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1 The association between delays in screening for and assessing dysphagia after
2 acute stroke and the risk of stroke-associated pneumonia

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3

4

1 Abstract

2 Background

3 There is no robust evidence that screening patients with acute stroke for dysphagia reduces the risk
4 of stroke-associated pneumonia (SAP), or of how quickly it should be done after admission. We
5 aimed to identify if delays in bedside dysphagia screening and comprehensive dysphagia
6 assessments by a speech and language therapist (SALT) were associated with patients' risk of SAP.

7 Methods

8 Nationwide registry based prospective cohort study of patients admitted with acute stroke in
9 England and Wales. Multilevel multivariable logistic regression models were fitted, adjusting for
10 patient variables and stroke severity. The exposures were time from 1) admission to bedside
11 dysphagia screen, and 2) admission to comprehensive dysphagia assessment.

12 Results

13 Of 63650 patients admitted with acute stroke, 55838 (88%) had a dysphagia screen and 24542 (39%)
14 a comprehensive dysphagia assessment. Patients with the longest delays in dysphagia screening (4th
15 quartile adjusted OR 1.14, 1.03-1.24) and SALT dysphagia assessment (4th quartile adjusted OR 2.01,
16 1.76-2.30) had a higher risk of SAP. The risk of SAP increased in a dose-response manner with
17 delays in SALT dysphagia assessment, with an absolute increase of pneumonia incidence of 1% per
18 day of delay.

19 Conclusion

20 Delays in screening for and assessing dysphagia after stroke, are associated with higher risk of
21 stroke-associated pneumonia. Since stroke-associated pneumonia is one of the main causes of
22 mortality after acute stroke, early dysphagia assessment may contribute to preventing deaths from

- 1 acute stroke and could be implemented even in settings without access to high technology specialist
- 2 stroke care.

3

1 Introduction

2 Stroke-associated pneumonia (SAP) is a common complication of acute stroke, affecting 6-10% of
3 patients¹. SAP independently increases the risk of mortality and is one of the main causes of death
4 in the first few days and weeks after stroke². It is also associated with worse functional outcomes,
5 longer length of stay and increased healthcare costs^{3,4,5,6,7,8}. One of the main risk factors for SAP is
6 dysphagia, which affects 37-55% of patients⁹ after stroke. Dysphagia screening using a brief bedside
7 screening tool (such as a water swallow test), and comprehensive clinical assessments of aspiration
8 risk by speech and language therapists (SALT), are therefore performed commonly in stroke care.
9 Typically, all appropriate patients are screened for dysphagia and those in whom dysphagia is
10 suspected go on to receive a comprehensive assessment. Despite being well established in clinical
11 practice, there is however very little evidence of effectiveness for these interventions. Previous
12 studies have generally used weak designs and provided no information to guide recommendations
13 on how quickly dysphagia assessments after stroke should occur^{10,11}. Swallowing assessment prior to
14 eating and drinking is recommended in European¹², United States¹³ and United Kingdom clinical
15 guidelines but none recommend a specific approach to assessment or treatment of dysphagia.

16 As SAP develops most frequently within the first 7 days of stroke¹, the timing of both dysphagia
17 screening and SALT assessment after admission are likely to be of importance. In England and Wales,
18 dysphagia screening is recommended within 4 h of admission for acute stroke, and comprehensive
19 assessment by a SALT (if required) within 72 h of admission¹⁴. The aim of this study was to
20 investigate the association between delays in dysphagia screening and SALT assessment and the
21 incidence SAP within the first 7 days after admission. The hypothesis was that delays in these
22 assessments would be associated with an increased incidence of SAP.

23

24

1 Methods

2 Data were from the Sentinel Stroke National Audit Programme (SSNAP), the national register of
3 stroke in England and Wales, of patients aged ≥ 16 years admitted with acute stroke (ischaemic
4 stroke or primary intracerebral haemorrhage) between April 2013 and March 2014. SSNAP is a
5 prospective continuous register with participation from all hospitals admitting adults with stroke in
6 England and Wales and is estimated to include 90-95% of all stroke admissions¹⁵. Ethical approval of
7 SSNAP was granted by the Ethics and Confidentiality Committee of the National Information
8 Governance Board. Mortality data were obtained through data linkage with the statutory register of
9 deaths. Data linkage was carried out by a third party and the investigators used an anonymised
10 dataset with all patient identifiers removed.

11 Dysphagia screening was defined as use of a bedside swallow screening test by an appropriately
12 trained clinician (typically a trained nurse). The exact dysphagia screening protocol was not specified
13 by SSNAP. The times from admission to documented dysphagia screen and comprehensive
14 assessment by SALT were recorded to the nearest minute for all patients in whom these were
15 carried out. For patients who had a stroke as an inpatient, the time from stroke onset was used
16 instead of time of admission. All patients without clinical exclusions (e.g. being treated palliatively
17 only) were eligible for dysphagia screening, and eligibility for comprehensive dysphagia assessment
18 was determined by clinical indications, such as a positive dysphagia screen or clinical suspicion of
19 dysphagia. Patients (n=965) admitted directly to an intensive care unit (ICU) on admission were
20 excluded from the primary analysis, since most of these patients would have been intubated.

21 SAP was defined as the administration of antibiotics for a new clinical diagnosis of pneumonia in the
22 first seven days after admission and was determined by the treating physician.

23 **Statistical analysis**

1 The adjusted odds of SAP were estimated by fitting multivariable logistic regression models. Time
2 from admission to dysphagia screen and SALT dysphagia assessment were analysed both as
3 continuous variables and by division into quartiles. When included as a continuous variable they
4 were fitted as restricted cubic regression splines using the POSTRCSPLINE module¹⁶. Spline
5 coefficients cannot be interpreted directly and so the models were displayed graphically, showing
6 the modelled association (and 95% confidence interval) between time to dysphagia screen or
7 comprehensive dysphagia assessment and estimated adjusted SAP incidence. Multilevel
8 multivariable logistic regression models were also fitted using quartiles of these times to enable
9 quantification of the study results into odds ratios and also to account for clustering at the hospital
10 level. These models were specified as two level models with hospital level random intercepts.

11 All models included age, sex, stroke subtype (ischaemic, primary intracerebral haemorrhage, or
12 undetermined), pre stroke functional level using the modified Rankin Scale (mRS), place of stroke
13 (out of hospital or inpatient), vascular comorbidity (heart failure, hypertension, atrial fibrillation,
14 diabetes mellitus, previous stroke or transient ischaemic attack) and either NIH Stroke Scale (NIHSS)
15 or level of consciousness on admission.

16 Data were complete for all data items apart from the NIHSS on admission, which was available for
17 73% of patients. Models were therefore also fitted using level of consciousness on admission as a
18 proxy for severity (available for 100% of patients) and the results of the models compared to explore
19 the effect of these missing data on the results.

20 We carried out several sensitivity analyses. Firstly, competing risk from early mortality was explored
21 by excluding patients dying or starting palliative care in the first 3 days. Secondly, models were fitted
22 including a variable indicating change (increase, no change, decrease) in the level of consciousness in
23 the first seven days after stroke, to explore the possible confounding effect of changing
24 consciousness level. Thirdly, ICU patients excluded in the main analysis were included in a complete
25 data set analysis. Fourthly, time from admission to stroke unit admission was included in the models

1 as a possible confounder. Finally, we fitted models of 30 day all cause mortality, excluding patients
2 dying or starting palliative care in the first 3 days (on the grounds that death in these latter patients
3 is more likely due directly to brain injury from the stroke rather than stroke associated pneumonia).
4 These models explored whether delays in dysphagia screening and assessment were associated with
5 mortality after stroke.

1 Results

2 There were 63650 patients with acute stroke included in the cohort, admitted to 199 hospitals. Of
3 these, 55838 (87.7%) had a dysphagia screen, and 24542 (38.6%) proceeded to a comprehensive
4 assessment. The characteristics of the whole cohort, and the subgroups of patients according to
5 receipt of dysphagia screening and comprehensive dysphagia assessment are described in Table 1.
6 Patients in whom a dysphagia screen was not performed had a greater incidence of inpatient stroke
7 and primary intracerebral haemorrhage, lower level of consciousness on admission and were less
8 likely to have NIHSS on admission completed.

9

	Cohort	Dysphagia screening not performed	Dysphagia screening performed	Comprehensive dysphagia assessment
<i>n</i> (%)	63650	7812 (12.3)	55838 (87.8)	24542 (38.6)
Median age(IQR)	77 (67-85)	80 (70-86)	77 (67-85)	80 (70-87)
Female (n, %)	32054 (50.4)	4264 (54.5)	27790 (49.8)	13160 (53.6)
Stroke type (n, %)				
Ischaemic	56167 (88.2)	5948 (76.1)	50219 (91.0)	21751 (89.6)
Primary intracerebral haemorrhage	6575 (10.3)	1592 (20.4)	4983 (8.9)	2523 (10.4)
Undetermined	908 (1.4)	272 (3.5)	636 (1.1)	268 (1.1)
Inpatient stroke (n, %)	3155 (5.0)	974 (12.5)	2181 (3.9)	1599 (6.5)
Pre-Stroke mRS (n,%)				
0	36208 (57.9)	3808 (48.8)	32400 (58.0)	12174 (49.6)
1	9726 (15.3)	1109 (14.2)	8617 (15.4)	3919 (16.0)
2	6036 (9.5)	851 (10.9)	5185 (9.3)	2614 (10.7)
3	6708 (10.5)	1073 (13.7)	5635 (10.1)	3163 (12.9)
4	3734 (5.9)	670 (8.6)	3064 (5.5)	1988 (8.1)
5	1248 (2.0)	301 (3.9)	937 (1.7)	684 (2.8)
Admission NIHSS complete (n,%)	46447 (73.0)	3792 (48.4)	42655 (76.4)	17041 (69.4)
Median admission NIHSS (IQR)	4 (2-9)	5 (2-19)	4 (2-9)	7 (3-14)
Level of consciousness on admission				
0 (Alert)	53433 (84.0)	4961 (63.5)	48472 (86.8)	19156 (78.1)
1 (Not alert: Responds to voice)	6032 (9.5)	1069 (13.7)	4963 (8.9)	3697 (15.1)
2 (Not alert: Responds to pain)	2498 (3.9)	828 (10.6)	1670 (3.0)	1267 (5.2)
3 (Totally unresponsive)	1687 (2.7)	954 (12.2)	733 (1.3)	422 (1.7)
Co-morbidity (n,%)				
Heart failure	3463 (5.4)	491 (6.3)	2972 (5.3)	1625 (6.6)
Hypertension	34212 (53.9)	3930 (50.3)	30382 (54.4)	13323 (54.3)
Atrial fibrillation	13159 (20.7)	1801 (23.1)	11358 (20.3)	5929 (24.2)
Diabetes mellitus	12372 (19.4)	1482 (18.9)	10890 (19.5)	4720 (19.2)
Previous stroke/TIA	17626 (27.7)	2144 (27.4)	15482 (27.7)	7109 (29.0)
Time from onset to admission (n, %)				
Unknown (e.g. wake up stroke)	24668 (38.8)	4233 (54.2)	20435 (36.6)	9631 (39.2)
0-179 minutes	21504 (33.8)	2113 (27.1)	19391 (34.7)	9086 (37.0)
180-359 minutes	6144 (9.7)	539 (6.9)	5605 (10.0)	2289 (85.6)
360+ minutes	11334 (17.8)	927 (11.9)	10407 (18.6)	3536 (14.4)
Thrombolysis (n, %)	7087 (11.1)	417 (5.3)	6670 (12.0)	3415 (3.1)
SAP (n,%)	5533 (8.7)	1077 (13.8)	4456 (8.0)	3592 (14.6)
30 day mortality (n,%)	8397 (13.2)	2701 (34.6)	5696 (10.2)	3599 (14.7)

1

2 **Table 1. Characteristics of the study cohort**

1

2 The overall incidence of SAP was 8.7%. SAP incidence was highest in the dysphagic group referred
3 for comprehensive dysphagia assessment (14.6%). Thirty day mortality was 13.2% overall, 10.2% in
4 patients screened for dysphagia, 14.7% in patients referred for SALT assessment, and 34.6% in
5 patients in whom a dysphagia screen was not carried out.

6 The median time from admission to dysphagia screening was 2.9 hours (IQR 1.3-5.7 hours) and for
7 comprehensive dysphagia assessment was 22.9 hours (IQR 6.2-49.4 hours). In unadjusted analyses
8 there was a strong association between time from admission to dysphagia screen and incidence of
9 SAP, rising from 7-8% from 0-8 hours and increasing to 15% by 72 hours after admission. Although
10 the association was attenuated after adjusting for patient characteristics, there was still a modest
11 association (equating to approximately 1% absolute increase in the incidence of SAP) between
12 delays in dysphagia screening and incidence of SAP (Figure 1). After adjustment, patients in the
13 fourth quartile (i.e. those with the longest delays in dysphagia screening) had 36% higher odds of
14 SAP compared to those in the first quartile (aOR 1.36, 1.20-1.53) (Table 2).

15

		Time (mins)	OR	95% CI	p
Univariable (n=55838)	1st quartile	0-79	REF		
	2nd quartile	80-176	0.89	0.81-0.98	0.016
	3rd quartile	177-344	0.85	0.77-0.94	0.001
	4th quartile	≥345	1.33	1.21-1.46	<0.0001
Multivariable, including NIHSS (n=42655)	1st quartile	0-79	REF		
	2nd quartile	80-176	0.94	0.83-1.05	0.27
	3rd quartile	177-344	1.06	0.94-1.20	0.36
	4th quartile	≥345	1.36	1.20-1.53	<0.0001
Multivariable, including level of consciousness (n=55838)	1st quartile	0-79	REF		
	2nd quartile	80-176	0.92	0.83-1.01	0.08
	3rd quartile	177-344	0.89	0.81-0.99	0.03
	4th quartile	≥345	1.14	1.03-1.24	0.008

1

2 **Table 2.** Odds ratio for SAP in univariable and multivariable models of time from admission to
3 dysphagia screening. All multivariable models were also adjusted for age, sex, stroke type, pre-
4 stroke functional level, place of stroke and comorbidity, and measure of stroke severity (NIHSS or
5 level of consciousness)

6

7 There was a strong relationship between delays in comprehensive dysphagia assessment and
8 incidence of SAP, and delays in comprehensive dysphagia assessment were associated with an
9 absolute increase in the risk of SAP of 3% over the first 24 hours (Figure 2). Delays in SALT dysphagia
10 assessment beyond 24 hours were associated with an additional 4% absolute increase in the
11 incidence of SAP (approximately 3-fold increase in the relative incidence). Patients in the slowest
12 quartile had 1.98 (1.67-2.35) the odds of SAP compared to patients receiving the quickest SALT
13 dysphagia assessments (Table 3). Findings were similar in the sensitivity analyses (Supplementary
14 material). The secondary analysis of 30 day mortality broadly supported these findings: there was
15 very weak evidence that delays in dysphagia assessment were associated with an increase in 30 day
16 mortality (aOR 1.14, 0.99-1.30 in the slowest quarter). There was moderately strong evidence that
17 delays in comprehensive SLT assessment were associated with an increase in mortality risk in the
18 second (aOR 1.22, 1.02-1.47), third (aOR 1.55, 1.29-1.85) and fourth (aOR 1.35, 1.12-1.63) quarters

- 1 of time to assessment respectively. Unlike pneumonia, a dose-response relationship was not
- 2 demonstrated for the association with mortality (Supplementary material)

1

		Time (mins)	OR	95% CI	p
Univariable (n=24542)	1st quartile	0-369	REF		
	2nd quartile	370-1371	1.53	1.34-1.74	<0.0001
	3rd quartile	1372-2961	1.95	1.71-2.22	<0.0001
	4th quartile	≥2962	2.65	2.33-3.01	<0.0001
Multivariable, including NIHSS (n=17041)	1st quartile	0-369	REF		
	2nd quartile	370-1371	1.35	1.15-1.60	<0.0001
	3rd quartile	1372-2961	1.61	1.37-1.91	<0.0001
	4th quartile	≥2962	1.98	1.67-2.35	<0.0001
Multivariable, including level of consciousness (n=24542)	1st quartile	0-369	REF		
	2nd quartile	370-1371	1.40	1.22-1.60	<0.0001
	3rd quartile	1372-2961	1.60	1.41-1.84	<0.0001
	4th quartile	≥2962	2.01	1.76-2.30	<0.0001

2

3 **Table 3.** Odds ratio for SAP in univariable and multivariable models of time from admission to SALT
4 dysphagia assessment. All multivariable models were also adjusted for age, sex, stroke type, pre-
5 stroke functional level, place of stroke and comorbidity, and measure of stroke severity (NIHSS or
6 level of consciousness)

7

8

1 Discussion

2 In this national cohort of unselected stroke patients, we found that there was evidence of a modest
3 association between delays in performing dysphagia screening and the risk of SAP. There was
4 stronger evidence for an association between the risk of SAP and delays in carrying out a
5 comprehensive dysphagia assessment. Although limited by the risk of residual confounding, these
6 findings provide the first evidence from a large multicentre cohort that prompt dysphagia screening
7 and comprehensive dysphagia assessment stroke are associated with clinically significant reductions
8 in the risk of SAP, one of the principal causes of early death after stroke.

9 Detecting dysphagia through the use of bedside screening assessments and comprehensive
10 dysphagia assessments carried out by a SALT is widely recommended in clinical guidelines¹²⁻¹⁴.
11 However, these recommendations are largely based on consensus and there is little direct evidence
12 for dysphagia screening or assessment after stroke¹⁷. Previous studies have been limited to
13 ecological studies demonstrating an association between site level rates of screening assessment
14 and SAP rates after stroke^{8,10,11}. Several observational studies have described an association between
15 dysphagia screening at any time after stroke and reduced post stroke mortality^{10,18,19,20}, and
16 dysphagia screening was a component of a stroke care bundle found in a cluster randomised
17 controlled trial to reduce death and dependency after stroke²¹. By contrast, an analysis of the “Get
18 with the Guidelines – Stroke” registry data from the USA found that dysphagia screening was
19 associated with a higher risk of SAP, although the results suggest that confounding by stroke
20 severity contributed to the observed association²². There is no current evidence of how quickly
21 dysphagia assessment should occur after stroke or good quality evidence of whether dysphagia
22 assessment reduces the risk of SAP. As a result of this lack of evidence, dysphagia screening has been
23 dropped from the list of stroke quality indicators used in the USA²³, although they remain part of
24 quality indicators used in the UK²⁴.

1 If our findings represent causal effects, then they imply that dysphagia screening and assessment is
2 effective in reducing the risk of SAP. Since SAP is one of the main causes of death in acute stroke,
3 reducing the risk of SAP would be expected to lead to reduced mortality after stroke. The secondary
4 analyses of mortality in this study provide supporting evidence that this might be the case. We
5 would however emphasise caution in interpreting the mortality findings - there are many causes of
6 death in acute stroke and so reductions in SAP will only prevent a proportion of deaths (in keeping
7 with the reduced effect sizes for mortality we observed) and we did not observe a dose-response
8 relationship between delays in comprehensive dysphagia assessment and mortality, suggesting that
9 there might be additional confounding or bias not accounted for in the analysis.

10 There are several possible mechanisms for why delays in dysphagia assessment might lead to an
11 increased risk of SAP and further studies would be required to test these hypotheses and confirm
12 (or refute) a causal relationship: early screening may reduce the risk of inappropriate administration
13 of oral fluid or food, prompt measures to reduce aspiration risk through positioning, nursing care
14 and appropriate feeding strategies, and avoid unnecessary nasogastric tube insertions. As well as
15 exploring mechanisms, further research might usefully also explore organisational aspects of
16 dysphagia assessment, such as the use of specific assessment and treatment protocols and the
17 relationship between specialist SALT provision on stroke units and patient outcomes.

18 These data are strengthened by being drawn from a national register of unselected patients,
19 reducing the risk of selection bias. Similarly, the study used clinical rather than administrative data,
20 providing more detail than would be available from routine administrative data alone. There are
21 however a number of limitations. Firstly SAP was not defined by specific criteria but was based on
22 the judgement of the treating physician, and we did not have information on the date of diagnosis of
23 SAP and whether it occurred before or after dysphagia screening and assessment. Nonetheless, the
24 overall rate of SAP observed in this study is consistent with other studies, suggesting that differences
25 in ascertainment between centres was not a significant source of bias. In addition, although data

1 completeness was high, NIHSS data were not available for one quarter of patients. We used level of
2 consciousness as a proxy for this and found that the findings were similar, but having complete data
3 on stroke severity may have strengthened the study. The dataset lacked information on the nature
4 of the bedside dysphagia screening tools used, the details of the comprehensive assessment (e.g.
5 videofluoroscopy or fibre-optic evaluation of swallowing), and the results of these assessments.
6 Further studies should aim to capture in more detail the components of these interventions. The
7 main limitation of this study is the risk of residual confounding. The hypothesis that early dysphagia
8 screening and SALT assessment reduce the risk of SAP could be tested in a cluster randomised
9 controlled trial of a protocol of expedited comprehensive dysphagia assessment and this would help
10 guide clinical practice in an important area of stroke care which currently has a poor evidence base.

11 Implementing faster dysphagia assessments in clinical practice is principally a matter of training
12 healthcare professionals appropriately and in most instances does not require expensive medical
13 equipment. Dysphagia screening has been identified by the World Stroke Organisation as being
14 achievable even in health economies with the lowest level of resources²⁵; ensuring that all stroke
15 patients receive rapid dysphagia assessments could therefore be a part of global efforts to improve
16 the outcomes of acute stroke, even in settings without advanced specialist stroke care.

17

18 Summary

19 Delays in screening for dysphagia and carrying out SALT dysphagia assessments after stroke are
20 associated with an increased risk of SAP. This hypothesis that expedited dysphagia screening and
21 assessments reduce the risk of SAP would be testable in an appropriately designed trial or controlled
22 evaluation. In the meantime, these findings suggest that reducing delays in screening and assessing
23 for dysphagia in people with acute stroke should be a focus of quality improvement in stroke care.

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13 Contributions

14 BDB - study design, analysis, writing

15 CJS - study design, writing

16 GCC - writing

17 PE - writing

18 MJ - writing

19 LP - analysis, writing

20 PJT - writing

21 CDAW - writing

22 AGR - writing

1

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- 1 **Figure 1.** *Modelled relationship between estimated incidence of SAP in the first seven days of*
- 2 *admission and time to dysphagia screening. (A): Multivariable model including NIHSS. (B):*
- 3 *Multivariable model including level on consciousness*

- 4 **Figure 2.** *Modelled relationship between estimated incidence of SAP in the first seven days of*
- 5 *admission and the time to SALT dysphagia assessment. (A): Multivariable model including NIHSS.*
- 6 *(B): Multivariable model including level on consciousness*