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Original Research Article

Role of the sonographic assessment of fluid estimate score on evaluating intravascular volume status in critically ill patients

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ABSTRACT

Background: Study aim to establish standardized scoring system using bedside ultrasonography to evaluate intravascular volume status in critically ill patients and to correlate this with traditional physician assessment methods.
Methods: A prospective pragmatic observational study was conducted at Narayana health city from August 2021 to February 2022, involving 100 adult medical ICU patients requiring volume status assessment. Patients with local infection, trauma, or increased intra-abdominal pressure were excluded. Volume status was categorized as hypovolemic, euvolemic, or hypervolemic using both the intensivist's methods and the sonographic assessment of fluid estimate (SAFE) score. The agreement between these methods was analyzed.
Results: The SAFE score showed a high agreement with the physician's assessment methods, with a Kappa value of 0.91. The SAFE score demonstrated sensitivity of 100 % and specificity of 100% for identifying hypervolemic (score>1) and (score≤-1) for patients with hypovolemia, both with 100% positive and negative predictive values. For euvolemic patients, the SAFE score had 57.47% specificity, a 26% PPV, and a 100% NPV. Subgroup analyses, including mechanically ventilated patients, those with ARDS, vasopressor requirements, and septic shock, confirmed statistically significant agreement between the two methods.
Conclusions: The SAFE score is a reliable, non-invasive, cost-effective, and time-efficient method to assess volume status in critically ill ICU patients. It offers a standardized alternative to traditional assessment techniques, with specific thresholds indicating hypovolemia (>-2), hypervolemia (> 2), and euvolemia (-1 to 1).

Keywords: SAFE score, Volume status, Ultracritically ill, Intravascular volume, ICU, Non-invasive assessment

INTRODUCTION

In the intensive care unit (ICU), assessing intravascular volume status is critical and can be achieved using clinical, static, and dynamic methods.[1,2] According to the American college of emergency physicians (ACEP) and the society of critical care medicine (SCCM) guidelines, point of care ultrasound (POCUS) is an effective tool for this purpose.[3,4] POCUS evaluates various organs and systems, including right and left cardiac chambers, cardiac contractility, inferior vena cava (IVC) collapsibility/distensibility index, internal jugular vein (IJV) collapsibility/distensibility index, lung water volumes, and pulmonary edema, all of which aid in assessing intravascular volume status.[5-9] Echo has become a cost and time effective imaging method for examination of heart. It helps determine ejection fraction (EF) and stroke volume, identifying whether hemodynamic instability is cardiac in origin.[10] Proper knowledge and training ensure that standard cardiac views are achievable in most patients. POCUS also differentiates causes of respiratory distress by evaluating lung water and detecting pulmonary edema.[11] It assists in

distinguishing heart failure from fluid overload by assessing the resolution of pulmonary edema after therapy. Evaluating the IVC is a common practice for volume status assessment in both mechanically ventilated and spontaneously breathing patients. The IVC evaluation guides fluid responsiveness and fluid therapy. Assessing the IJV provides insights into central venous pressure (CVP) and IVV status, serving as a surrogate marker for IVC collapsibility.[12] However, relying solely on these parameters can have limitations; combining them with other variables enhances their value in hemodynamic assessment. Previously proposed protocols, such as the RUSH (Rapid ultrasonography for shock and hypotension) protocol and the focused assessment with sonography for trauma (FAST), do not include a numerical score for fluid status assessment.[13,14] This study aims to establish and evaluate the SAFE score, a standardized scoring system that combines predetermined scores from heart, lung, IVC, and IJV examinations using bedside ultrasonography to evaluate volume status in critically ill patients.

METHODS

Study site

This study was conducted in the medical ICU of Mazumdar Shaw medical centre, Narayana health city, Bangalore.

Study population

The study included all patients over 18 years old who required an assessment of intra intra-vascular volume (IVV) status as selected by the treating ICU physician.

Study period

The study was conducted from August 2021 to February 2022, following ethical committee clearance.

Study design

This was a single-center, pragmatic, prospective observational study.

Sample size

Estimated using the proportion of subjects classified as hypovolemia (36.07%), euvolemia (32.79%), and hypervolemia (31.15%) based on SAFE scoring from a previous study by Killu et al.[4] Using these values and a confidence level of 95%, a sample size of 89 subjects was determined. Considering a 10% nonresponse rate, the final sample size was 98 subjects.

Formula

$n=Z^2P(1-P)/d^2$

$Z=1.96Z=1.96$ (for 95% confidence level)

$P=36.07\%=0.3607$, P=36.07%=0.3607

$q=1-P=63.93\%=0.6393$, q=1-P=63.93%=0.6393

$d=10\%=0.10$, d=10%=0.10

Inclusion criteria

Adults over 18 years in the medical ICU requiring volume status assessment as decided by the treating Intensivist were included.

Exclusion criteria

Patients were excluded if there is local infection or trauma to the chest, increased intra-abdominal pressure, or increased intrathoracic pressures.

Methodology

Treating intensivist selected patients for IVV status assessment on during their ICU stay. Patient information sheets were provided, and informed consent was obtained from patients/their surrogates. If consent was deferred, the patient was not included in study. Baseline data were collected, and IVV status was assessed using both the intensivist's preferred methods and the SAFE score calculated by researcher.[16,17] Patients were categorized as hypovolemic, euvolemic, or hypervolemic based on both methods, and data were analyzed to find the correlation between the intensivist's methods and the SAFE score.[18]

Data collection

Data collected included age, gender, height, weight, admission diagnosis, clinical history, comorbidities, baseline hemodynamic parameters, baseline investigations (ECHO, arterial blood gas, chest X-ray, POCUS, SAFE score), use of vasopressors/inotropes, cumulative fluid balance data, spontaneous breathing, invasive ventilation and acute respiratory distress syndrome.[19-21]

Statistical analysis

The Kolmogorov-Smirnov test was used to test the normality of the data. Continuous variables were presented as mean and standard deviation or median and interquartile range as appropriate, while categorical variables were reported as frequency and percentage. Kappa statistics were used to assess the agreement between volume status and SAFE score (Table 1). Associations between volume status and SAFE score with baseline parameters were found using ANOVA or Kruskal-Wallis test, and the Mc-Nemar-Bowker test was used to find the association between volume status and SAFE score. Correlation between volume status and SAFE score with other parameters was found using

Kendall correlation. Statistical significance was considered at $p<0.05$. Statistical analysis was performed using IBM SPSS Statistics 27.0, and graphical representation of data was done using MS excel and MS Word. Chi-square tests and ANOVA were used for qualitative and quantitative data, respectively.[22-24]

Agreement between SAFE score and standard measurement of intravascular volume status using Kappa statistic. If Kappa statistic values are between 0.8-1 it is considered as very good agreement

Ethical consideration

Patient information sheets and informed consent were obtained from the subjects. No additional cost was incurred for POCUS in the ICU as it is a routine bedside examination. The study was conducted by a single operator trained in POCUS to avoid interobserver variability and was double-blinded, with neither the researcher nor the patient knowing the volume status before the study.

RESULTS

The mean age of the patients in the study was 53.69±14.80 years. The gender distribution showed that 56% were male and 44% were female. Among the comorbidities, 51% of patients had diabetes mellitus, 38% had hypertension, 18% had coronary artery disease, 8% had small airway disease, 3% had cerebrovascular accident, 2% had acute myeloid pneumonia, 6% had chronic kidney disease, 1% had multiple myeloma, 5% had rheumatic heart disease, and 3% had chronic liver disease (Table 1 and 2).

The reasons for volume assessment were categorized as follows: Hypotension requiring fluid resuscitation: 51% due to septic shock, 2% due to obstructive shock, 5% due to hypovolemia, and 1% due to overdose-induced hypotension. Hypoxemia and suspected volume overload: 15% due to congestive cardiac failure, 2% due to fluid overload from chronic kidney disease, 1% due to decompensated liver disease, 4% due to renal failure needing assessment for renal replacement therapy, and 4% due to multiorgan failure. Initiation of therapy: 1% for diabetic ketoacidosis and 4% for acute pancreatitis. Correction of metabolic factors: 5% for sodium disturbances, 1% for contraction alkalosis, 3% for metabolic acidosis, and 1% for acute tubular necrosis (Table 3). Among the methods used by physicians, POCUS was the most common, used in 94% of the patients. Other methods included velocity time integral (1%), bioreactance (3%), dynamic hemodynamic monitoring using vigileo (1%), and CVP (1%) (Table 4). In the clinical assessment of the population, 10% were identified as euvolemic, 53% as hypervolemic, and 37% as hypovolemic. These assessments were closely mirrored by the SAFE score results, which indicated 12% as euvolemic, 50% as hypervolemic, and 38% as hypovolemic. The similarity between the clinical assessments and SAFE score percentages suggest a high level of agreement between the two methods in categorizing the fluid status of the population. This alignment highlights the potential reliability of the SAFE score in clinical settings for evaluating and managing patient hydration status (Table 4).

When compared with the physician's preferred methods: Among the 38 patients categorized as hypovolemic by the SAFE score, 37 were confirmed as hypovolemic and 1 as hypervolemic by the physician's methods. Similarly, of the 50 patients categorized as hypervolemic by the SAFE score, 49 were confirmed as hypervolemic and 1 as euvolemic by the physician's methods. Of the 12 patients categorized as euvolemic by SAFE score, 3 were found to be hypervolemic and 9 were euvolemic according to the physician's methods. The agreement between the SAFE score and the physician's methods was very high, with a Kappa value of 0.914, indicating statistically significant agreement (Table 5). For identifying hypervolemic patients with a SAFE score above 1, the SAFE score demonstrated 100% sensitivity and specificity, along with a positive predictive value and negative predictive value of 100%, and a Youden index of 1. For identifying hypovolemic patients with a SAFE score of ≤-2, the SAFE score also showed 100% sensitivity and specificity, with a positive predictive value and negative predictive value of 100%, and a Youden index of 1. For identifying euvolemic patients with a SAFE score of ≤1, the SAFE score had 100% sensitivity and 57.47% specificity, with a positive predictive value of 26% and a negative predictive value of 100% (Figure 1-3).

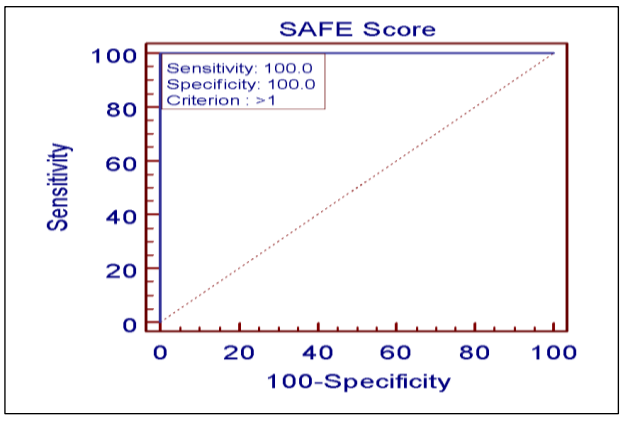

Figure 1: ROC curve showing validity of hypervolemia.

In our study when volume status assessment methods by the physician and SAFE score was compared, SAFE score had 100 % sensitivity and specificity for identifying hypervolemic patients when the score value was above 1 had statistically significant $p<0.001$, 100% positive predictive value, 100% negative predictive value and Youden index value of 1 indicating that the SAFE score values >1 had highest validity in predicting hypervolemia compared to physician's methods.

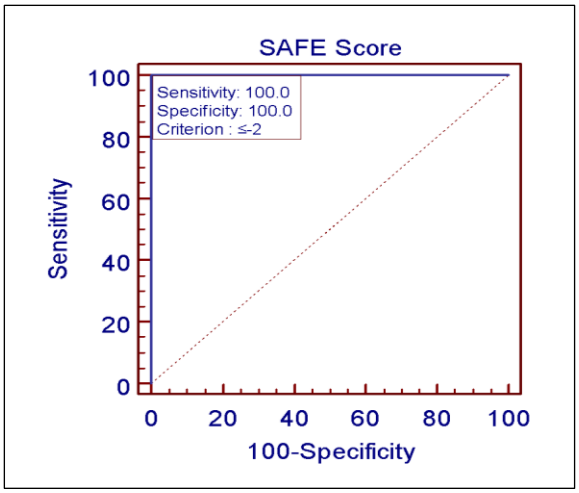

Figure 2: ROC curve showing validity of hypovolemia.

In our study when volume status assessment methods by the physician and SAFE score was compared, SAFE score had 100 % sensitivity and specificity for identifying hypovolemic patients when the score value was ≤-2 and had statistically significant p<0.0001, 100% positive predictive value and 100% negative predictive value and youden index value of 1 indicating that the SAFE score values ≤-2 had highest validity in predicting hypovolemia compared to physician's methods.

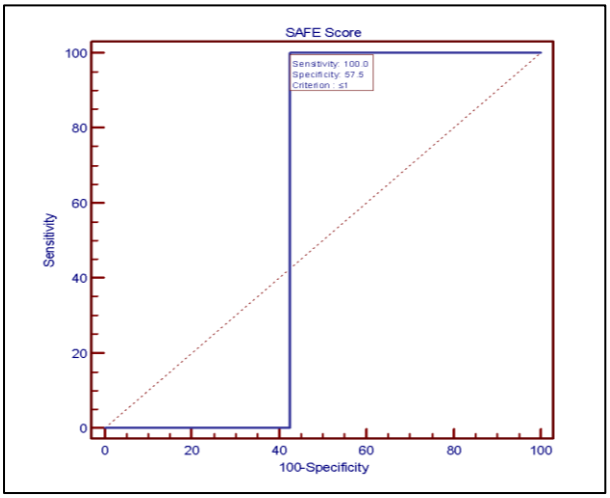

Figure 3: ROC curve showing SAFE score in predicting euvolemia.

In our study when volume status assessment methods by the physician and SAFE score was compared, SAFE score had 100% sensitivity and 57.47% specificity for identifying euvolemic patients when the score value was ≤1 and had 26% positive predictive value and 100% negative predictive value, hence had highest validity in predicting euvolemia compared to physician's methods.

In our study, when correlations between important variables and volume status assessed by physician's method were analyzed using Kendall's test, SAFE score and mean arterial pressure showed significant correlation with the volume status (Kendall p<0.001 and 0.033, respectively. Other variables, such as metabolic acidosis, lactates, and cumulative fluid balance, did not show a statistical correlation with volume status. In mechanically ventilated patients (49%), the volume status assessed by physician's methods had a statistically significant Kappa value and significant agreement with SAFE scores. Subgroup analysis showed significant agreement in ARDS patients (Kappa value 0.907), patients on the vasopressors (Kappa value=0.889), and patients with septic shock (Kappa value=0.924) (Table 7).

Table 1: Age and sex distribution of subject.

Variables		N	Percentage (%)
Age (in years)	21 to 30	8	8.0
	31 to 40	14	14.0
	41 to 50	15	15.0
	51 to 60	25	25.0
	61 to 70	28	28.0
	>70	10	10.0
	Total	100	100
Sex	Male	56	56.0
	Female	44	44.0
	Total	100	100

Table 2: Reason for volume assessment.

Categories for reason for fluid assessment	N	Percentage (%)
Hypotension	59	59
Sepsis / septic shock	51	
Obstructive shock	2	
Hypovolemia	5	
Overdose	1	
Hypoxemia-R/O volume overload	26	26
CCF / cor-pulmonale	15	
CKD	2	
To decide on RRT	4	
Liver disease	1	
MODS	4	
Fluid status for fluid resuscitation	5	5
DKA	1	
Pancreatitis	4	
Fluid resuscitation for correction of metabolic factors	10	10
Sodium disorders	5	
Metabolic acidosis	3	
Contraction alkalosis	1	
Acute tubular necrosis	1	

In our study, the reasons for volume assessment were categorized as-Patients who had hypotension requiring

fluid resuscitation mainly due to septic shock was 51%; due to obstructive shock was 2%; due to hypovolemia was 5% and due to overdose induced hypotension was 1%. Patients who had hypoxemia and suspected volume overload due to congestive cardiac failure was 15%; due to fluid overload due to chronic kidney disease was 2%; due to decompensated liver disease was 1%; renal failure patients who needed volume assessment for initiation of renal replacement therapy was 4% and hypoxemia volume overload due to multiorgan failure was 4%. Patients who needed volume status assessment for initiation of therapy of diabetic ketoacidosis was 1% and acute pancreatitis was 4%. Patients who needed volume status assessment for correction of metabolic factors like sodium disturbances was 5%, contraction alkalosis was 1% metabolic acidosis 3% and acute tubular necrosis 1%.

Table 3: Parameters used by the physician to assess volume status.

Categories for physician method	N	Percentage (%)
Pocus	94	94
VTI	3	3
Bioreactance	1	1
Vigileo	1	1
CVP	1	1

Among the parameters used by the physician in our study, POCUS was the most common method in 94% of the patients. Velocity time integral was used as a fluid assessment parameter in 1% of the patients. Bioreactance was used in 3% of the population. Dynamic hemodynamic monitoring using vigileo was used in 1% of the patients and CVP was used as volume assessment method in 1% of the patients.

In our study by using physician's clinical assessment and various parameters used, 10% of the population was categorized as euvolemic; 53% of the population were categorized as hypervolemic and 37% were categorized as hypovolemic group. Using SAFE score, in our study 12% of the population were categorized as euvolemic; 50% were categorized as hypervolemic and 38% were categorized as hypovolemic.

In our study when SAFE score was compared with physician's preferred methods, out of 38 patients who were categorized as hypovolemic by SAFE score, 37 patients were hypovolemic by physicians' methods and 1 patient was hypervolemic.

Table 4: Volume status distribution based on the physician's method and SAFE score distribution.

Variables		N	Percentage (%)
Volume status by physician's methods	Euvolemia	10	10.0
	Hypervolemia	53	53.0
	Hypovolemia	37	37.0
Volume status based on SAFE scores	Euvolemia	12	12.0
	Hypervolemia	50	50.0
	Hypovolemia	38	38.0

Out of 50 patients who were categorized as hypervolemic by SAFE score, 49 patients were hypervolemic by physician methods and 1 patient was euvolemic and out of 12 patients who were categorized as euvolemic by SAFE score, 3 patients were hypervolemic by physician methods and 9 patient was euvolemic.

In our study when the agreement between the SAFE score and physician's preferred methods used for volume status assessment was assessed, the kappa value was 0.914, which had statistically significant agreement.

In our study when volume status of patients who were mechanically ventilated i.e 49% when assessed by physician's methods had a statistically significant kappa value and hence statistically significant agreement with SAFE scores.

In our study, volume status of patients who had ARDS i. e., 19% when assessed by physician's methods had a statistically significant kappa value=0.907 and hence statistically significant agreement with SAFE scores.

In our study when volume status of patients who were on vasopressors i.e 31% when assessed by physician's methods had a statistically significant kappa value (0.889) and hence statistically significant agreement with SAFE scores.

In our study when volume status of patients who had septic shock i.e 51% when assessed by physician's methods had a statistically significant kappa value (0.924) and hence statistically significant agreement with SAFE scores.

Table 5: Agreement between physician's methods and SAFE score.

SAFE score	Volume status, N (%)			MC-Neymar p value	Kappa value	P value for Kappa
	Hypo	Hyper	Euvolemia			
Hypo	37 (100)	1 (1.9)	0 (0)	0.368	0.914	<0.001**
Hyper	0 (0)	49 (92.5)	1 (10)			
Euvolemia	0 (0)	3 (5.7)	9 (90)			

**Statistically significant.

Table 6: SAFE score.

Exam type	Exam method	Findings
Bedside ECHO	Patient placed in a supine position if no contraindications.	Hyperkinetic EF>70% = - 1 Normal EF 50-70% = 0 Hypokinetic EF<50% = +1
	Phased array transducer placed at the left sternal border 4-5th Intercostal space	
	Long-axis view of the heart obtained, cardiac function & the ejection fraction using the eyeballing method or the M-mode with the maximum systole and diastole Measurements were estimated	
	Short-axis view of the heart was done to estimate the ejection fraction and cardiac function	
	Images were for stored for review	
Lungs	Patient placed in a supine position if no contraindications	Total no of B lines in all segments = No. of segments examined Average <1 B lines = -1 Average 1-2 = 0 Average >3 or more =+1
	Phased array or linear transducer probe kept perpendicular between two ribs in all 4 lung sectors, L1– 4 on the right and left	
	Number of B-lines in each sector were calculated	
	Images were for stored for review	
Inferior vena cava	Patient placed in a supine position if no contraindications	In spontaneously breathing patients 2.5 cm in diameter and >50% variation in diameter during respiration =− 1 1.5–2.5 cm in diameter and <50% variation in diameter during respiration = 0 2.5 cm in diameter and <50% variation in diameter during respiration= +1 In mechanically ventilated patients DIVC = 100 x (Dmax – Dmin) /Dmin > 18% fluid responders - hypovolemia < 18% fluid non responders –hypervolemia (25)
	Phased array or curvilinear transducer was placed in the midline in the epigastric area to locate the inferior vena cava.	
	Inferior vena cava diameter just distal to the right hepatic vein, with the maximal and minimal diameter was measured	
	Collapsibility index was calculated: ((maximal diameter - minimal diameter)/minimal diameter) × 100.	
	During spontaneous breathing, the maximal diameter was calculated during expiration and the minimal during inspiration, and the opposite is true during mechanical ventilation.	
	Images were stored for review	
Internal jugular vein	Patient's head of the bed was elevated to 30 degrees if no contraindications.	In spontaneously breathing patients 40% respiratory variation = − 1 20–40% respiratory variation = 0 20% respiratory variation = +1 In mechanically ventilated patients >18 % fluid responders - hypovolemia <18% fluid non-responders - hypervolemia (25)
	Linear transducer probe was placed across the patient' neck in the area of the cricoid cartilage with no pressure applied to the vein.	
	The largest diameter image of the Internal Jugular Vein was obtained	
	Maximal and minimal diameter at the largest diameter point and the respiratory variation were measured. Collapsibility index: (maximal diameter - minimal diameter) / minimal diameter) × 100 was calculated.	
	Images were stored for review	
Final score and interpretation	Cardiac +lung +inferior vena cava +internal jugular vein = − 2 to − 4 =hypovolemia − 1 to +1 = euvolemia +2 to +4 = hypervolemia	

Table 7: Agreement of volume status in sub groups - assessed by physicians' method versus SAFE score.

SAFE score	Volume status score					
	Hypo (%)	Hyper (%)	Normal (%)	MC-Neymar P value	Kappa statistic	Kappa P value
Mechanical ventilation						
Yes						
Hypo	17 (100)	1 (3.6)	0 (0)	0.607	0.889	<0.001**
Hyper	0 (0)	26 (92.9)	1 (25)			
Normal	0 (0)	1 (3.6)	3 (75)			
ARDS						
Yes						
Hypo	10 (100)	1 (14.3)	0 (0)	0.317	0.907	<0.001**
Hyper	0 (0)	6 (85.7)	0 (0)			
Normal	0 (0)	0 (0)	2 (100)			
Vasopressor						
Yes						
Hypo	12 (100)	0 (0)	0 (0)	0.317	0.939	<0.001**
Hyper	0 (0)	17 (94.4)	0 (0)			
Normal	0 (0)	1 (5.6)	1 (100)			
SEPSIS						
Yes						
Hypo	24(100)	0 (0)	0 (0)	1.00	0.924	<0.001**
Hyper	0 (0)	24 (96)	1 (50)			
Normal	0 (0)	1 (4)	1 (50)			

P value using Mc-Neymar-Bowker's test; Agreement using kappa statistic; **-statistically significant.

DISCUSSION

Assessing intravascular volume status in critically ill patients poses significant challenges due to the absence of established standard methods. Clinical, static, and dynamic methods are employed, but historical findings and physical examinations offer limited value with poor correlation with invasive volume status measurements.[28] Static invasive measures like CVP and pulmonary artery occlusion pressure (PAOP) show poor correlation with fluid responsiveness, while dynamic invasive measurements like stroke volume variation/pulse pressure variation have prerequisites and technical requirements. The passive leg raise (PLR) method, a dynamic approach, has shown promise but requires continuous cardiac output monitoring and patient cooperation.[29] POCUS, involving examination of the IVC, IJV, echocardiography (ECHO), and Lung Ultrasound, individually demonstrated poor correlation in predicting volume status. Our study aimed to combine various point-of-care ultrasound methods to assess volume status, utilizing the SAFE score.[30] SAFE score, originally used in surgical ICU patients, combines various ultrasound findings to categorize patients based on volume status rather than fluid responsiveness.

The main objective of our prospective observational study was to compare the volume status assessed by physicians using routine clinical subjective or objective methods (POCUS/static and dynamic methods) with the SAFE score. We found significant agreement (Kappa value=0.91) between the SAFE score and the physician's methods in assessing volume status.[31] Our study results were comparable to a pilot study conducted by Keith et al. in surgical ICU patients, where volume status assessed by standard methods was compared with the SAFE score, yielding similar results with high validity. SAFE score demonstrated high sensitivity and specificity for identifying hypervolemic and hypovolemic patients, with moderate specificity for identifying euvolemic patients.[32] Subgroup analysis showed significant agreement across various patient groups, including mechanically ventilated patients, ARDS patients, and those with vasopressor requirements or septic shock. Additional variables such as MAP, cumulative fluid balance, metabolic acidosis, and lactate levels were compared with volume status assessed by both methods.[33] MAP showed a statistically significant correlation, while lactate values did not correlate significantly with volume status. Cumulative fluid balance also showed no significant correlation, consistent with prior studies. The SAFE score emerged as a time and cost-effective bedside tool with high validity and significant agreement compared to physicians' methods in assessing volume status in medical ICU patients.[34,35]

Strength

The study encompassed a heterogeneous group of patients with a wide range of diagnoses and clinical conditions, enhancing the generalizability of the findings. Utilization of an objective bedside scoring system and the

study's validity. Additionally, having a single operator, ensured consistency and minimized interobserver variability.

Limitations

One of the primary limitations was the exclusion of surgical ICU patients. Another critical consideration is the reliance on POCUS, as it is the primary method used in all ICUs for volume status assessment. Additionally, scoring in a smaller number of ARDS patients can be problematic, as lung USG findings in ARDS can confuse the SAFE score results. Furthermore, the IVC index for euvolemic patients remains unclear according to the literature.

CONCLUSION

Bedside ultrasound examination has become a routine practice in ICUs for assessing baseline volume status in patients by physicians. The SAFE score emerges as a valuable point-of-care tool, offering objectivity, time and cost efficiency, and non-invasiveness compared to conventional methods employed by senior physicians in ICU patients. Our study findings indicate that a SAFE score of >-2 is indicative of hypovolemia, >2 signifies hypervolemia, and -1 to 1 suggests euvolemia. This standardized scoring system holds promise as an effective means of assessing volume status in critically ill patients, offering a reliable alternative to existing invasive and non-invasive methods.

Recommendations

In assessing volume status in critically ill medical ICU patients, the Sonographic Assessment of Fluid Estimate (SAFE) can be used as a point-of-care, bedside, time- and cost-effective, objective, and standardized scoring system for initial and subsequent assessments. Future studies in various intensive care units and larger patient subgroups are warranted to determine the severity of the SAFE score and its correlation with standard methods, such as static and dynamic measures of volume assessment in critically ill patients, to validate its use in other ICU scenarios.

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Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Kalantari K, Chang JN, Ronco C, Rosner MH. Assessment of intravascular volume status and volume responsiveness in critically ill patients. Kidney Int Elsevier. 2015.
2. Vincent J-L. Intravascular Volume Assessment in the Critically Ill Patient. Clin J Am Society Nephrol. 2019;15(4):557-9.
3. Pourmand A, Pyle M, Yamane D, Sumon K, Frasure SE. The utility of point- of-care ultrasound in the assessment of volume status in acute and critically ill patients. World J Emergency Med. 2019;10(4):232.
4. Killu K, Coba V, Blyden D, Munie S, Dereczyk D, Kandagatla P, et al. Sonographic Assessment of Intravascular Fluid Estimate (SAFE) Score by Using Bedside Ultrasound in the Intensive Care Unit. Crit Care Res Pract. 2020;2020:1-9.
5. 5.Frankel HL, Kirkpatrick AW, Elbarbary M, Blaivas M, Desai H, Evans D, et al. Guidelines for the Appropriate Use of Bedside General and Cardiac Ultrasonography in the Evaluation of Critically Ill Patients-Part I. Critical Care Med. 2015;43(11):2479-502.
6. Levitov A, Frankel HL, Blaivas M, Kirkpatrick AW, Su E, Evans D, et al. Guidelines for the Appropriate Use of Bedside General and Cardiac Ultrasonography in the Evaluation of Critically Ill Patients-Part II. Critical Care Med. 2016;44(6):1206-2.
7. Mackenzie D, Noble V. Assessing volume status and fluid responsiveness in the emergency department. Clin Experimental Emergency Med. 2014;1(2):67-77.
8. The American College of Emergency Physicians, Ultrasound Guidelines: Emergency, Point of Care, and Clinical Ultrasound Guidelines in Medicine, American College of Emergencyphysicians, Irving, TX, USA, 2016. Available at: https://www.acep.org/globalassets/newpdfs/policy-statements/ultrasound-guidelines-emergency-point-of-care-and-clinical- ultrasound-guidelinesin-medicine.pdf. Accessed on 12 April, 2024.
9. Spencer K, Kimura B, Korcarz C, Pellikka P, Rahko P, Siegel R. Focused Cardiac Ultrasound: Recommendations from the American Society of Echocardiography. J Am Society Echocardiography. 2013;26(6):567-81.
10. Via G, Hussain A, Wells M, Reardon R, ElBarbary M, Noble VE, et al. International Evidence-Based Recommendations for Focused Cardiac Ultrasound. J Am Society Echocardiography. 2014;27(7):15.
11. Lichtenstein D, Mezière G. A lung ultrasound sign allowing bedside distinction between pulmonary edema and COPD: the comet-tail artifact. Intensive Care Med. 1998;24(12):1331-4.
12. Lichtenstein DA, Mezière GA, Lagoueyte J-F, Biderman P, Goldstein I, Gepner A. A-Lines and B-Lines. Chest. 2009;136(4):1014-20.
13. Lichtenstein DA. Lung ultrasound in the critically ill. Ann Intensive Care. 2014;4(1):1
14. Volpicelli G, Elbarbary M, Blaivas M, Lichtenstein DA, Mathis G, Kirkpatrick AW, et al. International evidence-based recommendations for point-of-care lung ultrasound. Intensive Care Med. 2012;38(4):577-91.
15. Zhang Z, Xu X, Ye S, Xu L. Ultrasonographic Measurement of the Respiratory Variation in the Inferior Vena Cava Diameter Is Predictive of Fluid

Responsiveness in Critically Ill Patients: Systematic Review and Meta- analysis. Ultrasound Med Biol. 2014;40(5):845-53.
16. Feissel M, Michard F, Faller J-P, Teboul J-L. The respiratory variation in inferior vena cava diameter as a guide to fluid therapy. Intensive Care Med. 2004;30(9):10.
17. Barbier C, Loubières Y, Schmit C, Hayon J, Ricôme J-L, Jardin F, et al. Respiratory changes in inferior vena cava diameter are helpful in predicting fluid responsiveness in ventilated septic patients. Intensive Care Med. 2004;30(9):1740-6.
18. Sefidbakht S, Assadsangabi R, Abbasi HR, Nabavizadeh A. Sonographic measurement of the inferior vena cava as a predictor of shock in trauma patients. Emergency Radiol. 2007;14(3):181-5.
19. Broilo F, Meregalli A, Friedman G. Right internal jugular vein distensibility appears to be a surrogate marker for inferior vena cava vein distensibility for evaluating fluid responsiveness. Revista Brasileira Terapia Intensiva. 2015;27(3):1.
20. Keller AS, Melamed R, Malinchoc M, John R, Tierney DM, Gajic O. Diagnostic accuracy of a simple ultrasound measurement to estimate central venous pressure in spontaneously breathing, critically ill patients. J Hospital Med. 2009;4(6):350-5.
21. Killu K, Coba V, Huang Y, Andrezejewski T, Dulchavsky S. Internal jugular vein collapsibility index associated with hypovolemia in the intensive care unit patients. Crit Ultrasound J. 2010;2(1):13-7.
22. Ilyas A, Ishtiaq W, Assad S, Ghazanfar H, Mansoor S, Haris M, et al. Correlation of Inferior Vena Cava Diameter and Collapsibility Index With Central Venous Pressure in the Assessment of Intravascular Volume in Critically Ill Patients. Cureus. 2017;9(2):e1025.
23. Kent A, Patil P, Davila V, Bailey JK, Jones C, Evans DC, et al. Sonographic evaluation of intravascular volume status: can internal jugular or femoral vein collapsibility be used in the absence of Inferior Vena Cava visualization? Ann Thoracic Med. 2015;10(1):44-9.
24. Seif D, Perera P, Mailhot T, Riley D, Mandavia D. Bedside Ultrasound in Resuscitation and the Rapid Ultrasound in Shock Protocol. Crit Care Res Pract. 2012;2012:1-14.
25. Scalea TM, Rodriguez A, Chiu WC, Brenneman FD, Fallon WF, Kato K, et al. Focused Assessment with Sonography for Trauma (FAST). J Trauma Injury Infect Crit Care. 1999;46(3):466-72.
26. Dakhale GN, Hiware SK, Shinde AT, Mahatme MS. Basic biostatistics for post-graduate students. Indian J Pharmacol. 2012;44(4):435-42.
27. Sunder Rao PSS, Richard J. An Introduction to Biostatistics, A manual for students in health sciences, New Delhi: Prentice Hall of India. 4th edition. 2006;86-160.
28. Elenbaas, RM, Elenbaas, JK, Cuddy, PG. Evaluating the medical literature, part II: Statistical analysis. Ann Emerg Med. 1983;12:610-20.
29. Yildizdas D, Aslan N. Ultrasonographic inferior vena cava collapsibility and distensibility indices for detecting the volume status of critically ill pediatric patients. J Ultrason. 2020;20(82):e205-9.
30. Marik PE. Lactate guided resuscitation-nothing is more dangerous than conscientious foolishness. J Thorac Dis. 2019;11(15):S1969-72.
31. Kattan E, Hernández G, Ospina-Tascón G, Valenzuela ED, Bakker J, Castro R, et al. A lactate-targeted resuscitation strategy may be associated with higher mortality in patients with septic shock and normal capillary refill time: a post hoc analysis of the ANDROMEDA-SHOCK study. Ann Intensive Care. 2020;10(1):114.
32. Mishra RK, Pande A, Ramachandran R, Trikha A, Singh PM, Rewari V. Effect of Change in Body Weight on Clinical Outcomes in Critically Ill Patients. Indian J Crit Care Med. 2021;25(9):1042-8.
33. Marik PE, Cavallazzi R, Vasu T, Hirani A. Dynamic changes in arterial waveform derived variables and fluid responsiveness in mechanically ventilated patients: a systematic review of the literature. Crit Care Med. 2009;37(9):2642-7.
34. Marik PE, Lemson J. Fluid responsiveness: an evolution of our understanding. Br J Anaesth. 2014;112(4):617-20.
35. Marik PE, Monnet X, Teboul JL. Hemodynamic parameters to guide fluid therapy. Ann Intensive Care. 2011;1(1):1.

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