Early chest CT-scan in emergency patients affected by community-acquired pneumonia is associated with improved diagnosis consistency

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Chest CT-scan (CT) exceeds chest X-ray (CXR) to diagnose community-acquired pneumonia (CAP) but actual use and results remain unclear. We examine whether CT performed at ED visit improved ED diagnosis of CAP as compared to a final diagnosis of CAP at hospital discharge (gold standard diagnosis for the study), and how it impacts relevant clinical outcomes. This retrospective monocenter observational study was based on the analysis of the hospital database. Patients with a diagnosis of CAP in the ED (ICD-10 codes: J110, J111, from J12- to J18-, J440, J690, U0710, and U0711) were included. We compared ED patients who were diagnosed with CAP using CXR and CT. We measured diagnostic consistency, duration of ED visit, percentage of CXR and CT during hospital stay, hospital length-of-stay, ICU admission, and in-hospital mortality. Multivariate analysis was adjusted for CRB65 score by multiple logistic regression analysis for binary outcomes and by multivariate analysis of variance for continuous outcomes. We included 994 ED patients with an initial diagnosis of CAP (751 receiving CXR, 243 receiving CT). CT prescription in the ED increased over time ($P < 0.001$). In patients admitted after ED, CT improved diagnosis consistency for CAP [88.2% vs. 80.9%; difference 7.3% (95% confidence interval 1.2–13.3%)] with a trend for lower hospital length-of-stay [10.2 vs. 12.2 days; difference $-2.0$ (95% confidence interval $-3.9$ to $-0.1$)], but not ICU admission ($P = 0.09$) and in-hospital mortality ($P = 0.056$). Diagnosis of patients admitted with CAP improved when CT was obtained at ED visit. These results should be reproduced at a larger scale to test whether early CT conserves healthcare resources. European Journal of Emergency Medicine 29: 417–420 Copyright © 2022 The Author(s). Published by Wolters Kluwer Health, Inc.

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All major decisions regarding management of community-acquired pneumonia (CAP) revolve around initial assessment [1]. To improve CAP patients’ outcome, an accurate and early diagnosis is crucial, allowing adequate treatment [2] notably prompt antimicrobial therapy [3].

As symptoms alone have weak performances, diagnosis of CAP relies on clinical assessment and imaging [4]. Reference imaging for diagnosis of CAP is chest X-ray (CXR) that worryingly lacks both sensitivity and specificity [5]. In addition, combining clinical assessment and CXR performs poorly, as sensitivity and specificity ranges are 31.3–73.0% and 56.4–93.6%, respectively [6]. Unsurprisingly chest CT-scan (CT) exceeded CXR for accurate diagnosis in patients with suspected CAP visiting the emergency department (ED) [7]. Besides improving diagnosis of CAP, CT alters decision for treatment and decision for admission or discharge. However the actual benefit of CT on patients’ outcome remains uncertain [8]. Therefore we aimed to assess if CT improved diagnosis of CAP at ED, whether ED physicians had changed over time their behavior toward prescription of CT in lieu of CXR, and how it modified patients’ outcome.

Methods
We retrospectively analyzed medical charts of adult patients visiting the ED of a general hospital center (Princess Grace Hospital, Monaco) with an ED diagnosis of CAP. Adults were enrolled from 1 January 2015 to 30 June 2020, as our geographical area mostly escaped the first wave of the COVID-19 pandemic [9]. No funding was obtained for this study. The ethical board held for the study approved the protocol. The study complied with the National laws for Ethics and the Helsinki ethical principles for medical research involving human subjects.
Study population
Adults (≥18 years) with an ED diagnosis of CAP were eligible if they had a CXR or CT during their ED visit regardless of subsequent admission. ED diagnosis of CAP was based on the following ICD-10 codes: J110, J111, from J12- to J18-, J440, J690, U0710, and U0711. For this study, the final reference was the hospital diagnosis. The choice of chest imaging (i.e. whether CT alone or if a CXR was also taken) was at the discretion of the attending physician. Imaging was interpreted on a routine care basis. For this period, CT were low-dose, and patients with CT pulmonary angiogram were not considered.

Study groups for comparison
Patients with CT alone or associated with CXR were compared to patients with CXR alone.

The analysis involved a comparison between patients with CT-only CAP and those with CAP on CXR. We also analyzed patients admitted after ED visit and patients discharged after ED visit as subcategories.

Outcomes
ED diagnosis of CAP and hospital diagnosis of CAP in patients admitted were based on the following ICD-10 codes: J110, J111, from J12- to J18-, J440, J690, U0710, and U0711. For this study, final hospital diagnosis was the reference. CAP diagnosis was considered as consistent if main diagnosis at discharge was an ICD-10 code of CAP.

Clinical outcomes during the index visit were obtained from medicalized information system program. These outcomes included (1) for all the population, percentage of admission, duration of ED visit, (2) for patients discharged after ED visit, percentage of recurrent ED visit at day 7, and (3) for patients admitted after ED visit, accuracy of ED diagnosis in respect to final hospital diagnosis (i.e. principal diagnosis among the following ICD-10 codes: J12-J18), duration of ED visit, (2) for patients admitted after ED visit and patients discharged after ED visit as subcategories.

Statistical analysis
Outcomes were compared between patients with CT and those with CXR with the Wilcoxon rank-sum test for continuous variables, the χ² test for categorical variables, and the Cochran–Armitage test for trend for ordinal variables. Multivariate analysis was done to adjust for CRB65 score (1) by multiple logistic regression analysis for binary outcomes (hospitalization, ICU admissions, in-hospital mortality, recurrent visit at day 7, and consistency of diagnosis at ED and discharge), (2) by multivariate analysis of variance for continuous outcomes (duration of ED visit and hospital length-of-stay).

Results
Characteristics of the patients
We included 994 ED patients with an initial diagnosis of CAP, distributed as 654 (65.8%) patients admitted after ED visit and 340 (34.2%) patients discharged after ED visit (Table 1). Patients admitted after ED visit were older [73.8 vs. 53.3 years; difference 20.5 [95% confidence interval (CI) 18.2–22.9]], had higher mean CRB65 score [0.95 vs. 0.34; difference 0.61 [95% CI 0.54–0.69]] and mean duration of ED visit [4:43 vs. 3:50 hours; difference 0.53 [95% CI 0.37–1.09]].

In patients admitted after ED visit, CXR was less frequently ordered over time in the ED (from 86 to 72% \( P < 0.001 \)) but not during hospital stay (from 56 to 47%, \( P = 0.62 \)). Simultaneously, CT was more frequently ordered in the ED (from 19 to 32%, \( P = 0.003 \)) but less frequently during hospital stay (from 52 to 29%, \( P = 0.001 \)). Interestingly, for patients admitted after ED visit, percentage of CT during hospital stay remained stable over years (between 65 and 64% for CT, \( P = 0.93 \), and between 67 and 71% for CT and computed tomography with pulmonary angiogram, \( P = 0.15 \)).

| Table 1 Characteristics of the population and outcomes
|--------------------------------------|----------------------|----------------------|----------------------|
|                                      | Chest CT-scan at ED  | Chest X-ray at ED    | \( P \) value |
| All patients                         | \( N = 243 \)        | \( N = 751 \)        | \( P \) value |
| Age (years)                          | 64.0 (18.9)          | 67.7 (20.8)          | 0.002          |
| Female                               | 111 (45.7)           | 349 (46.6)           | 0.83           |
| CRB65 + Score (mean SD)              | 0.65 (0.66)          | 0.77 (0.66)          | 0.013          |
| Hospitalization                      | 161 (66.3)           | 493 (65.7)           | 0.86           |
| Outpatients                          | \( N = 82 \)         | \( N = 258 \)        |               |
| Duration of ED visit (hours:minutes) | 4:51 (1:43)          | 3:30 (1:50)          | <0.001         |
| New ED visit within 7 days           | 8 (9.8)              | 11 (4.3)             | 0.06           |
| Inpatients                           | \( N = 161 \)        | \( N = 493 \)        |               |
| Comorbidities                        |                       |                      |               |
| Chronic respiratory disease          | 30 (18.6)            | 118 (23.5)           | 0.20           |
| Neoplastic disease                   | 18 (11.2)            | 70 (14.2)            | 0.33           |
| Liver disease                        | 2 (1.2)              | 1 (0.2)              | 0.09           |
| Chronic heart failure                | 13 (8.1)             | 59 (12.0)            | 0.17           |
| Cerebrovascular disease              | 2 (1.2)              | 5 (1.0)              | 0.81           |
| Renal disease                        | 11 (6.8)             | 31 (8.3)             | 0.81           |
| Number of comorbidities              | 0                    | 94 (58.4)            | 0.18           |
|                                      | 1                    | 55 (34.2)            |               |
|                                      | 2                    | 12 (7.4)             |               |
| Duration of ED visit (hours:minutes) | 5:24 (1:41)          | 4:30 (2:14)          | <0.001         |
| Final diagnosis (other than CAP)     | \( N = 19 \)         | \( N = 94 \)         |               |
| Infectious respiratory disease       | 7 (37)               | 39 (41)              |               |
| Others respiratory disease           | 11 (58)              | 41 (44)              |               |
| Infectious non-respiratory disease   | 0                    | 7 (7)                |               |
| Cardiovascular disease               | 0                    | 4 (4)                |               |
| Miscellaneous                        | 1 (5)                | 3 (3)                |               |
| Accuracy of ED diagnosis             | 142 (88.2)           | 399 (80.9)           | 0.034          |
| Chest X-ray during hospital stay     | 176 (72.4)           | 720 (95.9)           | <0.001         |
| CT scan during hospital stay         | 24 (14.9)            | 263 (35.4)           | <0.001         |
| Hospital length-of-stay              | 10.2 (8.6)           | 12.2 (11.8)          | 0.05           |
| ICU admission                        | 14 (5.8)             | 25 (3.3)             | 0.09           |
| In-hospital mortality                | 6 (2.5)              | 41 (5.5)             | 0.056          |

CAP, community-acquired pneumonia; ED, emergency department; ICU, intensive care unit.
Among the 994 CAP patients who visited the ED, those who had CT in the ED were younger [mean age 64.0 vs. 67.7 years; difference −3.7 (95% CI −6.7 to −0.8)] and had a lower severity score [mean CRB65 0.65 vs. 0.77; difference −0.12 (95% CI −0.21 to −0.02)]. CT increased mean duration of ED visit [5:13 vs. 4:09 hours; difference 1:03 (95% CI 0:46−1:21)] and but had no impact on admission [66.3% vs. 65.7%; difference 0.6% (95% CI −6.2 to 7.5%)].

Outcome measurements for patients discharged after emergency department visit

For patients discharged after ED visit, CT increased length-of-stay in the ED [4:51 vs. 3:30; difference 1:21 (95% CI 0:54–1:48)] while no significant difference was recorded for recurrent visit at day 7 [9.8% vs. 4.3%; difference 5.5% (95% CI −1.4 to 12.4%)].

Outcome measurements for patients admitted after emergency department visit

In the 654 patients admitted after ED visit, consistency for diagnosis of CAP was improved in those who received CT at ED [88.2% vs. 80.9%; difference 7.3% (95% CI 1.2–13.3%)], that is, 14 CT were necessary for one additional diagnosis of CAP (95% CI 7–84); in these patients, hospital length-of-stay was shortened [10.2 vs. 12.2 days; difference −2.0 (95% CI −3.9 to −0.1)] while ED length-of-stay was increased by 54 min (95% CI 0:31mn to 1:17mn). In-hospital mortality [2.5% vs. 5.5%; difference −3.0% (95% CI −5.5 to 0.1%)] and ICU admission [5.8% vs. 3.3%; difference 2.4% (95% CI −0.8 to 5.6%)] did not vary.

After adjustment for CRB65 (Table 2), diagnosis consistency was maintained [odds ratio (OR) 1.75 (95% CI 1.03–2.97)] while an increase was observed for duration of ED visit [adjusted mean difference 1:08 hours (95% CI 0.50–1.25)] and ICU admission [OR 2.03 (95% CI 1.03–4.03)]. No change was observed for recurrent visit at day 7 [OR 2.37 (95% CI 0.92–6.13)], admissions [OR 1.31 (95% CI 0.93–1.85)], hospital length-of-stay [adjusted mean difference 1.36 days (95% CI −0.61 to 3.33)], and in-hospital mortality [OR 0.49 (95% CI 0.20 to 1.18)].

Discussion

In this retrospective monocentric study, ordering CT gradually increased overtime in CAP patients visiting the ED. Although CT modified duration of ED visit, it was associated with an increase in diagnosis consistency for patients admitted after ED visit, and decreased hospital length-of-stay for patients admitted with CAP.

A study published in 2015 [7] demonstrated that CT reclassified 31% of ED patients with suspected CAP including 18% with no infiltrate on CXR. In this study, CT findings prompted attending physicians to start antibiotics in 16%, and antibiotic treatment was more frequently adherent to guidelines. Similar observation was reported in a group of older patients admitted after ED visit [11]. Precise diagnosis in patients visiting the ED for dyspnea has been associated with better treatment and prognosis [2]. This is consistent with previous results as CT modified decision for admission or discharge, antibiotics, and other categories of treatment [7]. Conversely, a retrospective study [8] reported that CAP patients received the same antibiotics regardless of imaging; moreover, antimicrobial therapy was delayed in patients receiving CT. In the present study, delay in antimicrobial treatment could not be analyzed. Nevertheless, the average duration of ED visit for subjects who had a CT scan was completed before the 8-hour time limit for initiation of antibiotic treatment whereas we were unable to specifically address this outcome. As our study points out, it was reported that patients who received CT for CAP diagnosis were younger, had different clinical presentation, lower severity scores, and lower procalcitonin level [8]. This seems confusing since patients with inconclusive CXR tend to be older [10,11]. Note that no difference in terms of outcomes was observed by these authors.

In our series, CT was frequently obtained since the ED visit. CT is often prescribed for patients admitted with CAP [12]. Therefore ordering CT for ED patients with suspected CAP should be seen as an early diagnosis procedure rather than an overuse of hospital resources, as reported here.

Limitation
We acknowledge that our results suffer from limitations. The main benefit of CT is to prevent over-diagnosis as it efficiently rules out a diagnosis in case of a suspected CAP [7]. We drew conclusions from patients with final ED diagnosis of CAP. Consequently, we did not examine all extents of potential benefits of CT. Indeed suspected CAP patients were not taken into account if an alternative

| Outcome | Crude OR/mean difference | 95% CI | P value | Adjusted OR/mean difference | 95% CI | P value |
|---------|--------------------------|--------|---------|-----------------------------|--------|---------|
| Duration of ED visit (h:min) | 1.03 | 0.46; 1.21 | <0.001 | 1.08 | 0.00; 1.25 | <0.001 |
| Admission | 1.03 | 0.93−1.39 | 0.86 | 1.31 | 0.93; 1.85 | 0.13 |
| ICU admission | 1.87 | 1.01; 3.47 | 0.094 | 2.03 | 1.03; 6.03 | 0.042 |
| In-hospital mortality | 0.44 | 0.18; 1.05 | 0.063 | 0.49 | 0.20; 1.18 | 0.11 |
| Hospital length-of-stay (days) | 1.96 | −0.002−3.94 | 0.05 | 1.36 | −0.61; 3.33 | 0.18 |
| Recurrent visit at day 7 | 2.43 | 0.94; 6.26 | 0.086 | 2.37 | 0.92; 6.13 | 0.093 |
| Accuracy of ED diagnosis | 1.76 | 1.04; 2.98 | 0.036 | 1.72 | 1.03; 2.97 | 0.04 |

CI, confidence interval; ED, emergency department; ICU, intensive care unit.
diagnosis was made after ED assessment. This also questions confidence in CAP diagnosis for patients who did not receive CT; this applies to both patients discharged after ED visit and patients admitted after ED visit who did not receive CT during their hospital stay. The generalization of our results is questionable as use of CT for ED patients with suspected CAP is still debated [13]. CT is associated with better diagnosis accuracy in patients with suspected CAP visiting the ED. However clinical rules to select patients who will most benefit from CT have moderate accuracy [14,15] and the actual advantage remains unclear since no medico-economic evaluation is currently available. Finally, we observed in the present study that the advantage of CT on outcomes was negated after adjustment on severity.

Conclusion
The COVID-19 outbreak has established CT as the first-line imaging for suspected lower respiratory tract infection. In our daily practice, the use of CXR had decreased while CT was more frequently prescribed, even before the pandemic, and this process will probably be irreversible. Since CT associates with better outcome in our series, we believe that these results should be replicated on a larger scale before changing practices and challenging current definition of CAP.

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Y.E.C. and X.D. designed the study, analyzed the data, and wrote the manuscript. F.B. conducted the statistical analysis and participated in the writing of the manuscript. O.K.-P., M.F., C.P., and M.B.-J. critically reviewed the manuscript. The final manuscript was approved by all the authors.

The ethical board held for the study approved the protocol. The study complied with the National laws for Ethics and the Helsinki ethical principles for medical research involving human subjects.

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request

Conflicts of interest
There are no conflicts of interest.

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