Acute brain Injury/acute lung injury as life-threatening organ Dysfunction and with outcomes due to sepsis

Dao-Ming T¹*; Guang-Sheng W¹; Shao- Dan W²; Yuan-Wei W¹; Ying W¹

¹Department of Neurology, Affiliated Shuyang Hospital of Xuzhou Medical University, Jiangsu, China.

²Department of Intensive Care Medicine, Affiliated Shuyang Hospital of Xuzhou Medical University, Jiansu, China.

*Corresponding Author: Dao-Ming T, Department of Neurology, Affiliated Shuyang Hospital of Xuzhou Medical University, Jiangsu, China.
E-mail: dmtong@xzhmu.edu.cn

Abstract

Background: The early diagnosis of sepsis requires a rapidly screening life-threatening organ dysfunction caused by infection. Sepsis related life-threatening ABI and ALI have not been reported.

Objective: To investigate ABI and ALI whether is the leading life-threatening organ dysfunction and its prognosis in sepsis.

Methods: A retrospective study from January 1, 2018 to January 1, 2021 was performed in a general ICU. Those critical ill adult patients who were undergone a brain+ chest + abdominal CT screening before arriving at the ICU were included in this study. Primary outcome was to determine the prevalence of both acute brain and lung injuries and to investigate the hazards of both brain and lung injuries with worse survival in sepsis. The second outcome was the Glasgow Outcome Scale-Extended (GOSE) score at the first 30 days in ICU.

Results: Of 1178 ICU admissions, 376 (31.9%) critically ill adults with sepsis were identified by a brain + chest + abdominal CT screening before on ICU. The median age was 66.7 years (IQR 18-91 years) and 246 (65.4%) patients were males. The median time from onset to CT screening before on ICU was 1hour (IQR, 0.5-229 h). The rapid CT screening before on ICU showed that most patients had either sepsis related ABI (94.7%, 356/376) or ALI (93.4%, 351/376), and 335 (89.1%) of 376 patients had evidence of both ABI and ALI due to infection/sepsis. 359 (95.5%) of 376 patients were invasively mechanical ventilated on the day of ICU admission. The risk factors for sepsis with worse outcomes were presentation with both ABI and ALI (OR, 3.8; 95% CI, 2.019- 7.108), systemic inflammatory storm (SIRS≥2, OR, 2.7; 95% CI, 0.999- 7.191), and shorter length of stay in ICU (OR, 0.9; 95% CI, 0.837-0.958). Predictors of 30-day mortality were both ABI and ALI (RR, 2.5. 95% CI, 1.553-2.799), requiring mechanical ventilation (RR,0.05. 95% CI, 0.005-0.459), and elevated procalcitonin (RR,1.0. 95% CI, 1.001 -1.010). During the 24 days in the ICU, the dynamic profile of inflammatory mediators and organ injury in sepsis with nonsurvivors were significantly higher than those survivors(all p<0.05). A worse outcome (59.4% dead) of sepsis with ABI and ALI at 30 day follow-up was also assessed by GOSE (Glasgow Outcome Scale-Extended) scores, and most of them died in the ICU.

Conclusions: This study highlights a previously unreported that the life-threatening ABI / ALI and potential poor outcomes were identified by brain + chest + abdominal CT scans before on ICU. A recognition of this issue facilitate for sepsis patients timely care to improve outcome.

Key words : Sepsis; Coma; Acute brain injury; Acute lung injury; Systemic inflammatory storm syndrome; Organ failure, Mortality.

Introduction

Sepsis related acute brain injury(ABI) and acute lung injury(ALI) is the life-threatening organ dysfunction following critical illness.1-3 The ascending reticulum activation system (ARAS) is located in the bilateral thalamus and midbrain , as a wake-up "switch"(Fig. 1, A and B) , which is very sensitive to ischemia and hypoxia, if simultaneous closed in bilateral will lead to ABL/acute coma. Sepsis related ABI and ALI affects up to the wake-up "switch" of critically ill patients, are strongly associated with worse outcomes and high mortality in critical illness.4-6 Despite the SIRS criteria is still used as a tool to screening infection and inflammatory storm for acute critical ill, 6,7 but it only used to screening suspected infection in the ICU admissions. However, how to rapid screening sepsis related life-threatening ABI and ALI, which is still unrecognized. We hypothesized that the critical ill adults in ICU would be having a high prevalence of infection-induced life-threatening ABI and ALI, which may be identified by a rapid brain + chest + abdominal CT screening before on ICU. The aim of this study was to investigate the sepsis related life-threatening ABI and ALI in critical ill adult patients, including the clinical features of early CT screening, risk factors with worse outcomes, and laboratory findings. We hope that our study results will verity this hypothesis and provide evidence of CT screening before on ICU for sepsis with ABI and ALI, so that to improve early diagnosis and management, and to reduce the mortality of sepsis.

Methods

Procedures and population

We conducted a retrospective cohort study from the critical ill adult patients with sepsis who were admitted to a general ICU in the Affiliated Shuyang Hospital of Xuzhou Medical University, from Jan 1, 2018, to Jan 1, 2021 with a length of stay of more than 24 hours. During this study period, those critical ill adult patients who were performed a brain + chest + abdominal CT screening before on ICU were included in this study. We excluded those critical ill patients who did not have CT data before on ICU, or no medical records due to either death or automatically out of the ICU due to family asked to give up treatment within the first 24 hours. The study was approved by the ethical committee on clinical research of the Affiliated Shuyang Hospital of Xuzhou Medical University, Because the study involved only a review of records obtained as a part of routine medical care, it did not require written information consent from all patients

Screening sepsis

Despite new guideline recommend ' SIRS criteria for screening suspected infection of critical illness in the ICU admissions, but few tools are available to screen for sepsis related ABI and ALI before on ICU. In recent years, in the emergency center of our hospital, many critical ill adult patients have been performed a brain+ chest + abdominal CT screening before on ICU. In the
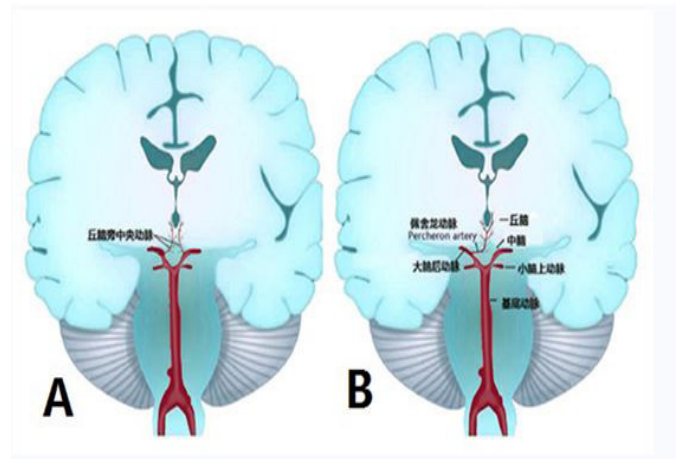

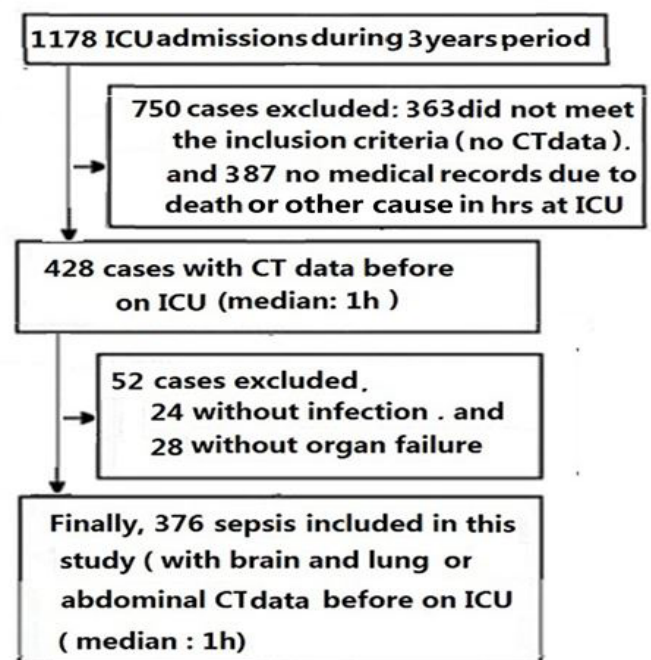*Figure1: The supply blood of a "switch" for the wake-up.*

Figure 2: Flow Chart. The patients who were not met the eligibility for this study design were excluded. Finally, 376 patients with sepsis were included in the present study.

present study, sepsis related ABI and ALI was based on a large sample of clinical practice in ICU, which was from the electronic medical records of critical ill adult patients who were used a brain+ chest + abdominal CT screening before on ICU. Thus, we studied these patients who had confirmed sepsis related ABI and ALI which identified by CT screening. We defined the features of CT screening for sepsis with ABI as diffuse brain edema or vasogenic brain edema, while sepsis with ALI as infection related pulmonary edema or consolidation, which were showed in the Table 1 in the appendix. We also used the recent update SOFA criteria 7 for sepsis-associated organ dysfunction to verify the CT screening of ABI and ALI before on ICU. The SOFA score ≥2 for the brain may indicate a ABI. Also, the SOFA score ≥2 for the lung may indicate a ALI(in the Table 2 in the appendix).
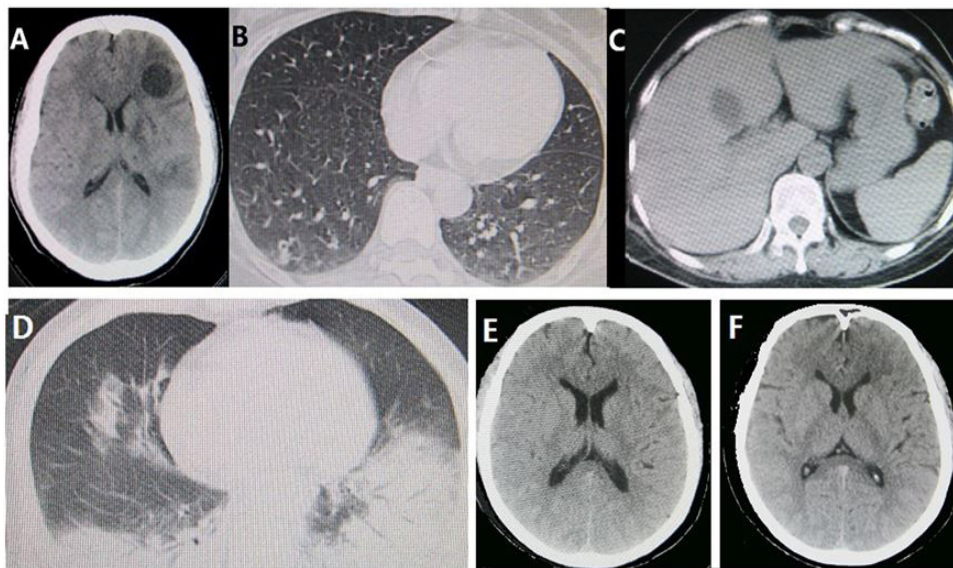
Figure 3: TThe features of brain + chest+abdominal computed tomographic (CT) images. Figure 2 A-C is from a more than 50 year-old female patient with fever 2 days and drowsiness 1day was admitted. Before on admission, brain CT showed the focus of infection and diffuse edema (A), chest CT showed bilateral pneumonia(B), and abdominal CT showed a focus of infection(C). Figure 2 D-F is from a more than 55 year-old female with fever 2 days and coma 2 hours was admitted. Before on admission, chest CT screening showed bilateral pneumonia(D), brain CT showed the brain diffuse swelling (E and F). On ICU, two patient had brain failure and lung failure needing intubation respiratory, suggesting early brain and lung failure from community-required pneumonia.

Table 1: Baseline characteristics of the study population on ICU(n=376).

Characteristics	Total(n=376)
Male, n. (%)	246(65.4)
Age (years)	69(23-82)
Prior history, n. (%)	
Hypertension	172(45.7)
cardiac-cerebral vascular disease	138(36.7)
Chronic pulmonary disaese	130(34.6)
Diabetes	61(16.2)
Cancer	33(8.8)
Findings of CT screening before on ICU,n,(%)	
ABI (brain edema or ischemic lesions)	356(94.7)
ALI/ARDS	351(93.4)
Both ABI and ALI	335(89.1)
Acute gastrointestinal perforation or liver/gall lesion	41(10.9)
Pneumonia/lung infection	325(86.4)
Abdominal infection	42(11.2)
CNS infection	9(2.4)
Median(IQR) time from onset to CT screening(hours)	1(0.5-229)
Median Time from onset to ICU(hours)	3.2(0.5-230)
LOS in ICU(day, medians[IQR])	9 (1-127)
Invasively mechanical ventilation	359(95.5)
GCSE=1 score(dead) in sepsis at 30 days	211(56.1)
GCSE=1 score(dead) in both brain and lung failure at 30 days	199/335(59.4)

Abbreviation: *ICU= intensive care unit; GCS= Glasgow Coma Scale; SOFA= Sequential [sepsis-related] Organ Function Assessment; MODS= multible organ dysfunction;. LOS, length of stay; GCSE= Glasgow Outcome Scale-Extended.*

Screening suspected infection:

Systemic inflammatory response syndrome (SIRS) mainly involves to a massive inflammatory cytokine release.8 More recently, it's called a cytokine storm, which is a life-threatening systemic inflammatory storm.9 Moreover, this inflammatory syndrome also involves other inflammatory mediators in the blood (e,g., D-dimer, C-reactive protein, and procalcitonin). The clinical manifestations of SIRS include follow 4 points: (1) temperature> 38°c or < 36°c; (2) heart rate >90 beats per minute; (3) tachypnea> 20 respirations per minute or Pco2 less than 32mmHg ; (4) white blood cell count > 12.0×109/L or < 4.0×109/L, or > 10% band forms. The identified criteria for SIRS must be at least ≥2 points. SIRS only used to screening suspected infection rather than inflammatory mediators. Thus, we also measured the dynamic profile of inflammatory mediators and others laboratory findings during the 24 days in ICU.

Outcomes: Our primary outcome were the high risk factors of both ABI and ALI with worse survival. Our secondary outcomes were the Glasgow Outcome Scale-Extended (GOSE) scores 10 at the initial 30 days in ICU. The outcome events were reviewed by two of the investigators (the first and second author). In order to assessment the GOSE score of patients at the initial 30 days, survival state was confirmed by the medical records. If the patient died after discharge, the information was followed-up to 30 days.

Data collected

All clinical data were gathered from the electronic medical records written by residents or attending physicians of the emergency and ICU. In addition to collect the brain + chest +abdominal CT scans findings, the collected clinical profile for this study in ICU included the patient demographics, time from

Table 2: *Baseline characteristics in patients with sepsis (n=376).*

	Non-survivors (n=211)	Survivors (n=165)	*p Value*
Age (years, mean ±SD)	67.7± 15.7	65.4± 16.5	0.297
Male gender (n,%)	140 (66.4)	106 (64.2)	0.774
Medical history,(n,%)			
Hypertension	96(45.5)	76(46.3)	1
Previous cardiac-cerebral vascular disease	87(41.2)	51(24.2)	0.013
Diabetes	44(21.0)	17(10.5)	0.042
Chronic lung diseases	19(9.0)	33(20.0)	0.029
Cancer	21(10.1)	12(7.3)	0.63
Initial presenting symptoms			
Fever,(>38°C)	105(49.8)	55(33.3)	0.026
Severe delirium or drowsiness	110(47.9)	54(32.7)	0.026
Acute coma,(GCS<8 scores)	87(41.2)	42(25.5)	0.02
Cough/dyspnea	78(37.0)	35(21.2)	0.016
Chest/abdominal pain	10(5.0)	10(6.1)	0.769
Dizziness/headache	9(4.2)	10(6.3)	0.554
Other	5(2.5)	4(2.4)	1
Findings of CT screening before ICU,(n,%)			
ABI(brain edema or ischemic lesions)	209(99.1)	139(84.2)	0
ALI/ARDS	198(93.8)	134(81.2)	0.005
Both ABI and ALI	199(94.3)	136(82.4)	0
Pneumonia/lung infection	195(92.4)	130(78.8)	0
Abdominal infection	31(14.7)	11(6.7)	0.02
CNS infection	6(2.8)	3(1.8)	0.737
Median(IQR) time from onset to ICU(hours)	4.5(0.5-230)	2.4 (0.5-144)	0.013
Median(IQR)GCS score	12(5-15)	13(5-15)	0.044
Median(IQR) temperature (°C)	37.8(36-40.0)	36.9(35.3-39.7)	0.075
Median(IQR)arterial pressure(mmHg)	93(40-160)	98.7(90-130)	0.266
Median(IQR)Heart rate(beats/min)	102(70-107)	102(58-148)	0.354
Median(IQR)Respiratory rate(breaths/mim)	27(5-35)	27(0-45)	0.818
MODS	211(100.0)	151(91.6)	0.007
Requiring mechanical ventilation	207(98.0)	152(92.0)	0.006
Continuous kidney replacement therapy	85(40.3)	40(24.2)	0.014
LOS (days, IQR)	7.5(1-30)	15(2-55)	0.002

Abbreviations: *ICU, intensive care unit; GCS, Glasgow Coma Scale; SOFA, Sequential [sepsis-related] Organ Function Assessment; IMV, invasive mechnical ventilation; LOS, length of stay; IQR;interquartile range; MODS; multiple organ dysfuunction syndrome.*

critically ill event to infection, initial SIRS level, initial SOFA score, initial GCS score (or GCS motor score (if the patients were in intubation), vital sign data, experimental / laboratorial data, mechanical ventilation, traditional treatment, length of stay (LOS) in the ICU, and outcomes assessment (GOSE).

Statistical methods

As septic patients were in intubation, we used the GCS motor score (GCS m) to assess acute brain failure , e.g., GCS m<5 indicate a mild/moderate brain failure, GCS m<3 indicate a severe brain failure. The results for each group are expressed as the mean ± standard deviation (SD) or median (IQR), and n (%) indicates qualitative values. Fisher's exact test and the Mann-Whitney U test were used to examine the relationship between baseline patient variables. Continuous variables were compared using Student's t test. The area under ROC curve (AUC) were measured by the systemic CT screening for infection/organ failures, and its area of ACU was compared between the systemic CT screening before on ICU and SIRS screening on ICU. Multivariate-adjusted odds ratios (OR) and 95% confidence intervals (CIs) were estimated using a logistic-regression model if they were significant in the univariate analysis, or using Cox proportional hazards model to examine sepsis baseline status and determine whether the variables played a role in the risk of death. Differences between patients was considered significant if the p-value was <0.05. Statistical calculations were performed using a proprietary, computerized statistics package (SPSS 17.0.).

Table 3: Laboratory findings in patients with sepsis who died and survivor (n=376)

	Non-survivors (n=211)	Survivors (n=165)	*p Value*
Age (years, mean ±SD)	67.7± 15.7	65.4± 16.5	0.297
Male gender (n,%)	140(66.4)	106(64.2)	0.774
Medical history,(n,%)			
Hypertension	96(45.5)	76(46.3)	1
Previous cardiac-cerebral vascular disease	87(41.2)	51(24.2)	0.013
Diabetes	44(21.0)	17(10.5)	0.042
Chronic lung diseases	19(9.0)	33(20.0)	0.029
Cancer	21(10.1)	12(7.3)	0.63
Initial presenting symptoms			
Fever,(>38°C)	105(49.8)	55(33.3)	0.026
Severe delirium or drowsiness	110(47.9)	54(32.7)	0.026
Acute coma,(GCS<8 scores)	87(41.2)	42(25.5)	0.02
Cough/dyspnea	78(37.0)	35(21.2)	0.016
Chest/abdominal pain	10(5.0)	10(6.1)	0.769
Dizziness/headache	9(4.2)	10(6.3)	0.554
Other	5(2.5)	4(2.4)	1
Findings of CT screening before ICU,(n,%)			
ABI(brain edema or ischemic lesions)	209(99.1)	139(84.2)	0
ALI/ARDS	198(93.8)	134(81.2)	0.005
Both ABI and ALI	199(94.3)	136(82.4)	0
Pneumonia/lung infection	195(92.4)	130(78.8)	0
Abdominal infection	31(14.7)	11(6.7)	0.02
CNS infection	6(2.8)	3(1.8)	0.737
Median(IQR) time from onset to ICU(hours)	4.5(0.5-230)	2.4 (0.5-144)	0.013
Median(IQR)GCS score	12(5-15)	13(5-15)	0.044
Median(IQR) temperature (°C)	37.8(36-40.0)	36.9(35.3-39.7)	0.075
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MODS	211(100.0)	151(91.6)	0.007
Requiring mechanical ventilation	207(98.0)	152(92.0)	0.006
Continuous kidney replacement therapy	85(40.3)	40(24.2)	0.014
LOS (days, IQR)	7.5(1-30)	15(2-55)	0.002

Abbreviations: *GCS, Glasgow Coma Scale; SIRS, systemic inflammatory response syndrome; SOFA, Sequential [sepsis-related] Organ Function Assessment; qSOFA, quick SOFA.*

Table 4: Logistic regression analysis to identify the death risk factors of sepsis patients in ICU (n=376)

Variable	OR	955 ci	*P* Value
Sepsis with ABI and ALI	4	2.019-7.108	< 0.001
SIRS≥2	3	0.999-7.191	0.05
Shorter length of sday in ICU	1	0.837-0.958	0.001

Abbreviations: *SIRS, systemic inflammatory response syndrom; ICU, intensive care unit.*

Table 5: The Cox multivariate logistic regression analysis of outcomes for sepsis with worse survival in ICU(n=376)

Variable	RR	955 ci	*P* Value
Sepsis with ABI and ALI	2.5	1.553-2.799	< 0.001
Requiring mechanical ventilation	0.05	0.005-0.459	0.008
Elevated procalcitonin	1	1.001-1.010	0.014

Results

A total of 1178 critical illness patients were admitted our ICU during the study period. 750 patients were excluded based on our screening criteria, including 363 patients without CT data before on ICU and 387 length of stay less 24 hours or without medical data. Among 428 patients with CT data before on ICU , we excluded those patients without infection (N = 24) and without acute organ failure(n=28). Finally, 376 (31.9%) critically ill adults patients with sepsis were included in the present investigation.(Figure2)

The baseline characteristics of the study population were

showed in the Table1. Of 376 sepsis patients, the median age was 66.7 years (IQR 18-91 years) and 246 (65.4%) patients were males. Most patients had chronic diseases. The median time from onset to ICU admission was 3.2 hours (IQR, 0.5-230 h). The median time from onset to CT screening before on ICU was 1hour (IQR, 0.5-229 h). By a rapid brain+ chest + abdominal CT screening before on ICU, These patients had various degrees of sepsis related ABI (94.7%,356/376), in most cases were manifested as the sulcus of the brain is shallow(Figure3), severe cases may be manifested as brain displacement. While these patients had also ALI (93.4%,351/376), The rapid CT screening before on ICU showed that most patients (89.1%,335/376) had evidence of both ABI and ALI due to pneumonia (Figure2). The community-acquired pneumonia (86.4%,325/376) was the common infection, followed by the abdominal infection(11.2%) and CNS infection(2.4%). Most ABI and ALI were caused by community-acquired pneumonia. 359 (95.5%) of 376 patients were invasively mechanical ventilated on the day of ICU admission.

By using the update SOFA criteria, we have also validated the accuracy of the brain+ chest + abdomen CT screening for infection-induced organ failure (in the Table 3 in the appendix). The diagnostic test showed that the AUC of CT screening was 0.95 (95% CI, 0.000-1.000, p=0.000), with the sensitivity was 97.6% and and specificity was 74.6%, which was more than SIRS screening on ICU (AUC=0.75, 95% CI, 0.525-0.981).

Among 376 sepsis, 211 were nonsurvivors and 165 were survivors. A poor outcome (56.1% dead) of sepsis and a worse outcome of sepsis with both ABI and ALI (59.4% dead) at 30 days of follow-up was confirmed by GOSE score. By the initial data on admission, the multivariate logistic analysis revealed that both ABI and ALI (OR, 3.8; 95% CI, 2.019- 7.108), systemic inflammatory storm(SIRS≥2, OR, 2.7; 95% CI, 0.999- 7.191), and lees length of stay (LOS) in ICU (OR, 0.9; 95% CI, 0.837-0.958) were established as early risk factors for sepsis with worse outcomes.

In a multivariate Cox proportional hazards analysis at last step, sepsis with ABI and ALI (RR,2.5; 95% CI, 1.563-2.799), requiring mechanical ventilation (RR,0.049; 95% CI, 0.005-0.459), and elevated procaleitonin (RR,1.0; 95% CI, 1.001-1.010) were significantly associated with death.

In ICU, the dynamic profile of laboratory findings in patients with sepsis with inflammatory findings and organ failures. The data of the surviving or nonsurviving sepsis patients are described in Table 2. The laboratory findings in the survivors were from the worst value during the clinical course in the ICU, but the major critical values in the nonsurvivors were tracked before death. The main dynamic findings during sepsis progression included 6 laboratory parameters, which were from within the initial 1 days to 24 days after ICU admission at 3-day intervals. interleukin-6 (IL-6), procalcitonin , SIRS≥2, SOFA scores, GCS scores, and PaO2/FiO2 levels were higher in the nonsurvivors than in the survivors. In addition, we found that nonsurvivors were more likely to present with elevated

C-reactive protein, elevated D-dimer, elevated creatinine, elevated blood glucose, and elevated lactic acid than survivors (all p<0.05).

Discussion

Sepsis-3 criteria defines sepsis as a life-threatening one or more acute organ dysfunction caused by infection. However, the leading life-threatening acute organ dysfunction have not well recognized and have also not been reported. In this large retrospective cohort, a brain+ chest + abdominal CT screening before on ICU for rapid screening infection-induced organ dysfunction was used in critically ill adult patients. We found that the AUC of the CT screening for infection-induced acute organ dysfunction before on ICU was 0.95 (95% CI, 0.000-1.000) , which is greater than that the AUC (0.75) of SIRS criteria screening in the ICU, and SIRS criteria screening can only predict the suspected infection rather than organ dysfunction. According to the systemic CT screening results, we found that both ABI and ALI were strongly associated with worse outcomes in sepsis after adjusting for numerous potential confounders. These data are consistent with the hypothesis that ABI and ALI contributes to the worse outcomes in sepsis patients before on ICU.

Importantly, our study found that sepsis with worse outcomes may have complex interactions between the frequency ABI and ALI. Previous studies showed that the interactions between the ABI and ALI were related to the inflammatory storm.11-13 In the present study, severe inflammatory storm were higher in nonsurvivors than in those survivors, suggesting that the inflammation was stronger and more severe in sepsis with worse outcomes.

More importantly, we found that most of sepsis cases were mainly caused by community-acquired pneumonia and most of them with early brain edema and lung edema were confirmed by CT screening. Moreover, the results of the Cox regression analysis were also suggested this high risk of both ABI and ALI as clinically relevant risk factors for worse survival in sepsis.

In addition, our continuous observation found that these dynamic profile of inflammatory mediators and ABI and ALI in sepsis with worse survival during initial 24 days period were related to the worse survival. which is also consistent with the initial analysis from Cox regression forecast .

Several possible interpretations for ABI and ALI becoming a worse survival organ dysfunction are as following. The first, the brain itself is a leading organ of host response to infection, which is believed to be the blood-brain barrier (BBB) leakage due to an overwhelming in the pro-inflammatory cytokines and anti-inflammation factors released and resulted in severe inflammatory storm.14 The severe inflammatory storm is further responsible for these inflammation factors/toxins leak into the brain, and leading to the brain edema and cerebral ischemic injure as well as cell death.15-17 The second,

our data shown that most ABI had ALI /ARDS before onset illness. The brain is the most vulnerable to hypoxia and oxidative stress caused by severe inflammatory storm.18,19 Moreover, an early postmortem brain MRI findings confirmed that ALI/ARDS play pivotal roles in the development of brain edema.20 The mechanisms of inflammation may be related to the angiotensin conversion enzyme 2 (ACE2) involved inflammatory response, leading to BBB leakage and inflammatory storm.21,22 In addition, massive cytokines (including interleukin-6 and tumor necrosis factor alpha (TNFα) lead inflammation-derived injurious storm (i.e; cytokine storm). 9,17,23 Cytokine storm can cause devastating inflammatory conditions, which include MODS.16,20 The previous studies indicated that sepsis with MODS have always existed an ABI and ALI,17,21-23 and that patients who were initial only with septic shock or liver failure or kidney failure can also rapidly be progressed to either ABI or ALI.16,24,25. Thus, our study showed that both ABI and ALI contributed to a high risk of death in patients with sepsis. Notably, our findings confirmed the evidence of a statistical interaction between the ABI and ALI both and mechanical ventilation on the risk for death in sepsis.Previous studies showed that requiring mechanical ventilation was commonly used in the management of the critically ill patients, which can induce an inflammatory response and involved in MODS.11-13 Our study was powered to support an interaction between the effects of ABI and ALI both and mechanical ventilation on worse survival in sepsis. Recent evidence suggests that requiring mechanical ventilation may increased the risk of ALI.12,26,27 Previous studies showed that inflammation factors had been recognized as a marker of infection and related to the severity of the disease.28-30 Especially, elevated procalcitonin was found to be significant predictors of worse prognosis in patients with sepsis.29,30

The strengths of this study include large samples and fully validated screening tools, that is, using brain + chest + abdominal CT scans before ICU to screen sepsis and predict the outcomes. It is clear that the leading life-threatening ABI and ALI is a clinical related risk factor for the worse survival rate of septic patients.

Some limitations of our study have to be addressed due to retrospective analysis. First, we use a well-validated tool for sepsis, but the current sample of sepsis was from a single center and may have selection bias. However, this hospital ICU is a unique regional ICU with an emergency center (with 10 ambulances) that is responsible for all critically ill referrals in this area. Thus, we believe that this sample does not have a large bias. Second, some patients were excluded because patients who were in ICU length of stay less 1 day or without medical data due to death in initial 24 hours in ICU. Thus, sepsis events may be still underreported. Third, some sepsis patients with severe persistent inflammatory storms may have undetermined infection sites other than in lungs. A diagnosis of CNS infection may be missed because CT screening cannot replace MRI and lumbar puncture examination. In addition, although the prognosis for sepsis is was related to inflammatory storm, requiring mechanical ventilation, and elevated procalcitonin , further prospective studies of some causal links is necessary.

Conclusions

This study highlights a previously unreported the brain + chest + abdominal CT scans before on ICU as a new screening tool for infection/sepsis can early identified the leading life-threatening brain and lung failure and potential worse outcome. A cognition of this issue facilitate for sepsis patients timely care to improve outcome

Abbreviations
ICU: intensive care unit; CT: computed tomography; GCS:: Glasgow Coma Scale; SOFA: Sequential [sepsis-related] Organ Function Assessment; ARDS:adult respiratory distress syndrome; IMV: invasive mechnical ventilation; LOS: length of stay; IQR: interquartile range, MODS: multiple organ dys-fuunction syndrome.

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