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Pneumonia admissions to the ICU: Prevalence of comorbidities and outcome

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ABSTRACT

Background: Intensive care unit (ICU) patients with pneumonia have significant mortality and morbidity. *Objectives:* To identify different types and outcomes of pneumonia cases admitted to ICU in our center and the prevalence of comorbidities in death and survival cases. *Methods:* We enrolled a total of 94 ICU patients presented with pneumonia during January 2015 to March 2020. We described the prevalence of types of pneumonia and associated comorbidities (diabetes (DM), hypertension (HTN), congestive heart failure (CHF), bronchial asthma (BA), and chronic obstructive airway diseases (COPD)) among cases. We also reported the outcome in terms of death rate and length of stay in ICU. Results: This study included 94 participants with an average age of 58.3 (±18.6) and 43.6% were female. The prevalence of DM, HTN, CHF, BA and COPD were (51.1%, 55.3%, 25.5%, 4.3%, 8.5%) respectively. Pneumonia types were community-acquired pneumonia (CAP) in 62.8%, atypical pneumonia in 15.9%, aspiration pneumonia in 15.9%, and hospital-acquired pneumonia in 3.2%. The crude death rate was 35.1%. Death cases were associated with decompensated heart failure in 18.8%, other coexistent infection in 6.1%, and bedridden cases in 9.1%. HTN, DM, CHF, COPD and BA were similarly distributed between death and survival cases. *Conclusion:* The crude mortality rates of pneumonia patients in the ICU remain high. CAP was the most common type. The prevalence of measured comorbidities was similar between death and survival cases. The strength of care provided to ICU pneumonia cases should not be negatively influenced by the presence of these measured comorbidities alone.

Keywords: pneumonia, comorbidities, ICU, outcome

1. INTRODUCTION

Pneumonia is common cause of death and morbidity worldwide. It can have heterogenous clinical presentations, starting from fever and mild pneumonia and productive cough to severe pneumonia with respiratory failure and sepsis

(Jain et al., 2021). Pneumonia is typically classified according to the site of infection into 1) community-acquired pneumonia (CAP), in which an infection is attained outside the hospital; 2) nosocomial pneumonia includes hospital-acquired pneumonia (HAP) and ventilator-associated pneumonia (VAP). (HAP) describes pneumonia that occurs within 2 days or more after hospital admission and (VAP) is pneumonia that is contracted 2 days or more after endotracheal intubation (Jain et al., 2021). When patients with notable healthcare contact develop pneumonia it is referred to as healthcare-associated pneumonia (HCAP) (Am, 2005).

CAP can be diagnosed based on a compatible clinical condition and imaging findings suggestive of pneumonia. Disease severity is determined by clinical judgment, which can be supplemented by the use of several available severity scores. Although CAP is associated with a mortality rate of 1% in the outpatient setting and between 8% and 10.6% in various inpatient cohorts (Luna et al., 2016), a mortality rate of up to 24% has recently been reported in patients requiring admission to the ICU (Cavallazzi et al., 2015). Even when patients with CAP survive in the ICU and are discharged, they suffer from the long-term effects of pneumonia and have higher long-term mortality than other groups of patients requiring hospitalization (Bordon et al., 2010). According to a recent American study, 23% of the 7,449 CAP patients were treated in the intensive care unit. Cavallazzi and his group reported CAP incidence in the ICU as high as 145 cases per 100,000 adult populations (Cavallazzi et al., 2015). In addition, community-acquired pneumonia (CAP) requiring admission to the ICU was found to account for 9% to 14% of all CAP cases requiring hospitalization (Liapikou et al., 2009).

Another form of pneumonia is atypical pneumonia, which differs from typical pneumonia in radiographic findings and pathogens. It usually does not respond to the first-line antibiotic used for pneumonia (Dueck et al., 2021). A study in France has shown that the mortality rate of ICU patients with atypical pneumonia is 11% (Valade et al., 2018). Aspiration pneumonia is another form of pneumonia and occurs after aspiration of oropharyngeal secretions or gastric contents, most commonly in hospitalized patients with altered mental status due to failure of natural defense mechanisms such as cough, esophageal motility disorders, or gastric outlet obstruction. The mortality rate in such patients ranges from 11 to 30% (Sanivarapu and Gibson, 2021).

Despite the availability of studies describing CAP, HAP and aspiration pneumonias, there are few studies describing all ICU admitted pneumonia cases in a single cohort. The goal of this study was to identify different types and outcomes of pneumonia cases admitted to the ICU at our center and to determine the prevalence of comorbidities in death and survival cases.

2. SUBJECTS AND METHODS

We retrospectively reviewed all pneumonia patients admitted to the intensive care unit of King Abdulaziz University Hospital. The ethics committee approved the study. Inclusion criteria were all pneumonia patients older than 14 year old patient admitted to the ICU during January 2015 to March 2020. Exclusion criteria were non pneumonia cases admitted to the ICU. Cases of pneumonia were identified from ICU admission records, electronic medical records, and clinical laboratory records. We recorded several variables, including age, sex, BMI, date of ICU admission, diagnosis of ICU admission, duration of ICU stay, outcome (hospital discharge/mortality), invasive vs. noninvasive ventilation, duration of ventilation, comorbidities (diabetes, heart failure, hypertension, asthma, and chronic obstructive pulmonary disease (COPD), PaO2 and PaCO2 on the day of admission, and sputum culture. We enrolled a total of 94 patients.

Findings

We estimated the prevalence of variable pneumonia types among patients admitted to the ICU. We also studied the prevalence of (diabetes, hypertension, heart failure, asthma and chronic obstructive pulmonary disease (COPD) among the pneumonia cases in ICU. We described the outcome of pneumonia in terms of mortality rate and length of stay in the ICU. We also compared the prevalence of comorbidities, pneumonia types, oxygen and carbon dioxide tension in ventilated and non-ventilated patients, and between survival and death cases. Finally, we examined the possible predictors of survival.

Statistical analysis

Patient characteristics, prevalence of pneumonia types, and comorbidities were described using mean, standard deviation, median, interquartile range (IQR), and frequencies, as appropriate. Comparison between dichotomized outcomes (survival vs death and ventilated vs nonventilated patients) was performed using the Wilcoxon rank sum test (Mann-Whitney), $\chi 2$ test, and Fisher's exact test. To explore the predictors of outcome, we used logistic regression analysis. Data were statistically analyzed using (SPSS) version 26 and STATA version 13 (Stata-Corp, College Station, TX, USA).

3. RESULTS

Ninety-four patients were included and their clinical characteristics were summarized in Table 1. We found that the mean age of our patients with ICU pneumonia was middle-aged, with similar rates in men and women. Most of our patients were not obese, and few (12.7%) had pulmonary disease (asthma, COPD). Almost half of our cases had diabetes and hypertension, while 25.5% had heart failure. The most common form of pneumonia is community acquired pneumonia.

Table 1 Patients' clinical characteristics

Variable	N=95
Age (years), mean ± SD	58.3±18.6
BMI (kg/m$^{2)}$, mean ± SD	26.9± 6.8
Female, n (%)	41(43.6)
Asthma, n (%)	4 (4.3)
COPD, n (%)	8 (8.5)
Heart failure, n (%)	24 (25.5)
Hypertension, n (%)	52 (55.3)
Diabetes, n (%)	48 (51.1)
Ventilation, n (%)	89 (94.7)
Type of ventilation	
BIPAP, n (%)	24 (25.5)
BIPAP followed by MV, n (%)	5 (5.3)
MV, n (%)	60 (63.8)
Community acquired pneumonia, n (%)	59 (62.8)
Atypical pneumoina, n (%)	15 (15.9)
Aspiration pneumonia, n (%)	15 (15.9)
Hospital aquired pneumonia, n (%)	3 (3.2)
Acute pulmonary Tuberculosis, n (%)	2 (2.13)
Length of ICU admission mean ± SD	10.4 ± 10.9
Length of ventilation mean ± SD	7.5 ± 8.5

(SD): standard deviation, (BMI): body mass index, (COPD): chronic obstructive airway disease, (BIPAP): Bilevel Positive Airway Pressure, (CPAP): Continues Positive Airway Pressure (MV): Mechanical ventilation.

The most common causative organisms based on sputum cultures were Coagulase negative *staphylococci, Pseudomonas aeruginosa, Streptococcus viridans, Klebsiella pneumoniae, E-coli* and *Staphylococcus aureus* table 2. The mean level of carbon dioxide tension was higher than the normal level and mean level of oxygen tension was lower side table 2. Comorbidities (diabetes, hypertension, heart failure, asthma, and chronic obstructive pulmonary disease (COPD)) were similarly distributed in ventilated and nonventilated patients. However, all cases of aspiration pneumonia ended up ventilated Table 3, with no difference noted between oxygen and carbon dioxide tensions.

Table 2 Sputum culture and arterial oxygen and carbion dioxide tension findings.

Variable	No. (%)
no organism	39(41.49)
Staphylococcus aureus	3 (3.19)
E-coli	4 (4.26)
Staphylococcus aureus MRSA	3 (3.19)
Coagulase negative *staphylococci*	9(9.57)
Pseudomonas aeruginosa	7 (7.45)
candida albicans	1 (1.06)
Acinetobacter baumannii	2 (2.13)
Mixed bacterial growth	3 (3.19)

klebsiella pneumoniae	4 (4.26)
Streptococcus viridans	4 (4.26)
Mycobacterium tuberculosis	2 (2.13)
Enterococcus faecalis	2 (2.13)
Streptococcus pneumoniae	5 (5.32)
Two organisms	6 (6.38)
Oxygen and carbon dioxide tension	Mean (± SD)
PCO2 (arterial)	49.2 ±22.1
PO2 (arterial)	86.6 ±50.8

(SD): standard deviation; (MRSA): Methicillin-resistant Staphylococcus aureus.

Table 3 Prevalence of comorbities and pneumonia types and level of oxygen and carbon dioxide tension among ventilated and non-ventilated patients

Variable	Ventilation		p-value
	No	Yes	
Age, median (IQR)	54 (38-60)	60 (48-73)	0.234
BMI, median (IQR)	27.7 (27.68 – 31.14)	25.7 (22-30.8)	0.563
Female, n (%)	1(2.44)	40 (97.56)	0.382
Male, n (%)	4 (7.55)	49 (92.45)	
DM, n (%)	2 (4.17)	46 (95.83)	0.674
No DM, n (%)	3 (6.5)	43 (93.5)	
Hypertension, n (%)	2 (3.85)	50 (96.15)	0.653
No hypertension, n (%)	3 (7.14)	39 (92.86)	
Heart failure, n (%)	0 (0.00)	24 (100)	0.324
No heart failure, n (%)	5 (7.14)	65 (92.68)	
Asthma, n (%)	1 (25)	3 (75)	0.248
COPD, n (%)	0 (0.00)	8 (100)	
No pulmonarydisease, n (%)	4 (4.82)	78 (95.12)	
CAP, n (%)	3(5.08)	56 (94.92)	0.527
Atypical pneumonia, n (%)	2 (13.33)	13 (86.67)	
Aspiration pneumonia, n (%)	0 (0.00)	15 (100)	
HAP, n (%)	0 (0.00)	3 (100)	
Acute pulmonary TB, n (%)	0 (0.00)	2 (100)	
PaCO2 (arterial) , median (IQR)	36.6 (29.8-40-2)	42 (36.5-58.2)	0.093
PaO2 (arterial) , median (IQR)	79.4 (60.5-80,2)	76 (62-101)	0.443

Data are presented as the number with the percentage in parenthesis, or the median with interquartile range (IQR) in parenthesis, as appropriate. (BMI): body mass index, (DM): diabetes mellitus, (CAP): community-acquired pneumonia, (HAP): hospital-acquired pneumonia, (COPD): chronic obstructive airway disease.

We found a higher mortality rate among aspiration pneumonia cases and atypical pneumonia cases compared to community acquired pneumonia, although this was not statistically significant figure 1 and table 4. The mortality rate with coexistence infections such as sepsis, decompensated heart failure or bedridden cases were 33.3% with CAP, 100% with atypical pneumonia and 75% with aspiration pneumonia. In comparison, the mortality rate with the absence of these factors was 27.5% with CAP, 42.8% with atypical pneumonia and 36.3% with aspiration pneumonia. The initial arterial pressure of carbon dioxide and oxygen at the admission was not different between death and survivors' cases table 4.

In addition, comorbidities (diabetes, hypertension, heart failure, asthma, and chronic obstructive pulmonary disease (COPD)) were similarly distributed among survivors and deaths, figure 2 and no difference was found between oxygen and carbon dioxide tension.

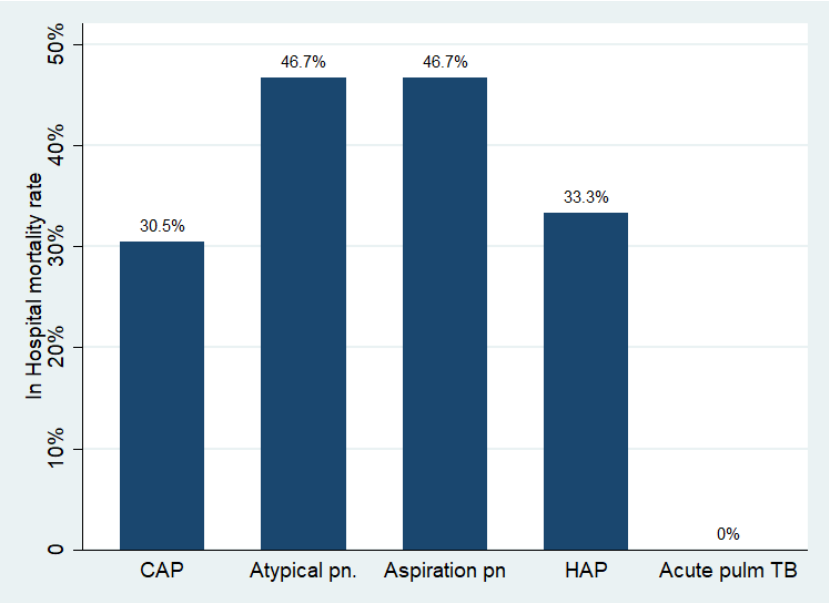

Figure 1 Mortality rate among different type of pneumonia cases admitted to ICU. CAP: community acquired pneumonia. Pn: pneumonia. HAP: hospital acquired pneumonia.

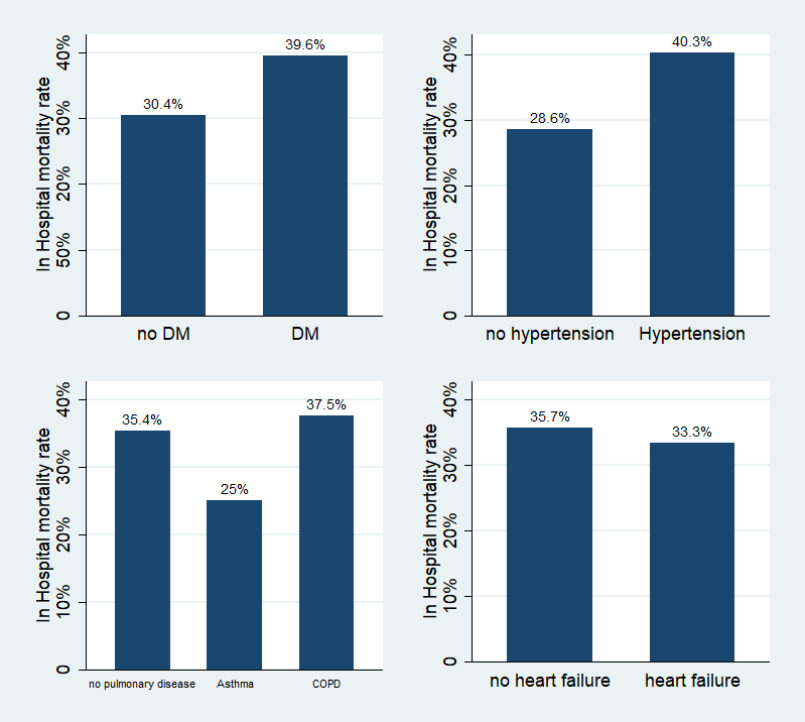

Figure 2 prevalence of mortality among comorbidities in ICU pneumonia cases. DM: diabetes mellitus. COPD: chronic obstructive pulmonary disease.

Table 4 Prevalence of comorbities and pneumonia types and level of oxygen and carbon dioxide tension among survival and death cases.

Variable	Outcome		p-value
	Deceased (N=34)	Alive (N=61)	
Age, median (IQR)	6061 (49-73)	56 (46-73)	0.562
BMI, median (IQR)	25.9(21.26-30.82)	25.71 (22.72-31.11)	0.785
Female, n (%)	12 (29.27)	29 (70.73)	0.384
Male, n (%)	21 (39.62)	32 (60.38)	

DM, n (%)	19 (39.58)	29 (60.4)	0.393
No DM, n (%)	14 (30.4)	32 (69.6)	
HTN, n (%)	21 (40.4)	31 (59.6)	0.28
NO HTN, n (%)	12 (28.6)	30 (71.4)	
Heart Failure, n (%)	8 (33.3)	16 (66.7)	1.00
No heart failure, n (%)	25 (35.7)	45 (64.3)	
Asthma, n (%)	1 (25)	3 (75)	1.000
COPD, n (%)	3 (37.5)	5 (62.5)	
No pulmonarydisease, n (%)	29 (35.4)	53 (64.6)	
Ventilated, n (%)	33 (37.08)	56 (62.92)	0.158
Non-Ventilated, n (%)	0 (0.00)	5 (100)	
Invasive, n (%)	27 (39.7)	41 (60.3)	0.154
Non- invasive, n (%)	6 (23.08)	20 (76.9)	
CAP, n (%)	18 (30.51)	41 (69.49)	0.506
Atypical pneumonia, n (%), n (%)	7 (46.67)	8 (53.33)	
Aspiration pneumonia, n (%)	7 (46.67)	8 (53.33)	
HAP, n (%)	1 (33.3)	2 (66.7)	
Acute pulmonary TB, n (%)	0 (0.00)	2 (100)	
PaCO2 (arterial), median (IQR)	43.75 (37.6 – 65.3)	41.7 (36.05-55.1)	0-46
PaO2 (arterial), median (IQR)	72.8 (59.6-96.47)	77.35 (63.2-102)	0.453

* interquartile range (IQR)

(BMI): body mass index, (DM): diabetes mellitus, (CAP): community-acquired pneumonia, (HAP): hospital-acquired pneumonia, (COPD): chronic obstructive airway disease, (HTN): hypertension

Logistic regression did not reveal an influence of the measured demographic and comorbidities on the outcome of the survival table 5.

Table 5 logistic regression analysis of the independent predictors (risk factors) of death among studied patients

	Odds ratio (CI: 95%)	P value
Age	1.01 (0.98-1.03)	0.406
BMI	1.01 (0.95-1.07)	0.802
Female	0.63 (0.26- 1.5)	0.298
Heart failure	0.9 (0.34-2.39)	0.833
Asthma	0.61 (0.06-6.12)	0.674
COPD	1.09 (0.06-6.13)	0.674
Diabetes	1.49 (0.64-3.51)	0.354
Hypertension	1.69 (0.71-4.03)	0.235

(BMI): body mass index, (COPD): chronic obstructive airway disease

4. DISCUSSION

The present study included 94 patients admitted to the ICU with pneumonia between 2015 and 2020, and it shows that the crude mortality rate was 35.1%. In previous reports, the mortality rate in CAP ranged from 24-55% (AlOtair et al., 2015; Ferrer et al., 2018; Aydogdu et al., 2010). The mortality rate at CAP in our study was 30.5%, which is comparable to the findings of Ferrer et al., (2018) who prospectively studied patients with severe CAP over 12 years. He found that the 30-day mortality rate in invasively ventilated and non-intubated patients was 33% and 18%, respectively. AlOtair et al., (2015) also found that the overall ICU and hospital mortality rates were 24.4% and 30.3% for CAP and HAP, respectively. Aydoğdu et al., (2010) found a mortality rate of 55% at ICU CAP.

Our study showed an independent association between risk factors such as diabetes, hypertension, chronic heart failure, and COPD and mortality rate. Heart failure was present in 25.5% of our patients; however, in previous studies (Aydogdu et al., 2010),

the rate ranged from 4% to 33.6% (Li et al., 2016). In the study by Aydoğdu et al. (2010), there was no difference in the rate of heart failure between deaths and survivors, while Li and his group found that non-survivors (8.7%) were more likely to have heart failure than survivors (3.7%). The prevalence of diabetes was 51% in our study compared to 22.6% in previous reports; however, similar to our results, no association with mortality was found (Ferrer et al., 2018). The rate of COPD among ICU pneumonia cases was low in our study (8.5%). In several studies (Hespanhol and Barbara, 2020), COPD accounted for 12% and up to 20% of all hospital pneumonia cases (Al-Muhairi et al., 2006). Several studies found that diabetes or COPD did not increase the risk of death from pneumonia in the ICU and hospital (Li et al., 2016; Dwivedi et al., 2020; Sirvent et al., 2013). Regarding the contribution of bronchial asthma (BA) to in hospital mortality for pneumonia cases admitted to ICU, our study did not show difference in prevalence among death and survivors and this is consistent with previous report (Dwivedi et al., 2020). However, in another study that included all CAP admitted to hospital, they found that BA associated with lower risk of mortality (Hespanhol and Barbara, 2020). Hypertension was not more prevalent among ICU pneumonia cases with in hospital mortality in other study which is also consistent with the previous reports (AlOtair et al., 2015).

The prevalence of aspiration pneumonia among ICU admitted pneumonia cases in our study was 15.8%, which is consistent with most previous studies reporting a prevalence of 7.1%-18.2% in hospitalized patients, with rare outliers (Komiya et al., 2016; Marrie et al., 2003; Lanspa et al., 2015). The mortality rate for aspiration pneumonia admitted to the ICU was 46.6% in our cohort. No study specifically examined aspiration pneumonia admitted to the ICU. However, the reported in-hospital mortality rate varied from 12.9% to 59.1% (Komiya et al., 2016). Lanspa et al., (2015) compared the outcome of aspiration pneumonia with the outcome of CAP mortality and found that the mortality rate for all hospitalized aspiration pneumonia (23%) was significantly higher than hospitalized CAP (9%), even after adjustment for age, severity, and comorbidities (Lanspa et al., 2015). Our study focused on ICU pneumonia cases and found a similar higher mortality rate for aspiration pneumonia than CAP.

Limitation

Our study has several limitations. The retrospective nature is inherited bias, especially in documentation. Since this is a single center study, the result could be influenced by local factors such as the type of community served by our center and the experience of the center. Several factors contributed to the high mortality rate in our cohort that we did not examine. For example, the duration of symptoms before hospital admission and the presence of sepsis on arrival at ER could contribute to the high mortality rate. We did not examine the severity of pneumonia and how it affected outcome. Another limitation is that we did not examine the impact of treatment strategies and protocols on outcome. In addition, we did not examine the predictive power of several clinical and laboratory variables, such as vital signs on admission and laboratory results of renal and liver function. Finally, we mainly report the unadjusted outcome rate, which is due to the small sample size. However, we believe that our study provides insight into the cases of pneumonia admitted to the ICU. Despite the availability of studies that discussed CAP, HAP admitted to the ICU, there are few studies in the literature that describe all cases of pneumonia admitted to the ICU.

5. CONCLUSION

We described the prevalence of types of pneumonia and associated comorbidities in ICU pneumonia patients. Our results were consistent with the available literature regarding in-hospital mortality rates. Although we found no difference in comorbidities between deaths and survivors, this is consistent with the available literature. This finding highlights the importance of avoiding negative influences of all measured comorbidities in our study and in previous studies on the strength of clinical care provided to these patients. Future studies with a prospective design and larger sample size are needed to better understand the predictors of ICU pneumonia outcomes.

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Author's contribution

Almalki A, Almuteeri R, Althalabi R, Sahli H, Hayash F, Alrayiqi R: Acquisition of data, drafting of the final report, and provision of final approval of the version to be published.

Abuzinadah A: Conception and design of the study, analysis and interpretation of results, critical revision of the final report, and provision of final approval of the version to be published.

BamagaA, Alhejaili F: Conception and design of the study, critical revision of the final report, and provision of final approval of the version to be published.

Ethical approval

This study was approved by the Medical Ethics Committee of King Abdulaziz University (ethical approval code: 534-21).

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Conflict of Interest

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are presented in the paper. Further inquiries can be directed to the corresponding author.

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