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Experience in using focused cardiac ultrasound in patients with acute heart failure in the intensive care unit

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Portable ultrasound devices in initial cardiac patient examination in intensive care units are seen as an essential addition to conventional physical examinations.

Aim. To assess the potential of using focused cardiac ultrasound for patients admitted in the intensive care unit with a clinical performance of acute heart failure.

Material and methods. The study included 180 patients, 110 of whom were men. The mean age was 57 (40;74) years. The patients included in the study were divided into 2 groups: group 1 consisted of patients who, upon admission, underwent a general clinical examination and an ultrasound with a portable device; group 2 — patients who, upon admission, underwent only a conventional examination. Using portable ultrasound scanners, the doctors evaluated ventricular contractility, the presence of significant valve regurgitation, the diameter and degree of inferior vena cava collapse, as well as the presence, prevalence and number of B-lines. The differences in the time required for the diagnosis using various methods were determined. Structural changes in the heart and lungs, identified using a portable ultrasound device, were also assessed.

Results. In the group of patients who underwent focused cardiac ultrasound, the time from admission to initiation of therapy was 11 (7;18) minutes. In the group 2, the median time from admission to initiation of intravenous diuretic administration was 86 (52;116) min (p<0,001). According to the results of an ultrasound with a portable device, the following changes were noted: significant left ventricular contractility decrease were found in 32,4% of patients; a decrease in right ventricle contractility — in 16,2%. In 50% of patients, the left ventricular contractility was sufficient. In 43,3% of patients, bilateral B lines were identified as a sign of interstitial pulmonary syndrome; in 38,8%, there were signs of hypervolemia when assessing the inferior vena cava. Hemodynamically relevant mitral regurgitation was noted in 28,8% of cases; hemodynamically relevant tricuspid regurgitation — 21,1%; relevant aortic regurgitation — 6,6%. In 10% of patients, there was restricted mobility of aortic valve leaflets, which was suspected as aortic stenosis. In 18% of cases, no significant intracardiac hemodynamic changes were noted.

Conclusion. It has been shown that examination with focused cardiac ultrasound in the intensive care unit reduces decision time by more than an hour. Initial examination of a patient with acute heart failure using pocket cardiac ultrasound devices reveals clinically relevant intracardiac hemodynamic disorders.

Keywords: focused cardiac ultrasound, assisted examination, acute heart failure, portable ultrasound systems.

Relationships and Activities: none.

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The possibilities of clinical use of assisted examination with ultrasound diagnostic methods in cardiac patients are regulated and listed in a consensus paper of the European Association of Cardiovascular Imaging (EACVI) [1]. Pocket ultrasound systems are modern portable handheld systems that represent a smartphone, or a tablet and a transducer, or transducers that are synchronized with mobile devices [2]. These are convenient systems for routine practice that a physician can place in the pocket of work clothes, constantly carry with him/her, and use them in his/her work. Pocket ultrasound systems are very easy to use and have a simple and self-explanatory user interface (Figure 1). Mobile ultrasound systems make it possible to scan in both two-dimensional mode and color Doppler imaging; some systems allow using a one-dimensional mode. The available measurements are limited to measuring the distance and area; for these reasons, a mobile ultrasound system cannot provide an accurate quantitative assessment of the contractility and volumetric parameters, as well as velocity characteristics of transvalvular flows. In all the existing limitations, scanning is carried out in real-time, the images have optimal quality, which makes it possible to answer a specific clinical question in most cases [3]. The main advantage of handheld devices is that they are easy to be carried; so, they can be easily accessible to specialists in various situations anywhere: in the ward, at the patient's bedside, and during transportation that provide improvement of the quality of medical care. Using mobile ultrasound devices in the primary assessment of a patient in Cardiac Intensive Care Units is increasingly considered to be a significant addition to the traditional physical examination of the cardiovascular system [4].

The purpose of the study is to assess the possibility of reducing the decision-making time in a focused cardiac ultrasound in patients admitted with a clinical presentation of acute heart failure (AHF) in the Intensive Care Unit (ICU) for cardiac patients of the City Clinical Hospital Named After S. S. Yudin of the Moscow City Health Department.

Figure 1. Pocket ultrasound systems.

Material and methods

180 patients were included in the observational study; the number of males was 110. The patients' average age was 57 (40;74) years old. In admission, 27,7% of patients (n=50) had atrial fibrillation rhythm disorders, and 67,7% of patients (n=122)

Table 1

General characteristics of patients upon admission to the hospital

Parameter	All patients (n=180)
Age, years	57 (40;74)
Males, n (%)	110 (61,1)
Diagnosis of AHF, n (%)	180 (100)
AF, n (%)	50 (27,7)
ACS, n (%)	122 (67,7)

Note: the data are presented as a median and an interquartile range (Q1; Q3), as well as in absolute numbers (n) and shares in percentages (%).

Abbreviations: ACS — acute coronary syndrome, AHF — acute heart failure, AF — atrial fibrillation.

Table 2

Time intervals (minutes) from the patient admitting to the hospital until obtaining US results

Parameter	Focused cardiac ultrasound by a cardiologist	US examination performed by a physician of instrumental diagnostics	p
Minutes	11 (7;18)	86 (52;116)	<0,001

Note: the data are presented as a median and an interquartile range (Q1; Q3).

Abbreviation: US — ultrasound.

Table 3

Treatment and diagnostic measures initiated based on the results of the focal ultrasound examination

Parameter	Patients (n=90)
Diuretic infusion, n (%)	54 (60)
CT angiography, n (%)	4 (4,4)
Emergency consultation with a cardiac surgeon upon admission, n (%)	6 (6,6)

Note: the data are presented as a median and an interquartile range (Q1; Q3), as well as in absolute numbers (n) and shares in percentages (%).

Abbreviation: CT — computed tomography.

were diagnosed with the acute coronary syndrome at the prehospital stage (Table 1).

In the Cardiac Intensive Care Unit, several specialists completed additional training for 36 hours on the use of targeted diagnostic focal ultrasound in emergency cardiology. As an additional procedure to the primary clinical examination of patients, these physicians could use pocket ultrasound systems to more precisely define the parameters of intracardiac hemodynamics.

The patients who participated in the study were divided into 2 groups. The patients of the first group, upon admission, underwent a general clinical examination combined with an objective assessment of the parameters of intracardiac hemodynamics with the help of a focal US mobile device. The patient of the second (control) group, who were subsequently selected, upon admission, underwent a general examination without additional focal US examination. Patients of the control group were managed according to the standard protocol, with the engagement of specialists of instrumental diagnostics, who performed ECG examination at the patient's bedside.

As part of an focused cardiac ultrasound, physicians evaluated the following parameters: ventricular hypocontractility; significant regurgitant flows on the mitral, aortic, and tricuspid valves; the inferior vena cava diameter and degree of its collapse; and interstitial pulmonary syndrome in terms of its prevalence and number of B-lines that are determined by moving the US transducer along the surface of the patient's chest over the entire pulmonary fields at the appropriate points. The differences in the time intervals were determined, during which the diagnosis was confirmed using US data (obtained by a pocket handheld device or a standard method of examination) and specific therapy was initiated. Also, changes in intracardiac hemodynamics were assessed, which were determined by focal US examination of the heart and lungs using a mobile device.

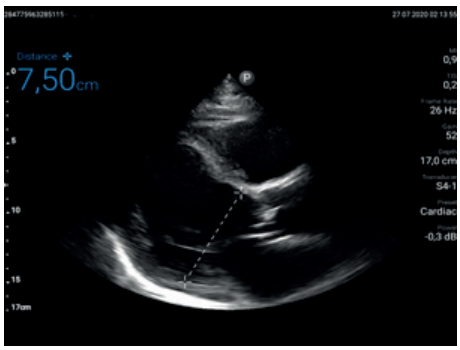

Figure 2. LV dilation according to the focused cardiac ultrasound.

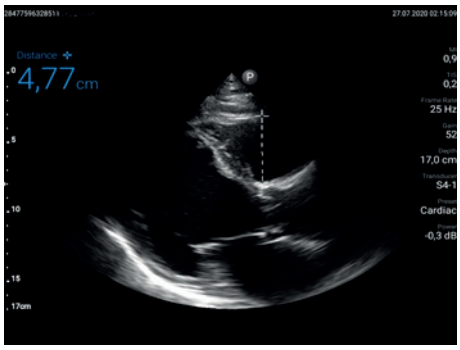

Figure 3. Dilation of the RV outflow tract according to the focused cardiac ultrasound.

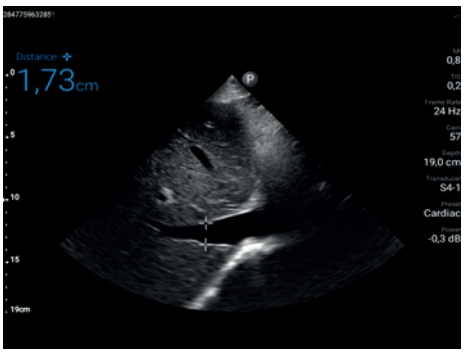

Figure 4. Assessment of the patient's volemic status according to the focused cardiac ultrasound.

Results

The time intervals were assessed, according to the records in the case history, after what period from admission information on the parameters of intracardiac hemodynamics was available, based on which the subsequent therapeutic and diagnostic tactics were selected. In the patient group who underwent a focused cardiac ultrasound, a median was 11 (7;18) minutes. In the patient group where a specialist of diagnostic services was required, the median of the time interval from the patient

admission to the hospital to the obtaining ultrasound results was 86 (52;116) minutes (p<0,001) (Table 2).

In the patients who underwent a US examination with a mobile ultrasound system, the following changes were perceived: 32,4% of patients (n=40) had significant violations of the left ventricle (LV) contractility, and 16,2% of patients (n=20) had right ventricular (RV) hypocontractility. 50% of patients (n=45) had LV contractility that was considered to be satisfactory. In 43,3% of patients (n=39), bilateral B-lines were identified as a symptom of the interstitial pulmonary syndrome, and in 38,8% of patients (n=35) had symptoms of hypervolemia when assessing parameters of the inferior vena cava. Hemodynamically significant mitral regurgitation was in 28,8% of patients (n=26); hemodynamically significant tricuspid regurgitation was in 21,1% of patients (n=19), and significant aortic regurgitation was in 6,6% of patients (n=6). Mitral stenosis was detected in 3,3% of patients (n=3), and a significant limitation of the mobility of the aortic valve cusps, which allows suspecting aortic stenosis, was detected in 10% of patients (n=9). No significant changes in the parameters of intracardiac hemodynamics were revealed in 18% of patients (n=20).

Based on the results of the focal US examination, the following therapeutic and diagnostic measures were initiated in the first hour of the patient's stay in the hospital: therapy with intravenous diuretics was immediately started in 60% of patients (n=54); 9,9% of patients (n=9) were urgently referred for computed tomography (CT) — angiography; 6,6% of patients (n=6) were consulted by a cardiac surgeon and transferred to the Surgical Department to perform emergency cardiac surgery (Table 3).

Discussion

Patients with AHF or acute decompensated heart failure (ADHF) represent a significant portion of all patients in Cardiac Intensive Care Units. AHF is a clinical syndrome characterized by a combination of symptoms (breathlessness; orthopnea; edema of the lower extremities) and signs (increased pressure in the jugular veins; lung congestion), often caused by structural and/or functional heart disorders leading to a decrease in LV contractility and/or an increase in LV filling pressure [5-8]. The time of therapy initiation is an important question in the treatment of patients with AHF and ADHF, and the question is uncertain until now. At present day, little information is available on whether there is a therapeutic window in AHF treatment that can improve long-term outcomes, and patients with different stages of cardiac functional decompensation are causing heterogeneity in clinical trials. Unlike studies devoted to the treatment of acute myocardial infarction, the concept of a "golden hour" for treating AHF has not yet been defined. Data from the ADHERE (Acute Decompensated Heart Failure National Registry) show that earlier initiation of therapy can improve long-term outcomes [9]. The authors of the concept of the earliest possible administration of an intravenous diuretic believe that the delay in therapy may explain the increased mortality since AHF provokes the development of multiple organ failure and the need to use vasoactive medications in higher doses, as well as a higher likelihood of adverse effects [9]. In REALITY-AHF, a prospective multicenter observational cohort study, in patients admitted to the emergency department for AHF, early treatment with intravenous loop diuretics was associated with lower in-hospital mortality [10]. Data from this study showed that early initiation of intravenous treatment with furosemide significantly reduced in-hospital mortality.

Echocardiography performed with a pocket handheld device does not provide a comprehensive non-invasive assessment of intracardiac hemodynamics, but it allows assessing the presence of signs that are pathognomonic for AHF [11]. Evaluation of the severity of cardiac dysfunction and congestion using pocket US systems allows initiating the therapy with diuretics and/or vasodilators in the shortest possible time. This was shown in our study: the initiation time of medication therapy in the case of a focused cardiac ultrasound was reduced by more than 60 minutes. Considering this fact, the possibility of a focused cardiac ultrasound is an important component of a comprehensive assessment of a patient with a clinical presentation of AHF and contributes to making a quick clinical decision.

When analyzing the changes that were identified with the help of the pocket US device, several features were revealed. In particular, it is remarkable that 50% of patients retained the LV myocardial contractility. These data are consistent with the ADHERE, the largest international registry, according to which up to 55% of patients with AHF or ADHF have a preserved ejection fraction [12]. By carrying out focal echocardiography, LV dysfunction was revealed in 32,4% of patients (Figure 2), and LV dysfunction was revealed in 16,2% of patients (Figure 3), which also contributed to the acceleration of decision-making, for example, about transporting the patient to the X-ray operation room or for carrying out CT angiography. Focal ultrasound with a pocket device allows evaluating the patient's volume status when examining the size and degree of collapse of the inferior vena cava (Figure 4). This method quickly helps to objectify the symptoms of lung congestion,

such as interstitial pulmonary syndrome and inferior vena cava dilatation with its unsatisfactory collapse. The presence of these signs, in combination with clinical symptoms, allows making a differential diagnosis for breathlessness, diagnosis of heart failure, and initiation of medication therapy. Focal US examination with pocket handheld devices does not allow assessing the velocity characteristics of transvalvular flows. The ability of these systems in the diagnosis of valve stenosis lies only in the qualitative visual characteristic of limiting the mobility of the valve cusps. Currently, the work on studying this problem to assess the short-term and long-term outcomes in patients whose management tactics have changed with the introduction of focused cardiac ultrasound is being continued in the clinic. Our results showed the importance of using mobile US devices for making clinical decisions in emergencies suggesting an additional possibility for direct and indirect resource savings if US examination is more routinely and earlier included in making a clinical decision. The limitation of the competence of physicians in Cardiac ICUs in using and interpreting these US methods is a problem of widespread implementation of the focal protocol. Modern educational programs and medical schools increasingly combine focused cardiac ultrasound training in training modules. Our study provides additional evidence that using mobile ultrasound systems in the Cardiac ICUs can shorten the time for making clinical decisions, especially in the context of a City Clinical Hospital.

In the group of patients with suspected AHF who underwent a focused cardiac ultrasound with the help of mobile systems, medication therapy was initiated in 11 minutes. In the patient group where a specialist of diagnostic services was required, medication therapy was initiated in 86 minutes.

Conclusion

The introduction of mobile US systems into cardiologists' clinical practice is a reflection of modern trends towards miniaturizing diagnostic facilities. A clinician's ability to perform a focused cardiac ultrasound allows shortening the time for making a clinical decision and improving the quality of health care for patients in the ICU. It is necessary to carry out further clinical studies devoted to the optimal scenarios for the implementation of using mobile US systems in clinical practice.

Relationships and Activities: none.

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