

The diagnostic accuracy of multi-organ point-of-care ultrasonography for life-threatening conditions: The case of cancer patients who visit the emergency department: retrospective observational study

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Abstract

Background The number of cancer patients visiting the emergency department (ED) is increasing globally, and this has highlighted the importance of diagnosing and coping with related life-threatening complications early. There may be efficacy in employing multi-organ point-of-care ultrasonography (M-PoCUS) for this purpose; however, there has been no study on the usefulness of this diagnostic tool for cancer patients only. The aim of this study was to evaluate the diagnostic accuracy of M-PoCUS for a life-threatening condition in cancer patients who visited the ED.

Methods We conducted a retrospective observational study in one tertiary university hospital ED in Seoul, Republic of Korea. We selected three emergency medicine specialists to perform a protocolized M-PoCUS evaluation of cancer patients according to the requests of emergency physicians since the SARS-CoV-2 pandemic began. We enrolled 94 cancer patients in the study. The M-PoCUS diagnosis was then compared with an audit diagnosis. The primary outcomes measured were the sensitivity, specificity, positive predictive value, and negative predictive value of M-PoCUS in the above-described diagnosis.

Results The M-PoCUS showed a sensitivity of 83% (95% CI, 61-95), specificity of 96% (95% CI, 88-99), positive predictive value of 86% (95% CI, 65-97), and negative predictive value of 94% (95% CI, 85-97). M-PoCUS produced 4 false negative (4.3%) pulmonary thromboembolism diagnoses and 3 false positive (3.2%) pleural effusion diagnoses.

Conclusions M-PoCUS was useful in ruling out a life-threatening condition among the cancer patients. However, pulmonary thromboembolism was hard to distinguish using M-PoCUS due to pre-existing diseases scattered in cancer patients' thorax.

Background

Point-of-care ultrasonography (PoCUS) has become a very important diagnostic tool for emergency physicians in terms of its radiation-free, quickness, and accuracy [1-3]. In fact, ultrasound in general is vigorously used in various emergency department (ED) settings, not only for diagnostic modality, but also for procedural success [4, 5]. It is well known that lung ultrasound (LUS) has higher sensitivity than x-rays for pneumonia, pneumothorax, pulmonary edema, and pleural effusion [6-13]. In pulmonary thromboembolism, the combination of focused transthoracic echocardiography (TTE), LUS and lower extremity vein ultrasound (LEVUS) showed higher sensitivity [14, 15]. Focused TTE with LUS has been valuable in discriminating cardiogenic from non-cardiogenic dyspnea [16-18]. Therefore, multi-organ point-of-care ultrasonography (M-PoCUS), which incorporates these methods, showed high diagnostic accuracy in the ED for undifferentiated hypotension and respiration symptoms and reduced time to diagnosis in the ED [19-22]. However, for most PoCUS studies, cancer patients accounted for only 5–10% of their cohorts [20, 21]. Thus, in our knowledge, the diagnostic accuracy and usefulness of M-PoCUS for cancer patients only in the ED is yet to be proven, prompting a more focused investigation into the efficacy of this method in this context.

Importance

Because the survival rate of cancer patients is increasing due to the advancement of modern medicine the number of cancer patients visiting the ED is also increasing [23, 24]. In addition, the number of cancer patients requiring palliative care is also increasing [25-27]. Therefore, emergency physicians need to have a rapid approach to address the many complaints and complications commonly voiced and experienced by cancer patients. Regarding these complications, according to previous studies, it is known that respiratory distress, fever, and pain are the main symptoms of cancer patients visiting the ED; particularly, respiratory distress, shock, and sepsis are known to be associated with poor clinical outcome [23, 28]. Considering the efficacy of M-PoCUS for the general population of ED, we expected that life-threatening conditions, common in cancer patients, could also be accurately diagnosed using M-PoCUS.

Goals of this investigation

The goal of the present study was to evaluate the diagnostic accuracy of M-PoCUS for a life-threatening condition in cancer patients who visited the ED. We hypothesized that M-PoCUS incorporated with initial clinical evaluation could correctly identify pre-defined life-threatening conditions in cancer patients.

Methods

Study design and setting

This retrospective, single center observation study was conducted at the ED of the Seoul National University Hospital, Republic of Korea. This center is a tertiary level university hospital with approximately 60,000 annual adult ED visits. Of these, cancer patients accounted for an average of 15,000 (25%) for a year, most of them are evaluated and treated at the ED for various complications related to underlying cancer. In this institution, the PoCUS program has been included in emergency medicine resident training since April 2018, and emergency medicine specialists with over 5 years of experience in emergency ultrasound have been conducting bedside teaching. Every year, thousands of PoCUS examinations are performed in our institution, including heart, lung, abdomen, deep vein, procedural ultrasound, airway ultrasound, and extended focused assessments with sonography for trauma [29]. Since the onset of the SARS-CoV-2 pandemic, we started to use M-PoCUS for heart, lung, inferior vena cava (IVC), and lower extremity vein examinations as initial modality more actively in order to evaluate life-threatening conditions in cancer patients that had been visiting the ED since February 2020. M-PoCUS was available during the daytime and performed primarily at the request of duty emergency physicians in patients complaining of dyspnea, chest pain, shock, and hypoxia. In addition it was also performed when requested in patients with fever, gastrointestinal symptoms, and general weakness. All the examinations were performed by three emergency medicine specialists (YAC, TKK, MSL), each with experience of performing more than 200 focused TTE, 100 LUS, and 100 LEVUS previously. This study was approved by our institutional review board and met the criteria for exemption from informed consent. (Seoul National University IRB No. 2010-110-1165)

Selection of Participants

We retrospectively reviewed our institution's electrical medical records since February 2020. Any cases with M-PoCUS performed at the ED were considered eligible for the current study. The inclusion criteria were as follows; active cancer patients [30] admitted to the ED during the study period, patients older than 18 years old, and patients whose M-PoCUS examinations were performed by selected emergency medicine specialist during their ED visit. Patients whose ultrasound image quality was poor due to their poor cooperation, resulting in inadequate retrospective interpretation, were excluded.

Measurements

M-PoCUS was performed with a multiprobe portable machine (Venue GE) with a 1.6–4.5 MHz phased array probe, 4.0–12.0 MHz linear probe, and 1.5–6.0 MHz convex probe. The requested emergency medicine specialist performed M-PoCUS after reviewing the patients' chief complaints and past medical histories. All examinations were performed according to a predefined M-PoCUS protocol described as follows.

Cardiac view

A cardiac 1.6–4.5 MHz phased array probe was used for examining the heart through the subcostal, parasternal long axis, and the apical four chamber and/or five chamber views. The visual estimation of the left ventricle (LV) systolic function was examined by the parasternal long axis and/or apical 4 chamber view [31, 32]. The LV systolic function was qualitatively classified as hyperdynamic when LV ejection fraction (EF) was $\geq 70\%$, normal for LV EF 50–70%, mild to moderate dysfunction for LV EF 30–49%, and severe dysfunction for LV EF $< 30\%$ according to the American college of cardiology (ACC). Right ventricular (RV) dilatation was diagnosed in the presence of at least one of the following criteria: right/left ventricular end-diastolic diameter ratio > 0.9 in the apical four chamber or subcostal view [33-35]. RV strain was indicated by the presence of septal dyskinesia or flattening [32]. Cardiac tamponade was diagnosed whenever pericardial effusion was associated with right atrium (RA) collapse and/or RV collapse during diastole plus a plethoric IVC [36, 37]. The IVC maximal diameter (end-expiration), minimal diameter (end-inspiration), and IVC collapsibility index ($=$ maximal diameter – minimal diameter / maximal diameter) were measured in the subcostal view at 0.5 to 2.0 cm from the RA junction [38].

Lung view

A cardiac 1.6–4.5 MHz phased array probe was mainly used for the lung study; 4.0–12.0 MHz linear probe or 1.5–6.0 MHz convex probe were used together according to the ED ultrasound examiner's preference. The standardized eight anterior-posterolateral areas examination was used [39, 40]. An LUS test was performed with the patients in the supine or near-to-supine position, or in the semi fowler's position if the patient was unable to sustain the supine position because of aggravating symptoms. A normal lung was defined as showing A-lines with the lung sliding on all eight areas without alveolar consolidation or pleural effusion [41]. B-pattern was defined as the presence of three or more B-lines between two ribs in a single scan, which is indicative of interstitial syndrome [39, 42]. B-pattern was classified as either focal or diffuse [40, 43]. Consolidation of the lung was visualized as an echo poor or tissue like

pattern, depending on the extent of aeration loss and fluid predominance [44]. Pleural abnormalities were defined as a pleural thickening, irregularities of the pleural margins, or small bands of consolidations [40, 43]. Pleural effusions were categorized as simple or complex. Simple pleural effusions are anechoic, while complex pleural effusion are echogenic, with or without septations [45, 46]. The use of terms 'small, moderate, and large' in reference to pleural effusions is common, with no consensus on these size limits [47]. Therefore, our team defined moderate pleural effusion as a maximal interpleural distance ≥ 25 mm (≥ 500 ml) [48, 49]. Pneumothorax was defined as the presence of lung point, an absence of lung sliding, an absence of lung pulse, an absence of B-line, an absence of consolidation, and an absence of pleural effusion [39].

Lower extremity vein view

A 4.0–12.0 MHz linear probe was used for the lower extremity vein study. We used the two-point (two zone) deep vein thrombosis (DVT) compression examination [50]. The regions of common femoral vein (CFV) and the greater saphenous vein (GSV) bifurcation, as well as the popliteal vein trifurcation region were scanned for compressibility; a positive DVT scan was recorded whenever the vein was not compressible or thrombus was identified in the venous lumen.

The M-PoCUS findings and diagnoses were reported in a predefined standardized form (see Additional file 1). For each patient, up to two concomitant sonographic diagnoses could be present, and the most crucial diagnosis that caused patients' symptoms was entered in the first column. Tumor progression was one of ten M-PoCUS diagnoses. However, this diagnosis had to be entered in the second column. This is because tumor progression can concomitantly exist with any acute illnesses in the first column, and the ultrasonographic definition of tumor progression has not been studied. All patient video clips and images were saved and transferred to a picture archiving communication system of Seoul National University Hospital.

The electronic medical records of all patients were reviewed in structured forms. In addition to the patients' demographics and other baseline characteristics, "time to ultrasound", and other time to procedure variables were gathered to evaluate the time-dependent ultrasound efficacy. Specifically, age, sex, type of cancer, reason of requested study, eastern cooperative oncology group (ECOG) performance status, time of ED arrival, time to start M-PoCUS, time to end M-PoCUS, time to perform x-ray, time to perform computed tomography (CT), time to administer antibiotic, time to fluid bolus infusion, time to administer diuretic, time to pleurocentesis, time to pericardiocentesis, M-PoCUS findings, and M-PoCUS diagnoses were abstracted from electronic medical record system.

Outcomes

The M-PoCUS diagnoses were cardiogenic pulmonary edema (CPE), bilateral alveolar interstitial syndrome (AIS), unilateral AIS, pleural effusion (moderate to large), pulmonary thromboembolism (PTE), cardiac tamponade, pneumothorax (PTX), hypovolemia (including distributive shock), tumor progression and normal or other disease. The AIS, which is a radiologic term, was included in the M-PoCUS diagnoses because it is the same ultrasonographic findings that cancer patients might also exhibit with a variety of lung diseases, such as primary lung cancer, solid metastasis, lymphangitic metastasis, infectious pneumonia, and drug-induced interstitial lung disease. Diagnoses and corresponding ultrasonographic findings combination were given (see Additional file 2). The predefined acute life-threatening conditions have consisted of CPE, pleural effusion (moderate to large), cardiac tamponade, PTE, PTX. Those conditions require urgent treatment such as diuresis, pleurocentesis, pericardiocentesis, anticoagulation, or tube thoracostomy.

The reference standard was the audit clinical diagnosis using an electronic chart review. For each patient, up to two concomitant diagnoses could be present. The main diagnosis was placed in the first column when two concomitant diagnoses were present. Tumor progression must be entered in the second column. At least one month after the patient visits the ED, two emergency medicine specialists reviewed all relevant clinical documentation of cases, including laboratory data, imaging tests except M-PoCUS examinations, consultative reports, and other data recorded during the hospital stay. The auditors were blinded to the results of the initial ultrasonography evaluation. The electronic chart review consisted of two separate steps. First, each auditor independently formulated one or two clinical diagnoses for the leading causes of patients' visits to the ED using ten diagnoses, the same as the M-PoCUS diagnoses. In addition, they described a definite diagnosis corresponding to 10 categories of audit diagnosis. Secondly, the two auditors, joined by another emergency medicine specialist, held a plenary meeting and discussed cases where the two independent personal diagnoses were not concordant. When the plenary discussion did not create full consensus, the contradiction was resolved by the majority. Cases without the agreement of at least two of the three auditors were described as indeterminate cases.

Analysis

In one study, a presumed ED diagnosis using chest x-ray was able to diagnose life-threatening conditions with a sensitivity of 65% and a specificity of 78% [20]. The sensitivity and specificity of PoCUS for diagnosing life-threatening conditions in the ED were around 90%, and there were only a few cancer patients enrolled [20]. Though we cannot predict the diagnostic performance of M-PoCUS for cancer patients, the sensitivity may slightly decrease when discriminating life-threatening conditions caused by similar ultrasonographic findings of primary cancer and/or metastatic cancer in the chest. We preliminarily reviewed some cancer patients who visited the ED for the same period and set the expected prevalence of life-threatening conditions as 30%. When we set the expected sensitivity as 86% (a 5%-lower value based on the above-mentioned 90% level), 90% for specificity, 5% for type I error, and 80% for power. Ninety-three subjects were calculated for the adequate sample size.

To assess the diagnostic performance of M-PoCUS for the predefined acute life-threatening conditions, sensitivity, specificity, positive predictive values (PPVs), negative predictive values (NPVs), and their 95% confidence intervals were calculated. For the secondary outcome, Cohen's kappa inter-rater coefficient was used to evaluate the agreement between nine M-PoCUS diagnoses and audit diagnoses. The reference standard was the first column of the audit diagnosis among the calculations. Cohen's kappa inter-rater coefficient was also used to evaluate the agreement of the two audits' first column diagnoses. For the descriptive analysis, continuous variables were shown by means with standard deviation (SD) or medians with interquartile range (IQR). Two-sided P-values of less than 0.05 were considered statistically significant. All the statistical analyses and sample size calculations were done using R software version 4.0.4 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Characteristics of study subjects

From March 1, 2020, to October 31, 2020, 1286 PoCUS cases were performed in our ED. We recorded 98 patients who were eligible for participation in the study. Among them, four patients were excluded due to low quality of their archived M-PoCUS images. Finally, 94 patients were enrolled in the study (Figure 1). Among them, 62 were men, and the mean age of the entire sample was 67.1 ± 10.3 years. Lung cancer was the most common type of cancer and dyspnea was the most common reason of requested study. The baseline characteristics are shown in Table 1.

After the patient arrived at the ED, the median time to M-PoCUS was 63.0 minutes (Interquartile range [IQR], 39.0–195.0). The median time to complete M-PoCUS evaluation was 10 minutes (IQR, 7–14). For chest X-ray and CT, the median time was 75.0 minutes (IQR, 46.0–111.5) and 240.5 minutes (IQR, 148.0–467.0), respectively. There was no adverse event associated with M-PoCUS. No complications were reported after interventional procedures such as pleurocentesis and pericardiocentesis were conducted. All intervention data are specified in Table 2.

Main results

Cardiac and lung views were performed in 94 (100%) patients. A lower extremity vein view was performed only in 17 (18.1%) patients. The M-PoCUS findings are given in Table 3.

The M-PoCUS and audit diagnosis are reported in Table 4. Overall concordance between the two audits was substantial (Cohen's kappa, 0.763) [51]. There was no indefinite case in the audit diagnosis. No examiners diagnosed pneumothorax through M-PoCUS, and there was no pneumothorax audit diagnosis. The main outcome of M-PoCUS for the predefined acute life-threatening conditions is shown in Table 5. M-PoCUS had a sensitivity of 83% (95% CI, 61–95); specificity of 96% (95% CI, 88–99); PPV of 86% (95% CI, 65–97); NPV of 94% (95% CI, 65–98) and accuracy of 93% (95% CI, 85–97) for detecting life-threatening conditions. The secondary outcome, the overall agreement of the nine diagnoses between the M-PoCUS and audit was substantial (Cohen's kappa, 0.742) [51].

We missed four patients with PTE when using M-PoCUS. Four false negative cases were diagnosed as unilateral AIS (n=2), bilateral AIS (n=1) and hypovolemia/distributive (n=1) in M-PoCUS diagnosis. Three false positive cases were reported as pleural effusion in the M-PoCUS diagnosis but were diagnosed as hypovolemia/distributive (n=2) and bilateral AIS (n=1) in the audit diagnosis.

Definite diagnoses are reported in Table 6. The most common diagnoses were pneumonia (n=29, 30.9%), increased tumor burden (n=26, 27.6%), and pleural effusion (n=15, 16.0%).

Discussion

This investigation is the first study to evaluate the diagnostic accuracy of M-PoCUS for a life-threatening condition in cancer patients. In our study, M-PoCUS for cancer patients has shown slightly lower sensitivity in diagnosing life-threatening conditions than the previous study. Laursen et al [20]. examined that M-PoCUS has a sensitivity of 100% and specificity of 93.3% in diagnosing life-threatening conditions in ED patients whose chief complaints were respiratory difficulty, desaturation, cough, or chest pain. Identified 19 patients with life-threatening conditions by M-PoCUS were as follows; 4 cases of PTE including 3 cases of DVT, 9 cases of heart failure with pulmonary edema, 1 case of pericardial effusion, 4 cases of empyema including 1 large amount pleural effusion, and 1 case of pneumonia with large amount pleural effusion. In contrast, we missed 4 cases of PTE. The current study's lower sensitivity is most likely due to the cancer patients' thorax condition. A meta-analysis showed that LUS offers sensitivity and specificity of 77% and 75%, respectively, for PTE [52]. Those studies from the meta-analysis mainly detected the presence of triangular/wedge or rounded pleural-based lung lesions, as well as hypo-echogenic, homogeneous, pleural-based lung lesions. However, there are also many similar pleural-based lung lesions in cancer patients due to other pathologic lung diseases such as pneumonitis, primary cancer, or metastasis; thus, the sensitivity of PTE with LUS was reduced and not quite as effective. A diagnostic test study including LUS, TTE, and LEVUS showed sensitivity and specificity of 90% and of 86.2%, respectively, for PTE [14]. However, our team performed LEVUS only in 18% of patients. This lower performance of LEVUS may have further decreased the sensitivity for PTE. A plausible explanation of lower performance of LEVUS is that examiners began to examine the lungs or heart first. When pathogenic findings were suspected in the process, they tended not to look at the lower extremity vein view. If LEVUS had been performed in the majority of patients, then the sensitivity of M-PoCUS would have been improved

The missed life-threatening conditions were 4 cases of PTE. In the audit diagnosis, they were confirmed by chest CT angiography including chest pulmonary artery and deep vein angiography in two cases, chest CT contrast without angiography in one case, and abdominal CT angiography in 1 case. Of them, only one DVT case was confirmed using chest CT angiography including chest pulmonary artery and deep vein angiography. DVT could not be identified in the remaining cases due to limited CT protocols (Chest CT without angiography, abdominal CT angiography). In the TTE finding of M-PoCUS, there were no cases of RV dilatation and IVC plethora. In the LUS findings, pleural-based lung lesions were shown as combined with other finding such as lobar consolidation or B pattern in 3 cases, and 1 case was shown as normal. As mentioned earlier, those LUS findings suggest that it is difficult to rule in PTE through only pleural-based lung lesions in cancer patients. Even if there was an alternative diagnosis in LUS and/or TTE, PTE can be present in those cancer patients. Therefore, in the case of cancer patients, if PTE is clinically suspected, we believe that it might be better to actively perform CT angiography.

The false positive cases were 3 cases of pleural effusion. For those cases, the audit diagnoses were hypovolemic or distributive for 1 case and bilateral AIS for the remaining 2 cases. Even in the presence of a moderate amount of pleural effusion, the audits determined that sepsis, pneumonia, and tumor progression were the final diagnosis for false positive cases. In light of these false positive cases, we believe that when diagnosing the pleural effusion as the main diagnosis for cancer patients, careful clinical interpretation considering previous statuses must be combined to lower false positive rates. That way, emergency physicians will be able to detect problems that are more important to their patients and prevent unnecessary pleurocentesis and consequent adverse events.

Limitations of the study

The major limitation of this study is the retrospective design. Due to the study design, the reference standard could not be predefined. For example, cardiac tamponade must be confirmed with advanced transthoracic echocardiography (TTE), which is performed and interpreted by cardiologists. However, in our ED settings, unstable patients with highly suspected cardiac tamponade screened through M-PoCUS were treated by emergency pericardiocentesis with cardiologist' interpretations of M-PoCUS instead of advanced TTE. In order to overcome this significant limitation, a strict audit diagnosis was necessary. Subsequently, three emergency medical specialists performed the audit diagnosis at least one month after the patient visited the ED, completely blinded to the ultrasound evaluation. Besides, to objectively determine the most crucial diagnosis that caused the patient's chief complaint, discussions were conducted several times through plenary meetings. Second, we performed convenient sampling. All tests were performed by three emergency medical professionals whenever possible during the daytime. Third, there may have been a selection bias in the process, as M-PoCUS was only performed on patients whom the charged emergency physicians requested. Fourth, M-PoCUS performers were not blinded to clinical information, rather they performed the index test after reviewing the chief complaints associated with present illnesses, past medical history, and past radiologic test results. This could bias the diagnostic effectiveness of M-PoCUS. However, we assumed that such way might be helpful to distinguish pathogenic findings in cancer patients, whether acute or chronic. When

radiologists interpret CT and x-rays, they compare the test result with previous ones. We believe that it should be the same in the PoCUS interpretation used in daily clinical practice for cancer patients in the ED.

Conclusions

In summary, in this study, M-PoCUS, used collectively with the initial clinical evaluation, was useful to rule out life-threatening conditions in cancer patients who visited the ED during SARS-CoV-2 pandemic. However, PTE was hard to distinguish using only M-PoCUS because the patients' characteristics regarding the pre-existing diseases might have been scattered in the thorax. We believe a CT angiography should be encouraged when clinical suspicion is found. A large prospective cohort study is needed to confirm the results of this study, and to determine M-PoCUS' role in terms of clinical efficacy for cancer patients in the ED.

List Of Abbreviations

ED: emergency department; M-PoCUS: multi-organ point-of-care ultrasonography; PoCUS: Point-of-care ultrasonography; LUS: lung ultrasound; TTE: transthoracic echocardiography; LEVUS: lower extremity vein ultrasound; IVC: inferior vena cava; LV: left ventricle; EF: ejection fraction; RV: right ventricle; RA: right atrium

Declarations

Ethic approval and consent to participate

This study was approved by our institutional review board and met the criteria for exemption from informed consent. (Seoul National University IRB No. 2010–110–1165)

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request

Competing interests

The authors declare that they have no competing interests.

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None

Authors' contributions

YAC and MSL conceived of the presented idea. YAC, MSL, TKK, and YHL reviewed the ultrasonographic examinations and contributed to the interpretation of the results. KHK, JWP, and SGYL retrospective review all relevant data and made audit diagnoses. YAC and MSL took the lead in writing the manuscript. JYJ and JYK provided critical feedback and helped shape the research, analysis and manuscript. All authors discussed the results and commented on the manuscript. MSL takes responsibility for the paper as a whole.

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Tables

Table 1. Population characteristics	
Characteristics	Mean ± SD
	or
	n (%)
Age, years	67.1 ± 10.3
Sex, n (%)	
Male	62 (66.0)
Female	32 (34.0)
Type of cancer, n (%)	
Lung	22 (23.4)
Upper-GI	6 (6.4)
Hepatology	7 (7.4)
Biliary	4 (4.3)
Pancreas	12 (12.8)
Lower-GI	5 (5.4)
Genitourinary	8 (8.5)
Prostate	2 (2.1)
Breast	8 (8.5)
Lymphoma	5 (5.3)
Leukemia	5 (5.3)
Others	10 (10.6)
Reason of requested study, n (%)	
Dyspnea	51 (54.3)
Hypotension	17 (18.1)
Chest pain	3 (3.2)
Hypoxia	4 (4.3)
Others	19 (20.1)
ECOG Performance, n (%)	
1	27 (28.7)
2	19 (20.2)
3	12 (12.8)
4	26 (27.7)
5	10 (10.6)
ECOG = eastern cooperative oncology group	
*others include: fever, gastrointestinal symptoms, general weakness	

Table 2. Time (minute) to intervention from arrival at ED		
Characteristics	n	Median (IQR)
M-PoCUS evaluation time*	94	10 (7.0–14.0)
M-PoCUS	94	63 (39.0–195.0)
Chest x-ray	88	75 (46.0–111.5)
Computed tomography	62	240.5 (148.0–467.0)
Antibiotic	53	138 (70.0–241.0)
Fluid loading	39	88 (50.5–122.5)
Intravenous diuretic	9	85 (53.0–135.0)
Pleurocentesis	9	156 (71.0–677.0)
Pericardiocentesis	3	273 (264.0–537.0)
M-PoCUS = multi-organ point-of-care ultrasound; IQR = interquartile range *M-PoCUS evaluation time is spending time to complete M-PoCUS examination.		

Table 3. M-PoCUS Findings	
Findings	Value (n=94)
Heart, No. (%)	
Hyperdynamic LV function	49 (52.1)
Normal LV function	36 (38.4)
Reduced LV function	5 (5.3)
Severe depressed LV function	2 (2.1)
No access visual systolic function	2 (2.1)
Pericardial effusion without tamponade feature	10 (10.6)
Pericardial effusion with tamponade feature	3 (3.2)
Marked dilatation of the Right ventricle	2 (2.1)
Inferior vena cava, No. (%)	
Normal	20 (21.3)
IVC with signs of intravascular volume depletion	47 (50.0)
IVC with signs of markedly increased right atrium pressure	10 (10.6)
Not possible to or no assess IVC using sonography	17 (18.1)
Lung, No. (%)	
Normal	39 (41.5)
Pleural abnormality	11 (11.7)
Pneumothorax	0 (0.0)
Focal interstitial syndrome	19 (20.2)
Diffuse interstitial syndrome	19 (20.2)
Unilateral consolidation	26 (27.7)
Bilateral consolidation	36 (38.3)
Simple pleural effusion	30 (31.9)
Complex pleural effusion	10 (10.6)
Lower extremity, No. (%)	
No signs of DVT	16 (17.0)
Signs of DVT	1 (1.1)
No access lower extremity vein	77 (81.9)
LV = left ventricle; IVC = inferior vena cava; DVT = deep vein thrombosis	

Table 4. M-PoCUS and audit diagnoses										
	CPE	Bilateral AIS	Unilateral AIS	Pleural effusion	PTE	Tamponade	Hypovolemic/ Distributive	PTX	Normal	Tumor progression
M-PoCUS No. (%)	3 (3.2)	25 (26.6)	11 (11.7)	16 (17.0)	0 (0.0)	3 (3.2)	29 (30.9)	0 (0.0)	7 (7.4)	23 (24.5)
Audit No. (%)	3 (3.2)	26 (27.7)	7 (7.4)	13 (13.8)	4 (4.3)	3 (3.2)	31 (33.0)	0 (0.0)	7 (7.4)	26 (27.7)
CPE= cardiogenic pulmonary edema; AIS= alveolar interstitial syndrome; PTE = pulmonary thromboembolism; PTX = pneumothorax; Normal = normal or other										
M-PoCUS total n = 117, Audit total n = 120, * Total n difference result from the different number of tumor progression										

Table 5. Diagnostic accuracy of life-threatening condition			
Test	Life-threatening condition		
	Present	Absent	Total
M-Pocus positive	19	3	22
M-Pocus negative	4	68	72
Total	23	71	94

Table 6. Definite diagnosis	
Diagnosis	Value (n=118)
Heart, No. (%)	
Tamponade	3 (3.2)
Cardiogenic pulmonary edema	3 (3.2)
Lung, No. (%)	
Pneumonia*	29 (30.9)
Pleural effusion	15 (16.0)
Hypovolemia, No. (%)	
Hemorrhage, symptomatic anemia	7 (7.4)
Dehydration, hypoalbuminemia, prerenal AKI, DKA, ileus	12 (12.8)
Septic shock, No. (%)	
GI origin	8 (8.5)
Genitourinary origin	1 (1.1)
Necrotizing fasciitis	2 (2.1)
Inconclusive origin	1 (1.1)
Venous thromboembolism, No. (%)	
Pulmonary embolism	3 (3.2)
Pulmonary embolism + deep vein thrombosis	1 (1.1)
Increased tumor burden, No. (%)	
Radiologically confirmed	13 (13.8)
Clinically suspected	13 (13.8)
Others, No. (%)	
Postrenal AKI	1 (1.1)
Neutropenic fever	1 (1.1)
Cellulitis	1(1.1)
Normal	4 (4.3)
AKI = acute kidney injury; GI = gastrointestinal; DKA = diabetic ketoacidosis;	
Total n = 118, two concomitant diagnoses could be present	
*Pneumonia category includes not only infectious pneumonia, but also drug induced pneumonitis and aspiration pneumonitis.	
Patients with pneumonia septic shock were categorized under pneumonia.	

Figures

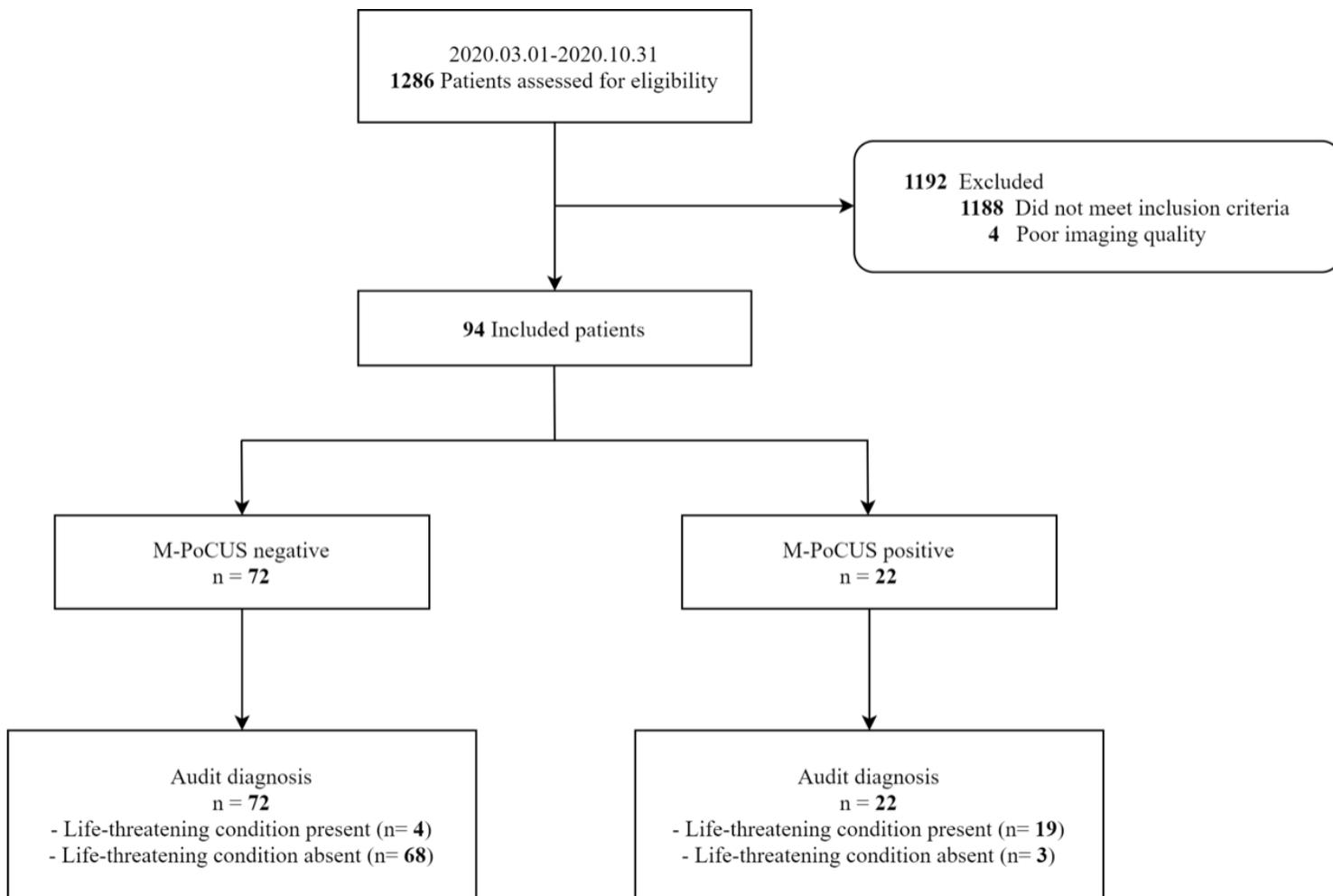


Figure 1

Participants flow chart, M-PoCUS = multi-organ point-of-care ultrasound

Supplementary Files

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