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Address: Mashhad Nursing and Midwifery School, Ebn-e-Sina St., Mashhad, Iran
P.O.Box: 9137913199
Tel.: (098 51) 38591511-294
Fax: (098 51) 38539775
Email: EBCJ@mums.ac.ir

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Comparison between Emergency Severity Index plus Capnometer and Emergency Severity Index in the dyspneic patients with Chronic Heart Failure

Ahmad Talebpour[1], Javad Malekzadeh[2], Seyed Reza Mazlom[3], Amir Mirhaghi[4*], Mohammad Davood Sharifi[5]

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Abstract

Background: The Emergency Severity Index (ESI) may not recognize high-risk patients with heart failure (HF) efficiently.

Aim: This study aimed to compare the diagnostic validity and mistriage rates of the ESI plus the Capnometer (Capno) and ESI alone among dyspneic patients with HF.

Method: This quasi-experimental group (random assignment) study was conducted within April 2019-February 2020. Patients were randomly assigned to the ESI+Capno and ESI groups. Triage levels, resources used, disposition and door to an electrocardiogram, and physician visit were compared among patients admitted to the Cardiac Care Unit (CCU), the Cardiac Unit (CU), or discharged from the ED. Interobserver agreement (Kappa) was used to assess the reliability of the ESI.

Results: In this study, 65 HF patients were assigned to the ESI+Capno (n=36) and ESI (n=29) groups. The undertriage rates were 0% and 10% and the overtriage rates were 10% and 31% in the ESI+Capno and ESI groups, respectively. Sensitivity, specificity, and accuracy to recognize high-risk HF patients were 100%, 60%, and 90% for the ESI+Capno group and 62.5%, 42.86%, and 48.36% for the ESI group.

Implications for Practice: The addition of Capno to the ESI increased the validity of triage decisions to recognize high-risk HF patients, compared to the ESI alone. It is recommended that decisions regarding triage HF patients be made after that an End-tidal Co2 is considered into the decision-making process.

Keywords: Capnometer, Triage, Heart failure, Emergency severity index

1. MSc in Nursing, Nursing and Midwifery Care Research Center, School of Nursing and Midwifery, Mashhad University of Medical Sciences, Mashhad, Iran
2. MSc in Nursing, Department of Prehospital Emergency Care, School of Nursing and Midwifery, Mashhad University of Medical Sciences, Mashhad, Iran
3. Assistant Professor, Department of Medical-Surgical Nursing, School of Nursing and Midwifery, Mashhad University of Medical Sciences, Mashhad, Iran
4. Assistant Professor, Department of Prehospital Emergency Care, School of Nursing and Midwifery, Mashhad University of Medical Sciences, Mashhad, Iran
5. Associate Professor, Department of Emergency Medicine, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

* Corresponding author, Email: mirhaghia@mums.ac.ir

Introduction

As a chronic debilitating disease, heart failure (HF) is often accompanied by significant morbidity and mortality rates (1). In this regard, the severe complications and varying nature of this medical condition make patients visit the emergency department (ED) frequently. These patients are presenting with such signs and symptoms as shortness of breath (SOB; namely, dyspnea), acute coronary syndrome (ACS), hypertension, pulmonary edema, and cardiogenic shock, among which, SOB is the most common symptom (75%) significantly and directly associated with morbidity and mortality. Shortness of breath has also an acceptable diagnostic value, with 83% sensitivity and 54% specificity, respectively (2). The average left ventricular ejection fraction (LVEF) in patients with SOB caused by HF has been thus far reported to be about 44%, and the accuracy of the LVEF in diagnosing HF-associated SOB has been obtained at 0.836 .(۳)

Even though SOB is a reliable sign for patient acuity, determining its severity seems complicated. Therefore, the results of studies have so far shown that mistriage is significant in HF patients. Pouyamehr et al. found up to 86.6% of undertriage using Emergency Severity Index (ESI) during the triage of patients with HF (1). The area under the curve (AUC) of the Manchester Triage System (MTS) and the Andorran Triage Model/Spanish Triage System (MAT/SET) for the first 3 days of mortality had been also equal to 0.661 and 0.632, respectively, less than the acceptable level of 0.7 (4). Van Spall et al. had further revealed that 1.4 patients assigned to levels 3-5 based on the Canadian Triage and Acuity Scale had passed away on the first day, which could indicate mistriage (5). One limitation contributing significantly to this issue is that the ESI includes general triage criteria for all types of disease, making it much more difficult to correctly identify the sub-types of patients, such as those affected with HF. For instance, only high-risk patients have been declared at level 2 on this scale (6), while it is the responsibility of triage nurses to mentally relate the patient's condition to HF or high risk. This may be somewhat expected for experienced nurses; nevertheless, given that most ED nurses always lack such experiences, the need for specialized scales for some important sub-groups is of utmost importance.

Respiratory rate and blood oxygen saturation (SpO2) can be thus among good indicators of SOB severity. However, these indicators are limited in HF patients. Measuring the number of breaths in EDs is often ignored due to being time-consuming or accompanied by some errors (7). In the study conducted by Van Spall et al., the mean respiratory rate at triage levels of 1-5 varied by 28.8, 23.4, 21.3, and 20.4, respectively (5). Nevertheless, in the ESI, breathing more than 20 times per minute was at level 2. Similar limitations can be further observed in SpO2. Baseline SpO2 less than 93% has accordingly shown 65% sensitivity, 90% specificity, and 83% accuracy in predicting HF stages. The mean SpO2 in patients at stages 1, 2, and 3 of HF had been 94%, 91%, and 85%, respectively (8). However, the ESI allocates SpO2 less than 92% to level 2. As a result, SpO2 in the ESI for HF patients does not have a good diagnostic value to determine patient acuity. Although SpO2 is measured as a quantitative indicator of an SOB in the ESI, patients may be able to keep their SpO2 at acceptable levels with a slight increase in respiratory rate and heart rate. In this sense, paying no attention to small changes in respiratory and heart rates by nurses can be an important reason for the significant rate of mistriage in HF patients. On the other hand, SpO2 in patients presenting with SOB fails to make a difference in determining whether the cause of SOB is HF or chronic obstructive pulmonary disease (COPD) (9). Based on the findings of a study performed by Hunter et al. (2013), the respiratory rate could not be a suitable indicator to predict hospital mortality rate. In contrast, exhaled end-tidal carbon dioxide (ETCO2) with the AUC of 0.76 was mostly associated with mortality, followed by SpO2 (0.74) and hypertension (0.73), respectively (10). The average ETCO2 of those who had passed away was obtained at 25 mm Hg. Therefore, detailed research has been so far performed on the use of ETCO2 .

The results of studies carried out on patients with SOB have indicated that ETCO2 in cases with chronic HF averaged 31 mm Hg versus 39 mm Hg for those with COPD. In addition, the AUC was estimated at 0.70 for ETCO2 and 0.50 for SpO2, which suggested that SpO2 had no value for the diagnosis of HF, compared to COPD. It was reported that ETCO2 of < 40 mm Hg also had 93% sensitivity for predicting HF (9). Therefore, it had been recommended that ETCO2 could be employed as a valid quantitative measure to determine HF severity. However, Arena et al. conducted a more specific study on the relationship between ETCO2 and HF (11). They further showed a significant difference in ETCO2 between the group with major adverse cardiac events and those without such

incidents. The amounts of ETCO2 in both groups were obtained at 30 and 34 mm Hg, respectively. In this sense, they concluded that ETCO2, both at rest and during exercise, could be a good indicator for predicting HF patient acuity, and accordingly introduced it as a crucial indicator for the monitoring of such cases. As a result, accurate indicators to monitor SOB in patients affected with HF are required, and ETCO2 is endowed with unique strengths that can be measured in a non-invasive manner (10). It has been revealed that ETCO2 in patients with HF is lower than normal because pulmonary perfusion in these cases reaches the level of failure due to reductions in ejection fraction (EF). Therefore, a drop in ETCO2 can be helpful for identifying patient acuity even among those with normal SpO2 and be a confirming indicator for the cases with decreased SpO2 levels. Given the significant mistriage in patients with HF, the poor diagnostic value of SpO2, and the substantial diagnostic value of ETCO2 in the triage of HF patients, this study aimed to compare the effect of ESI with and without capnometer (Capno) use on mistriage.

Methods

This quasi-experimental (random assignment) study was conducted based on a 6-hour follow-up to obtain short-term outcomes within April 2019-February 2020 (Figure 1). The effect of ESI with and without Capno was compared on the mistriage of HF patients with dyspnea in the ED. The intervention group was composed of patients on whom the ESI+Capno was conducted, while the control group only received the ESI (version 4).

Ethical considerations: This study was conducted with the permission of the Ethics Committee of Mashhad University of Medical Sciences, Mashhad, Iran. Furthermore, informed consent was obtained from patients in the ED.

Setting: The study was conducted in the Imam Reza Hospital (Mashhad, Razavi Khorasan, Iran) .

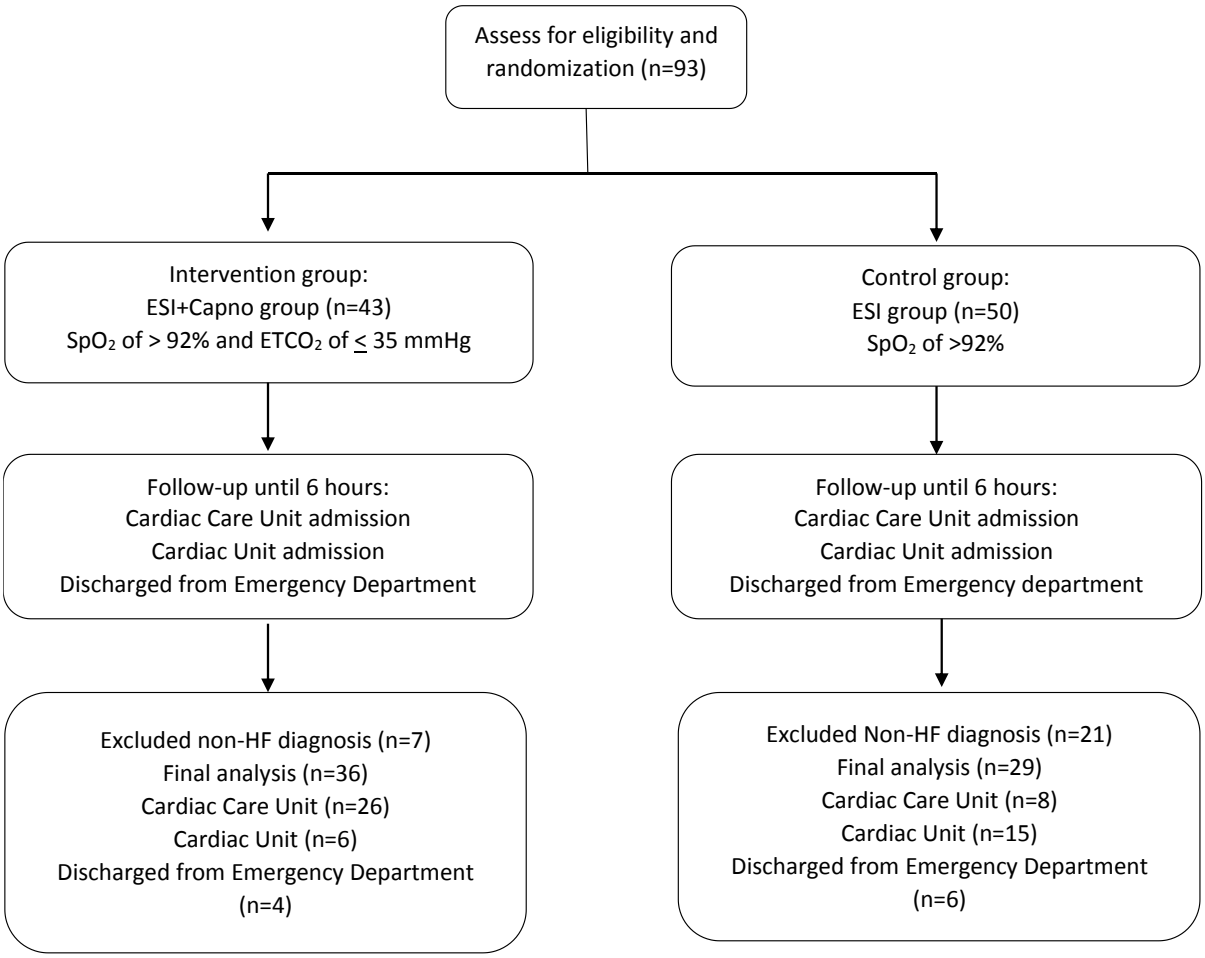

Figure 1. Flow chart for allocation and follow-up

Design: Patients with a chief complaint of dyspnea presenting to the ED were entered into the study if they suffered from the acute onset of dyspnea, had a history of hypertension or hospital admissions for cardiovascular disease, and were hemodynamically stable patients. The included patients were randomly assigned to the intervention (ESI+Capno) and control (ESI) groups in a 1:1 allocation ratio (simple and equal). To this end, 20 predefined sheets in a pocket (10 for each group in random order) were used to assign included patients to the intervention and control groups. This order was repeated until the complete randomization and full assignment to the entire study. In this respect, 50 and 47 patients were primarily assigned to the intervention and control groups, respectively. However, 28 patients were diagnosed with non-HF and excluded from the study (ESI+Capno 7; ESI 21) .

The doctors were blinded to grouping the patients. Sampling was conducted over weekdays except for the night shift. Triage nurses were unaware of one another's decisions in both groups. The age, gender, vital signs (blood pressure, pulse rate, respiratory rate), triage level, EtCO2, and clinical outcomes (i.e., number of used resources, ED admission, Cardiac Unit [CU] admission, Cardiac Care Unit [CCU] admission, and ED discharge) were recorded during the first 6 hours of hospitalization in the ED by the first researcher (i.e., A.T). The door-to-triage room time, physician visit time, and specialist visit time were recorded. The patients were excluded in case that they were unable to speak due to severe dyspnea, were transferred to another hospital, were not diagnosed with heart failure, and their documents were incomplete.

In the intervention group (ESI+Capno), HF patients with acute dyspnea were assigned to level 2 if they had SpO2 of < 92% or EtCo2 of ≤ 35; on the other hand, HF patients with SpO2 of ≥ 92% and ETCO2 of > 35 were assigned to levels 3 to 5 based on required resources.(۹)

In the control group (ESI), since the ESI is a valid triage scale already used in Iran (12), the ESI (version 4) was used as a validated triage tool to assign triage levels. The reliability between the two triage nurses was assessed using kappa statistics based on 10 cases .

The end-tidal carbon dioxide test (BCI® Capnocheck® Plus) was used to measure the ETCO2 in the triage room. It has a 4-channel analog output capability and lets the selection of ETCO2 numeric value, ETCO2 waveform, inspired CO2, respiratory rate, heart rate, and SpO2 numeric and waveform displays. Its accuracy is ±2 mmHg; ±0.3%; ±0.3 kPa, or 4% of reading, whichever is greater. Rise time is 360 milliseconds on average and averaging every 4 breaths. Routine calibration and maintenance of BCI® Capnocheck® Plus equipment are performed by equipment maintenance services and validity and reliability are approved.

Mistriage was consisted of undertriage and overtriage rates and defined by an expert panel. Overtriage was defined as a percentage of patients admitted to CCU and discharged from ED and had previously been received triage level 1 or 2. Undertriage was defined as a percentage of patients who were admitted to CCU and had previously been received triage levels 3, 4, or 5. Used resources were defined by the ESI Implementation Handbook (Version IV). The number of different types of resources, not individual tests (e.g., complete blood cell count [CBC) and electrolytes equal one resource; CBC plus chest x-ray equal two resources) were counted.

Statistical analysis: The descriptive data were expressed as mean, standard deviation (SD), and percentage. The comparison of variables between the two groups was performed using the independent t-test, Mann-Whitney U test, and Kruskal-Wallis statistics. Sensitivity, specificity, and accuracy to recognize high-risk HF were computed based on a contingency table for each group separately. A contingency table was developed a priori as a 2 × 2 table with the disposition (including high acuity admission: CCU admission vs. low acuity admission: CU admission and discharge from ED) and triage level (including high acuity level 1 and 2 vs. low acuity level 3-5). All the analyses were conducted in the SPSS software (version 22.0). A post hoc power analysis based on the mean difference of triage levels for two independent groups showed that the power was greater than 0.80 and the effect size was equal to 2 in CCU patients (Critical t=1.7; Df=32)

Results

In this study, 93 patients were included in the analysis, among which, 50 and 43 cases were in the ESI+Capno and ESI groups. However, 28 patients were diagnosed with non-HF and excluded from the study (ESI+Capno 7; ESI 21). The sociodemographic characteristics of the study samples are presented in Table 1.

Table 1. Comparison of sociodemographic characteristics between ESI+Capno and ESI groups

Characteristics	All	ESI+Capno	ESI	P-value
Age	66.48±13.38	65.06±14.53	68.24±11.82	0.34
Gender male (%)	37 (57)	20 (30.8)	17 (26.2)	0.8
Discharge (%)	10 (15.4)	4 (6.2)	6 (9.2)	
Cardiac unit (%)	21 (32.3)	6 (9.2)	15 (23.1)	0.003
Cardiac care unit (%)	34 (52.3)	26 (40)	8 (12.3)	
Triage level	2.27±0.45	2.16±0.37	2.41±0.5	
Level II	47 (72.3)	30 (46.2)	17 (26.2)	0.037
Level III	18 (27.7)	6 (9.2)	12 (18.5)	
Used Resources	10.63±1.38	10.72±1.4	10.51±1.37	0.5
Level II	10.85±1.33	10.90±1.37	10.76±1.30	0.73
Level III	10.05±1.39	9.83±1.32	10.16±1.46	0.63
Triage time (min)	3.46±1.65	3.64±1.47	3.24±1.84	0.3
Door to ECG (min)	8.46±11.37	6.52±10.34	10.86±12.30	0.13
Time to physician visit (min)	42.89±32.5	38.53±31.15	48.31±33.96	0.23
Time to cardiologist visit (min)	109.8±70.89	92.14±51.17	131.72±85.53	0.03
Time to final decision (min)	176.5±85.30	139.08±52.98	223.07±95.27	0.001
SpO_2 (%)	93.49±3.42	93.02±4.03	94.06±2.41	0.2
Systolic blood pressure (mmHg)	141.0±26.26	136.89±22.21	146.10±30.17	0.17
Diastolic blood pressure (mmHg)	88.09±15.81	88.56±14.74	87.52±17.3	0.79
Heart rate (bpm)	88.62±18.75	91.81±17.13	84.66±20.19	0.13
Respiratory rate (per min)	20.74±5.28	21.81±5.82	19.41±4.28	0.06
$ETCO_2$(mmHg)	30.44±2.86	30.44±2.86	----	---

ECG: Electrocardiogram; ETCO2: End-tidal carbon dioxide

The triage levels assigned to patients discharging from the ED and that of CU patients are summarized in Table 1. The triage level was compared between the ESI+Capno and ESI groups among CCU, CU, and discharged patients from the ED (Table 2). The triage level was significantly different between the ESI+Capno and ESI groups (Chi=5.4; P=0.037). Triage level was significantly different between the ESI+Capno and ESI groups regarding the CCU patients (Fisher's exact probability test, P=0.009). Undertriage rates were estimated at 0% and 10% and overtriage rates were calculated at 10% and 31% for the ESI+Capno and ESI groups, respectively. Sensitivity, specificity, accuracy to recognize high-risk HF patients were 100% (95% CI: 86.77-100), 60% (95% CI: 26.24-87.84), and 90% (95% CI: 75.35-97.46) for the ESI+Capno group and 62.5% (95% CI: 24.49-91.48), 42.86% (95% CI: 21.82-65.95), 48.36% (95% CI: 29.52-67.54) for the ESI group (Table 3).

Used resources were not significantly different between the ESI+Capno and ESI groups (Z=0.8; P=0.44). In the ESI+Capno group, used resources were significantly different among subgroups, namely CCU patients (11.12), CU patients (10.5), and patients discharged from the ED (8.5) (H=7.4; P=0.024). In the ESI group, used resources were not significantly different among subgroups (CU, CCU, and patients discharged from ED) (H=4.4; P=0.1) .

Reliability of triage scales: One triage nurse in the ESI group and one triage nurse in the ESI+Capno group triaged the patients. The ED experience of nurses was greater than 10 years for both groups. The difference between the mean SpO2 scores of 92% in level 2 patients and 95% in level 3 patients showed that triage nurses sufficiently adhered to the ESI triage scale (t=-2.26;

Table 2. Comparison of patients' characteristics between ESI+Capno and ESI groups regarding the status of admission

Used resources	All	ESI+ Capno	ESI	Statistics, P-value
in discharged patients	9.1±1.66	8.5±2.08	9.5±1.37	U=-0.8, P=0.43
in CU patients	10.80±1.24	10.5±1.22	10.93±1.27	U=-0.7, P=0.48
in CCU patients	10.97±1.08	11.11±0.99	10.5±1.30	U=-1.4, P=0.25
Triage level	All	ESI+ Capno	ESI	Statistics, P-value
of discharged patients	2.7±0.48	2.5±0.57	2.8±0.40	Exact, P=0.36
of CU patients	2.38±0.49	2.66±0.51	2.26±0.45	Exact, P=0.17
of CCU patients	3.0±2.08	2.0±0.00	2.37±0.51	Exact, P=0.009

CU: Cardiac Unit; CCU: Cardiac Care Unit

Table 3. Contingency table of diagnostic evaluation of intervention and control groups

ESI+Capno group	CCU	CU and discharged from ED	Total
Triage level 1-2	26	4	30
Triage level 3-5	0	6	6
Total	26	10	36
Fisher's exact test: -0.72 P<0.001			
ESI group	CCU	CU and discharged from ED	Total
Triage level 1-2	5	12	17
Triage level 3-5	3	9	12
Total	8	21	29
Fisher's exact test: -0.05 P<0.5			

CU: Cardiac Unit; CCU: Cardiac Care Unit; ED: Emergency department

P=0.027). The Cohen's Kappa was estimated at 0.29 (95% CI: 0.07-0.52), Linear weighted was 0.52 (95% CI: 0.32-0.73), Quadric weighted was 0.73 (95% CI: 0.65-0.80), and overall agreement was 43.33%, which was assessed via a Kappa coefficient to assess the nurses' reliability. The distribution of data for agreement was (1:1 n=4; 1:2 n=2; 2:3 n=4; 2:4 n=1; 3:1 n=1; 3:2 n=1; 3:3 n=2; 3:4 n=3; 4:2 n=1; 4:3 n=2; 4:4 n=5; 4:5 n=1; 5:4 n=1; 5:5 n=2).

Discussion

This study was the first attempt to investigate the role of ETCO2 in the triage of HF patients. As ETCO2 is highly dependent on pulmonary blood flow (PBF) and PBF is determined by cardiac output, it is a reliable indicator in patients with HF (9). In this respect, the results of studies have shown that EF and ETCO2 can predict mortality in HF patients up to 95% (11). The comparison of the triage levels between the study groups showed that, in general, the patients assigned to the intervention group received a higher acuity level than those in the control groups, which had been more affected by the cases hospitalized in the coronary care unit (CCU). Consequently, all patients admitted to CCU in the intervention group were at level 1, while in the control group, only 62.5% of the patients were at level 2 and the rest were placed at level 3. As patients with HF, taken to hospital EDs, often need to be hospitalized, and as a result, were at levels 2 and 3, this prioritization was predictable. The important point here was that the intervention group succeeded in placing all patients hospitalized in CCU at level 2, which demonstrated complete validity and made a significant difference in this regard .

The findings of a study conducted by Pouyamehr et al. on the triage of patients with HF had also revealed that the Heart Failure Triage Scale (HFTS), compared to the ESI, had been able to predict more patients for hospitalization in the CCU; regarding this, 100% of the cases in the intervention group admitted to CCU had been placed at level 2; however, in the control group (only ESI), 6.7% of the patients at level 1 had been admitted to the CCU and about 86.7% of them at level 3 had been hospitalized (1). This was because HFTS had given emphasis to HF stages, reflecting patients' EF. As the ESI leaves the diagnosis of level-2 high-risk patients to the decisions of triage nurses, and at the same time, provides no quantitative indicators other than SpO2, along with heart and respiratory rates, the error rate can be significantly increased (12).

Similarly, the use of quantitative indicators, such as troponin (cTnI) in diagnosing acuity in patients with complaints of chest pain has so far improved triage accuracy (13). In patients with low-risk chest pain, the use of cTnI in the ESI had also caused the average triage level in patients discharged from ED in the ESI+cTnI group, which was 3.9 vs. 3 in the ESI only group and was significantly different. Therefore, triage nurses had placed the patients at lower levels discharged from ED upon their arrival to the ESI+cTnI group, compared to the ESI only, prioritized by HFTS. This indicates that the rapid cTnI kit has been able to significantly enhance nurses' decisions by providing quantitatively accurate data. In a study carried out by Miro et al., the accuracy of the MTS and the MAT/SET in the triage of HF patients had been correspondingly examined, demonstrating that the AUC for these scales had been 0.62 and 0.64 for hospitalization outcome and equal to 0.58 and 0.59 for hospital mortality outcome, respectively (4). Since the minimum AUC should be higher than 0.7, it is possible to understand the need to use diagnostic aids, such as cTnI or ETCO2, to boost the

accuracy of triage scales. This showed that low validity in triage-related decisions was not specific to the ESI and other triage systems suffered from this problem due to the weaknesses of vital signs in determining HF patient acuity.

One of the expected performance indicators of triage scales is mistriage, calculated as undertriage and overtriage. Among the important goals of the present study was thus to utilize ETCO2 to better identify the acuity of patients with HF. The cases with low ETCO2, however, normal SpO2 were consequently identified by a capnometer, which helped the triage nurses more accurately identify acuity in patients with no obvious signs or symptoms. Accordingly, mistriage is significant in patients with HF (1, 5). In the study performed by Van Spall et al., it was observed that the mortality rates in the first week for triage levels 1, 2, and 3 were 17.2%, 5.95, and 3.8%, respectively, and 2.5% for levels 4 and 5 (5). Although they employed the CTAS, the mistriage was still significant. They also cited less than 90% SpO2 and more than 24 breaths per minute as important indicators of patient acuity. The measurement of the number of breaths in EDs is often neglected or is accompanied by some errors, as it is time-consuming (7). In the mentioned study, the mean respiratory rates at levels 1-5 also varied by 28.8, 23.4, 21.3, and 20.4, respectively (5). However, the respiratory rate more than 20 times per minute in the ESI was at level 2, which could lead to significant overtriage .

Similar limitations are also facing SpO2. Baseline SpO2 of less than 93%, as well as 65% sensitivity and 90% specificity with an accuracy of 83%, can be thus considered for predicting HF stages. The average SpO2 values in patients at HF stages of 1, 2, and 3 were estimated at 94%, 91%, and 85%, respectively (8). Nevertheless, the ESI allocated less than 92% SpO2 to level 2. As a result, SpO2 in the ESI for HF patients lacks a good diagnostic value to determine their acuity and can give rise to significant undertriage. It is noteworthy that although the ESI measures SpO2 as a quantitative indicator of SOB, patients may keep their SpO2 at acceptable levels with a slight increase in respiratory and heart rates. The fact that nurses often ignore small changes in respiratory and heart rates may be an important reason for the significant rate of mistriage in HF patients. On the other hand, SpO2 in patients presenting with SOB fails to make a difference in determining whether the cause of SOB is HF or COPD (9).

End-tidal carbon dioxide with an AUC of 0.76 was also mostly associated with mortality, followed by SpO2 (0.74) and hypertension (0.73) (10). In this study, ETCO2 could identify patients with normal SpO2, however, less than 35 mm Hg of ETCO2. Although these patients showed normal SpO2, they had poor EF, which was attributed to high-risk outcomes, such as hospitalization in the CCU. The mistriage of the ESI in patients with HF with complaints of SOB was also significant in the study conducted in Iran (1). Moreover, undertriage and overtriage were accordingly equal to 86.6% and 6.9%, respectively. The majority of the patients admitted to the CCU had been assigned to level 3 or lower, which could lead to longer patient wait times and a higher morbidity rate (1). In this study, mistriage in the intervention group was 11%, which was considered overtriage.

The addition of the ETCO2 indicator has therefore enabled triage nurses to identify patients that are likely to be overlooked with high sensitivity. In this respect, overtriage, to a lesser extent, is more acceptable than undertriage. Nevertheless, in the control group, mistriage was 41%, of which 10% was undertriage and 31% was overtriage. Even though the undertriage rate was lower than that reported by Pouyamehr et al., 10% undertriage was still significant in the control group in this study. Mistriage has been also investigated for patients with HF using the MTS and MAT/SET (4). The AUC for hospitalization outcome in the MTS and MAT/SET was 0.61 and 0.63, respectively, which was acceptable. However, the accuracy of the triage scales in the intervention and control groups were obtained at 90 and 48.3 in this study, respectively. Here, the extent to which the addition of ETCO2 can help identify patient acuity and enhance triage accuracy is acknowledged .

The use of quantitative indicators in HF patients is not limited to ETCO2. Rapid cTnI kit has been further shown to increase triage accuracy in patients with low-risk chest pain (13). In this study, overtriage rates in the intervention and control groups were estimated at 6% and 88%, respectively. Accordingly, the ESI+cTnI were able to accurately triage patients with lower mistriage and low-risk chest pain, compared with the only ESI group. The patients triaged based on the ESI+cTnI were more confidently assigned to low-risk levels in case of obtaining negative cTnI results by the nurses. Therefore, mistriage in the form of overtriage, significantly reduced because, in the group receiving only ESI, the triage nurse mostly overtriaged low-risk patients and assigned them to high-

risk levels. Since the ESI level 3 includes more than two facilities and most HF patients can consume more than this amount, the grounds for mistriage in the form of overtriage are provided.

As timing is an important indicator in monitoring the performance of EDs, particularly for critically ill patients, timing up to the first electrocardiography (ECG) is crucial because ECG is typically one of the basic treatments for patients with heart diseases. It has been recommended that an ECG be taken in less than 10 min, nevertheless, this time is often not realized in EDs that suffer from congestions (14). In this study, the mean time to the first ECG was 6.5 min in the intervention group and 10.9 min in the control one. This significant difference was attributed to the fact that a significant proportion of the patients in the intervention group were level 2, and as a result, they had received ECG faster. The longest time up to the ECG was up to 14 min for the patients with lower-level triage. In the study conducted by Pouyamehr et al., this time was lower in the HFTS group (2.1 min) than in the ESI one (16.8 min) (1). Since taking an ECG was part of the HFTS, the time to receive it was highly short in the intervention group in the mentioned study. In practice, triage reduces the access time to ECG; therefore, this time can be shortened from 23 to 13 min, which is a significant difference.

It is noteworthy that the mean access time in this study was much shorter than that reported in the survey performed at Imam Khomeini Hospital, Tehran, Iran, with a pre/posttest design (6.5 min in the intervention group and 10.5 min in the controls) (14). This difference could be traced back to the long history of performing ESI at Imam Reza Hospital since 2011 .

A comparison of the waiting time until the first doctor visit also showed no significant difference between both groups. In the intervention and control groups, the waiting times were 38.5 min and 48 min, respectively. This time was expected due to congestions at hospital EDs. As this time included examining a patient and recording a doctor's instructions, and in fact, the end of doctor visits in addition to initial diagnostic measures, such as ECG, the time to start the visit was less than this time. However, it was 36 min in the intervention group and 58 min in the control one for the patients hospitalized in the CCU; however, this difference was not significant. This time was also about 17 min for the intervention and control groups in the study conducted by Pouyamehr et al.; nevertheless, considering those hospitalized in the CCU, it was significantly higher in the group receiving HFTS (5.8 min) than in the one with ESI (12.9 min) (1). This inconsistency, as mentioned earlier, may be related to differences in hospital congestions in various studies .

The use of quantitative indicators, such as cTnI and ETCO2, reduces the time until the first doctor visit. In this study, the mean times to the first doctor visit in the ESI+cTnI and ESI groups were obtained at 9.7 min and 11.6 min, respectively, which was a significant difference (13). This difference with the present study was mostly due to the significant congestion of Imam Reza Hospital and the time that could take for initial examinations by doctors. In another study at Imam Khomeini Hospital, this time was 21 min before triage and 18 min after it, which was not significant. It should be noted that the given difference in the mean time was associated with all patients, and in any case, at hospitals where the triage system had been established, critically ill patients were visited by doctors faster than other cases. In the present study, the patients admitted to the CCU received first visits faster than the ones admitted to the cardiac ward (36 min vs. 56 min). However, this rate was lower in the patients discharged from ED than in other cases hospitalized in the CCU and CU (26.5 min) because such individuals had experienced shorter visit times due to reduced acuity; therefore, the average time was lower. However, not all differences between the groups were significant in the end.

The first limitation facing this study was related to the decisions made by triage nurses. Although the reliability of the triage nurses' decisions was acceptable and their validity was strongly correlated with the ones made by the expert group, some differences in the results may be attributed to the triage nurses (15). The following measures were accordingly adopted to minimize this bias. The triage nurses implementing both scales had more than 5 years of experience at EDs. In this regard, there were attempts to reduce individual differences. In addition, in this study, the nurses of the ESI group were not informed about the decisions of those of the ESI+Capno group. Moreover, random assignment in both groups caused no presupposition for assignment and the possibility of incorporating the opinions of the triage nurse was limited. When patients' vital signs were examined, it was acknowledged that the triage nurses in the ESI only group had performed the triage in accordance with this scale. For example, in the ESI group, the mean scores of SPO2 for

levels 2 and 3 were 93% and 95%, respectively, indicating that the patients were triaged according to the ESI criteria and patients with less than 93% SPO2 were assigned to levels 1 or 2.
The specialists' diagnosis for hospitalization in the CCU might have affected some differences. To diminish this effect, the doctors were blinded to grouping the patients, and the study was conducted during similar shifts in terms of time and the number of patients to lower the impact of such factors as congestions or doctor types. The doctors had also diagnosed HF based on clinical signs and ECG, and the reason for the admission of the patients included in this study was HF diagnosis. Moreover, the reason for hospitalization had been the basis for inclusion or exclusion criteria in numerous studies, for which the 10th revision of the International Statistical Classification of Diseases and Related Health Problems was utilized. Therefore, in this study, doctors' final diagnosis was considered the gold standard. Zannd et al., in a review study, had further stated that the diagnostic criteria for HF were extremely broad in different studies and were often based on clinical diagnosis (16). Consequently, creating a single definition of HF remains a challenge (17). In addition, patients with cardiac problems, including myocardial infarction and heart failure, need highly urgent treatments in order to reduce further complications (18, 19).

Implications for Practice

It can be concluded that ESI+Capno can better classify patients with high-risk HF referring to EDs than ESI alone. Moreover, ESI+Capno can triage critically ill patients with less undertriage and the ones with more stable general conditions with less overtriage. As a result, high-risk patients receiving the right triage can experience moderated complications. This scale can accordingly provide triage nurses with more information, and as a result, help them make robust decisions. The use of this scale is recommended for the triage of HF patients referring to EDs.

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Conflicts of Interest

The authors declare that they have no conflict of interest regarding the present study.

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