

Supplementary Material 1

Low estimated glomerular filtration rate and pneumonia in stroke patients:

Findings from a prospective stroke registry in the East of England

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Supplemental Table 1: Characteristics of sample population by level of estimated glomerular filtration rate (eGFR)

Characteristics	Level of eGFR (mL/min/1.73m ²)					
	≥90 (n=1,106)	60-89 (4,866)	45-59 (2,177)	30-44 (1,427)	15-29 (n=596)	<15 (n=157)
Age (years)	59.7 ± 12.8	77.1 ± 10.4	81.8 ± 8.9	84.2 ± 7.9	83.8 ± 8.5	78.5 ± 12.1
Sex (male)	62.8 (731)	48.9 (2,425)	42.6 (938)	38.5 (556)	40.8 (247)	50.3 (79)
Stroke history*, % (n)	16.3 (173)	23.2 (1,100)	26.8 (572)	28.2 (394)	33.4 (196)	26.5 (39)
Stroke type (Ischemic), % (n)	80.4 (889)	84.9 (4,135)	88.3 (1,923)	90.7 (1,294)	93.3 (556)	92.4 (145)
OSCP classification*						
- TACS	14.5 (149)	19.7 (895)	22.8 (470)	23.8 (322)	27.5 (157)	23.8 (35)
- PACS	29.1 (299)	33.1 (1,503)	34.9 (720)	35.3 (478)	31.2 (178)	25.2 (37)
- LACS	24.7 (253)	23.6 (1,072)	21.9 (452)	20.9 (284)	18.3 (104)	15.7 (23)
- POCS	24.3 (249)	17.6 (799)	14.3 (294)	13.4 (181)	14.4 (82)	16.3 (24)
- Other	7.3 (76)	5.9 (269)	6.1 (127)	6.5 (89)	8.5 (49)	19.1 (28)
Pre-stroke mRS*						
- 0	76.7 (779)	67.8 (3,121)	60.7 (1,236)	51.9 (677)	42.1 (230)	39.7 (50)
- 1	9.9 (103)	12.3 (566)	11.2 (228)	12.8 (167)	15.4 (84)	15.1 (19)
- 2	5.7 (59)	7.4 (341)	8.9 (182)	10.1 (131)	12.1 (66)	11.9 (15)
- 3	4.4 (46)	7.4 (339)	11.4 (232)	14.0 (183)	17.8 (97)	16.7 (23)
- 4	2.1 (22)	3.7 (171)	4.9 (100)	8.3 (108)	10.3 (56)	7.1 (9)
- 5	1.3 (13)	1.4 (63)	2.9 (58)	2.9 (38)	2.4 (13)	9.5 (12)
Diabetes, % (n)	11.6 (128)	11.6 (564)	13.4 (291)	15.3 (218)	21.1 (126)	28.0 (44)
Hypertension, % (n)	32.0 (354)	46.2 (2,249)	48.9 (1,064)	52.6 (750)	59.4 (354)	59.9 (94)
Dyslipidemia, % (n)	11.5 (127)	9.8 (478)	8.5 (186)	7.6 (109)	8.1 (48)	9.6 (15)
Coronary heart disease, % (n)	9.5 (105)	18.7 (912)	23.3 (507)	29.4 (419)	35.2 (210)	37.6 (59)
Heart failure, % (n)	3.4 (38)	7.5 (365)	12.4 (271)	17.8 (254)	28.0 (167)	27.4 (43)
Atrial fibrillation,% (n)	8.1 (89)	22.6 (1,098)	29.2 (635)	32.4 (463)	36.1 (215)	27.4 (43)
COPD, % (n)	5.4 (60)	6.6 (321)	6.9 (150)	7.9 (113)	10.2 (61)	9.6 (15)
Asthma, % (n)	8.2 (91)	8.5 (413)	6.8 (148)	8.1 (115)	8.1 (48)	7.0 (11)
Lung cancer, % (n)	1.7 (19)	0.9 (42)	0.7 (16)	0.4 (6)	0.3 (2)	0.0 (0)
Length of stay (days)	6 (2 – 12)	7 (3 – 16)	10 (4 – 20)	11 (4 – 21)	11 (5 – 23)	8 (3 – 18)

Abbreviations: OSCP=Oxfordshire Community Stroke Project; TACS: total anterior circulation stroke; PACS: partial anterior circulation stroke; LACS: lacunar stroke; POCS: posterior circulation stroke; mRS=modified Rankin score

Continuous variables with normal distribution are presented as mean ± standard deviation and non-normal distribution are presented as median (interquartile interval); categorical variables are presented as percentages (n); *253 participants missing information on previous stroke, 631 on OSCP classification and 674 on mRS

Supplemental table 2: Results for interaction between patient's clinical characteristics and reduced eGFR for pneumonia

	Patient characteristic/reduced eGFR (0/0)	Patient characteristic/reduced eGFR (1/1)
In hospital		
	(sHR; 95% CI)	
Age	Ref. [1]	1.36 (0.61 – 3.02)
Sex	Ref. [1]	1.09 (0.89 – 1.34)
Pre-stroke mRS	Ref. [1]	0.78 (0.58 – 1.06)
Diabetes status	Ref. [1]	0.96 (0.73 – 1.26)
Stroke type	Ref. [1]	1.17 (0.85 – 1.59)
After hospital discharge*		
	(sHR; 95% CI)	
Age	Ref. [1]	0.70 (0.36 – 1.28)
Sex	Ref. [1]	0.88 (0.68 – 1.12)
Pre-stroke mRS	Ref. [1]	0.70 (0.45 – 1.09)
Diabetes status	Ref. [1]	1.27 (0.91 – 1.76)
Stroke type	Ref. [1]	1.00 (0.64 – 1.55)

Abbreviations: sHR=sub-distribution hazard, CI=confidence interval

Adjusted for: age, sex, stroke type, pre-stroke modified Rankin score, Oxfordshire Community Stroke Project (stroke severity, asthma, chronic obstructive pulmonary disease, lung cancer, diabetes, hypertension, dyslipidemia, coronary heart disease, heart failure, arterial fibrillation)

*In patients that were alive at discharge (N=8,021)

Supplemental Table 3: Association between low estimated glomerular filtration rate (and pneumonia in stroke patients) (After excluding those with top and bottom 25th percentile of the difference in estimated kidney function between admission and discharge)

	Low eGFR (<60mL/min/1.73m ²)	
	No (n=4,827)	Yes (n=3,500)
In hospital		
Overall	(sHR; 95% CI)	
Events, % (n)	11.9 (576)	17.6 (615)
- Model 1	Ref. [1]	1.13 (1.00 – 1.26)
- Model 2	Ref. [1]	1.09 (0.97 – 1.23)
- Model 3	Ref. [1]	1.09 (0.96 – 1.23)
- Model 4	Ref. [1]	1.06 (0.94 – 1.20)
Aspiration	(sHR; 95% CI)	
Events, % (n)	7.0 (340)	10.9 (381)
- Model 1	Ref. [1]	1.17 (1.01 – 1.37)
- Model 2	Ref. [1]	1.15 (0.98 – 1.34)
- Model 3	Ref. [1]	1.15 (0.98 – 1.34)
- Model 4	Ref. [1]	1.12 (0.96 – 1.31)
Non-aspiration	(sHR; 95% CI)	
Events, % (n)	4.9 (236)	6.7 (234)
- Model 1	Ref. [1]	1.05 (0.87 – 1.27)
- Model 2	Ref. [1]	1.01 (0.84 – 1.23)
- Model 3	Ref. [1]	1.01 (0.83 – 1.22)
- Model 4	Ref. [1]	0.97 (0.80 – 1.18)
After hospital discharge*		
Overall	(sHR; 95% CI)	
Events, % (n)	11.5 (493)	16.1 (371)
- Model 1	Ref. [1]	1.33 (1.16 – 1.52)
- Model 2	Ref. [1]	1.29 (1.12 – 1.48)
- Model 3	Ref. [1]	1.30 (1.13 – 1.50)
- Model 4	Ref. [1]	1.21(1.06 – 1.40)
Aspiration, % (n)	(sHR; 95% CI)	
Events	4.4 (189)	4.9 (112)
- Model 1	Ref. [1]	1.04 (0.81 – 1.32)
- Model 2	Ref. [1]	1.03 (0.81 – 1.31)
- Model 3	Ref. [1]	1.02 (0.80 – 1.30)
- Model 4	Ref. [1]	0.98 (0.77 – 1.25)
Non-aspiration, % (n)	(sHR; 95% CI)	
Events	7.1 (304)	11.3 (259)
- Model 1	Ref. [1]	1.50 (1.27 – 1.78)
- Model 2	Ref. [1]	1.44 (1.21 – 1.71)
- Model 3	Ref. [1]	1.46 (1.23 – 1.73)
- Model 4	Ref. [1]	1.35 (1.14 – 1.60)

Abbreviations: eGFR=estimated glomerular filtration rate, sHR=sub-distribution hazard ratio, CI=confidence interval

Model 1: age, sex

Model 2: Model 1 + history of stroke, stroke type, pre-stroke modified Rankin score, Oxfordshire Community Stroke Project (stroke severity)

Model 3: Model 2 + asthma, chronic obstructive pulmonary disease, lung cancer

Model 4: Model 3 + diabetes, hypertension, dyslipidemia, coronary heart disease, heart failure, arterial fibrillation

*In patients that were alive at discharge (N=6,588)

Supplemental Table 4: Association between low estimated glomerular filtration rate and pneumonia in stroke patients by calendar year of hospital admission*

In hospital	Estimated glomerular filtration rate (mL/min/1.73m ²)	
	eGFR \geq 60	eGFR<60
	(sHR; 95% CI)	
Overall		
2003-2006 (n=3,454)	Ref. [1]	0.96 (0.79 – 1.16)
2007-2010 (n=2,916)	Ref. [1]	1.18 (0.98 – 1.38)
2011-2015 (n=3,959)	Ref. [1]	1.06 (0.89 – 1.25)
Aspiration		
2003-2006	Ref. [1]	1.07 (0.84 – 1.37)
2007-2010	Ref. [1]	1.23 (0.93 – 1.51)
2011-2015	Ref. [1]	1.01 (0.81 – 1.26)
Non-aspiration		
2003-2006	Ref. [1]	0.78 (0.56 – 1.08)
2007-2010	Ref. [1]	1.37 (0.98 – 1.92)
2011-2015	Ref. [1]	1.12 (0.85 – 1.46)
After hospital discharge		
Overall		
2003-2006 (n=2,458)	Ref. [1]	1.25 (1.02 – 1.54)
2007-2010 (n=2,267)	Ref. [1]	1.37 (1.07 – 1.77)
2011-2015 (n=3,296)	Ref. [1]	1.27 (1.04 – 1.52)
Aspiration		
2003-2006	Ref. [1]	0.93 (0.65 – 1.34)
2007-2010	Ref. [1]	0.68 (0.44 – 1.05)
2011-2015	Ref. [1]	0.88 (0.58 – 1.35)
Non-aspiration		
2003-2006	Ref. [1]	1.44 (1.12 – 1.86)
2007-2010	Ref. [1]	1.34 (1.02 – 1.76)
2011-2015	Ref. [1]	1.37 (1.00 – 1.88)

*Adjusted for age, sex, history of stroke, stroke type, pre-stroke modified Rankin score, Oxfordshire Community Stroke Project (stroke severity), asthma, chronic obstructive pulmonary disease, lung cancer, diabetes, hypertension, dyslipidemia, coronary heart disease, heart failure, arterial fibrillation
sHR=sub-distribution hazard

Supplemental Table 5: Association between level of estimated glomerular filtration rate and pneumonia in new stroke patients

	Level of estimated glomerular filtration rate (mL/min/1.73m ²)					
	≥90 (n=887)	60-89 (n=3,649)	45-59 (n=1,562)	30-44 (n=1,005)	15-29 (n=391)	<15 (n=108)
In-hospital	(sHR; 95% CI)					
Events	8.7 (77)	12.3 (448)	16.7 (261)	19.7 (198)	21.7 (85)	18.5 (20)
- Model 1	Ref. [1]	0.64 (0.49 – 0.83)	0.71 (0.53 – 0.94)	0.76 (0.56 – 1.03)	0.86 (0.61 – 1.20)	0.88 (0.54 – 1.45)
- Model 2	Ref. [1]	0.69 (0.53 – 0.89)	0.74 (0.56 – 0.98)	0.80 (0.60 – 1.09)	0.79 (0.56 – 1.10)	0.78 (0.47 – 1.29)
- Model 3	Ref. [1]	0.70 (0.54 – 0.91)	0.75 (0.56 – 0.99)	0.84 (0.62 – 1.13)	0.85 (0.60 – 1.19)	0.92 (0.57 – 1.50)
- Model 4	Ref. [1]	0.70 (0.54 – 0.91)	0.73 (0.55 – 0.98)	0.81 (0.60 – 1.10)	0.80 (0.57 – 1.13)	0.89 (0.54 – 1.45)
After discharge*	(sHR; 95% CI)					
- Events	7.5 (82)	12.3 (507)	14.7 (227)	16.4 (150)	21.3 (60)	17.7 (11)
- Model 1	Ref. [1]	1.39 (0.93 – 2.09)	1.68 (1.07 – 2.63)	2.06 (1.28 – 3.31)	2.15 (1.17 – 3.95)	4.50 (1.89 – 10.7)
- Model 2	Ref. [1]	1.35 (0.90 – 2.02)	1.60 (1.02 – 2.52)	1.95 (1.21 – 3.15)	2.04 (1.11 – 3.76)	4.33 (1.82 – 10.3)
- Model 3	Ref. [1]	1.32 (0.88 – 2.00)	1.61 (1.02 – 2.53)	1.92 (1.19 – 3.10)	1.99 (1.07 – 3.67)	4.40 (1.84 – 10.5)
- Model 4	Ref. [1]	1.32 (0.87 – 1.98)	1.56 (0.99 – 2.46)	1.84 (1.14 – 2.98)	1.87 (1.00 – 3.45)	4.07 (1.70 – 9.75)

Abbreviations: sHR=sub-distribution hazard CI=confidence interval

Model 1: age, sex

Model 2: Model 1 + stroke type, pre-stroke modified Rankin score, Oxfordshire Community Stroke Project (stroke severity)

Model 3: Model 2 + asthma, chronic obstructive pulmonary disease, lung cancer

Model 4: Model 3 + diabetes, hypertension, dyslipidemia, coronary heart disease, heart failure, arterial fibrillation

*In patients that were alive at discharge (N=6,003)

Supplemental Table 7: Association between pneumonia and mortality in stroke patients

In hospital	No	yes
Overall	(OR; 95% CI)	
Events, % (n)	47.2 (4,157)	81.2 (1233)
- Model 1	Ref. [1]	2.28 (1.07 – 2.52)
- Model 2	Ref. [1]	1.98 (1.79 – 2.19)
- Model 3	Ref. [1]	1.98 (1.79 – 2.19)
- Model 4	Ref. [1]	1.93 (1.74 – 2.14)
After hospital discharge*	No	Yes
Overall	(OR; 95% CI)	
Events, % (n)	35.5 (2,479)	58.1 (603)
- Model 1	Ref. [1]	1.43 (1.32 – 1.55)
- Model 2	Ref. [1]	1.42 (1.31 – 1.54)
- Model 3	Ref. [1]	1.42 (1.31 – 1.54)
- Model 4	Ref. [1]	1.41 (1.30 – 1.53)

Abbreviations: OR=odds ratio, CI=confidence interval

Model 1: age, sex, estimated glomerular filtration rate

Model 2: Model 1 + stroke type, pre-stroke modified Rankin score, Oxfordshire Community Stroke Project (stroke severity)

Model 3: Model 2 + asthma, chronic obstructive pulmonary disease, lung cancer

Model 4: Model 3 + diabetes, hypertension, dyslipidemia, coronary heart disease, heart failure, arterial fibrillation

*In patients that were alive at discharge (N=8,021)

Supplemental Table 8: Association between pneumonia and disability at discharge (using mRS score) in stroke patients*

In hospital	No	yes
Overall	(OR; 95% CI)	
- Model 1	Ref. [1]	2.89 (2.57 – 3.22)
- Model 2	Ref. [1]	2.62 (2.32 – 2.96)
- Model 3	Ref. [1]	2.63 (2.33 – 2.97)
- Model 4	Ref. [1]	2.57 (2.27 – 2.90)

Abbreviations: OR=odds ratio, CI=confidence interval

Model 1: age, sex, estimated glomerular filtration rate

Model 2: Model 1 + stroke type, pre-stroke modified Rankin score, Oxfordshire Community Stroke Project (stroke severity)

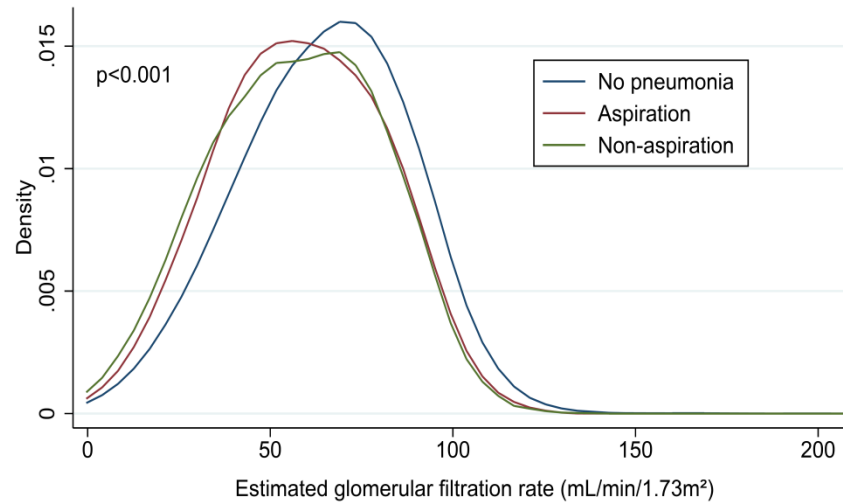
Model 3: Model 2 + asthma, chronic obstructive pulmonary disease, lung cancer

Model 4: Model 3 + diabetes, hypertension, dyslipidemia, coronary heart disease, heart failure, arterial fibrillation

***Association was only examined for in hospital pneumonia because disability information was only available at discharge**

Supplemental Figure 1: Kernel-Density plot of estimated glomerular filtration rate by pneumonia status

A) By in-hospital pneumonia



B) By pneumonia After hospital discharge

