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Computed tomography for the identification of a potential infectious source in critically ill surgical patients

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ABSTRACT

Introduction: Computed tomography (CT) seems already to have an important role to identify an infectious source in the management of patients with sepsis. However, our daily clinical behavior in ordering CT imaging was never scrutinized.
Methods: We conducted a retrospective single-center analysis of CT and its therapeutic consequences in an operative intensive care unit in a tertiary care hospital in Germany. All CTs of the abdomen and/or thorax between 1st January and 31st December 2012 were included. One hundred forty-four CT studies were enrolled: 60.4% visceral, 6.9% vascular, 17.4% thoracic, and 14.6% trauma surgical cases and in 0.7% other disciplines.
Results: In 76 CT studies (52.8%), a source of infection was found and was associated with a change in treatment in 65 (85.5%) cases. In contrast, in patients without identification of an infectious source in the CT imaging, treatment was changed after CT imaging in 11 (16.2%) cases. Computed tomography provided positive findings predominantly in the organ or the region of the surgical field.
Conclusions: Computed tomographic imaging detected an infectious source in more than 50% of cases. Our data suggest that CT should be recommended to identify a source of infection in critically ill patients. Furthermore, prospective studies are needed to investigate the potential impact of CT imaging on outcome and to define criteria when to perform a CT imaging study.

1. Introduction

Sepsis causes millions of deaths globally each year [1], whereas prevalence of severe sepsis in intensive care unit (ICU) patients is about 10% [2]. The speed and appropriateness of diagnosis and treatment are considered as highly important for successful therapy [1]. Beside blood cultures and microbiological samples from other sites, respectively, prompt imaging studies are recommended to identify a potential source of infection [1] as well as in fever of unknown origin in the critically ill [3]. For this purpose, bedside ultrasound is generally recommended [1,3], whereas computed tomography (CT) should be considered when ultrasound does not result in a specific finding [4]. Despite this recommendation, the guidelines of the Surviving Sepsis Campaign (SSC) and national societies do not provide clear evidence for the use of CT in septic patients [1,5]. Those 2 references quoted in the SSC guidelines are both limited to intra-abdominal infections [4,6] and, furthermore, recommending CT as technique of second choice with an evidence grade E [4]. However, to the authors' point of view, it seems like eminence has already placed evidence in clinical reality. Up to date, there is no clear standard whether and when to perform CT imaging in critically ill patients.

In suspected abdominal site infection, CT is suggested as standard technique for evaluation of the critically ill [6] not least due to the possibility of optional treatment via CT-guided drainage [7]. Given a strong benefit of CT-guided drainage in abscesses of the thorax and due to the sensitivity of CT imaging compared with chest x-ray, CT for evaluation of the thorax is commended as well [8].

Increasing incidence of sepsis and mortality, and coincidentally decreasing case fatality rate [9] might have led to more unstable septic patients on ICUs. Besides, there are some common disadvantages of the method: radiation, use of intravenous contrast media associated with risk of deterioration of renal function, and transportation of commonly cardiopulmonary unstable patients [1,6,8]. Therefore, balancing risk and benefit is mandatory in critically ill patients, and the clinical decision for a CT imaging should be considered carefully [1].

We performed a retrospective study to, primarily, analyze how often CT imaging is used in critically ill patients to search for an infectious source in clinical reality. Second, we wanted to assess usefulness of CT imaging, whether any consequences appeared in the treatment management, challenging our daily clinical behavior in ordering CT imaging for identifying an infectious source.

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2. Patients and methods

With approval by our institutional review board, we retrospectively analyzed CT imaging of ICU patients in our tertiary care hospital. All cases from an operative ICU who underwent one or more CT scans of the thorax and/or abdomen between 1st January and 31st December 2012 were included. In the year 2012, 1172 patients were admitted to this ICU with a median length of stay of 16 (quartiles: 9-32) days. A total of 220 CT studies of the thorax and/or abdomen were performed in 205 patients during their stay on the ICU. We enrolled all CT imaging studies of the thorax and/or abdomen, which were indicated to search for an infectious source. Because the study aim was to analyze clinical reality, ordering of CT imaging was not influenced by the study protocol. Computed tomographic imaging was ordered following the SSC guideline, when ultrasound was or could not be diagnostic [1,5]. Therefore, every time CT was done to search for an infectious source, we enrolled this CT study in our analysis. Computed tomographic imaging of the thorax and abdomen was coded as one imaging study. We analyzed patients from the attending surgical fields on this interdisciplinary operative ICU including visceral, vascular, trauma, and thoracic surgery. Very seldom, this ICU would also be used for patients of other disciplines such as other operative fields, medicine, or neurology.

Result of imaging was coded in a binary fashion (source found yes/no). When a source was found, the group was called CT-F (F: source found), when not found, CT-N (N: no source found). Furthermore, therapeutic consequences were recorded. No therapeutic consequence was separated from a change in treatment management. The latter one was defined as administration of a new antimicrobial, a nonsurgical intervention (ie, CT-guided drainage), or a surgical intervention in the operating room. In addition, we analyzed localization of the infectious source in relation to the specific surgical disciplines.

Besides, clinical information on each case was elicited. The Simplified Acute Physiology Score (SAPS II) and the Sequential Organ Failure Assessment (SOFA) score were recorded on ICU admission as well as on the day of CT imaging [10,11]. Furthermore, patient's condition on the day of CT imaging was examined taking infection parameters in blood tests (ie, white blood cell count [WBC], C-reactive protein [CRP], procalcitonin [PCT]). We recorded body temperature (temp) and heart rate (HR) as systemic inflammatory response syndrome (SIRS) criteria [12]. Need of catecholamine treatment and mechanical ventilation were respected.

3. Statistical analysis

Values of infectious source found and not found are given in absolute numbers and percentages. In addition, changes in treatment are presented in numbers and percentages. Furthermore, percentages of findings according to the medical field are given. Data of clinical characteristics are presented as mean ± standard deviation when normally distributed and as median (quartiles 25% and 75%) for nonnormally distributed data.

All data were tested for normal distribution according to Kolmogorov-Smirnov-Lilliefors. Data were compared using a 2-sided Student *t* test for normally distributed and a Mann-Whitney *U* test for nonnormally distributed data, as well as Fisher exact and χ^2 test, respectively, to analyze differences in percentages. All analyses were performed with SPSS statistical software package (version 20; IBM Inc., Armonk, NY).

4. Results

In this study, 144 CT studies in 130 patients with search for an infectious source were enrolled. Thus, some patients revealed more than 1 CT imaging study during their stay on ICU. These 144 studies belonged in 87 cases (60.4%) to visceral, in 10 (6.9%) to vascular, in 21 (14.6%) to trauma, in 25 (17.4%) to thoracic surgical, and one case (0.7%) belonged to another discipline. Details on patients' characteristics are given in Table 1.

In 76 CT studies, a source was found (CT-F: 52.8%); in 68 cases (CT-N: 47.2%), it was not found. Clinical characteristics of cases in the CT-F and the CT-N group were comparable and did not differ significantly. Details are given in Table 2.

There were statistically more therapeutic consequences in the CT-F group (Table 3; $\chi^2 = 71.3$, $P < .001$). In the CT-F group, imaging resulted in a therapeutic consequence in 65 CTs (85.5%), whereas 11 CTs (14.5%) induced no change in treatment management. In the CT-N group, imaging studies resulted in a nearly contrary distribution; 11 CTs (16.2%) led to a therapeutic consequence, 57 CTs (83.8%) not.

In the CT-F group, 27.6% of CT studies resulted in a prescription of a new antimicrobial, 23.7% led to surgery, and 34.2% induced a nonsurgical intervention like CT-guided drainage, whereas only 14.5% resulted in no therapeutic consequence. For comparison, in the CT-N group, imaging induced a new antimicrobial in 11.8%, 1.5% underwent surgery in the operating room, and 2.9% had a nonsurgical intervention. Accordingly, we found a large number of CTs that revealed no therapeutic consequence.

The CT finding often corresponded with the surgical specification of the case to a body region (Figure 1). However, we did not record, whether this finding was in the region of any surgical intervention. Most thoracic surgical imaging studies showed a pathological finding in the thorax (72%). The thorax was the predominant region of an infectious source in trauma surgical CT imaging as well (52%). Both visceral and vascular surgical CT imaging frequently had a pathological finding in the abdomen (43.7% and 40%, respectively). In addition, vascular surgical CT imaging resulted more often in no finding of an infectious source (60%). A pathological finding in the CT of abdomen as well as in CT of thorax was rarely found independent of the medical field (0-4%).

5. Discussion

In this study, we analyzed how often CT imaging is used to search for an infectious source and with what clinical result in critically ill surgical patients in a German tertiary care hospital. The CT imaging study resulted in most cases in a finding of an infectious source. More than half of all ordered CT of the thorax and/or abdomen on our ICU was indicated to search for an infectious source (144/220; 65.5%). This is in concordance with a study on CT of the chest in ICU patients performed in the 1980s [13], where CT was obtained to search for a source of sepsis in most of the cases (55.2%). Both studies were not designed to analyze sensitivity

Table 1
Patients' characteristics (n = 144)

On admission	
Age (y)[a]	68 (52-76)
SOFA[a]	10 (6-13)
SAPS II[a]	44 (35-52)
On the day of imaging	
SOFA	10 (6-13)
SAPS II	41 (32-52)
WBC, reference 3.5-9.8 × 10^3/μL (×10^3/μL)	17.6 (11.5-25.6)
CRP (mg/L)	186 (125-268)
PCT, reference <0.5 μg/L (μg/L)	2.4 (0.8-5.8)
HR (beats/min)	118 ± 20
Temp (°C)	37.6 ± 0.8
Fio_2	0.6 (0.4-1.0)
Sex, male (%)[a]	68.8
Mechanical ventilation (%)	80.6
Catecholamine administration (%)	78.5

Data are given as follows: mean ± SD and median (quartiles 25%-75%), respectively. Fio_2 indicates inspiratory O_2 fraction (for ventilated patients); sex, percentage of male; mechanical ventilation, percentage of mechanically ventilated patients on the day of imaging; catecholamine administration, percentage of patients receiving catecholamine treatment on the day of imaging.

[a] Only analyzed once per patient; therefore, n = 130.