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ABSTRACT

Objectives: Pneumonia is the most common medical complication after stroke. Although several risk factors have been reported, the role of common comorbidities in the development of pneumonia is not well established. Moreover, there is discrepancy in the literature regarding the impact of pneumonia on stroke outcomes.

Methods: This is a multicenter retrospective cohort study including consecutive patients with ischemic stroke admitted to Regional Stroke Centers participating in the Registry of Canadian Stroke Network in July 2003–March 2007. Pneumonia was defined as a complication that occurred within the first 30 days of the stroke and was confirmed radiographically. The main outcome measure was adjusted 30-day mortality. Secondary outcomes were adjusted 7- and 365-day mortality, institutionalization, length of stay, and modified Rankin score on discharge. We also assessed the impact of organized stroke care on pneumonia development and mortality.

Results: Overall, 8,251 patients were included in the study. Stroke-associated pneumonia was observed in 587 patients (7.1%). Pneumonia increased 30-day (odds ratio [OR] 2.2 [95% confidence interval (CI) 1.8–2.7]) and 1-year mortality (OR 3.0 [95% CI 2.5–3.7]), but not 7-day mortality. Pneumonia was associated with poor functional outcome. Higher access to organized inpatient care resulted in a reduction of 30-day mortality (OR 0.50 [95% CI 0.41–0.61]). Older age, male sex, stroke severity, dysphagia, chronic obstructive pulmonary disease, coronary artery disease, nonlacunar ischemic stroke, and preadmission dependency were independent predictors of pneumonia.

Conclusions: Development of pneumonia after stroke was associated with mortality at 30 days and 1 year, longer length of stay, and dependency at discharge. Patients who received more inpatient stroke services had reduced mortality after pneumonia. ***Neurology***® **2011;77:1338–1345**

GLOSSARY

CI = confidence interval; **CIHI** = Canadian Institute for Health Information; **COPD** = chronic obstructive pulmonary disease; **DALY** = disability-adjusted life-year; **mRS** = modified Rankin Scale; **OCI** = organized care index; **OR** = odds ratio; **RCSN** = Registry of the Canadian Stroke Network; **RR** = risk ratio; **RRR** = relative risk reduction.

Pneumonia is among the most common medical complications after stroke, with an estimated incidence ranging from 5% to 26%.[1–14] Pneumonia has been reported to increase long-term stroke mortality.[15–18] However, its effect on early mortality and functional outcome after stroke is not well established.[13–15] In addition, although stroke-induced oropharyngeal dysphagia is a relevant intermediate factor associated with the development of stroke-associated pneumonia,[19] the role of other risk factors and comorbid conditions is less well studied. A better understanding of the risk factors and early outcomes of stroke-associated pneumonia may guide the implementation of strategies in organized stroke care provision.[20]

The Registry of the Canadian Stroke Network (RCSN) is a clinical database of over 50,000 patients who have experienced an acute stroke or TIA. Since its inception in 2001, an impor-

Supplemental data at www.neurology.org

Supplemental Data

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A list of investigators of the Registry of the Canadian Stroke Network and Stroke Outcome Research Canada (SORCan) is available in appendix e-1 on the *Neurology*® Web site at www.neurology.org.

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tant goal of the RCSN has been to measure and monitor the quality of hospital stroke care delivery.[21,22]

In the present study, we used the RCSN to analyze 1) the impact of pneumonia on mortality and functional outcomes; 2) the influence of access to organized inpatient stroke care on the incident risk of pneumonia and on the outcomes of patients with pneumonia; and 3) risk factors and comorbid conditions associated with the development of stroke-associated pneumonia.

METHODS

Study design and data source. The RCSN was used to identify patients presenting with an acute ischemic stroke to designated stroke centers in Ontario (n = 11).

We identified consecutive patients over 18 years of age who were admitted to the hospital within 72 hours of onset of ischemic stroke between July 2003 and March 2007. Pneumonia that occurred during the index hospitalization was captured in the RCSN database. In order to capture pneumonia that occurred after hospital discharge, but within 30 days of the index stroke event, we linked the RCSN database to administrative databases maintained by the Canadian Institute for Health Information (CIHI). Using International Classification of Diseases–10 codes J12–18, we identified pneumonia hospitalizations from the CIHI Discharge Abstract Database and emergency department visits from the National Ambulatory Care Recording System. These databases were also linked with the Registered Persons Database, which contains demographic information and vital status. This approach allows a comprehensive capture of postdischarge mortality avoiding confounding by issues (i.e., length of stay) usually affecting other hospital cohort studies. Stroke severity was assessed on admission using the validated Canadian Neurological Scale[23,24]; higher scores in this scale indicate lower severity. Stroke severity was categorized as mild (Canadian Neurological Scale ≥8), moderate (Canadian Neurological Scale 4–7), or severe (Canadian Neurological Scale ≤4).

Standard protocol approvals, registrations, and patient consents. The protocol was approved by the Research Ethics Board of St. Michael's Hospital, Toronto. Patients' informed consent was not obtained because the study was based on the RCSN, which is a database that collects deidentified data from all patients' medical records without obtaining consent but with appropriate confidentiality safeguards in place.[22]

Exclusion criteria. Patients were excluded if they had a final nonischemic stroke diagnosis, hemorrhagic stroke, or a TIA. For individuals with more than one stroke during the study period, only the first stroke event was included.

Stroke-associated pneumonia definition. Pneumonia was defined as a radiographically confirmed medical complication that occurred within the first 30 days after the stroke onset.

Organized stroke care. We used the organized care index (OCI) to categorize the exposure to various stroke services.[20] The OCI is a summary score which assigns one point for receipt of each of the following services: 1) occupational therapy or physiotherapy, 2) stroke team assessment, and 3) admission to a stroke unit. A score of zero indicates that stroke patients received none of these services, and higher scores indicate access to more services. Further details on the construction of the OCI are provided elsewhere.[20] A stroke team was defined as a multidisciplinary group of stroke specialists including physicians, nurses, occupational therapists, physiotherapists, and speech language pathologists. Assessment by any of these allied health professionals was recorded in the RCSN as a visit at any point during the hospitalization.

Outcome measures. The main outcome measure was all-cause mortality at 30 days poststroke. Secondary outcome measures were mortality at 7 and 365 days, length of stay, modified Rankin Scale scores (mRS)[25,26] at discharge, and discharge destination. We also compared pneumonia incidence rates between stroke patients admitted on weekends (from Friday midnight to Monday morning) and weekdays.

Variables associated with development of pneumonia. In the present analysis, we assessed the influence of the following variables on stroke-associated pneumonia development: age, sex, Canadian Neurological Scale score, ischemic stroke subtype (lacunar vs nonlacunar stroke, anterior vs posterior circulation), hypertension, atrial fibrillation, coronary artery disease, dysphagia, chronic obstructive pulmonary disease (COPD), cancer, dementia, preadmission dependency, and diabetes. We also estimated impact of OCI and stroke unit admission on pneumonia development poststroke.

Statistical analysis. The pneumonia and non-pneumonia groups were compared on demographic and clinical variables. Frequency counts for categorical variables and mean (SD) and median for continuous variables were computed. χ^2 Test of independence for categorical variables and the one-way analysis of variance test for continuous variables were carried out to compare the pneumonia and non-pneumonia groups on the variables of interest. Variables that were significant in the bivariate analyses or thought to be independent predictors of pneumonia were included in the multivariate logistic model for predicting pneumonia to determine covariates that were independently associated with pneumonia development. Adjustment was made for age, sex, stroke severity (Canadian Neurological Scale score), ischemic stroke subtype, angina/coronary artery disease, dysphagia, COPD, preexistent dependency, hypertension, atrial fibrillation, cancer, preexisting dementia, and diabetes.

The 7-, 30-, and 365-day adjusted mortality rates for the SAP and non-SAP were computed to see the effect of developing pneumonia on stroke mortality. The adjusted mortality rates are calculated as the crude rate for the group (i.e., mortality rate in the pneumonia group) divided by the predicted mortality rate for the group multiplied by the overall mortality rate; the predicted mortality rate was derived from fitting a logistic model for mortality adjusting for age, sex, Canadian Neurological Scale score, and Charlson index.[27,28] Survival curves for 7-, 30-, and 365-day mortality were derived from Cox proportional hazards models. Survival at 30 days stratified by OCI for pneumonia and non-pneumonia groups was represented by Kaplan-Meier curves. Secondary outcomes (mRS score on discharge, mean length of stay, and discharge destination) were also adjusted by the above-mentioned variables.

RESULTS

Overall, there were 8,582 patients who met the study inclusion criteria. A total of 331 (3.9%) were excluded for not having a valid unique identifier, leaving 8,251 patients with acute ischemic

stroke for the analysis. Pneumonia within the first 30 days after stroke was identified in 587 patients (7.1%). The great majority of stroke-associated pneumonia occurred during the hospitalization (571/587, 97.3%), whereas the remaining 16 cases developed pneumonia after hospital discharge (2.7%). Table 1 represents baseline characteristics in patients with and without pneumonia. Patients in the pneumonia group were on average about 6 years older, were more likely to be dependent prior to admission, and had more severe strokes. There was a small but significant male predominance in the pneumonia group. There was no significant difference in pneumonia development between the patients with anterior vs posterior circulation stroke. The rate of previous stroke or TIA was slightly higher in the pneumonia group (39.7% vs 31.9%). Seventy-two patients (12.3%) in the pneumonia group were admitted from a long-term care facility, compared to 419 (5.5%) patients in the non-pneumonia group. Patients with pneumonia were more likely to receive palliative care (table 1).

Main outcome measures. Overall, 1,024/8,251 (12.4%) stroke patients died during hospital stay. Crude mortality was higher among patients with pneumonia (232/587 [39.5%]) compared to patients who did not develop pneumonia (792/7,664 [10.3%]). The effect of stroke-associated pneumonia on stroke mortality is summarized in table 2. After adjustment for age, gender, Canadian Neurological Scale score, and Charlson index, 7-day mortality was similar in those with and without pneumonia, whereas mortality at 30 and 365 days was significantly higher in the pneumonia group. Survival curves for 30- and 365-day stroke fatality in SAP and non-SAP patients are represented in figure e-1 on the *Neurology*® Web site at www.neurology.org.

Secondary outcome measures. Table 3 shows the secondary outcome measures between those with and without pneumonia adjusted by age, gender, Canadian Neurological Scale score, and Charlson index. Pneumonia was associated with a longer in-hospital stay. Mean length of stay was 20.8 days (95% confidence interval [CI] 20.5–21.1) in the pneumonia group compared to 13.3 days (95% CI 13.3–13.4) in the non-pneumonia group ($p < 0.001$). Patients with stroke-associated pneumonia had a worse functional outcome compared to a non-pneumonia group. After adjusting for covariates, only 12.3% (95% CI 7.0%–17.7%) of pneumonia patients were independent at hospital discharge (mRS <3) compared to 38.2% (95% CI 37.3%–39.1%) of patients without pneumonia. However, the proportion of patients discharged to a long-term care facility did not differ significantly among patients with and without pneumonia (10.5% vs 9.9%; $p = 0.27$ after adjustment for confounders).

There was no difference in the incident risk of pneumonia between patients admitted on weekends compared to those admitted on weekdays (7.2% vs 7.1%; odds ratio [OR] 0.99 [95% CI 0.82–1.19]).

Arrival from a long-term care facility was associated with increased risk of developing stroke-associated pneumonia (OR 2.4 [95%CI 1.9–3.2]).

Impact of organized stroke care. There was no significant difference in access to organized stroke care between patients with and without pneumonia.

Neither admission to a stroke unit (risk ratio [RR] 0.91 [95% CI 0.87–1.07], relative risk reduction [RRR] 9.0%) nor higher levels of organized stroke care (RR 0.89 [95% CI 0.74–1.07], RRR 10.8%) were associated with lower pneumonia incidence. However, increased use of stroke care services in hospital was associated with lower mortality after stroke-associated pneumonia (table 4). Figure e-2 represents the differences in 30-day mortality in pneumonia and non- pneumonia patients receiving different levels of organized stroke care.

Predictors of stroke-associated pneumonia. In the multivariable analysis, older age, dysphagia, male gender, stroke severity, preadmission dependency, coronary artery disease, and COPD were factors associated with pneumonia (table 5). Stroke severity was the factor with the strongest association (OR 4.17 [95% CI 3.23–5.26], $p < 0.001$ for Canadian Neurological Scale <4 [severe] vs Canadian Neurological Scale >7 [mild]). Hypertension, atrial fibrillation, cancer, preexisting dementia, and diabetes were not associated with the development of pneumonia in the first 30 days after stroke.

Patients with lacunar strokes were less likely to develop pneumonia (OR 0.59 [95% CI 0.42–0.82], $p = 0.0018$) than patients with other stroke types.

DISCUSSION In this large cohort study we report the incident risk of pneumonia within 30 days of stroke, its predisposing factors, and the impact of pneumonia on a variety of clinical outcomes. Pneumonia was found in 7.1% of patients presenting with an acute ischemic stroke, and was associated with lower early and long-term survival, longer hospitalization, and higher disability at discharge. Stroke severity was a factor with the most robust association with pneumonia development; other factors associated with poststroke pneumonia were age, male gender, dysphagia, stroke subtype, preexistent dependency, and comorbid conditions (COPD, coronary artery disease).

Table 1 Clinical characteristics of patients with and without pneumonia

	Total (n = 8,251) (%)	Pneumonia group (n = 587) (%)	Non-pneumonia group (n = 7,664) (%)	*p* Value
Age, y, mean ± SD	72.2 ± 13.9	77.4 ± 12.0	71.81 ± 14.0	0.01
Age group				
≤59	1,401 (17.0)	49 (8.3)	1,352 (17.6)	0.01
60–69	1,426 (17.3)	58 (9.9)	1,368 (17.8)	
70–79	2,430 (29.5)	173 (29.5)	2,257 (29.4)	
≥80	2,994 (36.3)	307 (52.3)	2,687 (35.1)	
Male sex	4,264 (51.7)	339 (57.8)	3,925 (51.2)	0.002
Ischemic stroke subtype				
Lacunar stroke	1,313 (15.9)	42 (7.2)	1,269 (16.6)	<0.001
Nonlacunar stroke	6,940 (84.1)	545 (92.8)	6,695 (83.4)	
Posterior circulation	1,914 (23.2)	118 (20.1)	1,796 (23.4)	0.065
Anterior circulation	6,337 (76.8)	469 (79.9)	5,868 (76.6)	
Stroke severity: Canadian Neurological Scale score				
Mean Canadian Neurological Scale score ± SD	7.7 ± 3.1	5.5 ± 3.1	7.9 ± 3.0	<0.001
Mild (Canadian Neurological Scale score ≥8)	4,943 (59.9)	172 (29.3)	4,771 (62.3)	<0.001
Moderate (Canadian Neurological Scale score 5–7)	2,009 (24.3)	207 (35.3)	1,802 (23.5)	
Severe (Canadian Neurological Scale score ≤4)	1,135 (13.8)	192 (32.7)	943 (12.3)	
Missing	164 (2.0)	16 (2.7)	148 (1.9)	
Charlson index				
Mean Charlson index ± SD	1.6 ± 2.2	2.3 ± 2.4	1.6 ± 2.1	<0.001
Charlson index 0–1	5,344 (64.8)	284 (48.4)	5,060 (66.0)	<0.001
Charlson index 2	1,857 (22.5)	181 (30.8)	1,676 (21.9)	
Charlson index >3	1,050 (12.7)	122 (20.8)	928 (12.1)	
Vascular risk factors				
Hypertension	5,589 (67.7)	428 (72.9)	5,161 (67.3)	0.005
Hyperlipidemia	2,728 (33.1)	187 (31.9)	2,541 (33.2)	0.52
Diabetes	2,061 (25.0)	157 (26.7)	1,904 (24.8)	0.31
Atrial fibrillation	1,465 (17.8)	154 (26.2)	1,311 (17.1)	<0.001
Smoking	1,580 (19.1)	87 (14.8)	1,493 (19.5)	0.006
Angina/CAD/MI	1,775 (21.5)	186 (31.7)	1,589 (20.7)	<0.001
History of previous stroke or TIA	2,675 (32.4)	233 (39.7)	2,442 (31.9)	<0.001
Other coexistent conditions				
Dysphagia	829 (10.0)	119 (20.3)	710 (9.3)	<0.001
Preexistent COPD	1,011 (12.3)	107 (18.2)	904 (11.8)	<0.001
Preexistent dementia	773 (9.4)	91 (15.5)	682 (8.9)	<0.001
Preexistent dependency	1684 (20.4)	205 (34.9)	1,479 (19.3)	<0.001
Cancer	768 (9.3)	77 (13.1)	691 (9.0)	<0.001
Stroke care				
tPA treatment	1,259 (15.3)	125 (21.3)	1,134 (14.8)	<0.001
Stroke unit admission	5,311 (64.4)	362 (62.2)	4,946 (64.5)	0.25
Organized Care Index				
Low (0–1)	1,722 (20.8)	134 (22.8)	1,588 (20.7)	0.23
High (2–3)	6,529 (79.2)	453 (77.1)	6,076 (79.3)	
Patients received palliative care	966 (11.7)	192 (32.7)	774 (10.1)	<0.001

—*Continued*

Table 1 Continued

	Total (n = 8,251) (%)	Pneumonia group (n = 587) (%)	Non-pneumonia group (n = 7,664) (%)	p Value
Arrived at emergency room from				
Home	6,889 (83.5)	455 (77.5)	6,434 (84.0)	
Nursing home/LTC	491 (6.0)	72 (12.3)	419 (5.5)	
Retirement home	110 (1.3)	13 (2.2)	97 (1.2)	
Other	732 (8.9)	43 (7.3)	689 (9.0)	
Undetermined	29 (0.4)	4 (0.7)	25 (0.3)	

Abbreviations: CAD = coronary artery disease; COPD = chronic obstructive pulmonary disease; LTC = long-term care facility; MI = myocardial infarction; OCI = organized care index; tPA = tissue plasminogen activator.

Our results are consistent with other studies that found similar predisposing factors.[3,6,13] Previous studies, however, either did not specify the time frame for pneumonia development or only took into account pneumonia that developed early, within 3 to 7 days after stroke,[2,3,6,7,13,17] and only captured pneumonia occurring during the index stroke admission.[5,8–11,16,18] In the present analysis, pneumonia was associated with 30-day and 1-year mortality, but not with 7-day mortality, after adjusting for age, gender, stroke severity, and comorbidities. Several previous studies found that pneumonia was associated with mortality during hospital stay (OR 1.9–3)[2,5,15,17] and at 1 year (OR 2.2–3.8).[2,15] However, one large study found no association between pneumonia and stroke mortality at discharge after adjusting for multiple covariates ($p = 0.78$).[13] Other studies also have found no association between pneumonia and early (7-day) stroke mortality.[14,15] This is likely explained by the overwhelming impact of other risk factors such as age and stroke severity on early mortality.

We found that patients with stroke-associated pneumonia were less likely to have a favorable functional outcome on discharge and to be discharged home, but were as likely to be discharged to a long-term care facility as patients without pneumonia. The impact of pneumonia on poststroke functional status has been reported in a number of previous studies, but the results are not consistent.[2,6,8,13,14,17]

Our study also evaluated the association between organized stroke care and the incidence and outcomes of stroke-associated pneumonia. We found that the incidence of pneumonia was similar in patients receiving different levels of inpatient stroke care. This might be explained by nonmodifiable nature of the factors predisposing to stroke-associated pneumonia development. However, the 30-day mortality of patients with pneumonia receiving higher (OCI 2–3) levels of organized stroke care was half of that seen in patients with pneumonia who received lower (OCI 0–1) levels of organized stroke care. Moreover, the association between stroke unit admission and decreased pneumonia mortality at 30 days poststroke was approaching statistical significance. This might be related to earlier detection and treatment of pneumonia.

We also found that pneumonia was associated with older age, stroke severity, male gender, coronary artery disease, dysphagia, chronic obstructive lung disease, and preadmission dependency in the multivariable analysis. Stroke severity was the factor with the strongest association with post stroke pneumonia (OR 4.17 for Canadian Neurological Scale score ≤4), a finding that is consistent with prior studies assessing this issue.[3,6,7,13,14] Older age was the second most strongly associated risk factor for stroke-associated pneumonia (OR 2.14 for age >80), which is also consistent with the results reported by other

Table 2 Early and long-term mortality in patients with and without pneumonia

	Total (n = 8,251)	Pneumonia group (n = 587)		Non-pneumonia group (n = 7,664)		Risk of death in patients with and without pneumonia	
	Overall mortality, %	Crude mortality, %	Adjusted mortality, % (95% CI)[a]	Crude mortality, %	Adjusted mortality, % (95% CI)[a]	Adjusted mortality, OR (95% CI)[a]	p Value
7-day mortality	6.9	14.5	7.6 (6.2–8.9)	6.35	7.2 (6.6–7.7)	1.1 (0.8–1.5)	0.47
30-day mortality	13.6	37.3	19.9 (18.2–21.6)	11.82	13.3 (12.6–14.0)	2.2 (1.8–2.7)	<0.0001
365-day mortality	24.5	60.1	36.5 (34.4–38.6)	21.72	23.9 (23.0–24.8)	3.0 (2.5–3.7)	<0.0001

Abbreviations: CI = confidence interval; OR = odds ratio.
[a] Adjusted for age, gender, stroke severity (Canadian Neurological Scale), and Charlson index.

Table 3 Secondary outcome measures in patients with and without pneumonia (adjusted and unadjusted)

Secondary outcomes	Total (n = 8,251), %	Pneumonia group (n = 587)		Non-pneumonia group (n = 7,664)		Comparative risk, OR (95% CI)	p Value
		Crude rate, %	Adjusted rate, % (95% CI)[a]	Crude rate, %	Adjusted rate, % (95% CI)[a]		
mRS on discharge <3	36.6	6.5	12.3 (7.0-17.7)	38.5	38.2 (37.3-39.1)	0.2 (0.14-0.29)	0.001
Disposition home	38.2	10.2	17.8 (12.6-23.0)	40.3	39.7 (38.7-40.7)	0.3 (0.22-0.4)	0.001
Disposition to long-term care	9.6	16.4	10.5 (9.0-12.1)	9.1	9.9 (9.3-10.5)	1.17 (0.89-1.55)	0.27
Mean length of hospital stay	13.86	24.2	20.8 (20.5-21.1)	13.1	13.3 (13.3-13.4)	1.91 (1.04-1.95)	0.001

Abbreviations: CI = confidence interval; LTC = long-term care facility; mRS = modified Rankin score; OR = odds ratio.
[a] Adjusted for age, gender, stroke severity (Canadian Neurological Scale), and Charlson index. Disposition to LTC and mean length of stay are also adjusted for place of arrival.

groups.[3,6,8,13,17] Male sex, coronary artery disease, dysphagia, COPD, preexistent dependency, and dysphagia were also associated with pneumonia, although with a lower magnitude of effect (OR <2). Previous studies have suggested that dysphagia may be more strongly associated with pneumonia.[4,7,20] Lacunar stroke was associated with decreased likelihood of pneumonia development compared to other ischemic stroke subtypes. Some studies have reported diabetes,[6] atrial fibrillation, and congestive heart failure[8] as risk factors of pneumonia development in stroke patients, but we did not find a significant association between pneumonia and these variables.

Our study suggests that poststroke pneumonia may not necessarily be a preventable event as the variables associated with pneumonia are not modifiable. Health care determinants (OCI, stroke unit admission) did not predict the occurrence of pneumonia, however, were associated with decreased pneumonia patients' mortality.

Strengths and limitations. Our study is one of the largest of consecutive stroke patients with both detailed clinical information and multiple clinical outcome variables available. The large sample size and multicentric nature of the study potentially overcomes many of the weaknesses described below.

First, only patients admitted to stroke care centers in Ontario were included in this study, and these centers may not be representative of other types of facilities across the province or country. However, we found similar results when using a dataset including patients admitted to community hospitals (data not shown). Other limitations are related to a retrospective design of our study. Thus, as we were not able to determine the precise date of the diagnosis of pneumonia, it is possible that some assessments (e.g., stroke unit admission, organized care, palliative care) may have taken place after this complication had occurred. This may explain the lack of benefit on the incident risk of pneumonia for patients receiving organized inpatient stroke care. Moreover, patients with pneumonia managed as outpatients in doctors' offices would not have been captured. Also, the study did not take into account the results of swallowing assessments; rather, dysphagia was determined from the RCSN as a symptom on initial presentation. In addition, although the RCSN contains detailed clinical information, we cannot rule out the possibility of unmeasured confounders. Finally, we have no reliable information on the cause of death (stroke-related or due to unrelated medical problems).

The incremental costs of poststroke pneumonia have been estimated at $14,800 to $27,300.[29,30] Given 700,000 annual stroke admissions in the United States and considering a more conservative incidence of stroke-associated pneumonia of 6%, the annual cost of pneumonia as a complication after acute stroke would be approximately $621 million.[29] Some health insurance providers may deny coverage for the extra costs of serious preventable events. The development of pneumonia has also been associated with a deprivation of additional healthy life measured in disability-adjusted life-years (DALY) lost. A recent study showed that stroke-associated pneumonia may be associated with DALY lost of 4.81 (95% CI 4.33–5.29) after the application of age-weighting and future discount rate.[31] A more pronounced DALY impact was observed in the adjusted analysis

Table 4 Effect of stroke unit admission and OCI on 30-day mortality for patients with stroke-associated pneumonia (n = 587)

	No.	30-day mortality, %	RR (95% CI)	RRR, %	ARR, %	NNT
Stroke unit admission	365	35.1	0.86 (0.69-1.06)	14.5	5.92	17
No stroke unit admission	222	41.0				
OCI high (2-3)	453	30.5	0.5 (0.41-0.61)	49.6	30.0	3
OCI low (0-1)	134	60.5				

Abbreviations: ARR = absolute risk reduction; NNT = number needed to treat; OCI = organized care index; RR = risk ratio; RRR = relative risk reduction.

Table 5 Multivariable analysis including factors associated with an increased risk of stroke-associated pneumonia[a]

Factor	OR estimate	95% CI	*p* Value
Age (70–79 vs ≤69)	1.60	1.23–2.08	0.0004
Age (≥80 vs ≤69)	2.14	1.66–2.75	<0.0001
Male vs female	1.88	1.56–2.27	<0.0001
Canadian Neurological Scale score (severe vs moderate)[b]	1.52	1.20–1.89	<0.0003
Canadian Neurological Scale score (severe vs mild)[b]	4.17	3.23–5.26	<0.0001
Nonlacunar vs lacunar stroke	1.69	1.22–2.38	0.0018
Angina/CAD	1.45	1.19–1.77	0.0002
Dysphagia	1.89	1.49–2.38	<0.0001
COPD	1.36	1.08–1.73	0.01
Preexistent dependency	1.6	1.29–1.98	<0.0001

Abbreviations: CAD = coronary artery disease; CI = confidence interval; COPD = chronic obstructive pulmonary disease; OR = odds ratio.
[a] Multivariable analysis adjusted for age, gender, stroke severity (Canadian Neurological Scale score), ischemic stroke subtype, angina/CAD, dysphagia, COPD, preexistent dependency, hypertension, atrial fibrillation, cancer, preexisting dementia, and diabetes. Only significant variables are shown in the table. *C*-statistics 0.751.
[b] Mild stroke >8, moderate 5–7, severe ≤4.[23]

when both age-weighting and future discount rate were not applied (12.09 [95% CI 11.34–12.85]).[31]

Our study clearly shows that some factors associated with pneumonia may not be attributable to the processes of care, but rather directly related to nonmodifiable factors such as age, stroke severity, stroke subtype, and preexisting comorbid conditions.

The results of the present study may provide useful information for patients, their families, clinicians, health insurance organizations, and policymakers to better understand factors associated with the development of pneumonia and clinical outcomes.

AUTHOR CONTRIBUTIONS

Dr. Finlayson contributed to design of the study and drafting the manuscript. Dr. Kapral contributed to conceptualization of the study, interpretation of the data, and revising the manuscript. Dr. Hall contributed to conceptualization of the study, interpretation of the data, and revising the manuscript. E. Asllani conducted statistical analysis. Dr. Selchen participated in design and conceptualization of the study. Dr. Saposnik participated in the design and conceptualization of the study, analysis and interpretation of the data, drafting and revising the manuscript.

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Neurology

Historical Abstract: July 1, 1986

REPETITIVE INTRAVENOUS DIHYDROERGOTAMINE AS THERAPY FOR INTRACTABLE MIGRAINE

Neil H. Raskin

***Neurology* 1986;36:995–997**

For patients with chronic intractable headache, we compared a new treatment and a traditional one. Fifty-five patients (36 dependent on ergotamine, analgesics, diazepam, or corticosteroids) were given IV dihydroergotamine (DHE) and metoclopramide every 8 hours. Fifty-four age- and sex-matched patients (38 drug-dependent) were given diazepam intravenously every 8 hours. Forty-nine of the 55 DHE-treated patients became headache-free within 48 hours, and 39 of them sustained benefits in a mean follow-up of 16 months. In contrast, 7 diazepam-treated patients became free of headache within 3 to 6 days, and 31 had improved somewhat in 10 days. Repetitive IV DHE helps to terminate cycles of intractable migraine.

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Comment from Robert A. Gross, MD, PhD, FAAN, Editor-in-Chief: *A study examining a treatment for intractable migraine, still in use.*