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THE USE OF LUNG ULTRASOUND IN EMERGENCY MEDICINE - ULTRASOUND PROTOCOLS AND POCUS

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ABSTRACT

Introduction: The development of ultrasound has led to an increase in its popularity and use in various medical fields. Emergency medicine, in particular, has enthusiastically adapted it to its needs by developing various examination protocols and diagnostic pathways, known as protocols, which allow for the rapid and effective diagnosis of life-threatening conditions.
Methods: This paper describes some of the emergency protocols we use in our work, along with our experiences. It also reviews the literature for various types of ultrasound protocols, and then selects those that include imaging of the lungs and pleura.
Results: The development of lung ultrasound has been extremely turbulent and controversial over the years, so this paper also serves as evidence of its very high usefulness in the diagnosis of life-threatening conditions. Ultimately, 19 protocols were selected, developed, and presented in the paper in terms of their method of execution, capabilities, popularity, and limitations.
Conclusions: Based on the review, it can be concluded that ultrasound protocols are very popular in medicine and their use allows for shortening the diagnostic time and, consequently, improving the patient's prognosis.

KEYWORDS

Lung, Ultrasound, Emergency, Pocus

CITATION

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Introduction

Emergency medicine is one of the most dynamic and demanding medical specialties. Caring for a patient in a life-threatening condition requires quick and decisive action, often based on scant clinical data. The repertoire of diagnostic and therapeutic tools is theoretically broad, but in practice, very limited, which is dictated by the patient's condition, insufficient equipment (lower-tier hospitals), or the conditions in which emergency medical teams are deployed. An additional problem is systemic limitations related to the shortage of medical personnel and the unavailability of certain medications [1]. Therefore, the history and physical examination remain the undeniable pillars of diagnostics. The medical history, which constitutes the most valuable part of information about the patient, cannot be collected in the case of an unconscious patient or one with profoundly impaired consciousness. Reports from witnesses, the patient's family, medical records available in the hospital's IT system, etc., can be helpful.

A physical examination of the patient allows for further guidance in the treatment and expanded information about the patient. This includes, among other things, auscultation with a stethoscope, which can be difficult, especially in a hospital setting due to noise [2]. Additional tests are generally implemented during hospital care, but thanks to technological advancements, it is possible to perform an ultrasound examination using portable transducers paired with a smartphone or tablet. This allows for obtaining valuable clinical information about the patient and often determines further treatment and transport to a dedicated facility [3]. In emergency medicine, the time needed for medical intervention is particularly important, and unnecessary delays in treatment can determine the patient's survival. Taking all of the above-mentioned aspects into account, conducting a full ultrasound examination in accordance with current standards may prove to be too time-consuming and too detailed for the presented pathology. This created the need to modify the ultrasound examination so that the physician could obtain the necessary information about potential pathology in the shortest possible examination time, but without the need for high-quality ultrasound equipment or specialized software, and by developing projections that are relatively easy to obtain [4]. To achieve these assumptions, precise measurements and calculations were abandoned, as subtle differences in these measurements would not alter patient management. Furthermore, pathologies that destabilize the patient's condition are clearly visible on ultrasound, as their image differs dramatically from the norm. It was also decided to limit the use of additional functions, such as various Doppler functions. Another important step was the development of projections, i.e., positions of the transducer (and the corresponding image) that allowed for obtaining the maximum amount of information possible without examining the entire area. Ultimately, special ultrasound protocols were developed, dedicated to specific clinical situations [5]. They combined the previously mentioned features and allowed for a quick decision regarding further patient management. Another important feature of these protocols is their repeatability, as through training, in addition to experience, a certain automaticity is acquired, which proves to be particularly important in situations of high stress, as it allows for appropriate action with a reduced risk of error. Due to the widespread popularity of ultrasound protocols, it is currently difficult to estimate their exact number. Furthermore, they have become popular in many fields of medicine and are readily used in everyday medical practice [6].

Methods:

This work is based on an analysis of our own experience from several hundred ultrasound examinations and medical publications published between 2000 and 2023, describing ultrasound protocols along with the development of techniques and key information. A literature review was conducted using the databases Pubmed, EMBASE, and Google School. Each selected protocol was described in terms of equipment and technical requirements, method of execution, characteristics, and limitations.

Results:

FAST (Focused Assessment with Sonography for Trauma) is currently the most popular and best-described ultrasound protocol. It was developed for the rapid diagnosis of free fluid in body cavities in patients after high-energy trauma. It is performed using a convex transducer and involves obtaining four ultrasound views. The first is a substernal view, which is focused on imaging the heart to exclude fluid in the pericardial sac. The second view involves placing the transducer longitudinally near the right midaxillary line below/at the rib border to visualize the liver and right kidney in longitudinal sections, as well as the space between them, the so-called Morrison's recess, a common site of fluid accumulation, in a single scan. If there is a significant amount of pleural fluid, it will also be visible on this scan. The third projection is obtained after the contralateral positioning to visualize the spleen and kidney in a single scan (depending on the patient's anatomy, it may be necessary to place the transducer in the posterior axillary line). The space between them is called the splenorenal recess (also called Koller's recess in German-language literature). Similarly, in the case of fluid in the left pleural cavity, it will be visible in the obtained projection. The final, suprapubic projection involves transversely positioning the transducer to visualize the urinary bladder and, in women, the vesicorectal recess (the so-called cavity of Douglas). The finding of a significant amount of fluid in either cavity or free fluid is considered a”FAST positive" and, in the case of a hemodynamically unstable patient, is an indication for emergency laparotomy. The FAST protocol is considered highly effective, simple to implement, and has a favorable learning curve. Limitations primarily relate to the possibility that a small amount of fluid may be interpreted as a”FAST positive." False positive diagnoses occur primarily in patients who have not suffered high-energy trauma. Another limitation is chronic ascites, which prevents differentiation from traumatic bleeding. Caution should be exercised when examining small amounts of fluid in the pouch of Douglas in menstruating women, as it accumulates during this time [7-10].

eFAST (Extended Focused Assessment with Sonography for Trauma) is an extension of the traditional FAST protocol, with additional imaging of the pleural line at the level of the 3rd-4th intercostal space in the midclavicular line (i.e., at the highest point of the chest in a supine patient) on both sides. In a normal lung, the”sliding" sign is visible, while in M-Mode, the”seashore sign" is visible. In the case of pneumothorax, the sliding sign will be eliminated, which in M-Mode creates the”barcode sign, " which is multiple horizontal lines lying horizontally across the entire height. Using a linear transducer is recommended for performing a lung examination, but it is not necessary. During the examination, the absence of pleural sliding may indicate respiratory or ventilation arrest in a given lung; in such cases, attention should be paid to the so-called”barcode sign."“Lung pulsation, " or resonance of the heartbeats on the lung, visible as vertical disturbances in the aforementioned”barcode, " is a symptom that excludes pneumothorax. Other limitations are similar to those for the FAST examination [11-14].

BLUE (Bedside Lung Ultrasound in Emergency) was developed in 2008 by French intensive care specialist Daniel Lichtenstein. This protocol is almost entirely based on lung ultrasound and is intended for patients with acute respiratory failure. In its original version, Lichtenstein used a microconvex transducer, but a standard convex transducer is also acceptable. Before starting the examination, ensure that all image enhancement software is turned off or the dedicated"lung" preset is selected. The procedure involves placing the transducer perpendicular to the intercostal spaces at the so-called"blue points, " which are determined by placing the hand on the chest so that the fifth finger of the upper hand is positioned above the clavicle and the fingertips are on the midline of the sternum. The location of the blue points corresponds to the base between the third and fourth fingers (the upper point) and the middle of the other hand. The additional PLAPS point is the intersection of the posterior axillary line with the line intersecting the anterior inferior point. If vascular analysis is necessary, the lower limbs are examined at the bifurcation of the common femoral vein (in the inguinal region) and on the anterior surface of the lower leg (between the tibia and fibula). In lung ultrasound, A-lines are artifacts parallel to the pleura and indicate the presence of air (in the alveoli or pneumothorax). B-lines are vertical artifacts and indicate the presence of fluid in the alveoli or interstitium. An abnormal number of B-lines is considered when at least three appear in a single scan. C-lines indicate consolidation, i.e., a fragment of atelectatic lung. Profile determination involves identifying artifacts during the first four applications of the transducer to the chest. According to the author of the BLUE protocol, its diagnostic accuracy hovers around 90.5%, making it an extremely effective tool. Over the years, the BLUE protocol has become one of the most frequently implemented tools in patients with acute respiratory failure. Its effectiveness has been confirmed in numerous studies and has also served as the basis for the development of more complex ultrasound or clinical-ultrasound protocols. A serious limitation of the BLUE protocol is the frequent false-positive diagnosis of asthma or COPD exacerbation in patients without these conditions. This is most often related to the hasty implementation of the protocol for examining patients presenting only with mild dyspnea. Another limitation related to the specific nature of lung ultrasound is that it can only image lesions located subpleurally, thus preventing pathologies in the hilar region from being visualized. The number of applications that may cause pathologies located in other parts of the lung to be missed is controversial [15-19].

M-BLUE is a modification of the BLUE protocol, in which the authors added an additional point to the examination, the so-called M-point. Its determination involves determining additional points, the intersection of which forms the M-point. The diaphragmatic point is formed by the lung-liver or lung-spleen junction at the midaxillary line, while the M-point is located midway between the upper BLUE point and the diaphragmatic point. The PLAPS point (posterior-lateral alveolar process and/or pleural junction) is the intersection of the posterior axillary line and a vertical line extending from the M-point. It was developed for the purpose of testing for Covid-19. Compared to the classic BLUE protocol, it is very sparsely documented. Determining the M-point is complicated and time-consuming, and its significant added diagnostic value cannot be assessed based on available research. The remaining constraints are similar to those for the BLUE protocol [20].

FATE (Focus-Assessed Transthoracic Echocardiography) is the most popular and widely used cardiac ultrasound protocol. It was developed in 1989 by Erik Sloth and is intended for patients with hemodynamic instability. The examination is performed with a sector transducer and involves assessing the heart in four views and additionally assessing the pleural cavities. The examination begins with a substernal view, followed by an apical four-chamber view, a parasternal long-axis view, and a short-axis view. The final element of the examination is an assessment of the pleural cavities in the mid/posterior axillary line. The protocol enables rapid imaging of obvious cardiac pathologies such as pericardial effusion, significant atrial and ventricular dilatation, cardiac hypertrophy, ballooning thrombi, myocardial perforation, ascending aortic dissection, hypo- and akinesia, and pleural effusion. The FATE protocol provides a wealth of clinical information about the patient, but its serious limitation is the difficulty of execution. Obtaining appropriate echocardiographic projections is difficult and requires experience and training. In patients who are lying down (the optimal position for obtaining echocardiographic projections is the supine position with a left lateral tilt) and with a high body weight, obtaining appropriate scans can often prove impossible, rendering the examination non-diagnostic. This difficulty does not occur with pleural imaging [21-24].

FEEL (Focused Echocardiographic Evaluation in Life Support) is a protocol analogous to the FATE protocol, with the difference that it is used in patients with sudden cardiac arrest (SCA) undergoing resuscitation. The main goal of the FEEL protocol is to identify the cause of cardiac arrest without analyzing abnormalities that do not lead to SCA. It is significantly more difficult to implement because it is performed during chest compressions and during pauses for rhythm assessment. Most importantly, its use must not interfere with or delay the resuscitation process. It requires high precision, experience in echocardiography, and a well-cooperating emergency medical team. It should be emphasized that the FEEL protocol is an optional tool during resuscitation and must not interfere with the course of rescue procedures in any way [25-26].

RUSH (Rapid Ultrasound for Shock and Hypotension) is a comprehensive protocol dedicated to patients with shock and hypotension. It is traditionally performed with a sector transducer, but when possible, it is recommended to use all three most popular transducers (sector, convex, linear). The first application is performed with a sector transducer to obtain a parasternal long-axis and short-axis view. This is followed by an apical 4-chamber and substernal view. Next, the width and collapsibility of the inferior vena cava (IVC) are assessed; either a sector or convex transducer can be used for this purpose. The pleural cavities are assessed in the midaxillary line or on both sides of the posterior axilla (currently, a convex transducer is recommended). In the area of the 3rd-4th intercostal space in the midclavicular line, the pleural sliding sign and the potential presence of consolidation or parabasal fluid are examined. Next, the Morrison's recess, the splenorenal recess, the urinary bladder, and the abdominal aorta are assessed. Examination of the lower limb vessels is recommended using a linear transducer, and the first application should visualize the femoral artery and femoral vein. The last structure examined is the popliteal vein. The RUSH protocol provides valuable clinical information, but its proper execution is time-consuming. Furthermore, accurate assessment of multiple structures, along with their correlation with the patient's clinical presentation, requires appropriate experience. Another limitation is the need to use multiple transducers, which were not required in the original version of this protocol, but studies have shown that they significantly increase the diagnostic efficiency of the protocol [27-30].

COVUS is a point-of-care protocol for COVID-19, developed by a team from New York. It is based on a clinical-ultrasound decision algorithm, which includes lung ultrasound. It is performed by applying the transducer to the chest six times (three for each lung) and assessing the presence of consolidation, B lines, and pleural sliding. The protocol is extensive but has not gained widespread popularity (it has only been described in one original paper and is also mentioned in one review), so it will not be described in detail in this paper [31].

SESAME-protocol Developed by Daniel Lichtenstein and Manu Malbarin, this protocol is dedicated to the rapid search for selected reversible causes of cardiac arrest during resuscitation. The use of a convex and sectoral transducer is recommended for this examination and is divided into five steps. The first step involves excluding a tension pneumothorax by examining the slippage sign in the area of the third intercostal space in the midclavicular line. The second step involves assessing the femoral vein for thrombosis. The next step involves applying the transducer to the abdominal cavity to visualize potential free fluid (patients with potential post-traumatic bleeding). The fourth step involves assessing the pericardial sac from a substernal view to exclude tamponade. The fifth step requires switching to a sectoral transducer and imaging the heart for any visible pathology. As already mentioned, ultrasound examination during cardiac arrest is very difficult and requires high skill, but according to the authors, an experienced sonographer can complete the entire SESAME protocol in as little as 46 seconds. Another limitation is the need to change the transducer during the examination. Other limitations are typical of ultrasound examination in SCA [32].

The PEA (Pulseless Electrical Activity) protocol is another protocol implemented in patients undergoing resuscitation to identify reversible causes of cardiac arrest. According to the authors, it can also be used for peri-arrest diagnostics. The protocol assesses the lungs for pneumothorax or B-line, the pleural cavities for free fluid, and the heart in substernal, left, and right ventricular views, overall cardiac contractility, and inferior vena cava filling. The protocol also includes an assessment of the abdominal cavity, focusing on: the presence of free fluid, aneurysm perforation or abdominal aortic dissection, and intestinal perforation or obstruction, which is not assessed in other protocols. The deep veins of the lower extremities are also assessed. The PEA protocol is extensive and includes the assessment of many areas and organs, which, on the one hand, increases the chances of finding the source of SCA, but on the other hand requires extensive experience and extensive ultrasound knowledge from the person performing it.

US-CAB (Ultrasound Circulatory-Airway-Breathing) is a protocol developed to confirm correct endotracheal tube placement and assess cardiac contractility. Intubation is confirmed by applying the transducer to the chest and assessing the slipping sign, with possible assessment of the esophagus (incorrect esophageal intubation). During pauses in resuscitation to assess the pulse and rhythm, the heart is simultaneously assessed in the substernal view. The protocol is simple to implement and does not interfere with resuscitation. Furthermore, according to the authors, ultrasound assessment of endotracheal tube placement is faster than capnometry. Additionally, a case report describes tamponade diagnosed during US-CAB, which was then followed by pericardiocentesis leading to return of spontaneous circulation [34].

CAUSE (Cardiac Arrest Altra-Sound Exam) is one of the first protocols developed for diagnosing reversible changes in cardiac arrest during resuscitation. The examination is performed with a sector transducer and is based on two elements. The first is an assessment of the heart using a substernal view, and the second is an assessment of the lungs in the region of the third intercostal space in the midclavicular line. The causes of cardiac arrest that can be diagnosed include: massive pulmonary embolism, hypovolemia, tamponade, and tension pneumothorax.The protocol is very simple and does not require obtaining views at the sites of chest compressions, which facilitates its use. The authors emphasized that it should not be implemented in cases of suspected cardiac arrest with a shockable rhythm [35].

LuCUS (Lung and Cardiac Ultrasound) is a protocol developed for the diagnosis of acute heart failure and sudden dyspnea. The examination begins with an assessment of the lungs using a convex transducer in four zones (anterior and lateral chest) of each lung for the presence of B lines. The presence of at least three in a single application was considered a pathological sign. Secondly, the heart is assessed using a sector transducer in a substernal view focused on the inferior vena cava, followed by a parasternal long- and short-axis view. There are several limitations and caveats to the protocol that should be considered. In the original paper, which first described the study design, there is a discrepancy between the examination procedure (described above) and the protocol description in the”Discussion" section, in which the authors positively assess the possibility of free assessment using abdominal views in the axillary lines and a detailed echocardiographic assessment. Furthermore, the protocol is poorly described in the literature [36].

CaTUS (Cardiothoracic Ultrasound Protocol) combines selected elements of detailed echocardiography with lung ultrasound and is used for the rapid diagnosis of heart failure. The entire examination is performed with a sector transducer and is divided into echocardiographic and pulmonary sections. The echocardiographic section of the examination involves measuring the E/e' ratio in the apical four-chamber view and assessing the width and respiratory collapsibility of the inferior vena cava. The pulmonary section is assessed by placing the transducer on the chest in the midclavicular line at the level of the second/third and then the fourth/fifth intercostal spaces. The assessment takes into account the presence of free fluid in the pleural cavities. A limitation of this protocol is the limited number of publications on the subject and the relatively small patient groups who underwent the examination. The development of a protocol that includes such a detailed measurement as the E/e' ratio is unusual, which indirectly indicates that it is intended for physicians experienced in echocardiography. Although it includes relatively few elements, they are very well-targeted for the diagnosis of acute heart failure. The CaTUS protocol is a promising screening tool for the diagnosis of acute heart failure, and therefore further research on its effectiveness is necessary [37].

CA-FAST (Chest Abdominal-Focused Assessment Sonography for Trauma) is an examination combining the eFAST protocol with additional detection of lung contusion features and is intended for trauma patients. The examination is performed similarly to the eFAST protocol, but the pleura and lungs are assessed in detail for features such as consolidation, altered pleural image, or increased fluid volume locally for consolidation. There are very few reports in the literature on the CA-FAST protocol, which, according to the authors, aims to reduce the number of computed tomography examinations ordered (only in questionable cases) [38].

FALLS (Fluid Administration Limited by Lung Sonography) is another protocol developed by Daniel Lichtenstein, based on lung ultrasound, for monitoring and treating shock by titrating administered fluids. It is also closely related to the BLUE protocol, as in practice it is still an extension. The first step is a simple imaging of the heart with a sector transducer to exclude pericardial tamponade and pulmonary embolism. Next, the transducer is changed to a convex transducer and the BLUE protocol is followed. If profile A is imaged, fluid titration is performed, which may lead to improvement in the patient's condition (indicating the occurrence of hypovolemic shock) or not (indicating septic shock). The FALLS protocol is a valuable supplement to the BLUE protocol and addresses the complex issue of rational fluid therapy. However, its effectiveness is controversial in the literature as it oversimplifies fluid therapy. Its significant advantages also include a rapid learning curve, allowing for an effective and well-described tool for many fluid therapy monitoring situations [39].

PAUSE (Prehospital Assessment with Ultrasound for Emergencies) is a protocol dedicated to paramedics during emergency medical services in mobile medical teams. In the first stage of the examination, a linear transducer is used to exclude pneumothorax by applying it transversely to the third intercostal space in the midclavicular line. In the second stage, a sector transducer is used to assess pericardial effusion and detect cardiac movement (or lack thereof) in the substernal and/or parasternal long-axis view. The protocol is extremely simple and quick, but it is mainly associated with logistical problems, as emergency medical teams are rarely equipped with ultrasound. The development of portable transducers, paired with a telephone, for example, has greatly simplified the procedure, but the cost remains a problem. Furthermore, a hypothetical purchase of the aforementioned device solely for the PAUSE protocol would be highly uneconomical and would not allow for the full utilization of the transducer's capabilities unless additional ultrasound training for paramedics were introduced. Currently, the greatest value of the PAUSE protocol lies in its educational potential, i.e., acquiring basic knowledge of ultrasound and the beginning of the development of ultrasound among paramedics [40].

The ICU (Intensive Care Unit/Ultra-sound) is a comprehensive protocol developed for the initial examination of patients admitted to the intensive care unit. The series of examinations includes: assessment of the width of the optic nerve sheath, lung examination in six areas (anterior, lateral, posterolateral on the upper and lower chest walls on both sides), echocardiographic assessment (parasternal long-axis and short-axis, apical five-chamber and four-chamber, as well as two-chamber and substernal views). Next, an abdominal examination is performed in all areas, and examination of the veins of the lower extremities (femoral and popliteal veins), upper extremities (cephalic, basilic, and axillary veins), and jugular veins (internal and external jugular veins). A compression test is also used during the venous examination. The protocol is very complex and requires extensive knowledge and experience in the field of ultrasound. Considering the specific nature of the intensive care unit for which this protocol was developed, it seems appropriate for its intended purpose, as it allows for obtaining a wealth of information about a critically ill patient regarding potentially lethal pathologies. Furthermore, during hospitalization in such a unit, the patient undergoes a series of diagnostic tests, and by implementing such an extensive protocol, further tests and interventions for suspected pathologies can be developed [41].

Tac-FAST (Tactical Focused Assessment with Sonography for Trauma) is a protocol developed by the United States Armed Forces for implementation in trauma patients during combat operations. First, a sector transducer is used to examine the pericardium and abdominal cavity according to the FAST protocol, followed by imaging the heart in the parasternal long-axis view. Application to the chest for the diagnosis of pneumothorax can be performed using a sector or linear transducer, as per the protocol. The final element of the examination is the measurement of the width of the optic nerve sheath using a linear transducer. This protocol was originally developed for combat use and can be successfully applied in civilian settings, as it represents a well-thought-out extension of the most popular FAST and eFAST examinations. While using a sector transducer allows for greater ultrasound penetration into the patient, it does not facilitate analysis of structures located close to the emitter. Especially when assessing the slipping symptom, this can be difficult and requires experience [42]

Discussion

In recent years, there has been a rapid popularization of ultrasound among non-radiologists, as well as among paramedics, physiotherapists, and others. This trend is undoubtedly due to the increasing availability of ultrasound equipment, a wide range of commercial training courses, and extensive literature. Data from ultrasound examinations are very valuable and often unobtainable during a traditional interview and physical examination, hence the rapid implementation of this technique in virtually all fields of medicine. Areas of medicine in which ultrasound is particularly important include: emergency medicine, anesthesiology, intensive care, and broadly defined emergency medicine [1-3]. The response to physicians' needs was to adapt the examination method to the given clinical situation, which resulted in the development of ultrasound protocols. Focusing the examination on selected elements, abandoning or significantly reducing measurements, and developing a repeatable and relatively simple-to-perform protocol led to the creation of rapid and highly effective diagnostic tools [43]. As protocols became more popular, new ones were quickly developed, which in most cases did not gain much popularity and often ended with only a single publication. Based on the 19 protocols cited, a certain schematic nature can be observed related to the areas examined or the pathologies diagnosed. It is important to precisely define the indications for the use of a given protocol, e.g., BLUE – acute respiratory failure; FAST/eFAST – patient with multi-organ trauma; as this will reduce false results, which collectively reduce its effectiveness and undermine its efficiency. If one wishes to develop diagnostic tools the increased number of pathologies led to the development of very extensive and complicated protocols, requiring extensive knowledge of ultrasound in many areas. This approach should not be viewed negatively, as it also has significant advantages, largely related to the specific nature of the work. The most extensive protocols are those designed to diagnose the causes of shock or as screening tools for abnormalities in patients admitted to the intensive care unit. Such broad issues justify the need to develop such complex protocols, which in practice were designed for intensive care specialists, who, as part of their specialization training, are required to master ultrasound [44].

Another important step was the development of protocols dedicated to examinations during cardiac arrest. These protocols are aimed at identifying reversible causes of SCA and were designed to avoid interfering with resuscitation efforts, which are prioritized over ultrasound. Ultrasound examinations in SCA are difficult and require extensive experience due to the short time required to obtain an appropriate view and collect as much data as possible. Obtaining views is significantly more difficult due to the chest compressions and the patient's supine position, which can make obtaining parasternal and apical views particularly difficult, or even impossible [45]. In addition to the protocols developed, the concept of POCUS (Point of Care UltraSound) is also important, i.e., ultrasound focused on the cause of a given problem. While both terms are often treated synonymously, certain differences can be distinguished between them. Common features undoubtedly include limiting the performance of a full examination to a shorter one, as well as omitting or limiting measurements. The differences are relatively fluid, but concern the performance of the examination itself. The protocol imposes a certain procedure and the diagnostic pathways that result from it. Point-of-Care ultrasound should be targeted at a given area or cause and should answer a specific clinical question that determines further management. Currently, the number of publications describing the effectiveness and use of POCUS is growing rapidly, and they increasingly demonstrate a comparison of ultrasound to the 21st-century stethoscope [46].

In this study, a review of many different protocols, from the most popular and widely used ones to those described in only one publication, demonstrates the desire to standardize the diagnostic approach and develop protocols that significantly reduce the risk of error. Protocols that include lung and pleural ultrasound in their procedure were selected for analysis. This is due to the rapidly growing popularity of this technique, which has been experiencing a renaissance since the onset of the COVID-19 pandemic. Prior to this event, its implementation was very limited and even controversial. The selection of protocols containing this element of the examination further demonstrates the rich tradition of lung ultrasound and how readily it is used, for example, in emergency ultrasound, where only trusted and proven methods are used.Further development and development of protocols is inevitable, but it is highly probable that many of them will not gain global popularity. Therefore, scientific papers frequently raise debates about the merits of developing new protocols, which often do not differ significantly from each other. Unfortunately, there is no clear answer to this question, and there is considerable room for individual interpretation. Without a doubt, the key issue is mastery of a given protocol and its correct application, which will be more valuable than extensive theoretical knowledge in this area [47]. Ultrasound protocols, like any diagnostic tool, have their advantages and disadvantages, which have been described in this paper. It is crucial that even the most comprehensive protocol will not always provide all the clinical answers. In such cases, a full ultrasound examination defined by standards or the use of other diagnostic imaging methods should be considered [48]. Having a complete clinical picture of the patient based on the history, physical examination, imaging, and laboratory tests will enable us to make the best therapeutic decisions for the patient.

Further development and development of protocols is inevitable, but it is highly probable that many of them will not gain global popularity. Therefore, scientific papers frequently raise debates about the merits of developing new protocols, which often do not differ significantly from each other. Unfortunately, there is no clear answer to this question, and there is considerable room for individual interpretation. Without a doubt, the key issue is mastery of a given protocol and its correct application, which will be more valuable than extensive theoretical knowledge in this area [47]. Ultrasound protocols, like any diagnostic tool, have their advantages and disadvantages, which have been described in this paper. It is crucial that even the most comprehensive protocol will not always provide all the clinical answers. In such cases, a full ultrasound examination defined by standards or the use of other diagnostic imaging methods should be considered [48]. Having a complete clinical picture of the patient based on the history, physical examination, imaging, and laboratory tests will enable us to make the best therapeutic decisions for the patient.

Conclusions:

Ultrasonography is an extremely valuable tool in emergency medicine and allows for the quick and effective diagnosis of serious pathology. The development of ultrasound protocols has created the possibility of implementing a test that allows for a quick assessment of the patient's condition and the subsequent management. Each protocol has certain limitations, making it crucial to use them only for strictly defined indications; otherwise, there is a risk of false results. Thanks to precisely developed execution and appropriate training, the risk of error in stressful conditions is significantly reduced. Further development of ultrasound in the form of protocols or Point of Care and their widespread popularization among physicians and even students is necessary.

Disclosure

Author's contribution:
Conceptualisation: Rafał Rajski
Methodology: Jarosław Jarosławski, Wiktor Warda
Software: Dominik Tenczyński, Michał Kostro
Check: Anna Żurakowska-Zadrożna
Formal analysis: Wiktor Warda, Patrycja Trentkiewicz
Investigation: Agata Wysocka, Jarosław Jarosławki
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