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FOCUSED EVALUATION WITH ULTRASOUND IN THORACOABDOMINAL TRAUMA

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Abstract: Introduction: The FAST protocol (Focused Assessment with Sonography for trauma), is called a focused assessment protocol with ultrasound for trauma, it is recommended by the international panel of advanced life support for trauma (ATLS) in the resuscitation of patients with open trauma and/or closed chest or abdomen, the patient's stability is not a limitation of said protocol, and it can be applied to both hemodynamically stable and unstable patients, applicable to thoracoabdominal trauma. **Goal:** to identify the sonographic criteria in the evaluation focused with ultrasound in thoracoabdominal trauma, through the analysis of scientific articles on evidence-based medicine, for timely care in daily medical practice. **Methodology:** Descriptive study, based on a systematic bibliographic review, the analysis of scientific articles from various evidence-based medicine journals with a high impact on health (Pubmed, Scopus, Cochrane, Springer, etc.) was carried out; of the last 5 years in progress, and literature of surgery and trauma, with the processing of scientific information in Mendeley. **Conclusion:** Because the effectiveness of the FAST protocol is operator dependent, it is important that all health personnel in the prehospital and hospital settings, directly related to the emergency service, know and adequately identify the sonographic patterns or criteria in the evaluation focused on ultrasound. for thoracoabdominal trauma, in order to obtain better sensitivity and specificity of the radiological study and make appropriate and early decisions to reduce patient morbidity and mortality.

Keywords: Trauma, Ultrasonography, Emergency, eFAST, thoracoabdominal trauma.

INTRODUCTION

Thoracoabdominal trauma is called all trauma and/or injury to the thorax and abdomen together with the expression of a lesion of the diaphragmatic muscle or diaphragm, this can be of a closed or open mechanism depending on the type or mechanical energy applied to the thoracoabdominal region (Long & April, 2019).

The FAST protocol (Focused Assessment with Sonography for trauma), is called a focused assessment protocol with ultrasound for trauma, it is recommended by the international panel of advanced life support for trauma (ATLS) in the resuscitation of patients with open trauma and/or closed (Azócar Ceballos & Vásquez Stuardo, 2021).

The purpose of FAST, as an auxiliary protocol for the primary evaluation of trauma patients, is the ultrasound scanning of three main cavities or body spaces: pericardial, pleural, and peritoneal cavities; by probing four fundamental areas that are: pericardial window, right upper quadrant window, left upper quadrant window and pelvic window (Gómez Montes & Trillo Fernández, 2019).

The ultrasound recognition or identification of the free fluid collection is performed, which could immediately translate into a hematic (blood) collection in patients with acute trauma, in the aforementioned body cavities (Gómez Montes & Trillo Fernández, 2019).

According to the World Health Organization (WHO), severe trauma has morbidity; in mortality it is the sixth cause and in physical disability it is the fifth cause worldwide, with the population under 40 years of age being the main people affected by severe trauma, mainly due to traffic accidents, up to 60% of polytraumatized patients (González et al., 2019). The population over 65 years of age is concerned about its mortality in relation to severe trauma, due to its high comorbidity and associated nosological entities, which complicates adequate therapeutic management (Lee et al., 2019).

It is estimated that global global mortality is approximately 3.5 million deaths at the expense of serious injuries, and nearly 50 million people injured annually; of which the greatest impact at a social, economic and health level is found in developing countries, especially Latin America, with about 90% of deaths and/or injuries worldwide, takes place in this geographical territory, according to the report of the Pan American Health Organization (PAHO) (Lee et al., 2019).

In Ecuador, the report of the Ecuadorian Institute of Statistics and Censuses (INEC); In 2018, injuries were reported as the second cause of morbidity at the country level, and in 2020, land transport accidents or traffic accidents were reported as the ninth cause of mortality in the country with 2,286 deaths (2.2%), with ischemic heart diseases with 15,639 (13.5%) and COVID-19 with 15,490 (13.4%) being the main causes of mortality (National Institute of Statistics and Censuses, 2021).

The focused evaluation protocol with ultrasound for trauma is a very useful tool as an annex to the primary evaluation in polytraumatized patients according to advanced life support for trauma, which can be extended and applied both in the prehospital and hospital setting, it does not have limitations according to the hemodynamic stability of the patient; however, a major limitation of said FAST protocol is the experience and radiological interpretation of the explorer, for which the experience of the examining physician is directly proportional to the result of the ultrasound evaluation (Lee et al., 2019).

FAST is an easily accessible, economical and valuable protocol in emergency services, which, when applied correctly and with qualified medical personnel for its implementation and interpretation, can determine target organ lesions with quality and speed. in thoracoabdominal trauma, being able to apply an effective clinical-surgical therapeutic management and with the necessary promptness, with the fundamental objective of improving the quality of life of the population, avoiding complications and/or deaths of patients with trauma (Lee et al., 2019; Liang et al., 2021; Sellon et al., 2021).

The objective of this systemic bibliographic review is to identify the sonographic criteria in the evaluation focused with ultrasound in thoracoabdominal trauma, through the analysis and synthesis of evidence-based medicine, for timely care in daily medical practice.

DEVELOPMENT

Trauma is defined as any injury resulting from any acute exposure of any type of energy (chemical, mechanical, radiant, electrical or thermal) at levels that exceed the physiological threshold of the human being, and as a result an injury occurs at the organic level of severe nature (Galvagno et al., 2019).

Thoracoabdominal trauma is called all trauma and/or injury to the thorax and abdomen with injury to the diaphragmatic muscle or diaphragm, this can be of a closed or open mechanism depending on the type or mechanical energy applied to the thoracoabdominal region (Recaséns et al., 2020).

FAST is called a focused evaluation protocol with ultrasound for trauma, the same one that evaluates the main body cavities, through different windows of ultrasound vision (Kornblith et al., 2022).

The review of patients with acute injuries and/or traumas are evaluated by health personnel, who are in charge of implementing various measures to preserve the patient's life, since time in the setting of acute trauma is crucial. The initial evaluation protocol must be applied quickly and with quality, to reduce mortality and/or complications in trauma patients (American College of Surgeon, 2020).

PROTOCOL: FAST

The FAST protocol (Focused Assessment with Sonography for trauma) is recommended by the international panel of advanced life support for trauma (ATLS) in the resuscitation of patients with open and/or closed trauma, the stability of the patient is not a limitation of said protocol. protocol, which can be applied to both hemodynamically stable and unstable patients (American College of Surgeon, 2020; Bautista-Parada & Bustos-Guerrero, 2022; Galvagno et al., 2019; Gómez Montes & Trillo Fernández, 2019; Richards & McGahan, 2017).

The purpose of FAST, as an auxiliary protocol for the primary evaluation of trauma patients, is the ultrasound scanning of three main cavities or body spaces: pericardial, pleural, and peritoneal cavities; by probing four fundamental areas that are: pericardial window, right upper quadrant window, left upper quadrant window, and pelvic window (American College of Surgeon, 2020; Bautista-Parada & Bustos-Guerrero, 2022; Gómez Montes & Trillo Fernández, 2019; Kornblith et al., 2020; Richards & McGahan, 2017).

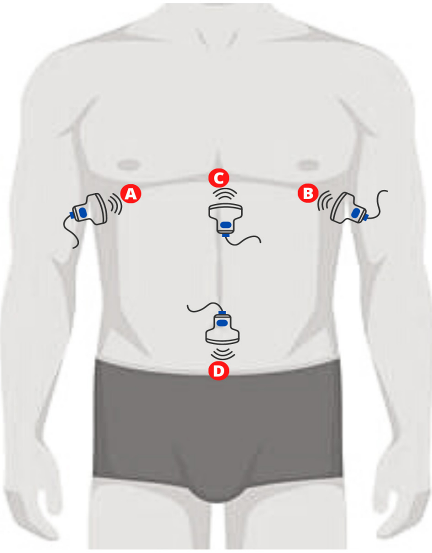

Figure 1: *Ultrasound windows in the FAST protocol. A: upper right quadrant window; B: upper left quadrant window; C: pericardial window; D: pelvic window.*
Elaborated: Authors
Source: Kornblith AE, Addo N, Plasencia M, Shaahinfar A, Lin-Martore M, Sabbineni N, et al. Development of a Consensus-Based Definition of Focused Assessment with Sonography for Trauma in Children. JAMA Netw Open. 2022;5(3):1–15. Available from: https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2790260

The ultrasound recognition or identification of the free fluid collection is performed, which could immediately translate into a hematic (blood) collection in patients with acute trauma, in the aforementioned body cavities (Fornell Pérez, 2017).

FAST ultrasound has an acceptable sensitivity of 69 to 98% for the detection of free fluid collection and 63% sensitivity in solid organ injury; it has a specificity of around 94 – 100% for the detection of free fluid and solid organ damage (Christian et al., 2018).

Fluid volumes from 100ml collected at the abdominal level (hemoperitoneum), can be detected with ultrasound assessment, and at the thoracic level from 5ml can be observed (hemothorax and pleural effusion), however, this is directly proportional to the operator's capacity (Monti & Perreault, 2020).

It is an easy, versatile and comfortable protocol to perform both in the pre-hospital area, and hospital both in the emergency, resuscitation or ICU (intensive care unit) area, it does not require patient mobilization, it can be applied by any medical personnel trained, with adequate training and knowledge (Kornblith et al., 2020).

An inexpensive, non-invasive tool for the patient and repeatable as many times as necessary in order to offer the most accurate diagnosis possible, and can be applied to any patient population, including the pediatric, geriatric and pregnant population (Muñoz Andrade et al, 2021).

- **Technique**

Adequate ultrasound scanning must not take more than 4 min in its evaluation, since we are in an emergency setting and time is limited (Nixon et al., 2019). For evaluation of the thoracic and abdominal regions, including the subxiphoid window, an ultrasound machine with a 3- to 5-MHz transducer is needed; for more specific scanning of the thoracic window, the ideal is to use a high-frequency transducer, however, if this is not available at the time, the low-frequency one is used as an alternative (Savatmongkorngul et al., 2017).

Within the FAST protocol, 4 windows are mainly identified, which:

- Right upper quadrant or hepatorenal window
- Left upper quadrant or splenorenal window
- Pelvic window
- Pericardial or subxiphoid window

Likewise, an Extended FAST (eFAST) protocol can be carried out, where the following is added:

- Pulmonary windows.

The right upper quadrant is the most suitable location to find free fluid with the FAST technique, which must be directed with a frequency of 3.5 to 5 MHz or use a curved array transducer (Richards & McGahan, 2017). It is necessary to use a sector transducer with optimized far-field technology, since it favors penetration, giving greater range in the deep pelvis and hepatorenal fossa; For optimization and a deeper reach, it is recommended to use a curved matrix transducer (Gómez Montes & Trillo Fernández, 2019).

For the exploration of the hepatorenal space and liver parenchyma, the ideal is to direct the transducer towards the liver since it will serve as an acoustic window (Mera Cáceres et al., 2020). When identifying the hemoperitoneum, a hypoechoic or anechoic image is usually observed. This is the characteristic that differentiates it from adjacent organs that are of solid consistency; if there is prolonged bleeding, an image with increased echogenicity is obtained (González et al., 2019).

In the exploration of the left upper quadrant, the main organ to focus on is the spleen accompanied by the perisplenic area and the splenorenal fossa; To have a focus on the pleural space, it is necessary to perform a cephalic exploration, and in the caudal direction the paracolic canal and the lower area of the left kidney can be observed (Lee et al., 2019).

When exploring the splenic area, it is necessary to turn the patient to the right side, as this will facilitate visualization in the upper part of the spleen, since small amounts of free fluid usually accumulate there, which makes access difficult in the supine position(Gottlieb et al., 2019; Liang et al., 2021; Sellon et al., 2021).

A suprapubic view is preferable for a correct evaluation of the peritoneal cavity (Leonel Mendoza-Neira et al., 2019). The placement of the transducer is directed in the sagittal plane above the pubic symphysis and it is scanned from side to side, to later repeat this maneuver, but transversely. To detect if there is free fluid in the pelvic region, it is necessary to place the patient in the reverse Trendelenburg position (Schellenberg et al., 2018).

The fornix of Douglas will be assessed taking into account the age and sex of the patient, since in women of childbearing age free fluid can be found in amounts of up to 50 ml because it is physiologically normal, if amounts higher than this are found, it is must be considered pathological after trauma; In men, regardless of age, if there is no pathology or lesion present, no free fluid must be found when exploring the gallbladder rectum space (Durso et al., 2020).

To facilitate the visualization of free fluid in the pelvic cavity, it is ideal for the bladder to be filled with fluid or for the bladder to be distended; and when there is free fluid, it is located in the posterior or upper part of the bladder or uterus in the case of women (Monti & Perreault, 2020). This can be interrupted in the detection of free fluid when the patient is previously placed a bladder catheter and the bladder is completely emptied, and if there is a compromise of the acoustic window it can only be detected if it occupies large amounts of free fluid (Carrera Sieiro JC et al., 2020).

Another of the important areas to detect liquid is in the subxiphoid region of the heart, in this, instead, the transducer is placed pointing upwards and towards the left muster in the upper part of the abdomen; an anechoic space can be found surrounding the myocardium or there may also be involvement of the ventricle, there may be confusion when detecting fluid in the posterior pericardial space due to the presence of fluid in the posteromedial pleural cavity, but in order to correctly differentiate it must be taken as reference to the descending aorta, if the pleural fluid is located in the posterior part of the descending aorta, while the pericardial fluid is located in the anterior part of it (Kornblith et al., 2020).

The pericardial cyst, a fat pad or a pre-existing effusion can give false positive results in the diagnosis of hemopericardium (Azócar Ceballos & Vásquez Stuardo, 2021). A limitation to explore the subxiphoid pericardial area is the presence of a suboptimal acoustic window, and for this it is necessary to increase the depth of view or explore left parasternal longitudinally and be able to locate pericardial fluid (Muñoz Andrade et al., 2021).

- **Ultrasound windows.**
- **Pericardial window.**

The aim is to evaluate the evidence of cardiac tamponade and, failing that, cardiac contractility, when assessing the pericardium (Mercer et al., 2021).

Using the liver as an acoustic refraction window, the transducer is placed at the subxiphoid level, and a left parasternal window can also be chosen in case of limitations (pain, poor window, or distension) (Riera et al., 2021).

The pericardium must not be visualized under physiological conditions, and in the case of any pathological condition, a fluid collection will be observed in the pericardium (Ianniello et al., 2021).

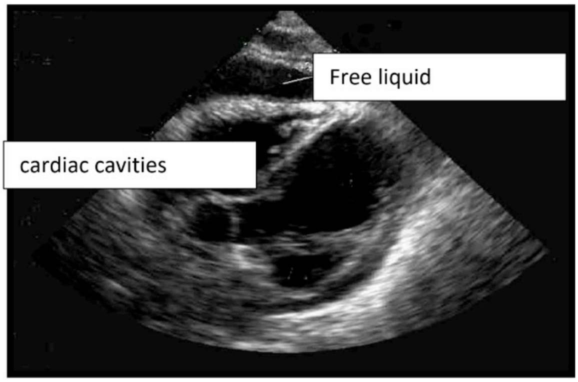

Figure 2: *Pericardial window – free fluid in the pericardial space.*

Source: Gómez Montes C, Trillo Fernández C. Ecografía en urgencias: E - FAST. Emergencias. 2019;23(6):498.

Available from: https://www.samfyc.es/wp content/uploads/2019/08/v20n1_AE_eFast.pdf

- **Right upper quadrant**

Its usefulness is to assess the hemoperitoneum, evaluating the hepatorenal space, Morrison space, and the right lung base (Ianniello et al., 2021).

At the level of the 7th and 8th costal arch in the right midaxillary line, the transducer is placed to evaluate this window. A hemothorax could be evidenced with proper identification of the diaphragm (Hempel et al., 2021).

The Trendelenburg position could facilitate the visualization of the liquid collection in the Morrison space, which is evidenced by an anechoic image (Kornblith et al., 2022).

The right pleural effusion could be evaluated with this window, which is evidenced as an anechoic image in the right lung base, behind the diaphragm (Long & April, 2019).

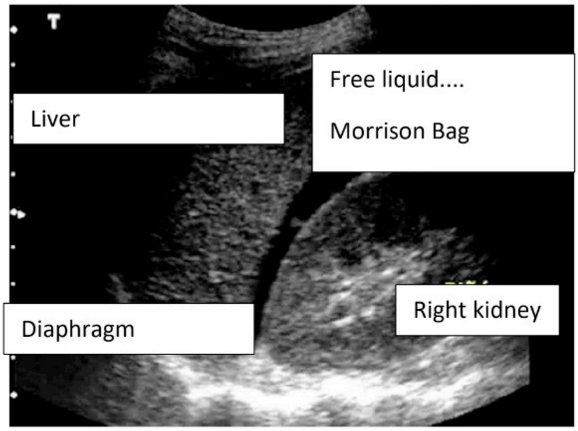

Figure 3: *Right upper quadrant window – Free fluid in Morrison bag.*
Source: Gómez Montes C, Trillo Fernández C. Ecografía en urgencias: E - FAST. Emergencias. 2019;23(6):498.
Available from: https://www.samfyc.es/wp content/uploads/2019/08/v20n1_AE_eFast.pdf

- **Left upper quadrant**

The hemoperitoneum is the main thing that evaluates this window, with the spleen being the organ that serves as the acoustic window. The spleen, ipsilateral parietocolic gutter, splenorenal space, and left lung base are evaluated (Akoglu et al., 2018).

Between the 7th and 8th costal arch, at the level of the left posterior axillary line, the transducer must be placed, as this window is the most difficult to visualize (Elbaih & Abu-Elela, 2017).

The anechoic image in the splenorenal space shows liquid collection in said space, which points towards a hemoperitoneum (Elbaih & Abu-Elela, 2017).

An anechoic image after the diaphragm at the level of the left lung base defines a possible left pleural effusion (Elbaih & Abu-Elela, 2017).

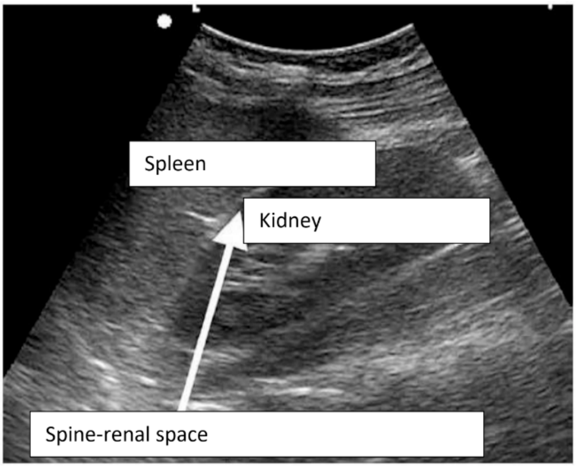

Figure 4: *Left upper quadrant window – Splenic space - renal*
Source: Gómez Montes C, Trillo Fernández C. Ecografía en urgencias: E - FAST. Emergencias. 2019;23(6):498.
Available from: https://www.samfyc.es/wp content/uploads/2019/08/v20n1_AE_eFast.pdf

- **Pelvic or suprapubic window**

The liquid collection at the pelvic level is what this window mainly evaluates. It is recommended to keep the bladder full to have a more reliable result (Fornell Pérez, 2017).

Performing an orientation in the longitudinal and transverse axis, the transducer is placed suprapubic level (Stengel et al., 2020).

The fornix of Douglas can be visualized in women and the vesicorectal space in men; Physiologically, minimal amounts of fluid (anechoic image) can be found at the level of the bottom of the Douglas bag, approximately 50ml. If it exceeds this amount, it is considered pathological, and it could be mainly due to hemoperitoneum (Calder et al., 2017).

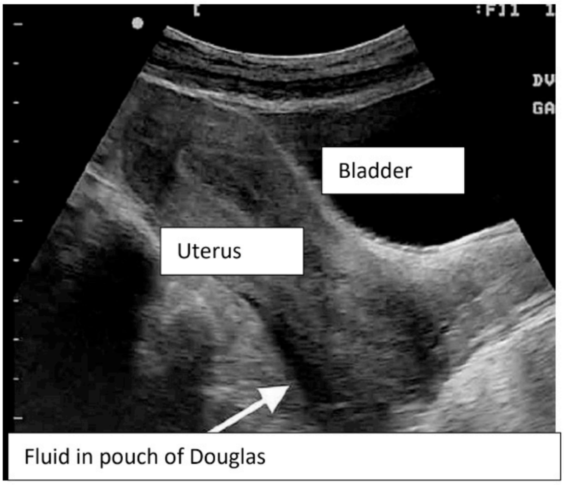

Figure 5: *Pelvic window – Free fluid in the pouch of Douglas.*
Source: Gómez Montes C, Trillo Fernández C. Ecografía en urgencias: E - FAST. Emergencias. 2019;23(6):498.
Available from: https://www.samfyc.es/wp content/uploads/2019/08/v20n1_AE_eFast.pdf

- **Lung windows**

In assessing the pulmonary windows, a 10 MHz transducer is explored on both sides, at the level of the upper pectoral region, looking for conclusive signs of hemothorax and pneumothorax; If a transducer with the indicated frequency is not available, it can be performed with a universal transducer (Christian et al., 2018).

Strategic ultrasound cuts are made in the pulmonary window to be able to issue a complete scan report; in the mid-clavicular line, in the second intercostal space, in the fourth intercostal space at the level of the anterior axillary line, in the sixth intercostal space at the level of the mid-axillary line, and in the eighth intercostal space at the level of the posterior axillary line (Zanobetti et al., 2018).

Modes B and M must be evaluated in the pulmonary window, to maintain greater sensitivity of the study (Zieleskiewicz et al., 2018).

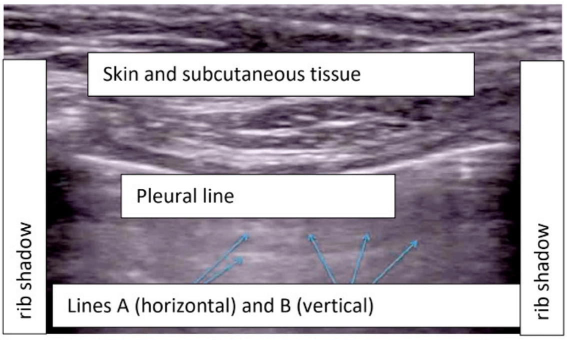

Figure 6: *Pulmonary window – Skin, subcutaneous tissue, pleural line, lung A and B lines.*
Source: Gómez Montes C, Trillo Fernández C. Ecografía en urgencias: E - FAST. Emergencias. 2019;23(6):498.
Available from: https://www.samfyc.es/wp content/uploads/2019/08/v20n1_AE_eFast.pdf

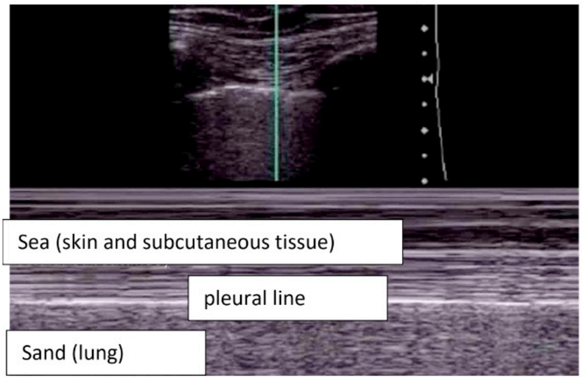

Figure 7: *Pulmonary window – Sea (skin and subcutaneous tissue), pleural line, sand (lung).*
Source: Gómez Montes C, Trillo Fernández C. Ecografía en urgencias: E - FAST. Emergencias. 2019;23(6):498.
Available from: https://www.samfyc.es/wp content/uploads/2019/08/v20n1_AE_eFast.pdf

To identify the findings that are found in pneumothorax, the ultrasound machine must be in M Mode, this function allows to identify the B lines or also called comet tail that is considered normal, the absence of B lines also indicates the presence of pneumothorax, In addition, images suggestive of pleural slippage are observed. This is called the sea sand sign or the beach sign. In the event that such slippage exists, the presence of pneumothorax is ruled out. but in the absence of pleural sliding it is interpreted as pneumothorax and is described as the barcode sign (Calder et al., 2017).

The presence of free fluid in the pleural cavity at the level of the lung bases is oriented towards a diagnosis of hemothorax (Christian et al., 2018).

The absence of line B, barcode sign in the M mode, absence of pleural displacement, and the presence of the lung point, are the ultrasound criteria of pneumothorax (Zanobetti et al., 2018).

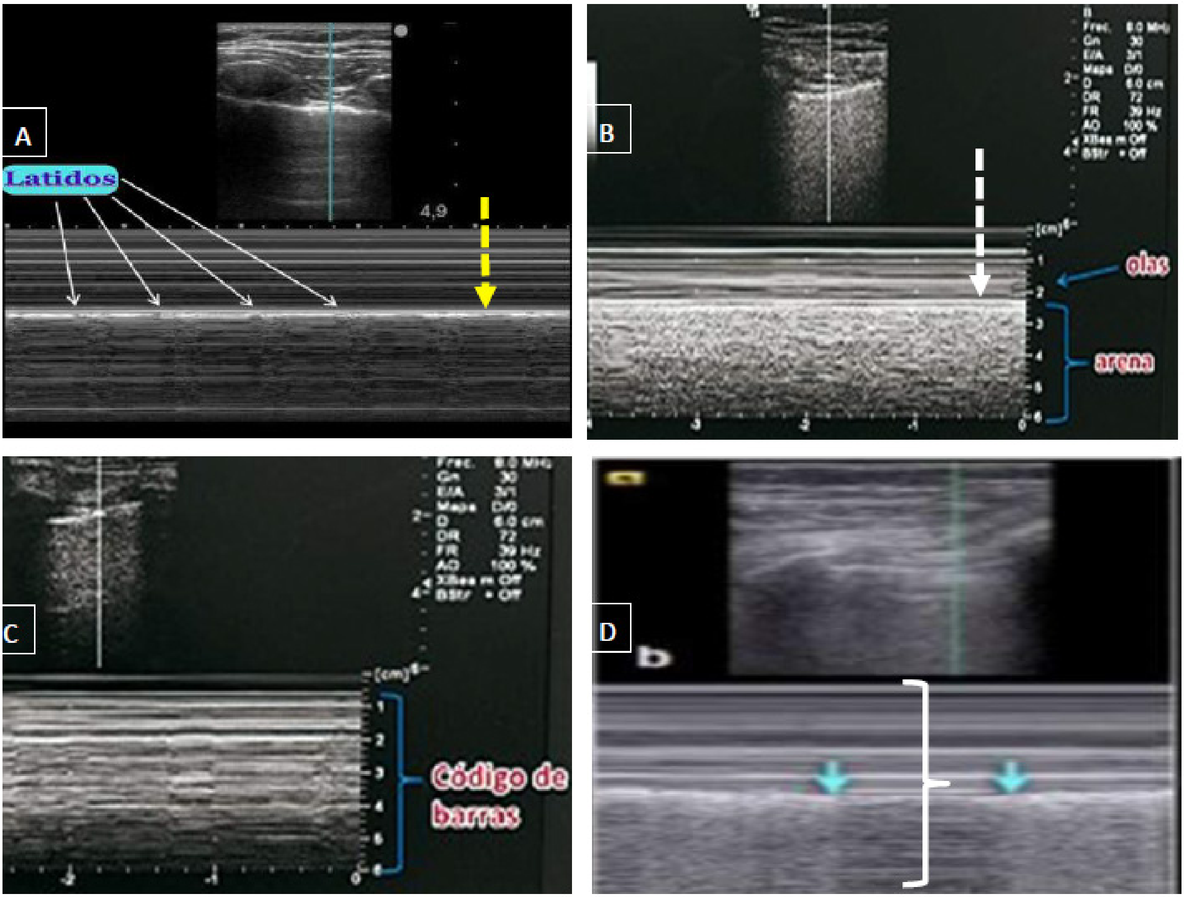

Figure 8: *Pulmonary window – A: Pulmonary pulses (white arrows) below the pleural line (dotted yellow arrow) are identified. B: Sign of the "beach or seashore": the pleural line is identified (dotted white arrow), the sign of the "waves" or sea above (blue arrow) and the sign of the "sand" below (brackets). blue). C: Sign of the "stratosphere" or "barcode" (blue bracket) where an alteration of the sign of the beach is evident, turning the granular pattern into a linear one. D: Sign of the "stratosphere" or "barcode" (white bracket) between the pulmonary points (blue arrows), where an alteration of the sign of the "beach" is identified, turning the granular pattern into a linear one.*

Source: Leonel Mendoza-Neira R, Angel Villena-Ruiz M, Alfredo Triveño-Rodríguez L, Ernesto Uriol-Valverde R, Erick Lino-González Y, Elmer Gamarra-Sánchez J, et al. Evaluación por Ecografía Focalizada en Trauma-FAST. Rev méd Trujillo. 2019;14(1):11–32.

Available from: https://revistas.unitru.edu.pe/index.php/RMT/article/view/2354/2229

- **Inferior vena cava**

In patients without mechanical ventilation and with mechanical ventilation, but without positive pressure, ultrasound of the inferior vena cava (IVC) can be used, based on the degree of inspiratory collapse and its diameter (Maldonado De Caceres, 2022).

The IVC has a physiological expiratory diameter in hemodynamically stable patients ranging from 1.5 to 2.5cm, said diameter collapses up to 50% during inspiration (Maldonado De Caceres, 2022).

In polytraumatized patients, ultrasound assessment of the IVC is useful, in order to determine the patient's hemodynamic stability, being able to establish a volume depletion correctly. This interpretation is based on inspiratory diameters of the IVC <1.5cm, which would be interpreted as such as volume depletion and risk of circulatory collapse in multiple trauma patients (Gómez Montes & Trillo Fernández, 2019; Lee et al., 2019; Maldonado De Caceres, 2022; Nixon et al., 2019)

The limitation with the greatest predominance and clinical importance in the medical field is the effective result with operator dependence, that is; It is an operator-dependent technique, whose greater sensitivity and specificity is based on the knowledge and experience of the operating physician (Akoglu et al., 2018; Kornblith et al., 2020; Long & April, 2019, 2019; Mercer et al, 2021; Muñoz Andrade et al., 2021; Recaséns et al., 2020).

It has a low sensitivity in the detection of solid organ lesions, since its usefulness and evaluation is primarily for the identification of fluid collection at the level of the pericardial, abdominal, and pelvic cavities; and said liquid collection limits the visualization of solid organ lesions (Christian et al., 2018; Zanobetti et al., 2018; Zieleskiewicz et al., 2018).

Overweight and obesity, due to the accumulation of visceral fat in these patients, makes it difficult to adequately visualize the different windows applied in the FAST protocol, which decreases the sensitivity and specificity in these patients in particular (Bautista-Parada & Bustos- Guerrero, 2022; Schellenberg et al., 2018).

False positives can be obtained in certain patients with superadded pathological conditions such as: ascites, ruptured ovarian cyst, peritoneal dialysis, peritoneal dialysis, among others (Fornell Pérez, 2017; González et al., 2019; Savatmongkorngul et al., 2017; Stengel et al., 2020).

CONCLUSION

Ultrasound in the emergency service is a very useful, innocuous, reproducible and economical tool, which provides great benefit to the evaluation of multiple trauma patients, improving the quality of the diagnostic approach and early decision-making in therapeutic management. clinical – surgical.

The FAST and eFAST protocol are tools that have revolutionized initial care in the emergency department in advanced life support in trauma, with the ultrasound evaluation of the thoracic, abdominal and pelvic cavities, it has been shown that the response time of the patient substantially decreases. health team, in the face of trauma, which directly influences the reduction in the time to make timely decisions, implementing the corresponding surgical interventions early, decreases the length of hospital stay of patients, reduces costs and complications.

An anechoic image at the level of any ultrasound window evaluated with FAST or eFAST is highly suggestive of the presence of fluid collection (hemorrhage) at that level (>5ml in the pleural space, and >100ml in the abdominal cavity): pericardial window (hemopericardium), right upper quadrant window or hepatorenal (hemoperitoneum), left upper quadrant or splenorenal window (hemoperitoneum), pelvic window (hemoperitoneum), such an effective interpretation allows opting for early surgical treatment and reducing mortality and complication of the patient with thoracoabdominal trauma.

At the level of the pulmonary or thoracic window itself, which is established in the eFAST protocol, we can find key ultrasound criteria, such as: the absence of B lines, absence of pleural sliding, presence of the pulmonary point and the code sign. Barcode in M-Mode: Indicates evaluation of a pneumothorax. The presence of an anechoic image in the pleural space indicates a pneumothorax.

Because the effectiveness of the FAST protocol is operator dependent, it is important that all health personnel in the prehospital and hospital settings, directly related to the emergency service, know and adequately identify the sonographic patterns or criteria in the evaluation focused on ultrasound. for thoracoabdominal trauma, in order to obtain better sensitivity and specificity of the radiological study and make appropriate and early decisions to reduce patient morbidity and mortality.

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