e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2023; 15(09); 627-634

Original Research Article

Incidence of Pulmonary Complication Mainly Pneumonia, Need of Mechanical Ventilation, Respiratory Depression after Acute Stroke

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Received: 01-06-2023 / Revised: 16-07-2023 / Accepted: 20-08-2023
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Conflict of interest: Nil

Abstract

Background: Pulmonary complications are among the most serious and potentially preventable medical complications following acute stroke. Stroke-associated pneumonia (SAP), respiratory depression, and the need for mechanical ventilation substantially worsen clinical outcomes, yet data integrating all three outcomes in a single cohort from Indian tertiary-care settings remain limited. This study aimed to determine the incidence, risk factors, and in-hospital outcomes associated with major pulmonary complications after acute stroke.

Methods: A hospital-based observational study was conducted among 153 adults with acute stroke. Demographic, clinical, and neurological characteristics were recorded at admission. Patients were monitored for pulmonary complications including SAP, respiratory depression, and mechanical ventilation requirement. Outcomes assessed included ICU admission, length of hospital stay, and in-hospital mortality. Statistical analyses included group comparisons and multivariable logistic regression to identify independent predictors of pulmonary complications.

Results: Pulmonary complications occurred in 26.8% of patients. SAP was the most common complication (19.0%), followed by respiratory depression (9.8%) and mechanical ventilation requirement (13.7%). Patients with pulmonary complications were older, had higher stroke severity (NIHSS 18.3 vs. 9.3; $p < 0.001$), more frequent impaired consciousness (GCS ≤8: 36.6% vs. 2.7%; $p < 0.001$), dysphagia (70.7% vs. 14.3%; $p < 0.001$), hemorrhagic stroke (34.1% vs. 17.0%; $p = 0.014$), and COPD (24.4% vs. 8.9%; $p = 0.007$). In-hospital outcomes were significantly worse among those with complications, including higher ICU admission (80.5% vs. 5.4%), longer hospital stay (15 vs. 7 days), and markedly higher mortality (46.3% vs. 5.4%) (all $p < 0.001$). Multivariable analysis identified NIHSS (OR 1.18 per point; $p < 0.001$), GCS ≤8 (OR 8.96; $p = 0.003$), and dysphagia (OR 7.42; $p < 0.001$) as independent predictors of pulmonary complications.

Conclusion: Pulmonary complications are frequent after acute stroke and are strongly associated with severe neurological deficits, impaired consciousness, dysphagia, and underlying respiratory comorbidity. Their occurrence significantly increases ICU utilization, prolongs hospitalization, and elevates mortality risk. Early identification and targeted preventive strategies for high-risk patients are essential to improving post-stroke outcomes.

Keywords: Acute stroke; Stroke-associated pneumonia; Dysphagia; NIHSS; GCS.

Introduction

Stroke is a major global health problem, ranking as the second leading cause of death and a primary cause of long-term disability worldwide, accounting for approximately 6.6 million deaths annually [1]. Beyond the neurological insult, medical complications in the acute phase of stroke occur in 40–70% of patients, with pulmonary complications being among the most common and clinically significant [2,3]. These complications, particularly stroke-associated pneumonia (SAP), respiratory depression, and the need for mechanical ventilation (MV)substantially influence morbidity, length of hospitalization, functional outcomes, and early mortality [2,3].

Stroke-associated pneumonia is the most frequently reported pulmonary complication, with incidence rates ranging from 5% to 30% depending on population, diagnostic criteria, and stroke severity [4,5]. It accounts for up to 20–35% of post-stroke deaths [6]. Patients with severe stroke, reduced consciousness, dysphagia, impaired cough reflex, advanced age, and comorbidities such as diabetes or COPD are at markedly increased risk [7]. The pathogenesis of SAP is multifactorial and includes aspiration due to dysphagia, post-stroke immune suppression, impaired airway clearance, and neurogenic respiratory dysfunction [8]. Early development of pneumonia has been shown to

worsen neurological recovery and increase the likelihood of dependency at discharge and at 3-month follow-up [9].

Respiratory depression after stroke is another important and under-recognized complication, particularly in cases involving brainstem infarction, large hemispheric strokes, or opioid/sedative administration during acute management [1]. Brainstem strokes disrupt central respiratory drive, while hemispheric strokes may impair voluntary respiratory effort and upper airway function [2]. Literature have reported respiratory depression rates of 8–15% in acute stroke cohorts, often necessitating close monitoring and airway protection [10].

The need for mechanical ventilation (MV) is closely linked to both neurological severity and respiratory compromise. Approximately 10–24% of acute stroke patients require intubation and ventilatory support during hospitalization, with higher rates observed in large vessel occlusion strokes and intracerebral hemorrhage [11]. Indications for MV include decreased level of consciousness (GCS < 8), respiratory depression, aspiration risk, pneumonia, airway obstruction, and hemodynamic instability. Importantly, the need for MV is itself an indicator of poor prognosis, with reported mortality rates of 40–60% among ventilated stroke patients [12]. Even among survivors, prolonged ventilation increases the risk of hospital-acquired infections, ICU stays, and long-term functional impairment [13].

Despite the well-recognized burden of pulmonary complications, regional variability exists due to differences in patient demographics, stroke subtypes, pre-hospital delay, availability of stroke units, and practices related to dysphagia screening, airway management, and early rehabilitation. Evidence from many low- and middle-income countries remains limited, and local data are essential to guide clinical protocols, resource allocation, and preventive strategies. Furthermore, few studies comprehensively evaluate all three major respiratory complications—pneumonia, respiratory depression, and MV requirement—within a single cohort, despite their interconnected nature. Given this gap, the present study aimed to determine the incidence and profile of pulmonary complications, including stroke-associated pneumonia, respiratory depression, and mechanical ventilation requirement, in patients with acute stroke, and to provide insights relevant to improving early stroke care and outcomes.

Materials And Methods

Study Design and Setting: This hospital-based observational study was conducted in the Department of Tuberculosis and Respiratory Disease at JNMCH, AMU, Aligarh, Uttar Pradesh. The study included all eligible patients admitted with a diagnosis of acute stroke over the defined study period of 2 years between July 2020 to June 2022. The hospital caters to a large catchment population, with an annual stroke admission load of approximately 70 to 80 patients, allowing adequate representation of diverse clinical profiles. The study aimed to determine the incidence and pattern of pulmonary complications, specifically pneumonia, respiratory depression, and the need for mechanical ventilation, during the acute phase of stroke.

Study Population and Eligibility Criteria: All consecutive adult patients aged ≥18 years presenting within 7 days of onset of stroke symptoms and confirmed to have ischemic or hemorrhagic stroke through neuroimaging (CT/MRI) were assessed for inclusion. Patients with transient ischemic attack, subarachnoid hemorrhage, pre-existing pneumonia, chronic respiratory failure requiring home oxygen or mechanical ventilation, known neuromuscular disorders affecting respiration, or those who developed pulmonary complications prior to hospital admission were excluded from the study. Patients transferred from other hospitals with inadequate documentation of pre-admission pulmonary status were also excluded to ensure accurate attribution of complications to the acute stroke event.

Data Collection Procedures: After obtaining informed consent, detailed clinical, demographic, and radiological data were recorded using a structured case record form. Baseline variables included age, sex, comorbidities, stroke subtype, severity assessed using the National Institutes of Health Stroke Scale (NIHSS) at admission, Glasgow Coma Scale (GCS), presence of dysphagia based on bedside swallow evaluation, and level of consciousness. Serial monitoring for respiratory status was performed throughout hospitalization, including respiratory rate, oxygen saturation, arterial blood gases when indicated, auscultatory findings, and need for airway interventions. Chest radiographs were obtained at baseline when clinically indicated and repeated if new respiratory symptoms appeared. All patients were followed for the development of pulmonary complications until discharge or death.

Definitions of Pulmonary Complications: Pneumonia was diagnosed according to the Centers for Disease Control and Prevention (CDC) criteria, requiring the presence of new infiltrates on chest imaging along with at least two clinical features such as fever >38°C, leukocytosis or leukopenia, purulent sputum, or worsening oxygenation.

Stroke-associated pneumonia (SAP) was defined as pneumonia occurring within the first 7 days of stroke onset. Respiratory depression was defined as a respiratory rate <10 breaths per minute, hypoventilation requiring assisted ventilation, persistent oxygen saturation <90% on room air, or

hypercapnia ($PaCO_2$ >45 mmHg) confirmed on arterial blood gas analysis, in the absence of metabolic or pharmacologic causes. The need for mechanical ventilation was documented when the patient required endotracheal intubation or initiation of invasive mechanical ventilation due to reduced consciousness (GCS ≤8), airway compromise, severe pneumonia, respiratory failure, or hemodynamic instability.

Outcome Measures: The primary outcome of the study was the incidence of pulmonary complications (pneumonia, respiratory depression, and mechanical ventilation requirement) during the acute hospitalization period. Secondary outcomes included time to onset of pulmonary complications from admission, association of complications with stroke severity, and in-hospital mortality. Duration of hospital stay and need for ICU admission were also recorded for additional descriptive analysis.

Ethical Considerations: The study was conducted in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines. Approval was obtained from the Institutional Ethics Committee prior to initiation. Written informed consent was obtained from patients or their legally authorized representatives before enrollment. Confidentiality of patient information was strictly maintained throughout the study.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 20.0 (IBM Corp., Armonk, NY). Continuous variables were expressed as mean ± standard deviation or median with interquartile range, depending on distribution. Categorical variables were summarized as frequencies and percentages.

The incidence of each pulmonary complication was calculated as the proportion of patients developing the complication among the total study population. Associations between pulmonary complications and clinical characteristics such as age, comorbidities, stroke type, NIHSS score, GCS, and dysphagia were analyzed using the chi-square test or Fisher's exact test for categorical variables, and independent t-test or Mann–Whitney U test for continuous variables. A p-value <0.05 was considered statistically significant.

Results

A total of 153 patients with acute stroke were included, with a mean age of 61.8 ± 12.0 years; 41.8% were aged ≥65 years. Males constituted 64.1% of the cohort. Ischemic stroke accounted for the majority of cases (78.4%), while 21.6% had hemorrhagic stroke. The median neurological severity was moderate, with a mean NIHSS score of 11.6 ± 7.6.

Reduced consciousness (GCS ≤8) was observed in 11.8% of patients. Dysphagia on initial screening was present in 29.4%. Hypertension (62.1%) and diabetes mellitus (37.9%) were the most common comorbidities, whereas COPD was present in 13.1%, and 26.1% were current or recent smokers (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics of the Study Population (n = 153)

Variable	Frequency (%)/mean ± SD
Age (years)	61.8 ± 12.0
Age group	
≥ 65 years	64 (41.8)
< 65 years	89 (58.2)
Gender	
Female	55 (35.9)
Male	98 (64.1)
Stroke type	
Ischemic	120 (78.4)
Haemorrhagic	33 (21.6)
NIHSS	11.6 ± 7.6
GCS	
≤ 8	18 (11.8)
> 8	135 (88.2)
Dysphagia on screening	45 (29.4)
Comorbidities	
Hypertension	95 (62.1)
Diabetes mellitus	58 (37.9)
COPD / chronic lung disease	20 (13.1)
Current or recent smoker	40 (26.1)

NIHSS – National Institutes of Health Stroke Scale; GCS – Glasgow Coma Scale; COPD – Chronic Obstructive Pulmonary Disease.

Pulmonary complications occurred in 26.8% (n = 41) of the study population. SAP was the most common complication, affecting 19.0% of patients, with a median onset of 3 days (IQR 2–5) after admission. Respiratory depression occurred in 9.8% and developed earlier, with a median onset at 1 day (IQR 0–2). Mechanical ventilation was required in 13.7% of patients, typically initiated by day 2 (IQR 1–4). There was considerable overlap between complications, with many ventilated patients having concurrent SAP and/or respiratory depression (Table 2).

Table 2: Incidence and Timing of Pulmonary Complications Following Acute Stroke (n = 153)

Complication	Frequency (%)	Time from admission to onset (days) Median (IQR)
Stroke-associated pneumonia (SAP)	29 (19.0)	3 (2–5)
Respiratory depression (hypoventilation / sustained hypoxaemia / hypercapnia)	15 (9.8)	1 (0–2)
Required invasive mechanical ventilation (MV)	21 (13.7)	2 (1–4)
Any pulmonary complication (one or more of above)	41 (26.8)	—

SAP – Stroke-Associated Pneumonia; MV – Mechanical Ventilation; IQR – Interquartile Range. SAP defined as pneumonia within 7 days of stroke onset using clinical and radiographic criteria.

Patients who developed pulmonary complications (n = 41) were significantly older (66.2 ± 10.8 years vs. 59.8 ± 12.0 years; p = 0.004), and a higher proportion were aged ≥65 years (58.5% vs. 35.7%; p = 0.013). Haemorrhagic stroke was more common in the complication group (34.1% vs. 17.0%; p = 0.014). Neurological severity was markedly higher among those with complications, as reflected by increased NIHSS scores (18.3 ± 6.1 vs. 9.3 ± 5.2; p < 0.001) and a greater frequency of reduced consciousness (GCS ≤8; 36.6% vs. 2.7%; p < 0.001). Dysphagia was strongly associated with complications (70.7% vs. 14.3%; p < 0.001). COPD was more prevalent among affected patients (24.4% vs. 8.9%; p = 0.007). Diabetes and smoking showed higher proportions in the complication group but did not reach statistical significance (Table 3).

Table 3: Comparison of Clinical Characteristics Between Patients With and Without Pulmonary Complications

Variable	With pulmonary complication (n = 41)	Without pulmonary complication (n = 112)	p-value
	Frequency (%)/mean ± SD		
Age (years)	66.2 ± 10.8	59.8 ± 12.0	0.004
Age group			
≥ 65 years	24 (58.5)	40 (35.7)	0.013
< 65 years	17 (41.5)	72 (64.3)	
Gender			
Female	10 (24.4)	45 (40.2)	0.070
Male	31 (75.6)	67 (59.8)	
Stroke type			
Ischemic	27 (65.9)	93 (83.0)	0.014
Haemorrhagic	14 (34.1)	19 (17.0)	
NIHSS	18.3 ± 6.1	9.3 ± 5.2	<0.001
GCS			
≤ 8	15 (36.6)	3 (2.7)	<0.001
> 8	26 (63.4)	109 (97.3)	
Dysphagia on screening	29 (70.7)	16 (14.3)	<0.001
Comorbidities			
Hypertension	28 (68.3)	67 (59.8)	0.360
Diabetes mellitus	21 (51.2)	37 (33.0)	0.051
COPD / chronic lung disease	10 (24.4)	10 (8.9)	0.007
Current or recent smoker	15 (36.6)	25 (22.3)	0.077

NIHSS – National Institutes of Health Stroke Scale; GCS – Glasgow Coma Scale; COPD – Chronic Obstructive Pulmonary Disease.

Pulmonary complications were associated with substantially poorer in-hospital outcomes. ICU admission was required in 80.5% of patients with complications compared to 5.4% of those without (p < 0.001). Length of hospital stay was significantly longer among patients with complications (median 15 days, IQR 10–22) than those without (median 7 days, IQR 5–10; p < 0.001). Hospital mortality was markedly higher in the complication group (46.3% vs. 5.4%; p < 0.001). Only 51.2% of patients with

complications were discharged home compared to 87.5% without complications ($p < 0.001$), indicating a strong impact of respiratory complications on functional disposition (Table 4).

Table 4: In-Hospital Outcomes According to Pulmonary Complication Status

Outcome	With pulmonary complication (n = 41)	Without pulmonary complication (n = 112)	p-value
	Frequency (%)/median (IQR)		
ICU admission	33 (80.5)	6 (5.4)	<0.001
Length of hospital stay (days)	15 (10–22)	7 (5–10)	<0.001
Hospital mortality	19 (46.3)	6 (5.4)	<0.001
Discharged home	21 (51.2)	98 (87.5)	<0.001

IQR – Interquartile Range; ICU – Intensive Care Unit.

In the multivariable logistic regression model, higher stroke severity independently increased the risk of pulmonary complications, with each 1-point rise in NIHSS associated with an 18% increase in odds (adjusted OR 1.18; 95% CI 1.10–1.27; $p < 0.001$). Reduced consciousness (GCS ≤8) was a strong predictor, conferring nearly nine fold higher risk (OR 8.96; 95% CI 2.13–37.6; $p = 0.003$). Dysphagia also remained a significant independent predictor (OR 7.42; 95% CI 3.00–18.4; $p < 0.001$). Although hemorrhagic stroke and COPD showed elevated odds (OR 2.11 and 2.51, respectively), these associations did not reach statistical significance after adjustment. Age ≥65 years was not an independent predictor when severity variables were included (Table 5).

Table 5: Multivariable Logistic Regression for Predictors of Pulmonary Complications

Predictor	Adjusted OR	95% CI	p-value
Age ≥ 65 years	1.72	0.72 – 4.07	0.220
Haemorrhagic stroke	2.11	0.88 – 5.06	0.093
NIHSS (per 1-point increase)	1.18	1.10 – 1.27	<0.001
GCS ≤ 8	8.96	2.13 – 37.6	0.003
Dysphagia	7.42	3.00 – 18.4	<0.001
COPD	2.51	0.89 – 7.10	0.081

OR – Odds Ratio; CI – Confidence Interval; NIHSS – National Institutes of Health Stroke Scale; GCS – Glasgow Coma Scale; COPD – Chronic Obstructive Pulmonary Disease.

Discussion

In this study of 153 patients with acute stroke, pulmonary complications were observed in 26.8% of the cohort, with stroke-associated pneumonia (SAP) being the most common (19.0%), followed by mechanical ventilation requirement (13.7%) and respiratory depression (9.8%). These findings align with previously reported rates of SAP ranging from 5% to 30%, mechanical ventilation in 10–25%, and respiratory depression in 8–15% of acute stroke populations in the studies by de Montmollin et al., and Weng et al., [14,15]. The incidence in our cohort reflects the typical burden of complications in a mixed-severity Indian tertiary-care setting in the study by Arunachala et al., where delayed presentation, limited pre-hospital stabilization, and higher prevalence of risk factors such as dysphagia and COPD may contribute to increased vulnerability [16].

The relationship between patient characteristics and pulmonary complications was pronounced. Patients developing complications were significantly older (mean age 66.2 years), consistent with literature indicating that advancing age impairs airway reflexes, mucociliary clearance, and immune response, thereby increasing susceptibility to pneumonia [17,18]. However, after adjustment in the multivariable model, age ≥65 years did not remain an independent predictor, suggesting that its effect is mediated through stroke severity and impaired consciousness, a pattern also observed in studies by Chaves et al., and Bazan et al.,[19,20].

Stroke severity emerged as a key determinant of pulmonary complications. Patients with complications had significantly higher NIHSS scores (18.3 vs. 9.3; $p < 0.001$), and NIHSS remained a strong independent predictor in the multivariable model (adjusted OR 1.18 per point increase). This relationship is biologically plausible, as severe strokes impair bulbar function, reduce voluntary respiratory effort, and diminish cough effectiveness. Similar observations have been consistently reported in major studies by Drakopanagiotakis et al., and Patrizz et al., which identified NIHSS >15 as a major risk factor for SAP and acute respiratory compromise [21,22].

Impaired consciousness (GCS ≤8) had the strongest association with pulmonary complications, with nearly ninefold increased risk on multivariable analysis (OR 8.96; $p = 0.003$). Reduced consciousness compromises airway protection, increases aspiration risk, and often necessitates invasive ventilation, explaining the particularly high rate of SAP and respiratory failure in this group.

This finding parallels studies by Dündar et al., and Lyu et al., where low GCS at admission is one of the most consistent predictors of respiratory failure, early pneumonia, and mortality [23,24].

Dysphagia, present in 70.7% of patients with complications, was a robust independent predictor (OR 7.42). This is concordant with prior studies by González-Fernándezet al., and Wang et al., showing dysphagia as a major contributor to SAP, owing to impaired swallowing mechanics, aspiration of oropharyngeal secretions, and ineffective cough reflex [25,26]. The magnitude of association in our cohort is similar to that reported in the Bazan et al., Boaden et al., and Ellis et al., studies, reinforcing the critical importance of early dysphagia screening and targeted swallowing interventions in reducing pulmonary complications [20,27,28].

The higher frequency of haemorrhagic stroke (34.1% vs. 17.0%; $p = 0.014$) among those with complications is noteworthy. Although haemorrhagic stroke did not achieve statistical significance in adjusted analysis, the trend (OR 2.11) supports existing literature suggesting that intracerebral haemorrhage carries a higher risk of respiratory complications due to mass effect, brainstem pressure, and rapid neurological deterioration [29]. The trend is similar to findings from the studies by Noushad et al., and Qureshi et al., where haemorrhagic strokes were shown to have higher rates of pneumonia and ventilation requirements [30,31].

COPD was more prevalent among patients with complications (24.4% vs. 8.9%; $p = 0.007$), and although the adjusted association approached significance (OR 2.51; $p = 0.081$), this highlights the influence of pre-existing pulmonary dysfunction on post-stroke respiratory stability. Studies from Verma et al., and Cvejic et al., have reported similar associations, with COPD contributing to poor respiratory reserve, higher rates of aspiration-related events, and prolonged ventilator dependence [32,33].

The impact of pulmonary complications on patient outcomes was profound. Complication-positive patients had dramatically higher ICU admission rates (80.5% vs. 5.4%; $p < 0.001$), longer hospital stays (median 15 vs. 7 days), and significantly higher in-hospital mortality (46.3% vs. 5.4%; $p < 0.001$). These findings corroborate earlier evidence demonstrating that SAP and respiratory failure are among the strongest determinants of short-term mortality after stroke, with mortality attributable to pneumonia reported in up to one-third of stroke deaths [17,18,21]. The substantial difference in discharge disposition (51.2% vs. 87.5%) further underscores the long-term functional implications of these complications.

The timing of complications also aligns with typical pathophysiology. SAP occurred around day 3, consistent with microaspiration and early immune suppression following stroke. Respiratory depression occurred earlier (within the first 24–48 hours), often reflecting acute neurological injury, sedative exposure, or evolving cerebral edema. Mechanical ventilation peaked around day 2, predominantly in those with severe strokes, mirroring patterns described in large observational studies by Robba et al., and Zhang et al., [34,35].

Limitations

The study was conducted in a single tertiary-care center, which may limit the generalizability of the results to community hospitals or primary stroke centers. Although efforts were made to capture all relevant variables, unmeasured factors such as pre-hospital delays, aspiration volumes, and stroke lesion location may have influenced complication risk. The overlap between complications, particularly in ventilated patients, may also challenge attribution to a single cause. Finally, the observational design precludes establishing causal relationships, and longer-term outcomes beyond hospital discharge were not assessed.

Conclusion

Pulmonary complications are common after acute stroke, affecting nearly one-quarter of patients, with stroke-associated pneumonia, respiratory depression, and mechanical ventilation constituting the major contributors. These complications are strongly associated with older age, severe neurological deficit, impaired consciousness, dysphagia, hemorrhagic stroke, and underlying COPD. Importantly, their occurrence markedly worsens clinical outcomes, including increased ICU admissions, prolonged hospitalization, and substantially higher in-hospital mortality. The study highlights the need for early identification of high-risk patients, routine dysphagia screening, close respiratory monitoring, and timely supportive interventions to mitigate the burden of post-stroke pulmonary complications and improve overall outcomes.

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