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Respiratory and Cardiac Characteristics of ICU Patients
Aged 90 Years and Older: A Report of 12 Cases

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Key words: elderly patients; respiratory failure; shock; Takotsubo; diastolic heart failure

Objective To investigate the respiratory and cardiac characteristics of elderly Intensive Care Unit (ICU) patients.

Methods Twelve senior ICU patients aged 90 years and older were enrolled in this study. We retrospectively collected all patients' clinical data through medical record review. The basic demographics, primary cause for admission, the condition of respiratory and circulatory support, as well as prognosis were recorded. Shock patients and pneumonia patients were specifically analyzed in terms of clinical manifestations, laboratory variables, echocardiography, and lung ultrasound results.

Results The mean age of the included patients was 95 years with a male predominance (8 to 4, 66.7%). Regarding the reasons for admission, 6 (50.0%) patients had respiratory failure, 1 (8.3%) patient had shock, while 5 (41.7%) patients had both respiratory failure and shock. Of the 6 patients who suffered from shock, only 1 was diagnosed with distributive shock, 5 with cardiogenic shock. Of the 5 cardiogenic shock patients, 1 was diagnosed with acute coronary syndrome. The rest 4 cardiogenic shock patients were diagnosed with Takotsubo cardiomyopathy. The patient with ST-segment elevation myocardial infarction died within 24 hours. Of the 4 Takotsubo patients, 1 died on day-6 and the other 3 patients were transferred to ward after heart function recovered in 1 to 2 weeks. Of the 10 pneumonia patients, 3 were diagnosed as community acquired pneumonia, and 7 as hospital acquired pneumonia. Only 3 patients were successfully weaned from ventilator. The others required long-term ventilation complicated with heart failure, mostly with diastolic heart failure. Lung ultrasound of 6 patients with diastolic dysfunction showed bilateral B-lines during spontaneous breathing trial.

Conclusions Elderly patients in shock tend to develop Takotsubo cardiomyopathy. Diastolic heart

dysfunction might be a major contributor to difficult weaning from ventilator in elderly patients. Bedside lung ultrasonography and echocardiography could help decide the actual cause of respiratory failure and shock more accurately and effectively.

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ACCORDING to US population statistics, individuals aged 85 years and older make up 1.8 percent of the total population, but account for 8 percent of all hospital discharges.¹ As the geriatric population grows, the number of older patients who require intensive care in hospital will increase accordingly. Pneumonia and cardiovascular diseases are highly prevalent in older adults.² And they also tend to have comorbid chronic illnesses, making them more vulnerable to nosocomial complications and other adverse events. So the older patients admitted to Intensive Care Unit (ICU) need more attention, but few studies have been focused on this subject. We therefore present 12 ICU patients who were 90 years and older with newly onset of shock or respiratory failure, trying to figure out the respiratory and cardiac characteristics of this special cohort of patients.

PATIENTS AND METHODS

Seventeen patients aged 90 years and older were admitted to the Department of Critical Care Medicine, Peking Union Medical College Hospital from August 2012 to August 2013. Five patients were excluded, including three who only had selective operation without sign of shock or respiratory failure and two in obvious terminal stage. We retrospectively collected all patients' clinical data through reviewing medical record files. The basic demographics as well as clinical and laboratory variables were analyzed. Bedside ultrasound records were carefully reviewed. We gave special attention to the lung ultrasonography and echocardiography reports upon admission to define the possible etiology of respiratory and/or circulatory failure and at day 7 after admission when their conditions were relatively stable.

RESULTS

Clinical data of the 12 enrolled patients are listed in Table 1. The mean age of the included patients was 95 (range, 90-98) years with a male predominance (8 to 4, 66.7%). Acute Physiology and Chronic Health Evaluation (APACHE) II score was 24 ± 9 . The major comorbid conditions included chronic obstructive pulmonary disease

($n=1$, 8.3%), hypertension ($n=7$, 58.3%), coronary artery disease ($n=6$, 50.0%), diabetes mellitus ($n=5$, 41.7%), chronic kidney dysfunction ($n=5$, 41.7%), and cerebral infarction ($n=1$, 8.3%). Regarding the reasons for admission, 6 (50.0%) patients had respiratory failure, 1 (8.3%) patient had shock, while 5 (41.7%) patients had both respiratory failure and shock. The primary cause for respiratory failure and/or shock was pneumonia ($n=10$), acute myocardial infarction ($n=1$), and urinary tract infection ($n=1$). In the 12 patients, 11 required mechanical ventilation and only 3 patients were successfully weaned from the ventilator. Six patients needed vasoactive drugs to maintain the hemodynamic stability. The prognosis on day 28 was death ($n=2$), transfer to ward ($n=4$), and long-term ventilatory support ($n=6$).

Clinical data of 6 shock patients are shown in Table 2. Of the 6 patients who were shock, only 1 was diagnosed with distributive shock exhibiting warm extremities and high central venous oxygen saturation (ScvO₂) level, and 5 with cardiogenic shock. Of the 5 cardiogenic shock patients, 1 presented with ST-segment elevation myocardial infarction (STEMI) on electrocardiogram, regional wall motion abnormality on echocardiography, and elevated serum troponin I concentration (98.00 ng/ml). The signs of the rest 4 cardiogenic shock patients were echocardiographic apical ballooning and T-wave inversion in the precordial leads on ECG and a slight increase of troponin I (the highest level 1.70 ng/ml), which were signs consistent with Takotsubo cardiomyopathy. The patient with STEMI died within 24 hours. Of the 4 Takotsubo patients, 1 died on day-6 and the other 3 patients were transferred to ward after their heart function recovered in 1 to 2 weeks.

Of the 10 pneumonia patients, whose clinical pneumonia infection score ranged from 6 to 8, 3 were diagnosed as community acquired pneumonia, and 7 were diagnosed as hospital acquired pneumonia. Only 3 patients were successfully weaned from ventilator. The remaining 7 patients required long-term ventilation complicated with heart failure, mostly with diastolic heart failure characterized by atrial fibrillation, enlarged left atrium, normal ejection fraction, and a higher E/E', which is a precise reflection of left atrial pressure. The 6 patients with diastolic dysfunction also showed bilateral B-lines on lung ultrasound during spontaneous breathing trial. (Table 3)

Table 1. Clinical data of the 12 patients enrolled

ID	Age (yrs)	Sex	Diagnosis	Reason for admission	Ventilation	Successfully weaning	Vasoactive drugs	Prognosis on day 28
1	98	Male	AMI	Shock+RF	Yes	No	Yes	Die within 1 day
2	92	Male	Urinary tract infection	Shock	No	-	Yes	Transfer
3	95	Male	Pneumonia	RF	Yes	No	No	Ventilation
4	94	Male	Pneumonia	Shock+RF	Yes	Yes	Yes	Transfer
5	95	Female	Pneumonia	Shock+RF	Yes	No	Yes	Die in 2 weeks
6	97	Female	Pneumonia	RF	Yes	No	No	Ventilation
7	90	Male	Pneumonia	RF	Yes	No	No	Ventilation
8	97	Male	Pneumonia	Shock+RF	Yes	Yes	Yes	Transfer
9	94	Male	Pneumonia	RF	Yes	Yes	No	Transfer
10	94	Female	Pneumonia	Shock+RF	Yes	No	Yes	Ventilation
11	98	Male	Pneumonia	RF	Yes	No	No	Ventilation
12	94	Female	Pneumonia	RF	Yes	No	No	Ventilation

ID: identification; AMI: acute myocardial infarction; RF: respiratory failure; -: without ventilation.

Table 2. Clinical data of 6 shock patients on admission

ID	Extre- mities	ScvO ₂ (%)	ECG	Troponin I (ng/ml)	Diastolic function		Systolic function		Form of shock	Complicated with RF	Prognosis
					LA	LV wall thickness	LV wall motion	EF (%)			
1	Cold	40	V1-6 ST elevation	98.00	Normal	Yes	RWMA of LV anterior wall	20	Cardiogenic	Yes	Die within 1 day
2	Cold	55	V3-6 T wave inversion	0.80	Normal	No	Apical ballooning	24	Cardiogenic	No	Transfer in 1 week
4	Cold	45	Pacemaker V1-6 T Inversion	1.20	Enlarged	No	Apical ballooning	30	Cardiogenic	Yes	Transfer in 1 week
5	Cold	58	V1-6 T wave inversion	1.70	Normal	No	Apical ballooning	28	Cardiogenic	Yes	Die in 2 weeks
8	Cold	51	V1-6 T wave inversion	0.76	Normal	No	Apical ballooning	32	Cardiogenic	Yes	Transfer in 2 weeks
10	Warm	69	Af without ST-T segment abnormality	0.05	Enlarged	Yes	No	78	Distributive	Yes	Ventilation

ScvO₂: central venous oxygen saturation; ECG: electrocardiogram; LA: left atrium; LV: left ventricular; EF: ejection fraction; RWMA: regional wall motion abnormality; Af: atrial fibrillation.

DISCUSSION

With the acceleration of aging population, older, disabled patients in ICU are considered as a new challenge that doctors need more proficiency in preserving their already impaired organ function and evaluating the probability of the patient weaned from ventilator and/or transferred from ICU. But few studies have involved ICU patients aged 90 years and older, therefore, we investigated the clinical

characteristics of a group of such patients, and hope that the results will improve the management of such patients in the future. We found much higher prevalence of Takotsubo cardiomyopathy and diastolic heart failure among these patients.

Bedside echocardiography and lung ultrasound help intensivists to clarify the most likely cause of shock and respiratory failure more easily, and to some extent help optimize the outcome.^{3, 4} We found bedside ultrasonography was a useful imaging technique to diagnose and treat

Table 3. Clinical data of 10 pneumonia patients on day 7 or at the day of dismissal

ID	Diagnosis	CPIS	HR	Echocardiography					Weaning from ventilator	Lung ultrasound when SBT	Heart function
				LA	LV	EF (%)	E/A	E/E'			
3	HAP	6	Pacemaker	Enlarged	Normal	63	1.7	19	No	Bilateral B-line	Diastolic dysfunction
4	HAP	6	Af	Enlarged	Normal	45	-	12	Yes	Withnot bilateral B-line	Normal
5	HAP	7	Sinus	Normal	Normal	30	0.7	10	No	Withnot bilateral B-line	Systolic dysfunction
6	HAP	7	Af	Enlarged	Normal	56	-	21	No	Bilateral B-line	Diastolic dysfunction
7	HAP	8	Pacemaker	Enlarged	Hypertrophy	54	-	24	No	Bilateral B-line	Diastolic dysfunction
8	HAP	7	Sinus	Normal	Normal	45	0.8	11	Yes	Withnot bilateral B-line	Normal
9	CAP	9	Af	Enlarged	Normal	68	-	14	Yes	Withnot bilateral B-line	Normal
10	CAP	6	Af	Enlarged	Hypertrophy	78	-	22	No	Bilateral B-line	Diastolic dysfunction
11	HAP	6	Af	Enlarged	Hypertrophy	71	-	19	No	Bilateral B-line	Diastolic dysfunction
12	CAP	7	Af	Enlarged	Hypertrophy	86	-	23	No	Bilateral B-line	Diastolic dysfunction

CPIS: clinical pulmonary infection score; HR: heart rate; E/A: transmitral Doppler E wave velocity/E wave velocity; E/E': transmitral Doppler E wave velocity/mitral tissue Doppler wave e'; HAP: hospital acquired pneumonia; CAP: community acquired pneumonia; SBT: spontaneous breathing trial; -: unmeasurable.

treat respiratory and cardiac lesions of elderly patients. The ultrasonic examinations were performed by qualified physician to accommodate the clinical need, such as shock differentiation, determining the reason for weaning failure, and the results were carefully recorded.

We found that infection, especially pulmonary infection accounts for the major reason for patients 90 years of age and older to develop respiratory failure and/or shock. As it is known to all that sepsis, a form of distributive shock, which is defined as infection plus systemic inflammatory response syndrome, can lead to septic shock. And sepsis related heart depression is also commonly recognized, perhaps just in different nomenclature such as septic cardiomyopathy, sepsis-associated myocardial dysfunction, or myocardial depression, and so on.⁵⁻⁷ This kind of heart dysfunction is characterized by biventricular impairment of intrinsic myocardial contractility. Usually the entire left ventricle is significantly hypokinetic with ventricular cavity dilation and ejection fraction reduced to around 30%.⁸ But to our surprise, we found Takotsubo cardiomyopathy, not septic cardiomyopathy was the most prevalent condition in this group of patients.

Takotsubo cardiomyopathy, is generally characterized by reversible systolic dysfunction of the apical and/or mid segments of the left ventricle with presentations mimicking myocardial infarction, but in the absence of obstructive coronary artery disease.⁹ Exclusion of coronary artery disease by coronary angiography is usually required for the diagnosis of Takotsubo cardiomyopathy.¹⁰ But in ICU settings, the following may indicates stress cardiomyopathy rather than acute coronary syndrome. Severe acute left ventricular dysfunction without a significant serum troponin and creatine kinase-MB elevation; symmetrical mid and apical regional wall motion abnormalities on echocardiography; repeated echocardiography from a few days to weeks confirming complete recovery of left ventricular function.¹¹

A systematic review showed that in-hospital mortality rates of Takotsubo cardiomyopathy ranged from 0 to 8%.¹² Most of the patients will survive the acute episode and recover normal left ventricular function within one to four weeks.¹³ Older patients developing Takotsubo cardiomyopathy are more likely to develop heart failure. A study on Takotsubo patients found that the following two variables were

the risk factors for acute heart failure: age >70 years and left ventricular ejection fraction (LVEF) <40%.¹⁴ The findings in our study were consistent with these research results.

Takotsubo patients who are in shock usually be divided into two categories depending on if left ventricular outflow tract obstruction is present. Patients without left ventricular outflow tract obstruction who are in shock due to pump dysfunction can be treated cautiously with inotropes. While those with left ventricular outflow tract obstruction should not be treated with inotropic agents, because they can worsen the degree of obstruction.¹⁵ In the present study, all the 4 Takotsubo patients were treated with vasoactive drugs after fluid optimization to maintain the blood pressure.

Diastolic heart failure can be diagnosed by the presence of symptoms and signs of heart failure in a patient with a normal LVEF according to the guidelines of the American College of Cardiology and the American Heart Association.¹⁶ Echocardiography is the most practical clinical approach for evaluating left ventricular diastolic function given enough evidence supporting its use as well as its safety and portability. Echocardiography can recognize the abnormal myocardial relaxation and increased left ventricular filling pressures. Other signs for diastolic dysfunction include the increase in thickness of the left ventricular wall and enlargement of the left atrium.¹⁷ A decrease in early mitral annulus velocity (E') is one of the earliest markers for diastolic dysfunction, the ratio between E and E' (E/E') correlates well with left ventricular filling pressure or pulmonary capillary wedge pressure and its accuracy has been tested in a variety of clinical settings.¹⁷⁻¹⁹ An E/E' ratio below 8 is often associated with normal filling pressures and the ratio being more than 12 but less than 15 is associated with elevated filling pressures. The ratio was clinically useful to evaluate the left ventricular function of patients with tachycardia and with atrial fibrillation.^{20, 21}

Ultrasonography is a useful tool to make differential diagnosis of respiratory failure, particularly in differentiating cardiogenic from non-cardiogenic etiologies.^{22, 23} Our results demonstrated that the patients who were unable to wean from ventilator presenting with bilateral B-lines after spontaneous breathing trial. The echocardiographic findings confirmed the diagnosis of diastolic heart dysfunction based on enlarged left atrium, preserved ejection fraction, and a much higher E/E' . Positive fluid balance, another etiology of acute pulmonary edema, was not a problem in the ventilator-dependent patients as reevaluating volume status was a prerequisite in our unit before the diagnosis of difficult-to-wean. These findings gave a strong indication

about a cardiac origin of respiratory failure in these patients.

In conclusion, elderly patients in shock tend to develop Takotsubo cardiomyopathy. Diastolic heart dysfunction might be a major contributor to weaning failure in elderly patients. Bedside lung ultrasonography and echocardiography could help decide the actual cause of respiratory failure and shock more accurately and effectively.

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