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Impact of unsuspected subsegmental pulmonary embolism in ICU patients

Background

Perioperative pulmonary embolisms (PE) are common events in the treatment of critically ill surgical patients in intensive care units (ICU). With a 3-month mortality of 17.4% in European and North American hospitals, PE remains an important clinical problem [11]. PE is also a significant cause of morbidity and mortality in patients undergoing major noncardiac surgery [4, 22]. Induction of modern multidetector computed tomographic angiography (MDCT) has enhanced the radiological visualization of PE and its diagnostic accuracy. MDCT was shown to be robust enough to serve as a single imaging test for the diagnosis of PE [14]. As a result of the increased visualization of peripheral pulmonary arteries, small peripheral emboli limited to the subsegmental pulmonary arteries are increasingly being detected [19]. Isolated subsegmental PE (ISSPE) were reported to be found in 4–7% of the patients evaluated in previous MDCT studies [5, 9, 10]. It was also revealed, that patients in an unselected cohort representing symptomatic ISSPE are at equivalent risk of mortality compared to more proximally located PE [8]. Nevertheless, a Cochrane meta-analysis revealed that currently there are no powerful data that proves evidence for the effectiveness and safety of anticoagulation therapy versus no intervention in patients with ISSPE [23].

The 2012 Surviving Sepsis Campaign Guidelines recommended prompt imaging studies to identify a potential source of infection in critically ill patients [7]. In this regard, current guidelines for diagnosis and treatment of hospital-acquired pneumonia recommend CT scans in treatment-refractory patients and for the identification of secondary pulmonary complications [6].

Previous studies indicated that CT scanning of the chest improves diagnostic accuracy, precisely defines anatomic abnormalities, frequently affects treatment decisions and has been performed safely in this fragile patient population [2, 20]. Examples of correctable lesions have included pneumothorax, empyema, lung abscess, mediastinal abscess, pleural effusion, and PE. Also CT-guided interventions often improve the outcome of critically ill patients.

MDCT uses iodinated radiographic contrast media to improve the visibility of internal organs and structures. Side effects of radiographic contrast media range from mild inconvenience, such as itching to a life-threatening emergencies [16]. Contrast media-induced nephropathy (CIN) is a well-known adverse reaction, associated with the use of intravenous contrast material. Therefore, critically ill

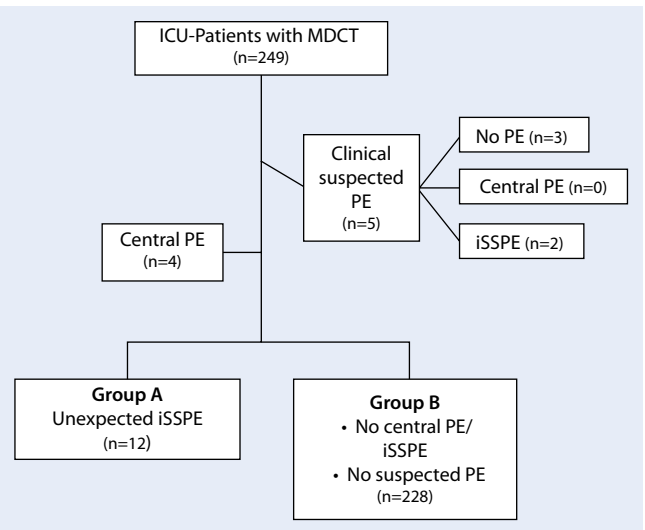

Fig. 1 ◀ Flowchart study groups. *MDCT* multi-detector computed tomographic angiography, *PE* pulmonary embolism, *ISSPE* isolated subsegmental pulmonary embolism

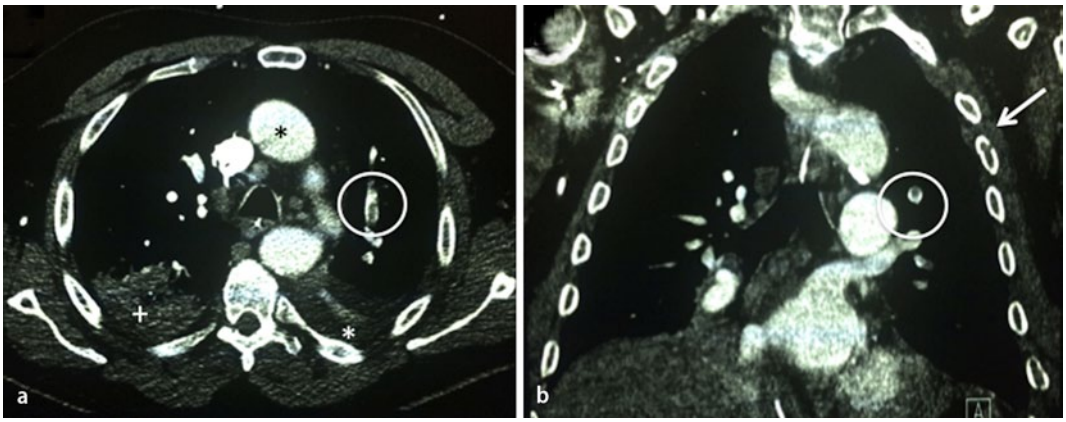

Fig. 2 ▲ Multi-detector computed tomographic angiography (MDCT) of an isolated subsegmental pulmonary embolism. MDCT in a 71-year-old male patient. **a** Transversal slice, *white circle*: subsegmental embolism of the left upper lobe; *black star*: aorta ascendens; *white star*: pleural effusion; *white plus*: atelectasis of the right lower lobe. **b** Coronary reconstruction, *white circle*: subsegmental embolism; *white arrow*: rib fracture

patients receiving MDCT are at high risk for CIN. Regarding ICU patients undergoing MDCT, a retrospective study revealed an incidence of 14% for CIN [15].

The aim of our study was to investigate the rate, impact on treatment, and outcome of unsuspected ISSPE in critically ill patients receiving MDCT. The secondary aim was to investigate the potential impact of CIN in our cohort.

Materials and methods

Patients

This study was performed at the University Hospital of Giessen, Germany. The study protocol was reviewed and approved by the local ethics board before conducting this study. We performed a retrospective single centre study, including each patients treated at the surgical ICU and received MDCT during January, 2009 and December, 2012. Records were identified by computerized identification of all current procedural codes for CT scans of the chest with the application of contrast media in ICU patients. Unsuspected ISSPE was defined as absence of PE inquiry in the MDCT request card and also no evidence for suspected PE in the electronic medical records. We excluded patients with suspected PE/SSPE and patients with MDCT confirmed central PE.

Assessment of study parameters

Identified patients were reviewed and validated manually using the ICU Patient Data Management System (PDMS) (ICU-Data, IMESO® GmbH, Giessen, Germany) and data were recorded in an external database. Baseline parameters including age, body weight index (BMI), gender, history of surgical treatment, history of anticoagulant therapy, and history of PE were determined. We also recorded severity of illness using Sepsis-Related Organ Failure Assessment (SOFA) Score, Simplified Acute Physiology Score (SAPS) II Score, Acute Physiology And Chronic Health Evaluation (APACHE) II Score, need and dose of vasopressor therapy, and need for mechanical ventilation. Serum parameters using hemoglobin (Hb), hematocrit (Hk), antithrombin III (AT III), partial thromboplastin time (PTT), international normalized ratio (INR), D-dimer level, and age-adjusted D-dimer cut-off value were also determined. Age-adjusted D-dimer cut-off value was defined as age (years) × 10 µg/L for patients aged over 50 years [18]. Further, type and localization of PE found in MDCT and following diagnosis of deep vein thrombosis were recorded. Therapeutic interventions following MDCT were engaged in order to facilitate surgical interventions or change in anticoagulation treatment. We also recorded 24-h mortality, 30-days mortality, and hospital mortality, respectively.

Statistical analysis

Results are expressed as mean ± standard deviation (SD). Data were analyzed using chi-squared test or Fisher's exact test, when appropriate. Laboratory findings at different dates were compared using Kruskal–Wallis test for nonparametric data. In case of global significance pairwise analyses were performed using Dunn's post test. All statistical analyses were performed using SPSS, version 22 (SPSS Inc., Chicago, IL, USA) and Graphpad Prism version 5.0 for Mac (GraphPad Software, La Jolla, CA, USA) two-tailed value of $p < 0.05$ was considered to be statistically significant.

Results

Clinical characteristics

During the observation period a total number of 5671 patients were admitted to our (noncardiac) surgical ICU. A total number of 249 consecutive surgical patients were enrolled in this study. Each patient underwent an intensive-care treatment and received a MDCT (**Fig. 1**). Patients with clinical suspected PE ($n = 5$) were excluded. Also patients with MDCT confirmed central PE ($n = 4$) were excluded from the study group. The remaining cases ($n = 240$) where divided into group A (unexpected ISSPE; $n = 12$; **Fig. 2**) and group B (no PE, no suspected PE; $n = 228$).

Clinical characteristics of the study population are demonstrated in **Table 1**.

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Impact of unsuspected subsegmental pulmonary embolism in ICU patients

Abstract

Background. Critically ill patients in intensive-care units are at high risk for pulmonary embolism (PE). As a result of modern multidetector computed tomographic angiography (MDCT) increased visualization of peripheral pulmonary arteries, isolated subsegmental pulmonary embolisms (ISSPE) are increasingly being detected.

Aim. The aim of this study was to investigate the rate, impact on treatment, and outcome of unsuspected ISSPE in critically ill patients receiving MDCT. The secondary aim was to investigate the potential impact of contrast media-induced nephropathy (CIN) in our cohort.

Methods. We conducted a retrospective single-centre analysis on critically ill adult patients treated between January 2009 and December 2012 who underwent a contrast-enhanced chest MDCT. We excluded patients with clinical suspicion of PE/ISSPE prior to CT and patients with MDCT confirmed central PE. Clinical findings, laboratory parameters, and outcome data were recorded.

Results. We identified 240 ICU patients not suspected for PE receiving MDCT. A total of 12 Patients (5 %) showed unexpected ISSPE representing increased 24 h mortality (16.7 vs. 3.5 %; $p = 0.026$) compared to non-ISPPE/non-PE patients. A 30-days mortality did not differ between the groups (33.3 vs. 33.8 %; $p = 0.53$). Highest mean creatinine serum level in our cohort ($n = 240$) was found before MDCT with a significant decrease to day 5 (1.4 ± 1.1 vs. 1.1 ± 0.9 mg/dl: $p < 0.0001$) after contrast media administration.

Conclusion. Critically ill patients are at relevant risk for ISSPE. ISSPE was associated with a poor 24 h outcome. In addition, in our cohort, contrast media application was not associated with increased serum creatinine.

Keywords

Subsegmental pulmonary embolism · Multi-detector computed tomographic angiography · Intensive care medicine · Outcome prediction

Inzidenz und klinische Bedeutung der subsegmentalen Lungenembolie beim operativen Intensivpatienten

Zusammenfassung

Hintergrund. Kritisch kranke Patienten auf Intensivstationen zeigen ein hohes Risiko für die Ausbildung pulmonaler Embolien (PE). Der heutige Einsatz der modernen Multidetektor computertomographischen Angiographie (MDCT) ermöglicht die Visualisierung peripherer pulmonaler Arterien und führt dadurch zu einer Zunahme der Diagnose von isolierten subsegmentalen pulmonalen Embolien (ISSPE).

Ziel der Arbeit. Das primäre Ziel der Arbeit war die Untersuchung der Anzahl an unerwartet diagnostizierten ISSPE in einem Kollektiv von kritisch kranken Intensivpatienten und deren Auswirkungen auf die Behandlung und das Outcome dieser Patienten. Das sekundäre Ziel war es den potentiellen Einfluss einer Kontrastmittelgabe auf die Entwicklung einer nachfolgenden Niereninsuffizienz (CIN) in unserem Kollektiv zu evaluieren.

Material und Methode. Zu diesem Zwecke initiierten wir eine retrospektive Datenanalyse aller Patienten, welche im Zeitraum von Januar 2009 bis Dezember 2012 auf der chirurgischen Intensivstation des Universitätsklinikums Gießen behandelt wurden und welche sich zusätzlich einer MDCT des Thorax unterzogen. Als Ausschlusskriterien definierten wir den klinischen Verdacht auf das Vorliegen einer PE/ISSPE, sowie eine in der MDCT diagnostizierte zentrale PE. Klinische Parameter, Laborwerte und Outcome-Daten aller Patienten wurden in einer Studiendatenbank erfasst.

Ergebnisse. Wir identifizierten 240 Patienten mit MDCT unter den 5671 im Beobachtungszeitraum behandelten Intensivpatienten. 12 Patienten (5 %) zeigten unerwartete ISPPE. Diese waren mit einer erhöhten 24 h-Letalität (16,7 vs. 3,5 %; $p = 0{,}026$), im Vergleich zu Patienten ohne ISSPE/PE assoziiert. Dagegen zeigte sich kein Unterschied bezüglich der 30-Tage-Letalität zwischen den beiden Gruppen (33,3 vs. 33.8 %). Zusätzlich zeigte sich im gesamten Kollektiv ($n = 240$) eine zeitabhängige Abnahme der Serum-Kreatininkonzentration (vor CT: $1{,}4 \pm 1{,}1$ mg/dl vs. Tag 5: $1{,}1 \pm 0{,}9$ mg/dl; $p < 0{,}0001$).

Schlussfolgerungen. Kritisch kranke Patienten auf chirurgischen Intensivstationen zeigen ein erhöhtes Risiko für die Entwicklung von ISSPE. Eine ISSPE war mit einer erhöhten 24 h-Letalität assoziiert. Dagegen konnten wir im untersuchten Kollektiv keinen Anhalt für eine kontrastmittelinduzierte Erhöhung der Serum-Kreatininkonzentration identifizieren.

Schlüsselwörter

Subsegmentale Lungenembolie · Intensivtherapie · Multidetektor-computertomographische Angiographie · Outcome

Patients' mean age was 64.2 ± 12.8 years with a mean BMI of 27.7 ± 7. A total of 142 (59.2 %) patients were men. The cohort demonstrated significant morbidity reflected by high APACHE II score (24.4 ± 10.53). In consequence, we found a large number of patients representing systemic inflammatory response syndrome (SIRS; $n = 43$; 17.3 %), sepsis ($n = 42$; 16.9 %), severe sepsis ($n = 13$; 5.2 %), and septic shock ($n = 95$; 39.6 %). Even the 30-days mortality within the observed cohort was 33.3 % ($n = 80$). Among each patient receiving MDCT, we identified 12 patients suffering from ISSPE (5.0 %). In our cohort, Iopromide containing 370 mg iodine/ml (Ultravist 370, Bayer Healthcare, Berlin, Germany) was used as i.v. Contrast Media (CM). During MDCT patients received 1.5 ml/kg bodyweight Ultravist 370. According to our internal protocol, each patient received 1000 ml Ringer solution (B.Braun, Melsungen, Germany) as prophylactic therapy before MDCT.

Relationship between patients with ISSPE and clinical findings

We further stratified patients by MDCT-related diagnosis of ISSPE (**Table 2**). Re-

Table 1 Demographics and descriptive statistics of the study cohort

		n = 240
Gender male		142 (59.2)
Age	Years	64.23 ± 12.79
BMI	kg/m²	27.67 ± 7.04
ICU length of stay	Days	26.85 ± 27.59
Hospital length of stay	Days	41.20 ± 33.17
APACHE II		24.40 ± 10.53
SOFA Score		8.37 ± 5.26
SAPS II		50.62 ± 15.17
SIRS		43 (17.3)
Sepsis		42 (16.9)
Severe sepsis		13 (5.2)
Septic shock		95 (39.6)
ISSPE		12 (5)
30-days mortality		80 (33.33)

Data are shown as mean ± standard deviation or numbers (%).
BMI body mass index, *ICU* intensive care unit, *APACHE II* Acute Physiology and Chronic Health Evaluation II Score, *SOFA* Sequential Organ Failure Assessment score, *SAPS II* Simplified Acute Physiology II Score, *ISSPE* isolated subsegmental pulmonary embolism.

garding group A and group B, we found no significant differences in gender, age, BMI, APACHE II, SOFA, SAPS II, and sepsis. Interestingly, patients with ISSPE revealed significant higher 24-h mortality (3.5 vs. 16.7 %; $p = 0.026$). 30-days mortality did not differ between the groups. Regarding established risk factors for PE, groups differed in the rates of deep vein thrombosis found after CT (3.9 vs. 16.7 %; $p = 0.04$) and the rates of patients treated with unfractionated heparin before MDCT (67.5 vs. 33.3 %; $p = 0.015$). In contrast, rates of other specific anticoagulants, rates of overall anticoagulant therapy, history of surgical treatment, and history of PE were similar in these two groups. According to the MDCT findings, we found significant differences in post-MDCT treatment between the groups. Patients representing ISSPE received higher rates of escalated anticoagulant therapy (40.4 vs. 75 %; $p = 0.018$) and more frequent a bolus of unfractionated heparin (2.2 vs. 16.7 %; $p = 0.004$). Nevertheless, laboratory findings did not reveal any significant differences between group A and group B. Patients did not differ in Hb, Hk, thrombocytes, leukocytes, fibrinogen, AT III, PTT, INR, D-dimer, Horowitz Index, C-reactive protein (CRP), creatinine, and blood urea. But using age-adjusted D-dimer cut-off values, we found significant differences between the groups (11 vs. 58.3 %; $p < 0.001$). The need for renal replacement therapy, mechanical ventilation at MDCT date, and the start of mechanical ventilation 24 h around CT did not differ.

Contrast media-related changes in renal function

We further searched the whole cohort ($n = 249$) for surrogates of contrast media related impaired renal function. Therefore, we compared creatinine and blood urea concentrations before MDCT (day 0) and at the following 5 days after (day 1 to day 5) contrast media exposure (**Fig. 3, 4**). With regards to the time-dependent changes of creatinine, we found a continuous decrease with highest mean blood level before MDCT (1.4 ± 1.1 mg/dl) and mean lowest level at day 5 (1.1 ± 0.9 mg/dl). Comparing the different observation points using Kruskal–Wallis test, we found a significant, global decrease ($p < 0.0001$). Further performing Dunn's post test, we revealed a significant decrease of creatinine from day 0 to day 4 ($p < 0.001$) and compared to day 5 ($p < 0.0001$). Regarding blood urea, we found a time-dependent trend to lower values (day 0 67.5 ± 59.7 vs. day 5 54.8 ± 47). But performing Kruskal–Wallis test described changes were not significant ($p = 0.160$). Searching our cohort for patients with increased creatinine serum level 48–72 h after CM application, we identified 10 patients (4.02 %) with > 25 % increase of serum creatinine and 5 patients (2.01 %) with > 50 % increase of serum creatinine compared to baseline. One patient (0.4 %) was found with need for new dialysis 48–72 h after CM application.

Discussion

In this retrospective data analysis, we investigated 249 ICU patients receiving MDCT to explore the prevalence and clinical impact of ISSPE. Secondary aim was to evaluate the rate of CIN in our cohort of critically ill patients. To our knowledge, this is the first study exploring a cohort of critically ill patients receiving MDCT not suspecting PE for the impact of ISSPE.

We identified 12 patients (5 %) with unexpected ISSPE. So, our findings demonstrate that critically ill patients are at relevant risk for ISSPE, associated with increased 24 h mortality (16.7 vs. 3.5 %; $p = 0.026$). Second, we did not identify increased creatinine serum level after i.v. contrast exposition. In contrast, we found the highest mean creatinine serum level of our cohort before MDCT with a significant decrease to day 4 ($p < 0.001$) and day 5 ($p < 0.0001$) after contrast media administration.

These findings reflect, that unexpected ISSPE are clinically important for ICU Patients. In contrast to common belief, den Exter revealed in a large prospective study, performed in an unselected cohort of 3728 patients with clinical suspected PE, that symptomatic ISSPE appear to demonstrate the same risk profile and short-term clinical course compared to PE. Even mortality among SSPE patients was higher than in the group without PE in this study [8]. Nevertheless, in contrast to 24-h mortality in the study mentioned above, 30-days mortality in ISSPE patients did not differ from the non-ISSPE group in our cohort. We suggest that this fact may be influenced by the high overall morbidity in our cohort, reflected by high APACHE II Score (24.40 ± 10.53).

Regarding risk factors for venous thromboembolism, we identified increased rates of deep vein thrombosis in patients with ISSPE compared to control (16.7 vs. 3.9 %; $p = 0.04$). We found no difference in D-dimer, but age-adjusted D-Dimer cut-off values differed significantly between the groups (11 vs. 58.3 %; $p < 0.001$). In contrast, other established risk markers did not differ between the two groups. We revealed no differences in the rate of anticoagulant therapy before CT, BMI, gender, history of surgical treatment, or history of PE. But analysis revealed a significant lower proportion of continuously i.v. administrated unfractionated heparin therapy before CT (33.3 vs. 67.5 %; $p = 0.015$) among the ISSPE group. As many as 7 out of 12 patients of the ISSPE group did not receive unfractionated heparin. Out of this group, 2 patients had a major risk of bleeding (after liver punction, before tracheotomy), 3

Table 2 Comparison between patients with and without isolated subsegmental pulmonary embolism

		No PE ($n=228$) $n=24$	ISSPE (n = 12) $n=26$	p
Gender male		136 (59.6)	6 (50)	0.507
Age	Years	64.49 ± 12.68	59.33 ± 14.39	0.174
BMI	kg/m^2	27.68 ± 7.17	27.55 ± 4.05	0.952
APACHE II		24.5 ± 10.53	22.58 ± 10.87	0.54
SOFA		8.38 ± 5.22	8.17 ± 6.21	0.891
SAPS II		43 ± 15.53	36.67 ± 14	0.142
Sepsis		140 (61.4)	6 (50)	0.43
30-days mortality		77 (33.8)	4 (33.3)	0.53
24 h mortality		8 (3.5)	2 (16.7)	0.026
Anticoagulant therapy before CT		183 (80.3)	8 (66.7)	0.255
Unfractionated heparin therapy before CT		168 (73.7)	5 (41.7)	0.016
Escalation of anticoagulant therapy after CT		92 (40.4)	9 (75)	0.018
Heparin bolus after CT		5 (2.2)	2 (16.7)	0.004
Deep vein thrombosis		9 (3.9)	2 (16.7)	0.04
History of surgical treatment		200 (87.7)	11 (91.7)	0.791
History of PE		6 (2.6 %)	0	0.569
Mechanical ventilation at CT		131 (57.5)	6 (50)	0.848
Start of mechanical ventilation 24 h around CT		36 (15.8)	3 (25)	0.399
Renal replacement therapy		44 (19.3)	1 (8.3)	0.343
Hemoglobine	g/l	96.25 ± 15.06	96.25 ± 12.32	0.999
Hematocrit	%	29.76 ± 4.17	29.49 ± 3.75	0.825
Thrombocytes	giga/l	257.6 ± 195.86	329.17 ± 200.92	0.219
Leukocytes	giga/l	16.31 ± 10.57	14.71 ± 6.73	0.604
Fibrinogen	g/l	2.88 ± 2.79	4.27 ± 2.74	0.095
Antithrombine III	%	39.96 ± 37.6	46.33 ± 38.9	0.568
Partial thromboplastin time	s	43.14 ± 11.58	39.75 ± 11.61	0.323
International normalized ratio		1.24 ± 0.29	1.25 ± 0.3	0.91
D-dimer	mg/l	13.01 ± 579.88	55.19 ± 1027.57	0.185
Age-adjusted d-dimer positive		26 (11)	7 (58.3)	<0.001
Horowitz Index		245.57 ± 106.75	203.25 ± 97.65	0.221
C-reactive protein	mg/l	191.86 ± 110.02	205.8 ± 108.36	0.669
Creatinine	mg/dl	1.4 ± 1.12	1.11 ± 0.5	0.342
Urea	mg/dl	82.46 ± 58.10	56.83 ± 45.45	0.134

Data are shown as mean ± standard deviation or numbers (%).
PE pulmonary embolism, *BMI* body mass index *APACHE II* Acute Physiology and Chronic Health Evaluation Score, *SOFA* Sequential Organ Failure Assessment score, *SAPS II* Simplified Acute Physiology Score, $ScvO_2$ central venous saturation, SaO_2 oxygen saturation of arterial blood, *MAP* mean arterial pressure.

patients were readmitted from peripheral ward and received subcutaneous low-molecular heparin, 1 patient was treated with Argatroban because of a suspected heparin-induced thrombocytopenia II that was not confirmed and 1 patient was admitted from another hospital and we did not receive any information about former anticoagulant therapy. Among our entire study cohort, we found 3 patients with confirmed heparin-induced thrombocytopenia. None of these cases was associated with ISSPE. Options for pharmacologic thromboprophylaxis include low dose unfractionated heparin (LDUH), low molecular weight heparins (LMWH) (i.e., Enoxaparin and Dalteparin), and pentasaccharides (i.e., Fondaparinux) [1]. Even LDUH may be administrated subcutaneous (one, two, or three times a day) or given as continuous i.v. infusion. Although there are few studies evaluating pharmacologic prophylaxis for the critically ill patients, current guidelines recommend the use of either LMWH or LDUH over no prophylaxis [12]. In a prospective evaluation of 89 critically ill ICU patients, Mayr et al. found that European standard dosages of 40 mg of enoxaparin once daily proved to be ineffective in achieving recommended antithrombotic aFXa levels. Authors also revealed that patients with high body weight and patients with multiple organ dysfunction where at highest risk for insufficient anticoagulant therapy [17]. Also, standard dosages of certoparin of 3000 IU given once or twice daily were identified to be ineffective for attaining the recommended aFXa levels in critically ill patients [13]. Authors suggest that antithrombine level, renal function, and vasopressor therapy may further influence the effectiveness of certoparin in ensuring adequate antithrombotic prophylaxis [13]. Regarding the high morbidity among our cohort, reflected by high APACHE II Score (24.4 ± 10.5), this fact might implicate that critically ill patients could benefit from continuous i.v. LDUH therapy compared to other anticoagulant agents.

Naturally, post-MDCT treatment differed according to the found CT diagnosis between the groups. Therefore, we identified that patients with confirmed ISSPE obtained higher rates in escalation of anticoagulant therapy (75 vs. 40.4 %; $p=0.018$) and more often received unfractionated heparin bolus therapy after MDCT (16.7 vs. 2.2 %; $p=0.004$). Nevertheless, a Cochrane review explored that there is currently no evidence for the effectiveness and safety of anticoagulation therapy versus no intervention in patients with isolated subsegmental pulmonary embolism [23]. But regarding den Exter's results, comparing a large number of patients with ISSPE and central PE, we would propagate consequent anticoagulation in patients with ISSPE until data form randomized controlled trials are available [8]. Regarding our cohort, we found a majority of patients suffering from infectious diseases. Coagulation abnormalities, especially thrombotic events, are common during sepsis [3]. A dysregulation of the hemostatic system may result in disseminated intravascular coagulation, microvascular thrombosis, and the downregulation of anticoagulant pathways [21]. That fact may explain the high number of ISSPE in our cohort and therefore the need for consequent anticoagulation therapy.

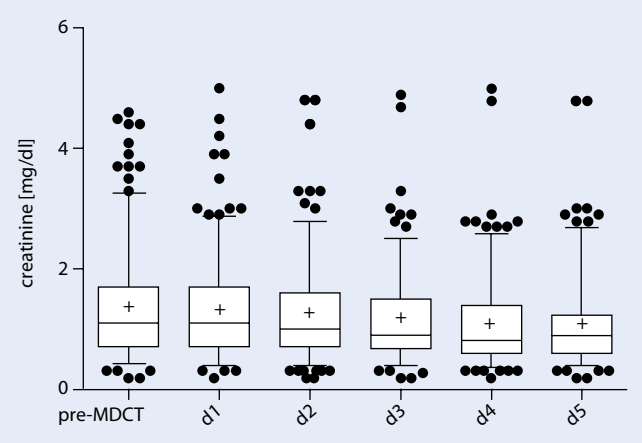

Fig. 3 ▲ Creatinine serum level during the observation period. Time-dependent change in creatinine serum concentration (mg/dl) from pre-MDCT date to day 5. Comparing the different observation points using Kruskal–Wallis test we found a significant, global decrease ($p < 0.0001$). Further, performing Dunn's post test values significantly decreased from day 0 to day 4 ($p < 0.001$) and compared to day 5 ($p < 0.0001$). *MDCT* multi-detector computed tomographic angiography

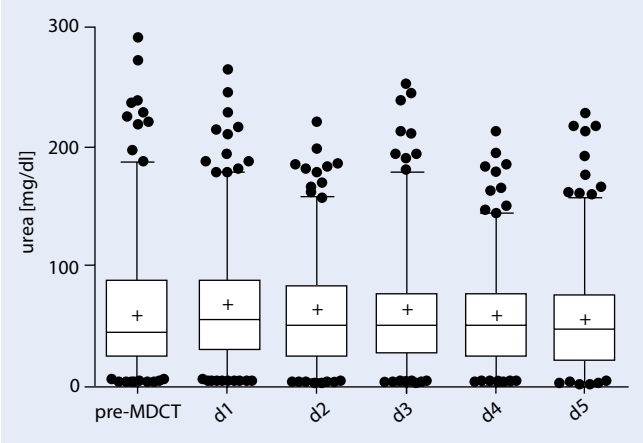

Fig. 4 ▲ Blood urea level during observation period. Time-dependent changes blood urea concentration (mg/dl) from pre-MDCT date to day 5. Performing Kruskal–Wallis test, no significant changes were observed (day 0 67.54 ± 59.7 vs. day 5 54.84 ± 46.97; $p = 0.160$). *MDCT* multi-detector computed tomographic angiography

Analysing our cohort concerning CIN, we found no evidence for negative effects of MDCT. In contrast, we found a reduction of serum creatinine with highest level before MDCT and lowest level and day 4 ($p < 0.001$) and day 5 ($p < 0.0001$) after (**Fig. 3**). Blood urea did not change significantly during the observation period (**Fig. 4**). In addition, we identified 10 patients (4.02 %) with > 25 % increase of serum creatinine and 5 patients (2.01 %) with > 50 % increase of serum creatinine 48–72 h after CM application compared to baseline. One patient (0.4 %) was found with need for new dialysis 48–72 h after CM application. These facts let us suggest that the gain of information by MDCT and potential treatment options in critically ill patients vindicates the risk of CIN. Nevertheless, this study has a number of limitations. Because of the low incidence of central PE, we were not able to compare patients with unsuspected ISSPE and central PE in our cohort for their clinical parameters, risk factors and outcome. Further, the number of included patients was too low to perform multivariate mortality analyses. According to the retrospective study design, we were not able to assess the clinical triggers to perform MDCT. But in clinical routine most MDCT for focus assessment were performed as a result of an unexpected clinical deterioration. Finally, larger prospective randomized controlled trials are needed to confirm these primary results. Nevertheless, we think that our findings demonstrate the importance of ISSPE in critically ill ICU patients.

Conclusions for clinical practice

- **Critically ill patients are at relevant risk for ISSPE.**
- **In our cohort ISSPE was associated with a poor 24 h outcome.**
- **Prospective randomized controlled trials are needed to investigate the effectiveness and safety of different regimes of anticoagulation therapy versus no intervention in patients with ISSPE.**
- **Contrast media application was not associated with increased mean serum creatinine.**

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Compliance with ethical guidelines

Conflict of interest. C. Koch, R. Schramm, F. C. Roller, A. Hecker, M. Henrich, E. Schneck, G. Krombach, M. A. Weigand and C. Lichtenstern declare no conflict of interest. Authors did not receive funding or any other kind of financial support.

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Management-System für Händehygiene

Das Universitätsklinikum Schleswig-Holstein (UKSH) testet ein Management-System für die Händehygiene. Im testweisen Einsatz sind rund 200 der „HyHelper"-Geräte auf sieben Stationen an den Standorten Kiel und Lübeck. Die Mitarbeiter nehmen sich zu Arbeitsbeginn das kleine Mobilgerät aus der Aufladestation und tragen es an der Brusttasche. Von dort aus erkennt HyHelper über einen Gassensor automatisch, wann eine Händedesinfektion durchgeführt wird. Ein Lämpchen gibt „grünes Licht" für eine hygienische Tätigkeit nach der erkannten Händedesinfektion. Jede Händedesinfektion wird gezählt. So kann sich der Träger des HyHelper seine persönlichen Gesamt- und Durchschnittswerte pro Arbeitstag am Display anzeigen lassen und bekommt ein persönliches Feedback zu seinem Händehygieneverhalten. Das Gerät ist jedoch nicht personalisiert. Die Gesamt- und Durchschnittswerte können auch für die gesamte Station berufsgruppenübergreifend zusammengefasst und auf einem Stationsmonitor angezeigt werden. So können sich die Stationsteams gemeinsame Ziele setzen und die Teamerfolge permanent überprüfen. Auf der Intensivstation 1, die von der Klinik für Innere Medizin I und III betrieben wird, haben die Mitarbeiter seit Anfang Oktober 2015 Erfahrungen mit dem HyHelper gesammelt. Die Unterstützung sei von allen ärztlichen und pflegerischen Kolleginnen und Kollegen sehr schnell und unproblematisch angenommen worden, teilt das Klinikum mit.

Quelle: Universitätsklinikum Schleswig-Holstein www.uksh.de