognostico negativo associato a maggiore necessità di steroide-terapia e a fallimento di terapia con NIMV durante la riacutizzazione di BPCO.

Mercurio *et al. Crit Care* (2021) 25:219
https://doi.org/10.1186/s13054-021-03638-x

Critical Care

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## Diaphragm thickening fraction predicts noninvasive ventilation outcome: a preliminary physiological study

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Critical Care

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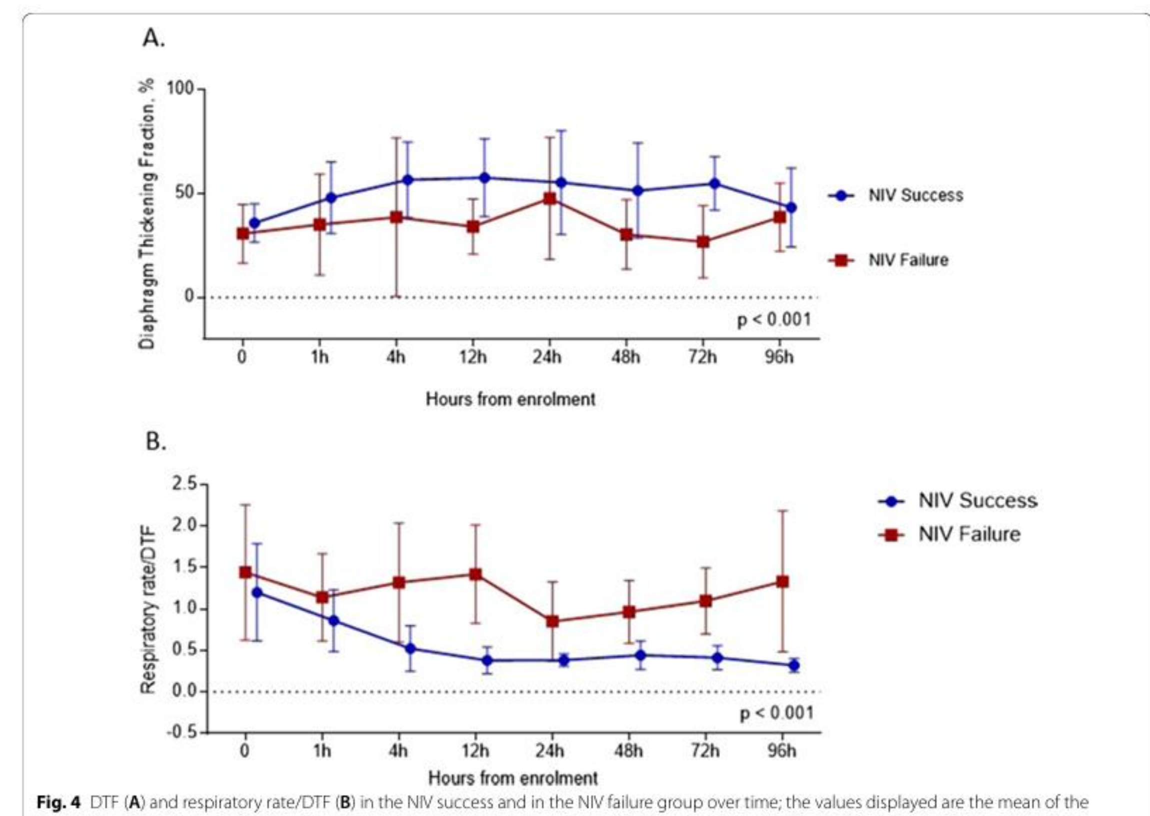
# Diaphragm thickening fraction predicts noninvasive ventilation outcome: a preliminary physiological study



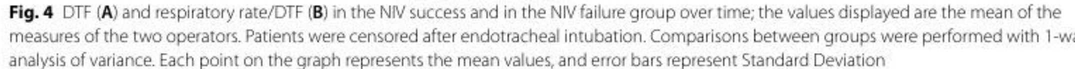



**Fig. 4** DTF (**A**) and respiratory rate/DTF (**B**) in the NIV success and in the NIV failure group over time; the values displayed are the mean of the measures of the two operators. Patients were censored after endotracheal intubation. Comparisons between groups were performed with 1-way analysis of variance. Each point on the graph represents the mean values, and error bars represent Standard Deviation

# Le applicazioni pratiche dell'ecografia diaframmatica[1]

1. **Terapia Intensiva:** disfunzione diaframmatica ed outcomes avversi come il fallimento dello svezzamento da ventilazione assistita, prolungamento della degenza in cure intensive e mortalità.

2. **Pneumologia:** spessore diaframmatico (TF < 20%) come fattore prognostico negativo associato a maggiore necessità di steroido-terapia e a fallimento di terapia con NIMV durante la riacutizzazione di BPCO.

E **in Geriatria**?

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

## Diaphragmatic muscle thickness in older people with and without sarcopenia

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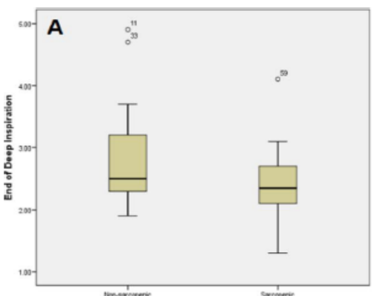


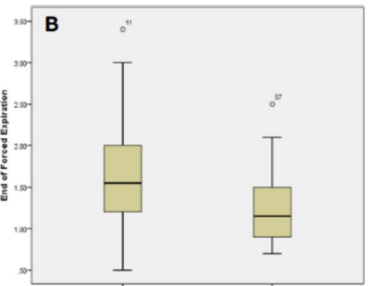


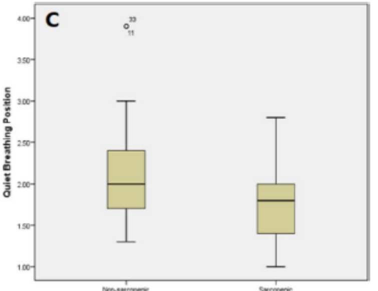


**Fig. 2** Comparison of the diaphragmatic muscle thickness in each position. Graphics of the diaphragmatic muscle thickness in three positions in millimeter: **a** end of deep inspiration, **b** end of forced expiration, **c** quiet breathing position

**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** |

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Associazione della **motilità diaframmatica** in pazienti affetti da scompenso cardiaco acuto

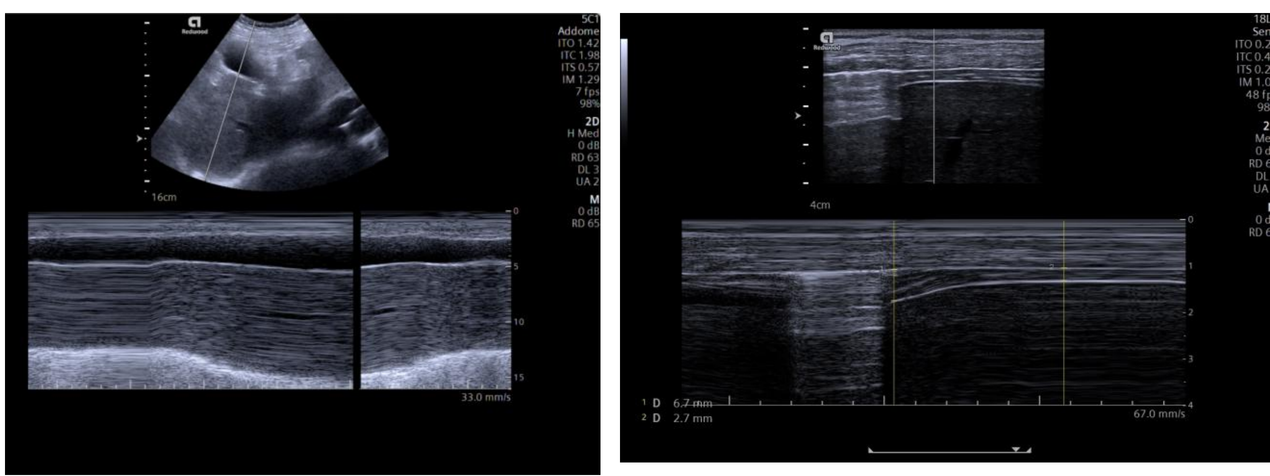


*Figure 1. Diaphragmatic excursion in M-Mode*

*Figure 2. Diaphgram tickness in inspirium and expirium on apposition zone*

**DIAPHRAGMATIC ULTRASOUND EVALUATION IN ACUTE HEART FAILURE: CLINICAL AND FUNCTIONAL ASSOCIATIONS.**

Simone Scarlata, MD,[1*] Evelyn Di Matteo, MD,[1] Panaiotis Finamore, MD,[1] Giuseppe Perri, MD[2] on behalf of the GRETA (gruppo di studio in ecografia toracica nell'anziano) research group endorsed by the Italian Society of Geriatrics and Gerontology (SIGG)

## Associazione della **motilità diaframmatica** in pazienti affetti da scompenso cardiaco acuto

- 72 patients (48% males) with HF showed a statistically significant diaphragmatic hypomotility versus controls at TLC (respectively 38.7 mm (SD 2.0) vs 60.9 mm (SD 14.4), p<0.001).
- Diaphragmatic motion was inversely associated with NYHA score and inversely correlated with PAP with a beta score of -0561 (p-value=0.02), still significant after adjustment for potential confounders (β=-0.499; p-value=0.05)

| | Total (n°=172) | No HF (n°=100) | HF (n°= 72) | p-value |
|---|---|---|---|---|
| Diaphragmatic motion mean (SD) (mm) | 51.4 (12.9) | 60.9 (14.4) | 38.7 (17.1) | <0.001 |
| Class NYHA I-II (n°= 41) | | | 41.5 (16.0) | <0.001 |
| Class NYHA III (n°= 25) | | | 35.4 (19.1) | <0.001 |
| Class NYHA IV (n°=6) | | | 33.4 (12.9) | <0.001 |
| Diaphragm thickness at FRC (mm) | 2.2 (0.3) | 1.8 (0.4) | 2.7 (0.1) | <0.001 |
| Diaphragm thickness at TLC (mm) | 3.1 (0.4) | 2.6 (0.5) | 4.1 (0.2) | <0.001 |
| Diaphragmatic thickness ratio | 1.5 (0.3) | 1.5 (0.2) | 1.5 (0.04) | -- |

**DIAPHRAGMATIC ULTRASOUND EVALUATION IN ACUTE HEART FAILURE: CLINICAL AND FUNCTIONAL ASSOCIATIONS.**

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# Integrated Lung, Diaphragm and Lower Limb Muscular Ultrasound: Clinical Correlations in Geriatric Patients with Acute Respiratory Illness

Nicoletta Cerundolo [1,2], Carmine Siniscalchi [1], Chukwuma Okoye [2,3,4], Simone Scarlata [2,5,6], Alberto Parise [1], Martina Rendo [7], Angela Guerra [1,8], Tiziana Meschi [1,8], Antonio Nouvenne [1,2,8] and Andrea Ticinesi [1,2,8,*]

**Results**:

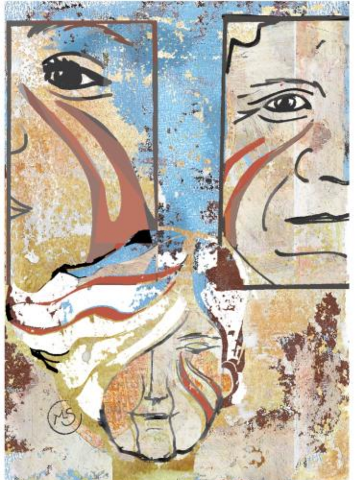
- All patients exhibited multifactorial causes of respiratory symptoms.
- The LUS score on T0 predicted 3-month rehospitalization.
- Frail patients exhibited higher LUS scores on T1.
- Diaphragm excursion on T0 was reduced in patients with COPD and heart failure and in those developing delirium during hospitalization.
- Diaphragm excursion on T1 was negatively associated with PC-FI.
- Diaphragm thickness, RVL thickness, and CSA exhibited a positive association with obesity.
- Right vastus lateralis CSA on T1, however, was also negatively associated with PC-FI.

Diagnostics **2025**, 15, 87

# Risultati preliminari

**Caratteristiche del campione**

| Variables | All patients | Diaphragmatic excursion | | Diaphragmatic thickening fraction | |
|---|---|---|---|---|---|
| | | Normal | Pathological | Normal | Pathological |
| N (n; %) | n=127 | n=78 | n=49 | n=75 | n=52 |
| Age (mean; SD) | 74.0 (10.9) | 73.3 (9.7) | 75.3 (12.6) | 72.3 (10.8) | 76.6 (10.7) |
| Sex (F) (n; %) | 68 (53.5) | 35 (44.9) | 33 (67.3) | 34 (45.3) | 34 (65.4) |
| BMI (mean; SD) | 28.7 (8.1) | 29.6 (8.9) | 27.2 (6.6) | 29.5 (8.1) | 27.6 (8.3) |
| CCI (mean; SD) | 5.5 (2.4) | 5.4 (2.3) | 5.5 (2.6) | 5.4 (2.6) | 5.6 (2.2) |
| ADLs (mean; SD) | 3.5 (2.2) | 3.7 (2.1) | 3.3 (2.2) | 3.8 (2.1) | 3.1 (2.2) |
| IADLs (mean; SD) | 3.4 (2.8) | 3.8 (2.7) | 2.8 (2.9) | 3.8 (2.9) | 2.9 (2.6) |
| MNA (mean; SD) | 16.9 (5.5) | 17 (5.8) | 16.8 (5.3) | 17.5 (5.8) | 16.1 (5.1) |
| NRS (mean; SD) | 2.6 (1.4) | 2.4 (1.4) | 2.8 (1.2) | 2.4 (1.4) | 2.7 (1.2) |
| MUST (mean; SD) | 2.5 (1.5) | 2.3 (1.6) | 2.7 (1.3) | 2.4 (1.4) | 2.6 (1.6) |
| SNAQ (mean; SD) | 13.6 (2.7) | 13.8 (2.7) | 13.2 (2.8) | 13.7 (2.6) | 13.4 (2.9) |
| MST (mean; SD) | 2 (1.7) | 1.9 (1.7) | 2.2 (1.7) | 2.1 (1.7) | 1.8 (1.7) |
| HGS (Kg) (mean; SD) | 19.7 (8.8) | 21.4 (8.2) | 17 (9.1) | 22.3 (8.9) | 15.9 (7.2) |
| pO2/FiO2 (%) (mean; SD) | 195.8 (77.5) | 196 (76) | 195 (80) | 204.3 (79.1) | 183.6 (74.3) |
| NIMV (n; %) | 75 (59.1) | 45 (57.7) | 30 (61.2) | 45 (60) | 30 (57.7) |
| Malnutrition (n; %) | 74 (59.7) | 40 (53.3) | 34 (69.4) | 35 (47.3) | 39 (78.0) |
| Sarcopenia (n; %) | 67 (52.8) | 36 (46.2) | 31 (63.3) | 35 (46.7) | 32 (61.5) |



17·20 Dicembre 2025 Napoli

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# Ecografia diaframmatica

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