Critical care ultrasound among Tunisian intensive care residents: A Cross-sectional Survey

Pratique de l'échographie par les résidents en réanimation médicale Tunisiens: Enquête transversale multicentrique

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Abstract

Introduction: Critical Care ultrasound (CCUS) is more and more used in Tunisian critical care units. An objective assessment of this training has not yet been performed.

Aim: To assess the theoretical and practical knowledge about CCUS among Intensive Care Unit (ICU) residents.

Methods: This is a cross-sectional study conducted during the period from January to June 2021. Data were collected using a French language questionnaire distributed on the day of the selection of the residents' posts for the next training period (at the end of June 2021).

Results: Out of 75 residents, 37 accepted to answer to the survey (Participation rate =49 %). The majority were female (66.4%). The mean age was 29±12.36 years. Only 5.4% of participants (n=2) had previously received training concerning echocardiography and only 8.1% of the participants have received dedicated training for lung ultrasound (LU). Among the participants, 80.1% of residents (n=30) had never performed a transthoracic echocardiography (TTE). Competence in performing echocardiography was self-assessed quite good and bad by 5.4% and 43.2% of responders respectively. Most of the residents (86%) did not insert before ultrasound-guided central venous catheters.

Views known by the participants using TTE were mainly parasternal long axis section (56.8%) and apical 4/5 chambers section (52.8%). All participants (100%) thought that teaching CCU is a necessary part of the training of intensivists.

Conclusion: Our study highlighted the lack of training of Tunisian ICU residents regarding CCUS learning. Therefore, it is crucial to integrate such learning and training into their training programs.

Key words: ultrasound, intensive care unit, resident, learning, survey

Résumé

Introduction: L'échographie en soins intensifs (ESI) est de plus en plus utilisée en réanimation médicale. Une évaluation objective de cette formation n'a pas encore été réalisée.

Objectif: Evaluer les connaissances théoriques et pratiques sur l'ESI parmi les résidents en réanimation.

Méthodes: Etude transversale menée auprès de janvier à juin 2021 dans plusieurs unités de soins intensifs en Tunisie. Les données ont été recueillies à l'aide d'un questionnaire en français distribué aux résidents le jour du choix des postes (fin juin 2021).

Résultats: Sur un total de 75 résidents, 37 ont accepté de répondre à l'enquête (49 %). La majorité étaient des femmes (66,4 %). L'âge moyen était de 29±12,36 ans. Seuls 5,4 % des participants (n = 2) avaient déjà reçu une formation en échocardiographie et seuls 8,1 % des participants avaient reçu une formation dédiée à l'échographie pulmonaire. Parmi les participants, 80,1 % des résidents (n = 30) n'avaient jamais réalisé d'échocardiographie transthoracique (ETT). La compétence dans la réalisation de l'ETT était auto-évaluée comme étant assez bonne et mauvaise respectivement par 5,4 % et 43,2 % des répondants. La plupart des résidents (86 %) n'avaient jamais inséré de cathéters veineux centraux sous échographie. Tous les participants (100 %) estimaient que l'enseignement de l'ESI est une partie nécessaire de la formation des intensivistes.

Conclusion: Notre étude a mis en évidence le manque de formation concernant l'apprentissage de l'ESI. Il est donc crucial d'intégrer un tel apprentissage dans les programmes de formation.

Mots clés: échographie, reanimation, resident, formation, enquête

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Introduction

In recent years, in many countries, cardiac, pulmonary, vascular and abdominal ultrasound has become a major tool for intensivists in the management of critically ill patients (1,2). With the evolution of intensive care medicine, there has been an increasing need for rapid and accurate diagnosis in critically ill patients (3,4). Critical Care ultrasound (CCUS) is one of the health technologies which is more and more used in Tunisian intensive care units (ICUs). The use of CCUS has been integrated into ICUs as a means of diagnosis, as well as, to direct management approaches and hands-on procedures (5). Ultrasound is a highly operative tool dependent whose mastery depends on both the quality of initial ultrasound training and subsequent practice. Therefore, appropriate training is required for using CCUS (6,7). After a global agreement reached in 2011, different national associations and groups have sought to create and provide training initiatives (8). However, in Tunisia, the practice of this tool by residents in the process of training in intensive care specialty is often limited. To the best of our knowledge, an objective evaluation of the practice of CCUS among these residents has not previously been performed in ICUs in our country. Improving the skills of residents in the practice of CCUS in ICUs following an assessment of their knowledge can lead to enhance diagnostic skills, guide various medical procedures, and improve patient care. Moreover, a thorough understanding of ultrasound techniques is essential for patient safety.
The objective of our study was to assess the theoretical and practical knowledge about CCUS among ICU residents and to delineate the expectations of residents.

Methods

Study design and setting

This is a cross-sectional study conducted among residents in ICU practicing during the period from January to June 2021 in several ICUs in Tunisia.

Study population

This study was conducted among Tunisian intensive care residents in training in the different medical ICU departments in different university hospitals in Tunisia.

Data collection

Data were collected using a French language questionnaire distributed on the day of the selection of the residents' posts for the following training period (at the end of June 2021).
A questionnaire was created and used to collect data
Data collected concerned characteristics of the residents, their degree of training in CCU, theoretical and practical assessment about CCU and perceptions about enhancing ultrasound and CCU teaching.
The first section of the questionnaire asked questions about the respondent's gender, age, and seniority in order to determine the resident's degree of critical care medicine skill. The purpose of the second section was to find out how much training the responder had in critical care ultrasonography and whether or not they held an ultrasound diploma. It also included information about the resident's opportunity to learn critical care ultrasonography, including the time and department of instruction.
The final section covered each resident's present theoretical and practical understanding of echocardiography, lung ultrasonography, and ultrasound-guided central venous catheter placement. The final section of the survey sought to ascertain what ICU residents' thought could be done to enhance the critical care ultrasonography education in the various teaching ICU units in Tunisia.

Data analysis

We used the Statistical Package for the Social Sciences (SPSS) version 21.0 to analyze data. We calculated frequencies and percentages for the qualitative variables and median with interquartile range for the quantitative variables.

Ethical considerations

Consent was obtained from each participant before starting the study. Our survey was anonymous and the confidentiality of the answers was ensured. Participation was completely voluntary.

Results

Out of a total of 75 residents, 37 accepted to answer to the survey (Participation rate = 49 %). Specialty of all participants was intensive care medicine (ICU). The majority were female (66.4%). The mean age was 29 ± 12 years.
Only 5.4% of participants (n=2) had previously received training concerning echocardiography and only 8.1% of the participants have received dedicated training for lung ultrasound (LU).
Among the participants, 80.1% of residents (n=30) had never performed a transthoracic echocardiography (TTE). Competence in performing echocardiography was self-assessed as quite good and bad by 5.4% and 43.2% of respondents respectively. 54.1% were used to attending quite often during the practice of TTE performed by seniors in ICU.
Most of the residents (86%) had never inserted an ultrasound-guided central venous catheter. Only 3% received training for this type of procedure. Participants considered that TTE was a mandatory examination in order to assess hemodynamics and patients in respiratory failure in 91.9% and 73% respectively. Most participants (89%) approved the role of trans thoracic echocardiography (TTE) in management plan.

Self-evaluation of transthoracic echocardiography skills

The evaluation of left ventricular size and global systolic function, and right ventricular size and systolic function were reported to be mastered in 10.8 % and 8.1 % respectively. The evaluation of homogeneous or heterogeneous left ventricular contraction was reported to be mastered in 32.4 % of participants. Nearly a third of intensive care residents were able to measure the size of the inferior vena cava and its respiratory variations, identify pericardial effusion / tamponade and differentiate between homogeneous or heterogeneous left ventricular contraction. Only 8.1% of residents could evaluate severe valvular regurgitation by Color Doppler.
Different views known by the participants in trans thoracic echocardiography (TTE) were parasternal long axis section (56.8%), short axis parasternal section (43.2%), apical 4/5 chambers section (52.8%), apical 2/3 cavities section (41.3 %), sub-costal 4 cavities section (41.7%), and subcostal section (inferior vena cava incidence) (51.4%).
Different views that the participant could obtain in trans thoracic echocardiography (TTE) were parasternal long axis section (16.2%), short axis parasternal section (10.8%), apical 4/5 cavities section (16.2%), apical 2/3 cavities section (5.4 %), sub-costal 4 cavities section (10.8%), and subcostal section (inferior vena cava incidence) (28.6%) (Table 1).

Self-evaluation of ultrasound-guided central venous catheters skills:

Only 13.5% of intensive care residents were used to insert central venous catheters (CVC) under ultrasound and only 8.1% have received ultrasound guidance training to insert CVCs (Table 2).

Self-evaluation of lung ultrasound skills

Only 8.1% of intensive care residents have received training. Twenty one percent found that lung ultrasound can replace chest radiography in intensive care. According to the participants, the two most frequent findings in lung ultrasound were pleural effusion (67.6%) and pneumothorax(54.1%) (Table 3).

Perceptions about improving ultrasound and echocardiography teaching

All participants (100%) thought that teaching CCU is a necessary part of the training of intensivists. Perceptions of intensive care residents about improving CCU teaching are described in Table 4.

Table 1. Self-evaluation of trans thoracic echocardiography skills by Tunisian intensive care residents (June 2021)

Echocardiography skills	n (%)
Left ventricular size and global systolic function	4 (10.8)
Homogeneous or heterogeneous left ventricular contraction	12 (32.4)
Right ventricular size and systolic function	3(8.1)
Identification of pericardial effusion / tamponade	13 (35.1)
Size of the inferior vena cava and its respiratory variations	13 (35.1)
Color Doppler evaluation of severe valvular insufficiency	3 (8.1)
Different views that the participant know in trans thoracic echocardiography	
Parasternal long axis section	21 (56.8)
Short axis parasternal section	16 (43.2)
Apical 4/5 cavities section	20 (52.8)
Apical 2/3 cavities section	15 (41.3)
Sub-costal 4 cavities section	15 (41.7)
Subcostal section (inferior vena cava incidence)	51.4 (19)
Different views that the participant can obtain in TTE	
Parasternal long axis section	6 (16.2)
Short axis parasternal section	4 (10.8)
Apical 4/5 cavities section	6 (16.2)
Apical 2/3 cavities section	2 (5.4)
Sub-costal 4 cavities section	4 (10.8)
Subcostal section (inferior vena cava incidence)	10 (28.6)
Do cardiorespiratory interactions (spontaneously ventilated or ventilated patient) influence echocardiographic measurements?	18 (48.6)
What parameters are routinely assessed during an echocardiographic examination?	
Heart cavities	18 (48.6)
Systolic function	24 (64.9)
Diastolic function	13 (35.1)
Valve status	14 (37.8)
Preload-dependence (*ΔITVao * ØVCI /VCS, LV size)	10 (27)
Pericardium	17 (45.9)
I don't know	7 (18.9)
Can you study the respiratory variability of the IVC diameter on TTE?	12 (32.4)
Can you analyze LV systolic function by TTE?	7 (18.9)
Can you analyze LV diastolic function by TTE and more specifically, identify with the measurements an increase in LV filling pressures (LVFP)?	2 (5.3)
Can you analyze right heart function by TTE?	3 (8.1)
Can you identify signs of acute pulmonary heart disease on TTE?	4 (10.8)
Can you identify a pulmonary hypertension on TTE?	2 (5.4)
Can you perform the different measurements of the heart chambers (LVEDV, LVEDV, LVEDV, LVEDV: RVEDD, RVTD, RVTD)	1 (2.7)
Do you know the interpretation of each of these different measurements (normal ,in favor of dilatation, hypertrophy .....)?	1 (2.7)
Can you identify severe valve insufficiency on doppler color TTE?	3 (7.9)
Can you identify a pericardial effusion and specify its abundance?	9 (23.7)
Can you identify a tamponade on TTE?	2 (5.4)

TTE: trans thoracic echocardiography ; **LVEF**: Left ventricular ejection fraction; **LVEDV**: Left ventricular end-diastolic volume; **LVEDV**: Left ventricular end-diastolic volume; **LVEDV**: Left ventricular end-systolic volume; **RVEDD**: Left ventricular end-systolic diameter; **RVTD**: Right Ventricular end- diastolic Diameter; **RVTD**: Right Ventricular end-systolic Diameter; **RV/LV ratio**: right ventricular diameter/left ventricular diameter ratio; SOG; Left atrial area; **DIVS**: Diastolic interventricular septum; **SIVS**: Systolic interventricular septum

Table 2. Self-evaluation of ultrasound-guided central venous catheters skills by intensive care residents, Monastir (Tunisia), June 2021

Statements	n (%)
1-Do you usually insert a CVC under ultrasound?	5 (13.5)
2-Have you received ultrasound guidance training to insert CVCs?	3 (8.1)
3-Do you think ultrasound guidance reduces catheter insertion time?	23 (62.2)
4-Do you think that ultrasound guidance reduces the risk of mechanical complications?	32 (86.5)
5-Do you think that ultrasound guidance increases the risk of catheter colonization?	12 (32.4)
6-Do you think that regular use of ultrasound guidance may lead to a loss of skills compared with the anatomical location method?	19 (51.4)

Table 4. Perceptions of intensive care residents about improving critical care ultrasound teaching among them, Monastir (Tunisia), June 2021

Statements	n (%)
Teaching CCU is a necessary part of the training of intensivists	36 (97.3)
It would be necessary to include mandatory diploma training in CCU during the residency program	
Strongly agree	29 (78.4)
Agree	7 (18.9)
disagree	1 (2.7)
This training should be included during	
1st year of residency	14 (37.8)
2nd year of residency	14 (37.8)
3rd year of residency	6 (16.2)
4th year of residency	3 (8.1)
CCU education lectures	
Indispensable	26 (72.2)
Useful	15 (40.5)
Unnecessary	6 (16.2)
Practical workshops	
Indispensable	26 (72.2)
Useful	9 (25)
Unnecessary	1 (2.8)
Ultrasound seminars	
Indispensable	17 (45.9)
Useful	19 (52.4)
Unnecessary	1 (2.7)
Simulation sessions	
Indispensable	27 (73)
Useful	8 (22.6)
Unnecessary	2 (5.4)
There is a need to develop new continuing education programs in echocardiography	33 (89.2)
Ultrasound theoretical knowledge tests among intensive care residents	
Indispensable	13 (35.1)
Useful	21 (56.8)
Unnecessary	3(8.1)
Ultrasound practical knowledge control among intensive care residents	
Indispensable	30 (81.1)
Useful	6 (16.2)
Unnecessary	1(2.7)
Ultrasound practical test, at the patient's bed	
Very appropriate	24 (64.9)
Appropriate	9 (24.3)
Inappropriate	4 (10.8)
Ultrasound practical test, on an ultrasound simulator	
Very appropriate	22 (59.5)
Appropriate	10 (27)
Inappropriate	5 (13.5)
Ultrasound practical test, on a volunteer	
Very appropriate	22 (59.5)
Appropriate	10 (27)
Inappropriate	5 (13.5)
Ultrasound theoretical test, by multiple-choice questions	
Very appropriate	7 (18.9)
Appropriate	14 (37.8)
Inappropriate	16 (43.2)
Ultrasound theoretical test, by essay question	
Very appropriate	7 (18.9)
Appropriate	14 (37.8)
Inappropriate	16 (43.2)
Ultrasound theoretical control, by clinical case	
Very appropriate	13 (35.1)
Appropriate	13 (35.1)
Inappropriate	11(29.7)

CCUS: Critical Care ultrasound

Table 3. Self-evaluation of lung ultrasound skills by intensive care residents, Monastir (Tunisia), June 2021

Statements	n (%)
1-Have you received training in lung ultrasound?	3 (8.1)
2-Do you think it is useful in intensive care?	33 (89.2)
3-Do you think Lung ultrasound can replace chest radiography in intensive care?	8 (21.6)
4-What abnormalities can be visualized by lung ultrasound in critically ill patients?	
Fluid effusions	25 (67.6)
Pneumothorax	20 (54.1)
Acute pulmonary edema	7 (18.9)
Pulmonary embolism	7 (18.9)
Pneumopathy	6 (16.2)
Atelectasis	**10 (27)**
5-Do you believe that Lung ultrasound can confirm endotracheal intubation?	10 (27)
6-Do you think ultrasound can be useful in percutaneous tracheostomy?	10 (27)

Discussion

Our study found that 37 out of 75 critical care residents agreed to participate in the survey (participation rate = 49%). Merely 5.4% of the participants had previously undergone echocardiography training, and only 8.1% had specifically received lung ultrasound (LU) instruction. Transthoracic echocardiography (TTE) was not conducted by the majority of the residents (n=30; 80,1%). 5.4% and 43.2% of respondents, respectively, self-assessed as having rather excellent and poor competence in doing echocardiography. The majority of residents (86%) did not previously install ultrasound guided central venous catheters.

Ultrasound is a key tool more and more used in intensive care. It is useful for assessing the cardiovascular system (9,10), assessing hemodynamics (10), and guiding vascular approaches (11,12). It is particularly helpful in the management of patients with cerebral, thoracic (13) or abdominal pathologies (acute cerebral, cardiovascular, lung or abdominal dysfunctions) (14).

In our study, the participation rate was medium 49 %. It was similar to a survey studying ultrasound learning among anesthesia and intensive care residents in the East inter-region between September 2011 and January 2012 in which the participation rate was 44% (15). The medium participation rate in our study can be explained by the fact that participants could be non-motivated or stressed when distributing questionnaires since our survey was conducted on the day of choice of their training critical care university center.

In our study, nearly 95% had not previously received training concerning TTE, and 80.1% of residents had never performed a TTE.

In a prospective study performed in two ICUs, residents were divided into two groups. Group 1 underwent a brief training program consisting of four hours of theorical training and 3 hours of practical training, while Group 2 participated in an extended training program with 6 hours of theorical training and 12 hours of practical training. This study found that residents in Group 1 exhibited a notably higher number of unanswered clinical questions

in comparison to the expert (264 (13%) versus 135 (7%) out of 2040 clinical questions; $p < 0.0001$), whereas no significant difference was found in the number of unanswered clinical questions between residents in Group 2 and the expert (235 (9%) versus 218 (8.5%) out of 2528 clinical questions; $p = 0.21$) (14).

According to a prospective study assessing the effectiveness of a limited training program designed for ICU residents with no prior ultrasound experience in conducting goal-oriented echocardiography among ICU patients, the experienced intensivist conducted shorter examinations than residents [4 ± 1 minutes versus 11 ± 4 minutes; $p < 0.0001$] with higher imaging quality [mean grade of 1.95 ± 0.76 versus 1.75 ± 0.66; $p < 0.0001$] (4).

While the presence of echocardiography machines equipped with advanced two-dimensional (2D) imaging and Doppler features is increasing in ICUs, their effective usage demands constant availability of trained operators (14).

Our study found that most of the ICU residents (86%) had never insert ultrasound-guided CVCs. Only 13.5% of them were used to inserting CVC under ultrasound, and only 3% have dedicated training for this type of procedure. In France, Bentzinger et al showed that 73% of French residents had a good knowledge or mastery of ultrasound-guided placement of CVCs (15). The learning curve for ultrasound-guided placement of an internal jugular venous access is rapid, suggesting that it requires only five to ten ultrasound scans and ultrasound-guided venipunctures under the supervision of a tutor (11). Echo guided placement of internal jugular CVCs is accessible to simulation, as described by Barsuk et al (16).

Almost 90 % of the participants have not received dedicated training for lung ultrasound (LU). In a study conducted among 27 physicians from Service D'Aide Médicale Urgente (SAMU) in Paris, only two physicians (7%) had a prior experience with LU, and that experience was limited to the diagnosis of pneumothorax. The remaining 25 out of 27 physicians reported having no prior experience with thoracic ultrasound and expressed difficulty in identifying the pleura on thoracic ultrasound (12).

In another multicenter study carried out in ten ICUs (France, China, Brazil and Uruguay), 100 residents, critical care physician and respiratory therapists' residents with no expertise in transthoracic ultrasound were assessed after training. Following 25 supervised examinations, trainees were able to correctly classify 80% of the lung regions (17).

Although LU is an interesting alternative to Chest X Ray, it is usually not well mastered or never practiced (18). LU performed among critically ill patients eliminates the need for radiation exposure, accelerates the process of obtaining pulmonary imaging, and offers the advantage of easy repeatability (18). Based on a clinical experience accumulated over ten years of resident training, it was proposed that 25 expertly supervised LU determinations would be sufficient for trainees with no expertise in LU to correctly assess it (19).

We found that the majority of students had never received ultrasound practical workshops, seminars or simulation sessions. In most cases, teaching was purely theoretical. Our survey clearly shows the preference of participants for practical rather than theoretical training. Among the respondents, 85% felt that ultrasound training should be part of the residency curriculum. Almost a third of participants thought that simulation sessions were very useful for CCUS learning. Our results were in line with a survey showing the same opinion among 60% of residents (15).

There is therefore a clear gap between the training received by residents in ICUs and their expectations. Our results were similar to those of the study carried out by P. Bentzinger in which 76% of interns who received the full ultrasound course were unsatisfied with this training. In this study, 84% considered receiving further training in the form of a university diploma or inter-university diploma was necessary. A survey assessing the status of point-of-care ultrasound training programs for Italian residents, by comparing the perspectives of residents and program directors reported that limitations included the absence of a standardized curriculum for residents and constraints related to mentors' time and expertise for program directors (19).

Several studies have shown the value of short CCUS training programs for intensivists. Manasia et al showed that a specialized course of ten one-hour sessions enabled instructors to perform simple and useful shock cardiograms in the vast majority of cases (19). The results of a pilot study performed by Vignon et al were in favor of the usefulness of a three-hour didactic course on basic echocardiography and its common pathology, followed by five hours of hands-on practice, enabling interns with no previous ultrasound experience to answer simple questions and intensive care questions (4). More recently, the same team has achieved even better results, by offering a quick training course in ultrasound, and a rapid 12-hour training course to interns with no ultrasound knowledge (20).

According to the literature, ultrasound bedside teaching and classroom lessons are the simplest and most established options (20). Recent research has recommended enhancing the face-to-face lecture format by integrating methods like the flipped classroom (21), embracing online learning and leveraging social media (22).

Strengths and limitations

Our study is the first study that has investigated the practice of CCU among Tunisian intensive care residents and delineated their expectations.

The main limitation was the medium response rate. Contacting ICU residents directly in their departments or using an online questionnaire could increase their response rate. In addition, self-assessment in this survey may result in an over- or under-evaluation of the results, since it is a subjective evaluation. The use of some theoretical tests and/or practical tests using CCUS may improve the objectivity and standardization of responses.

Recommendations

In our study, the number of Tunisian intensive care residents who mastered the practice of CCU was very low.

As the field of intensive care medicine has developed, the need for rapid and accurate diagnosis of diseases among critically ill patients has grown. The ultrasound operator skill is known to correlate positively with the number of exams performed. The practice of ultrasound is more and more used in clinical medicine. Therefore, there is a growing demand for education and training (21).

In critical care medicine, clinical practice requires many procedural skills in technical areas including critical care ultrasound, pleural procedures, vascular access, and airway management. Simulation provides options for standardized training and evaluates procedures without risk exposure for patients (22). Simulation training offers opportunity to acquire skills in a shorter time. The integration of such a simulation into training programs with an expert trainer should be promoted. The simulator contains several pathological conditions offering the possibility to develop multiple scenarios providing an opportunity to manage the different clinical problems (23).

Thus, for critically ill patients, competency in the practice of CCUS by intensivists becomes an absolute requirement to improve the medical care of critically ill patients. Every intensivist should have the technical knowledge and skills to perform CCUS and interpret its results (15).

Conclusion

Despite the study's moderate participation rate, our research showed the deficiency of critical care ultrasonography education among Tunisian ICU residents across several teaching units. The residents indicated that they would like to learn more to become proficient with this technology. When used to beginners, simulation can be a great way to quickly facilitate their training, which can then be done at the patient's bedside. Each university hospital's medical ICU is in charge of creating and setting up this hands-on instruction because the required tools are available. It should be the technical proficiency of every intensivist to execute CCU. As such, it is imperative that such education and training be incorporated into ICU resident training programs as soon as feasible. In Tunisia, critical care residents must receive regular and certified training in critical care ultrasonography. Indeed, to evaluate critical care ultrasound education in the ICU, more research is required.

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