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The decrement in the documentation of neurological findings in acute ischaemic stroke patients: Do physicians learn about neurology by studying stroke patients?

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ABSTRACT

Objective: To evaluate temporal differences in the documentation of neurological findings by the same physicians in ischaemic stroke patients while in hospital. We also investigated differences in rate of documentation of neurological findings in stroke patients between internists and neurosurgeons.

Design: A retrospective medical chart review.

Participants: Hospitalized adult patients with acute ischaemic stroke who stayed seven or more days in our hospital. Neurosurgeons (n=8) and internists (n=19) caring for those patients (including up to 10 patients per physician).

Main outcome measures: The documentation rate of any neurological finding in the patients on each day (from day 1 to 7 and on discharge). The documentation rates of eight neurological finding components (consciousness, mental status, cranial nerves, motor function, sensory function, coordination, reflexes, and gait). We included only documentation by the same physician. Fisher's exact test was used to evaluate differences in outcomes between neurosurgeons and internists.

Results: During the study period, we identified 172 stroke patients who were cared for by 27 physicians. The documentation rates of any neurological finding were 94% (day 1), 58% (day 2), 35% (day 3), 40% (day 4), 32% (day 5), 30% (day 6), and 23% (day 7). On discharge, all eight neurological finding components were documented in fewer than 10% of all cases. The documentation rate was significantly higher by internists than neurosurgeons on each day but not on discharge.

Conclusions: The documentation rate of neurological findings by physicians during usual stroke care decreased to less than 50% after the third hospital day. Given the importance of temporal changes in the neurological symptoms of stroke patients, further

study is needed to determine whether this low documentation rate after the third hospital day was due to a lack of physician interest in neurological findings or other factors.

Key words: Documentation, Neurology, Stroke

Strengths and limitations of this study

- This is the first study to evaluate temporal differences in the documentation of neurological findings by the same physicians in acute stroke patients.
- An association between documentation and patient outcomes was not evaluated.
- This study was conducted in only a single hospital in Japan in a small sample of patients.

INTRODUCTION

The renowned stroke neurologist C. Miller Fisher said that we learn about neurology stroke by stroke. The development of imaging tests has improved our ability to localize neurological symptoms, particularly in stroke patients, compared to previous decades.[1] The continuing development of more accurate neurological examination techniques allows us to learn symptomatology from stroke patients. Nonetheless, physicians, particularly non-neurologists, often omit important neurological examinations[2 3] and tend to depend on brain imaging during routine stroke care.[4] Furthermore, despite an emphasis on observations of temporal changes in neurological findings in stroke patients,[5-8] physicians often lose interest in such neurological signs in these patients, particularly after a definite diagnosis is achieved,[9] potentially reducing the documentation of neurological findings. This is problematic because temporal changes in neurological symptoms are key to predicting a prognosis. Moreover, given the limitations of brain imaging for diagnosing acute ischaemic stroke,[10] it is important to determine the typical clinical course in acute stroke patients. Nonetheless, no studies have evaluated the speed at which the documentation of neurological findings in stroke patients decreases after admission, whereas recent studies have evaluated the speed of consumption of chocolate in hospital wards[11] and of the disappearance of magazines in waiting rooms.[12] Hence, we evaluated temporal changes in the documentation rate of neurological findings by the same physician in ischaemic stroke patients during hospital stays. We also evaluated differences in the documentation rate of any neurological finding in stroke patients between internists and neurosurgeons. Given their specialty training and interest in neurology, neurosurgeons might document neurological findings more frequently than internists.

METHODS

Study design and participants

A retrospective medical chart review was conducted to assess data obtained between September 1, 2014 and June 30, 2017 at Tochigi Medical Center, a 350-bed acute care hospital in the Tochigi prefecture of Japan. Since September 2014, our hospital has used electronic medical records. We chose a retrospective study design because prospective research can introduce the Hawthorne effect,[13] which affects physicians' documentation in medical records. All consecutive patients aged 18 years old or older who were admitted with acute ischaemic stroke as a primary diagnosis, survived and stayed in our hospital at least seven days were included. We excluded patients who died because of other factors, such as non-neurological disease and terminal care, which might affect the documentation of neurological findings. Patients whose principal physicians changed during the hospital stay were also excluded. Up to 10 patients per physician were included. The purpose of the study was to characterize temporal changes in the documentation rate of neurological findings in ischaemic stroke patients by a single principal physician during a hospital stay. We also evaluated differences in the documentation rate of neurological findings between internists and neurosurgeons on each hospital day.

In our hospital, acute ischaemic stroke patients are randomly admitted to either the internal medicine or neurosurgical ward. However, stroke patients requiring surgery or interventional radiology are admitted to the neurosurgery ward. In most cases, these stroke patients are treated by a single principal internal medicine or neurosurgery physician without handoffs from admission to discharge. Additional physicians rarely

examine or document neurological findings in these stroke patients. Therefore, we could evaluate temporal changes in the documentation rate of neurological findings by a single physician. Furthermore, in Japan, the mean length of hospital stay among acute stroke patients is approximately 30 days,[14] which is longer than in other countries.[15] Thus, in most stroke patients, we could also evaluate temporal changes in the documentation rate of neurological findings during at least seven consecutive days. We assumed that the documentation rate would dramatically decrease after the second day and would thereafter change at a lower rate. Hence, even a short-term observation period was enough to evaluate the documentation rate of neurological findings. To reduce the effect of the day of the week at admission.[16] we selected a seven-day evaluation period.

Characteristics

Patient information, including age, sex, culprit lesion of stroke, and duration of hospital stay, was retrieved from medical records obtained at the time of each patient's admission. Physician-related information, including age, sex and specialty, was also retrieved from the database of Tochigi Medical Center.

Outcome measures

One of authors (J.K.) evaluated the medical records of all included patients. The primary outcome was the documentation rate of any neurological finding in ischaemic stroke patients by physicians on each hospital from the day of admission to the seventh day. We also evaluated the documentation rate of neurological findings at discharge (within the 24 hours before discharge). Neurological findings were classified as one of

eight categories (consciousness, mental status, cranial nerves, motor function, sensory function, coordination, reflexes, and gait) based on a previous study.[2] We allowed any documentation of neurological findings regardless of the quality of the examination. However, some documentations, such as "no change in neurological findings" and "no change", were not allowed because they often lacked information regarding which neurological findings were not different and to the extent of the examination. Documentation such as "no change for right hemiplegia" was allowed though it was low quality because it lacked the quantity of neurological findings. Furthermore, documentation of only a total score on the National Institute of Health Stroke Scale (NIHSS) was not allowed, although documentation of the detailed contents of NIHSS was allowed. Documentation of neurological findings by health care providers, including physicians, other than the principal physician was excluded because we sought to evaluate only documentation by a single principal physician.

Statistical analysis

We did not formally calculate sample size because the primary objective was to define the characteristics of neurological documentations by physicians in ischaemic patients. However, we expected a dramatic reduction in the documentation of neurological findings and therefore selected 10 patients per physician. Assuming that the documentation rate of any neurological finding would be 95% on admission and lower than 40% after the second hospital day, approximately 10 patients per physicians was needed to achieve a significance level of 0.05 with a power of 0.8. To minimize the effect on outcomes of a few physicians caring for many patients, only up to 10 patients per physician were included.

The baseline and demographic characteristics of patients and physicians were summarized using standard descriptive summaries. For the primary objective, we determined the documentation rate of any neurological finding in ischaemic stroke patients on each hospital day. For outcomes on each hospital day, 95% confidence intervals (CIs) were calculated. For the secondary objective, to evaluate the difference in the documentation rate of neurological findings on each hospital day between internists and neurosurgeons, we used Fisher's exact test. These analyses were performed using the Excel statistical software package version 2.11 (Bellcurve for Excel; Social Survey Research Information Co., Ltd., Tokyo, Japan), and the level of significance was set at 5%.

Patient involvement

No patients were involved in determining the research question or outcome measures nor were they involved in developing plans to design or implement the study. No patients were asked for advice during the interpretation or writing up of the results. There are no plans to disseminate the results of this research to study participants or the relevant patient community.

RESULTS

We identified 474 consecutive acute ischaemic stroke patients who were cared for by 29 physicians during the study period. Of these, 172 who were cared for by 27 physicians (19 internists and 8 neurosurgeons) met our inclusion criteria. Among these 172 patients, 105 were discharged to home, 40 to rehabilitation facilities, and 27 to other hospitals or

long-term care facilities. The baseline characteristics of the patients and physicians are presented in Table 1.

Figure 1 shows the temporal changes in the documentation rate of any neurological finding in all patients according to the specialty of their principal physician. The documentation rate of any neurological finding was 94% (95% CI 91 to 98) at admission and 58% (95% CI 50 to 65) on day 2. However, the average documentation rate of any neurological finding from the third to seventh day was lower than 40%. Furthermore, the documentation rate was only 14% within 24 hours of discharge. The documentation rate of any neurological finding was significantly lower in the neurosurgeon-treated group than in the internal medicine-treated group on each hospital day but not at discharge.

Among the eight neurological finding categories, motor function was the most frequently documented during the initial seven hospital days (Table 2). Mental status, reflexes and gait were documented in fewer than 50% of all patients during the same period. Furthermore, after the third hospital day, these three components were documented in fewer than 10% of all patients. At discharge, all categories of neurological findings were documented in fewer than 10% of all patients.

DISCUSSION

In this study, the documentation rate of neurological findings by principal physicians decreased to lower than 50% after the third hospital day during stroke care. Furthermore, the documentation of mental status, reflexes and gait was often omitted by principal physicians during routine stroke care, and the documentation rate of these three categories was astronomically low after the third day. These results indicate that

physician interest in neurological findings in stroke patients dramatically decreases after the third hospital day. This reduction in the documentation of neurological findings seems faster than the reduction in the effect of Pokémon GO on physical activity,[17] although it is unclear whether these temporal reductions reflect a loss of interest in neurological findings or Pokémon GO, respectively.

Among 8 categories of neurological findings, motor function was the most frequently documented in this study, is consistent with the results of previous studies.[18-20] Mental status and gait were documented less frequently, perhaps because the stroke textbook states that these important neurological assessment can be omitted.[7] Because cognitive impairment frequently occurs in stroke patients[21] and can be effectively treated with rehabilitation,[22 23] the low documentation rate of mental status by principal physicians is problematic, although such documentation may not reflect physician awareness.

We did not expect that neurological findings would be more frequently documented in stroke patients in our hospital by internists than by neurosurgeons, and this result should be interpreted cautiously. Unlike in the internal medicine ward, in the neurosurgery ward of our hospital, trained nurses often document NIHSS every day during routine stroke care, and such thorough assessment by other health providers might lower the need for neurosurgeons to document neurological findings. Furthermore, we did not evaluate the quality or volume of neurological findings. Given their specialty in neurology, neurosurgeons might be more likely than internists to document more detailed and important neurological findings. Further study is needed to investigate whether a physician's specialty affects documentation.

Strengths and weaknesses of the study

To the best of our knowledge, this is the first study to evaluate temporal changes in the documentation of neurological findings by the same physician in stroke patients. In our hospital, in most cases, a single principal physician cares for each acute ischaemic stroke patient. This allowed us to evaluate temporal changes in medical record documentation by the same physicians.

Its major limitation is that the extent of documentation does not necessarily reflect the interest of the recorder. Furthermore, in stroke patients, it is impossible to distinguish an interest in neurological findings from interest in a prognosis. In addition, the role of clinical documentation has changed in the modern era, and billing and quality indicators affect medical record documentation.[24-26] However, the documentation of neurological findings during stroke care does not affect medical fees and is not considered a quality indicator in Japan. Therefore, billing for inpatient hospital care, litigation, and quality indicators have few effects on the documentation of neurological findings by physicians. Furthermore, documentation itself is also important. As William Osler said, "observe, record, tabulate, communicate".[25] We were unable to retrospectively learn or perform detailed discussions about brain function without access to the sequential documentation of neurological findings, and physicians who are more interested in neurological findings will more thoroughly document them.

Other limitations include the following. First, this study included a small sample size and was limited to a single centre. Second, it is uncertain whether a higher rate of documentation of neurological findings is associated with higher clinical skill. However, interest in stroke is associated with the more accurate clinical diagnosis of lacunar stroke.[27] Third, we did not evaluate outcomes between the eighth hospital day and

discharge, but given the very low rate of documentation of neurological findings within 24 hours of discharge, we are confident that the documentation of neurological findings continued to gradually decrease after the eighth hospital day. Fourth, we did not individually evaluate the documentation of other important neurological signs, such as neuro-ophthalmic findings and visual problems,[7] and we did not evaluate the thoroughness of medical histories, which is important. As C. Miller Fisher showed, in ischaemic stroke patients, the frequency and importance of transient ischaemic attacks can be determined from a thorough history of prodromal symptoms.[28] Fifth, a single observer evaluation might introduce bias and affect our results. However, past studies reported good inter-rater reliability in audits of neurological finding documentation.[16 20] Sixth, the prevalence of inappropriate copying and pasting[29] suggests that we might have overestimated clinically meaningful documentation. Seventh, we regarded two or more documentations per day as one documentation per day. Hence, we might have underestimated documentation by physicians. Finally, although a higher patient volume is associated with a lower rate of documentation of important information,[30] we did not consider the effect of work load on outcomes.

Meaning of findings

Several factors could have caused the observed reduction in the documentation of neurological findings after the third hospital day. First, the low documentation rate of neurological findings after the third hospital day might derive from the initial stable course of stroke patients rather than a loss of physician interest in neurological findings.[18] However, because neurological findings often change day by day in the early course of acute stroke,[31 32] this possibility seems unlikely. Second, the temporal changes

in the documentation of neurological findings, especially by neurosurgeons, are similar to the decreasing response to 3-Hz repetitive nerve stimulation observed in myasthenia gravis[33] (Figure 1). The decrement in the documentation of neurological findings by neurosurgeons was higher but not maximal on the third hospital day, and thereafter, this rate slightly increased from the fourth to sixth hospital day but not in a typical U-shape.[34] Therefore, a fatigue phenomenon similar to the loss of acetylcholine receptor function observed in myasthenia gravis might occur in physicians. If so, a similar phenomenon could occur in the documentation of non-neurological findings in non-neurological disease. Third, spending more time communicating, such as during neurological examinations of patients, is of utmost importance for learning about neurology and might reduce the documentation of neurological findings after the third hospital day. However, a previous study demonstrated acceptable concordance between documentation in medical records and actual performance during direct observations.[35] Furthermore, in previous studies, time spent communicating with patients and direct patient care were not affected by time spent during medical record documentation.[36 37] Fourth, participation in annual meetings during conferences and holidays could affect medical record documentation.

Although these factors might have affected our findings, physicians interested in neurological findings are more likely to frequently document neurological signs regardless of their fatigue, and the temporal reduction in documentation observed in our study is considered a reflection of loss of physician interest. Nonetheless, further study is needed to determine whether the low documentation rate after the third hospital day is truly due to a lack of physician interest in neurological findings.

Implications for clinical practice

C. Miller Fisher described many syndromes and mechanisms using thorough neurological examinations and observations of stroke patients.[38] One of his significant contributions was an understanding of the relationship between carotid artery disease and ischaemic stroke. Before his work, approximately 55% of ischaemic strokes were thought to be caused by vasospasm.[39] When the first key patient who gave him an initial clue died while he was away for a weekend, the resident on call for the patient did not request an autopsy. When Fisher asked the medical staff why they did not request an autopsy, he was amazed that the resident on call did not consider it necessary.[28] This episode reflects a gap in interest in stroke patients between Fisher and the resident. Unlike Fisher's era, modern imaging tests provide us a more detailed localization of neurological symptoms, especially in stroke patients. Hence, our findings are disappointing even if they truly indicate a rapid loss of post-admission interest in stroke patients by physicians. We propose that now is the time for physicians to relearn about neurology stroke by stroke.[40]

Conclusions

The documentation rate of neurological findings by physicians in usual stroke care decreased to lower than 50% on the third hospital day and subsequently continued to decrease. Given the importance of learning and monitoring temporal changes in neurological symptoms in stroke patients, further study is needed to determine whether the low documentation rate after the third hospital day was caused by a lack of physician interest in neurological findings or other factors.

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Contributors

JK conceived the project. JK and TK wrote the protocol for this study. JK collected and analysed the data. JK and TK interpreted the results and wrote the manuscript. All authors gave final approval for the submission of this version for consideration for publication.

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Competing interests

All authors have completed the ICMJE unified disclosure from competing interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author). All authors declare they have no financial relationships with any organisations that might have an interest in the submitted work and no other relationships or activities that could appear to have influenced the submitted work.

Ethics approval

This study was approved by the Medical Ethical Committee of Tochigi Medical Center (protocol No. 29-14) and was performed in accordance with the Declaration of Helsinki.

This study was also conducted in accordance with the Ethical Guidelines for Epidemiological Research in Japan. We were not required to obtain individual informed consent because we used de-identified data obtained from medical records and did not contact the patients. According to Japanese Ethical Guidelines, we did display a poster in the waiting room of the hospital to provide information about the collection and use of data for this study and the protection of personal information.

Data sharing

Data sharing is not applicable because we did not receive informed consent for data sharing from the participants. The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

Transparency

The lead author (JK) affirms that this manuscript is an honest, accurate, and transparent account of the study being reported, that no important aspects of the study have been omitted, and that any discrepancies from the study originally planned have been explained.

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Fig 1. Temporal changes in the documentation rate of any neurological findings in 172 ischaemic stroke patients during hospital stay.

*p-value < 0.05

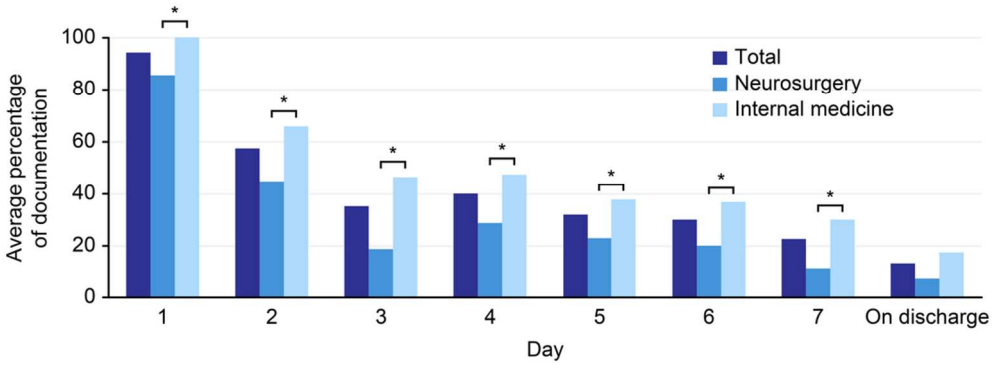
Table 1. Characteristics of patients with acute ischemic stroke and physicians. Values are shown as numbers (percentages) unless stated otherwise.

	Total	Neurosurgery	Internal Medicine
Physicians, n = 27			
Mean (SD) age (years)	35.5 (7.8)	41.9 (11.0)	32.8 (3.8)
Men	22 (81.5)	7 (87.5)	15 (78.9)
Patients, n = 172			
Mean (SD) age (years)	75.1 (11.5)	74.9 (11.6)	75.3 (11.5)
Men	93 (54.1)	38 (55.1)	55 (53.4)
Admission day of week			
Weekday	155 (90.1)	63 (91.3)	92 (89.3)
Weekend	17 (9.9)	6 (8.7)	11 (10.7)
Mean (SD) length of hospital stay (days)	27.1 (18.5)	25.3 (19.0)	28.4 (18.1)

Table 2. Temporal changes in the documentation rates of 8 categories of neurological findings. Values are shown as percentages (95% confidence intervals).

	Day of hospital stay							
	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**	**On discharge***
Any neurological finding	94 (91 to 98)	58 (50 to 65)	35 (28 to 43)	40 (33 to 48)	32 (25 to 39)	30 (23 to 37)	23 (16 to 29)	13 (8 to 17)
Level of consciousness	80 (74 to 86)	23 (16 to 29)	17 (11 to 23)	13 (8 to 19)	13 (8 to 19)	12 (7 to 16)	8 (4 to 12)	5 (1 to 8)
Mental status	46 (38 to 53)	12 (7 to 17)	9 (5 to 14)	5 (1 to 8)	6 (3 to 10)	6 (3 to 10)	4 (1 to 7)	3 (1 to 6)
Cranial nerves	84 (79 to 90)	35 (28 to 43)	19 (13 to 24)	22 (15 to 28)	15 (9 to 20)	13 (8 to 19)	10 (5 to 14)	6 (2 to 9)
Motor function	92 (88 to 96)	45 (38 to 53)	28 (21 to 35)	31 (24 to 38)	22 (16 to 28)	22 (15 to 28)	16 (10 to 21)	7 (3 to 11)
Sensory function	58 (51 to 66)	17 (12 to 23)	12 (7 to 17)	10 (6 to 15)	5 (2 to 9)	7 (3 to 11)	7 (3 to 11)	2 (0 to 4)
Coordination	51 (44 to 59)	13 (8 to 19)	9 (4 to 13)	6 (2 to 9)	5 (1 to 8)	3 (0 to 5)	5 (1 to 8)	3 (0 to 5)
Reflex	45 (37 to 52)	5 (1 to 8)	4 (1 to 7)	2 (0 to 4)	2 (0 to 5)	2 (0 to 5)	1 (-1 to 2)	1 (-1 to 2)
Gait	17 (11 to 23)	5 (1 to 8)	3 (0 to 5)	4 (1 to 7)	4 (1 to 7)	4 (1 to 6)	2 (0 to 4)	3 (0 to 5)

*Within 24 hours of discharge.



Temporal changes in the documentation rate of any neurological findings in 172 ischaemic stroke patients during hospital stay.

48x17mm (600 x 600 DPI)

STROBE (Strengthening The Reporting of OBservational Studies in Epidemiology) Checklist

A checklist of items that should be included in reports of observational studies. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Section and Item	Item No.	Recommendation	Reported on Page No.
Title and Abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/Rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study Design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	N/A
		Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls	N/A
		Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants	5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed	N/A
		Case-control study—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7

Section and Item	Item No.	Recommendation	Reported on Page No.
Data Sources/ Measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	5-8
Study Size	10	Explain how the study size was arrived at	7-8
Quantitative Variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical Methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A N/A N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive Data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome Data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	N/A
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	9

Section and Item	Item No.	Recommendation	Reported on Page No.
Main Results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
		(*b*) Report category boundaries when continuous variables were categorized	9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other Analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9
Discussion			
Key Results	18	Summarise key results with reference to study objectives	9-10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11-13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	11-12
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups cohort and cross-sectional studies.

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Temporal changes in the documentation of neurological findings among acute ischaemic stroke patients in a single centre in Japan: a retrospective cross-sectional study

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Temporal changes in the documentation of neurological findings among acute ischaemic stroke patients in a single centre in Japan: a retrospective cross-sectional study

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Running title: Documentation rate of neurological findings

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ABSTRACT

Objective: To evaluate temporal differences in the documentation of neurological findings by the same physicians in ischaemic stroke patients while in hospital. We also investigated differences in the rate of documentation of neurological findings in stroke patients between internists and neurosurgeons.

Design: A retrospective medical chart review.

Participants: Hospitalized adult patients with acute ischaemic stroke who stayed seven or more days in our hospital. Neurosurgeons (n=8) and internists (n=19) caring for these patients (including up to 10 patients per physician).

Main outcome measures: The documentation rate of any neurological finding in the patients on each day (from day 1 to 7 and on discharge). The documentation rates of eight neurological finding components (consciousness, mental status, cranial nerves, motor function, sensory function, coordination, reflexes, and gait). We included only documentation by the same physician. Fisher's exact test was used to evaluate differences in outcomes between neurosurgeons and internists.

Results: During the study period, we identified 172 stroke patients who were cared for by 27 physicians. The documentation rates of any neurological findings were 94% (day 1), 58% (day 2), 35% (day 3), 40% (day 4), 32% (day 5), 30% (day 6), and 23% (day 7).

On discharge, all eight neurological finding components were documented in fewer than 10% of all cases. The documentation rate was significantly higher by internists than that by neurosurgeons on each day but not on discharge.

Conclusions: The documentation rate of neurological findings by physicians during usual stroke care decreased to less than 50% after the third hospital day. Given the importance of temporal changes in the neurological symptoms of stroke patients, further study is needed to determine whether this low documentation rate after the third hospital day was due to a lack of physician interest in neurological findings or other factors.

Key words: Documentation, Neurology, Stroke

Strengths and limitations of this study

- This is the first study to evaluate temporal differences in the documentation of neurological findings by the same physicians in acute stroke patients.
- An association between documentation and patient outcomes was not evaluated.
- This study was conducted in only a single hospital in Japan in a small sample of patients.

INTRODUCTION

The renowned stroke neurologist C. Miller Fisher said that we learn about neurology stroke by stroke. The development of imaging tests has improved our ability to localize neurological symptoms, particularly in stroke patients, compared to previous decades.[1] The continuing development of more accurate neurological examination techniques allows us to learn symptomatology from stroke patients. Nonetheless, physicians, particularly non-neurologists, often omit important neurological examinations[2, 3] and tend to depend on brain imaging during routine stroke care.[4] Furthermore, despite an emphasis on observations of temporal changes in neurological findings in stroke patients,[5-8] physicians often lose interest in such neurological signs in these patients, particularly after a definite diagnosis is achieved,[9] potentially reducing the documentation of neurological findings. This is problematic because temporal changes in neurological symptoms are key to predicting a prognosis and a need for intervention.[10-13] Moreover, given the limitations of brain imaging for diagnosing acute ischaemic stroke,[14] it is important to determine the typical clinical course in acute stroke patients. Nonetheless, no studies have evaluated the speed at which the documentation of neurological findings in stroke patients decreases after admission. Hence, we evaluated temporal changes in the documentation rate of

neurological findings by the same physician in ischaemic stroke patients during hospital stays. We also evaluated differences in the documentation rate of any neurological finding in stroke patients between internists and neurosurgeons. Given their specialty training and interest in neurology, neurosurgeons might document neurological findings more frequently than internists.

METHODS

Study design and participants

A retrospective medical chart review was conducted to assess data obtained between September 1, 2014 and June 30, 2017 at Tochigi Medical Center, a 350-bed acute care hospital in the Tochigi prefecture of Japan. Since September 2014, our hospital has used electronic medical records. We chose a retrospective study design because prospective research can introduce the Hawthorne effect,[15] which affects physicians' documentation in medical records. All consecutive patients aged 18 years old or older who were admitted with acute ischaemic stroke as a primary diagnosis, survived and stayed in our hospital at least seven days were included. We excluded patients who died because of other factors, such as non-neurological disease and

terminal care, which might affect the documentation of neurological findings. Patients whose principal physicians changed during the hospital stay were also excluded. Up to 10 patients per physician were included. The purpose of the study was to characterize temporal changes in the documentation rate of neurological findings in ischaemic stroke patients by a single principal physician during a hospital stay. We also evaluated differences in the documentation rate of neurological findings between internists and neurosurgeons on each hospital day.

Usual care

In our hospital, consultation with a neurologist (T.K.) from an academic hospital once per week is possible; however, there is no ward neurologist. Therefore, either internists or neurosurgeons care for most acute ischaemic stroke patients without consultation with neurologists. All internists included in this study had received formal training for neurology during one or two months while in their junior residency. No internists included in this study had received additional formal training for neurology. However, all of the internists had cared for stroke patients on a regular basis in usual care. These practices are common in Japan, and approximately half of hospitals in Japan have no neurologists, even in certified training institutions such as the Japan

Neurosurgical Society, the Japanese Society of Neurology, and/or the Japan Stroke Society.[16] Furthermore, non-neurologists often care for acute ischaemic stroke patients even in hospitals with neurologists in Japan. During this study period, the average hospital stay of acute ischaemic patients (excluding those with a transient ischemic attack) was 25.1 days, and their in-hospital mortality was 7.0%. These rates were similar to those in other Japanese hospitals.[16, 17] This mortality in acute ischemic stroke patients was also similar to data from other countries.[18]

In our hospital, acute ischaemic stroke patients are randomly admitted to either the internal medicine or neurosurgical ward. However, stroke patients requiring surgery or interventional radiology are admitted to the neurosurgery ward. In most cases, these stroke patients are treated by a single principal internal medicine or neurosurgery physician without handoffs from admission to discharge. Additional physicians rarely examine or document neurological findings in these stroke patients. Therefore, we could evaluate temporal changes in the documentation rate of neurological findings by a single physician. Furthermore, in Japan, the mean length of hospital stay among acute stroke patients is approximately 30 days,[16, 17] which is longer than in other countries.[18] Thus, in most stroke patients, we could also evaluate temporal changes in the documentation rate of neurological findings during at least seven consecutive days.

We assumed that the documentation rate would dramatically decrease after the second day and would thereafter change at a lower rate. Hence, even a short-term observation period was enough to evaluate the documentation rate of neurological findings. To reduce the effect of the day of the week at admission,[19] we selected a seven-day evaluation period.

Characteristics

Patient information, including age, sex, and duration of hospital stay, was retrieved from medical records obtained at the time of each patient's admission. Physician-related information, including age, sex and specialty, was also retrieved from the database of Tochigi Medical Center.

Outcome measures

One of authors (J.K.) evaluated the medical records of all included patients. The primary outcome was the documentation rate of any neurological finding in ischaemic stroke patients by physicians on each hospital from the day of admission to the seventh day. We also evaluated the documentation rate of neurological findings at discharge (within the 24 hours before discharge). Neurological findings were classified as one of

eight categories (consciousness, mental status, cranial nerves, motor function, sensory function, coordination, reflexes, and gait) based on a previous study.[2] We allowed any documentation of neurological findings regardless of the quality of the examination. However, some documentations, such as "no change in neurological findings" and "no change", were not allowed because they often lacked information regarding which neurological findings were not different and to the extent of the examination. Documentation such as "no change for right hemiplegia" was allowed though it was low quality because it lacked the quantity of neurological findings. Furthermore, documentation of only a total score on the National Institute of Health Stroke Scale (NIHSS) was not allowed, although documentation of the detailed contents of NIHSS was allowed. Documentation of neurological findings by health care providers, including physicians, other than the principal physician was excluded because we sought to evaluate only documentation by a single principal physician.

Statistical analysis

We did not formally calculate sample size because the primary objective was to define the characteristics of neurological documentations by physicians in ischaemic patients. However, we expected a dramatic reduction in the documentation of

neurological findings and therefore selected 10 patients per physician. Assuming that the documentation rate of any neurological finding would be 95% on admission and lower than 40% after the second hospital day, approximately 10 patients per physicians was needed to achieve a significance level of 0.05 with a power of 0.8. To minimize the effect on outcomes of a few physicians caring for many patients, only up to 10 patients per physician were included.

The baseline and demographic characteristics of patients and physicians were summarized using standard descriptive summaries. For the primary objective, we determined the documentation rate of any neurological finding in ischaemic stroke patients on each hospital day. For outcomes on each hospital day, 95% confidence intervals (CIs) were calculated. For the secondary objective, to evaluate the difference in the documentation rate of neurological findings on each hospital day between internists and neurosurgeons, we used Fisher's exact test. These analyses were performed using the Excel statistical software package version 2.11 (Bellcurve for Excel; Social Survey Research Information Co., Ltd., Tokyo, Japan), and the level of significance was set at 5%.

Patient involvement

No patients were involved in determining the research question or outcome measures nor were they involved in developing plans to design or implement the study. No patients were asked for advice during the interpretation or writing up of the results. There are no plans to disseminate the results of this research to study participants or the relevant patient community.

RESULTS

We identified 474 consecutive acute ischaemic stroke patients who were cared for by 29 physicians during the study period. Forty-six patients (9.7%), including nine patients who had died, were excluded due to discharge before the seventh hospital stay. Of the remaining 428 patients, 172 who were cared for by 27 physicians (19 internists and 8 neurosurgeons) met our inclusion criteria. Among these 172 patients, 105 were discharged to home, 40 to rehabilitation facilities, and 27 to other hospitals or long-term care facilities. The baseline characteristics of the patients and physicians are presented in Table 1.

Table 1. Characteristics of patients with acute ischemic stroke and physicians. Values are shown as numbers (percentages) unless stated otherwise.

	Total	Neurosurgery	Internal Medicine
Physicians, n = 27			
Mean (SD) age (years)	35.5 (7.8)	41.9 (11.0)	32.8 (3.8)
Men	22 (81.5)	7 (87.5)	15 (78.9)
Mean (SD) experience of doctor (years)	8.5 (7.5)	14 (10.9)	6.2 (3.3)
Patients, n = 172			
Mean (SD) age (years)	75.1 (11.5)	74.9 (11.6)	75.3 (11.5)
Men	93 (54.1)	38 (55.1)	55 (53.4)
Admission day of week			
Weekday	155 (90.1)	63 (91.3)	92 (89.3)
Weekend	17 (9.9)	6 (8.7)	11 (10.7)
Mean (SD) length of hospital stay (days)	27.1 (18.5)	25.3 (19.0)	28.4 (18.1)

Figure 1 shows the temporal changes in the documentation rate of any neurological finding in all patients according to the specialty of their principal physician. The documentation rate of any neurological finding was 94% (95% CI 91 to 98) at admission and 58% (95% CI 50 to 65) on day 2. However, the average documentation rate of any neurological finding from the third to seventh day was lower than 40%. Furthermore, the documentation rate was only 14% within 24 hours of discharge. The documentation rate of any neurological finding was significantly lower in the neurosurgeon-treated group than in the internal medicine-treated group on each hospital day but not at discharge.

Among the eight neurological finding categories, motor function was the most frequently documented during the initial seven hospital days (Table 2). Mental status,

209 reflexes and gait were documented in fewer than 50% of all patients during the same
210 period. Furthermore, after the third hospital day, these three components were
211 documented in fewer than 10% of all patients. At discharge, all categories of
212 neurological findings were documented in fewer than 10% of all patients.

213

214 **Table 2.** Temporal changes in the documentation rates of 8 categories of neurological
215 findings. Values are shown as percentages (95% confidence intervals).

	Day of hospital stay							
	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**	**On discharge***
Any neurological finding	94 (91 to 98)	58 (50 to 65)	35 (28 to 43)	40 (33 to 48)	32 (25 to 39)	30 (23 to 37)	23 (16 to 29)	13 (8 to 2
Level of consciousness	80 (74 to 86)	23 (16 to 29)	17 (11 to 23)	13 (8 to 19)	13 (8 to 19)	12 (7 to 16)	8 (4 to 12)	5 (1 to 9
Mental status	46 (38 to 53)	12 (7 to 17)	9 (5 to 14)	5 (1 to 8)	6 (3 to 10)	6 (3 to 10)	4 (1 to 7)	3 (1 to 6
Cranial nerves	84 (79 to 90)	35 (28 to 43)	19 (13 to 24)	22 (15 to 28)	15 (9 to 20)	13 (8 to 19)	10 (5 to 14)	6 (2 to 9
Motor function	92 (88 to 96)	45 (38 to 53)	28 (21 to 35)	31 (24 to 38)	22 (16 to 28)	22 (15 to 28)	16 (10 to 21)	7 (3 to 1
Sensory function	58 (51 to 66)	17 (12 to 23)	12 (7 to 17)	10 (6 to 15)	5 (2 to 9)	7 (3 to 11)	7 (3 to 11)	2 (0 to 4
Coordination	51 (44 to 59)	13 (8 to 19)	9 (4 to 13)	6 (2 to 9)	5 (1 to 8)	3 (0 to 5)	5 (1 to 8)	3 (0 to 5
Reflex	45 (37 to 52)	5 (1 to 8)	4 (1 to 7)	2 (0 to 4)	2 (0 to 5)	2 (0 to 5)	1 (-1 to 2)	1 (-1 to 2
Gait	17 (11 to 23)	5 (1 to 8)	3 (0 to 5)	4 (1 to 7)	4 (1 to 7)	4 (1 to 6)	2 (0 to 4)	3 (0 to 6

216 *Within 24 hours of discharge.

217

218 **DISCUSSION**

In this study, the documentation rate of neurological findings by principal physicians decreased to lower than 50% after the third hospital day during stroke care. Furthermore, the documentation of mental status, reflexes and gait was often omitted by principal physicians during routine stroke care, and the documentation rate of these three categories was extremely low after the third day. These results indicate that physician interest in neurological findings in stroke patients dramatically decreases after the third hospital day.

Among 8 categories of neurological findings, motor function was the most frequently documented in this study, is consistent with the results of previous studies.[20-22] Mental status and gait were documented less frequently, as the stroke textbook describes that these important neurological assessments are unfortunately often omitted in routine care.[7] Because cognitive impairment frequently occurs in stroke patients[23] and can be effectively treated with rehabilitation,[24, 25] the low documentation rate of mental status by principal physicians is problematic, although such documentation may not reflect physician awareness.

We did not expect that neurological findings would be more frequently documented in stroke patients in our hospital by internists than by neurosurgeons, and this result should be interpreted cautiously. Unlike in the internal medicine ward,

trained nurses often document NIHSS every day during routine stroke care in the neurosurgery ward of our hospital, and such thorough assessment by other health providers may reduce the need for neurosurgeons to document neurological findings. Furthermore, we did not evaluate the quality or volume of neurological findings. Given their specialty in neurology, neurosurgeons might be more likely than internists to document more detailed and important neurological findings. Further study is needed to investigate whether a physician's specialty affects documentation.

Strengths and weaknesses of the study

To the best of our knowledge, this is the first study to evaluate temporal changes in the documentation of neurological findings by the same physician in stroke patients. In our hospital, in most cases, a single principal physician cares for each acute ischaemic stroke patient. This allowed us to evaluate temporal changes in medical record documentation by the same physicians.

Its major limitation is that the extent of documentation does not necessarily reflect the interest of the recorder. Furthermore, in stroke patients, it is impossible to distinguish an interest in neurological findings from interest in a prognosis. In addition, the role of clinical documentation has changed in the modern era, and billing and

quality indicators affect medical record documentation.[26-28] However, the documentation of neurological findings during stroke care does not affect medical fees and is not considered a quality indicator in Japan. Therefore, billing for inpatient hospital care, litigation, and quality indicators have few effects on the documentation of neurological findings by physicians. Furthermore, documentation itself is also important. As William Osler said, "observe, record, tabulate, communicate".[27] We were unable to retrospectively learn or perform detailed discussions about brain function without access to the sequential documentation of neurological findings, and physicians who are more interested in neurological findings will more thoroughly document them.

Other limitations include the following. First, this study included a small sample size and was limited to a single centre in which stroke patients are admitted to neurosurgeons or internists. Therefore, our findings may not be applicable to hospitals in which stroke patients are admitted to a neurology ward. However, this practice is common in Japan,[16] and a previous German study also reported that acute ischemic stroke patients were admitted in the internal medicine ward in approximately half of 225 acute care hospitals that participated in a stroke registry.[29] Moreover, given that the number of neurologists is not sufficient worldwide,[30] our findings for

non-neurologists are important. Nonetheless, these findings should be confirmed in other settings, such as neurology ward in other countries. Second, it is uncertain whether a higher rate of documentation of neurological findings is associated with higher clinical skill and better patient outcomes. However, interest in stroke is associated with a more accurate clinical diagnosis of lacunar stroke.[31] Furthermore, poor documentation may mean poor monitoring, which causes a delay in awareness of acute changes in patient status. Therefore, poor documentation may result in worse patient outcomes because a delay in the response to an acute change in patient status is associated with increased mortality.[10] Third, we did not evaluate outcomes between the eighth hospital day and discharge, but given the very low rate of documentation of neurological findings within 24 hours of discharge, we are confident that the documentation of neurological findings continued to gradually decrease after the eighth hospital day. Fourth, we did not individually evaluate the documentation of other important neurological signs, such as neuro-ophthalmic findings and visual problems,[7] and we did not evaluate the thoroughness of medical histories, which is important. As C. Miller Fisher showed, in ischaemic stroke patients, the frequency and importance of transient ischaemic attacks can be determined from a thorough history of prodromal symptoms.[32] Fifth, a single observer evaluation might introduce bias and

affect our results. However, past studies reported good inter-rater reliability in audits of neurological finding documentation.[19, 22] Sixth, the prevalence of inappropriate copying and pasting[33] suggests that we may have overestimated clinically meaningful documentation. Seventh, we regarded two or more documentations per day as one documentation per day. Hence, we might have underestimated documentation by physicians. Finally, although a higher patient volume is associated with a lower rate of documentation of important information,[34] we did not consider the effect of work load on outcomes.

Meaning of findings

Several factors could have caused the observed reduction in the documentation of neurological findings after the third hospital day. First, the low documentation rate of neurological findings after the third hospital day might derive from the initial stable course of stroke patients rather than a loss of physician interest in neurological findings.[20] However, because neurological findings often change day by day in the early course of acute stroke,[35, 36] this possibility seems unlikely. Second, fatigue might occur in the documentation of neurological findings by physicians. If so, a similar phenomenon could occur in the documentation of non-neurological findings in

non-neurological disease. Third, spending more time communicating, such as during neurological examinations of patients, is of utmost importance for learning about neurology and might reduce the documentation of neurological findings after the third hospital day. However, a previous study demonstrated acceptable concordance between documentation in medical records and actual performance during direct observations.[37] Furthermore, in previous studies, time spent communicating with patients and direct patient care were not affected by time spent during medical record documentation.[38, 39] Fourth, participation in annual meetings during conferences and holidays could affect medical record documentation.

Although these factors might have affected our findings, physicians interested in neurological findings are more likely to frequently document neurological signs regardless of their fatigue, and the temporal reduction in documentation observed in our study is considered a reflection of loss of physician interest. Nonetheless, further study is needed to determine whether the low documentation rate after the third hospital day is truly due to a lack of physician interest in neurological findings.

Implications for clinical practice

C. Miller Fisher described many syndromes and mechanisms using thorough neurological examinations and observations of stroke patients.[40] One of his significant contributions was an understanding of the relationship between carotid artery disease and ischaemic stroke. Before his work, approximately 55% of ischaemic strokes were thought to be caused by vasospasm.[41] When the first key patient who gave him an initial clue died while he was away for a weekend, the resident on call for the patient did not request an autopsy. When Fisher asked the medical staff why they did not request an autopsy, he was amazed that the resident on call did not consider it necessary.[32] This episode reflects a gap in interest in stroke patients between Fisher and the resident. Unlike Fisher's era, modern imaging tests provide us a more detailed localization of neurological symptoms, especially in stroke patients. Hence, our findings are disappointing even if they truly indicate a rapid loss of post-admission interest in stroke patients by physicians. We propose that now is the time for physicians to relearn about neurology stroke by stroke.[42]

CONCLUSIONS

The documentation rate of neurological findings by physicians in usual stroke care decreased to lower than 50% on the third hospital day and subsequently continued

to decrease. Given the importance of learning and monitoring temporal changes in neurological symptoms in stroke patients, further study is needed to determine whether the low documentation rate after the third hospital day was caused by a lack of physician interest in neurological findings or other factors.

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Contributors: JK conceived the project. JK and TK wrote the protocol for this study. JK collected and analysed the data. JK and TK interpreted the results and wrote the manuscript. All authors gave final approval for the submission of this revised version for consideration for publication.

Competing interests: All authors have completed the ICMJE unified disclosure from competing interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author). All authors declare they have no financial relationships with any organisations that might have an interest in the submitted work and no other relationships or activities that could appear to have influenced the submitted work.

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Ethics approval: This study was approved by the Medical Ethical Committee of Tochigi Medical Center (protocol No. 29-14) and was performed in accordance with the Declaration of Helsinki. This study was also conducted in accordance with the Ethical Guidelines for Epidemiological Research in Japan. We were not required to obtain individual informed consent because we used de-identified data obtained from medical records and did not contact the patients. According to Japanese Ethical Guidelines, we did display a poster in the waiting room of the hospital to provide information about the collection and use of data for this study and the protection of personal information.

Data sharing: Data sharing is not applicable because we did not receive informed consent for data sharing from the participants. The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

Transparency: The lead author (JK) affirms that this revised manuscript is an honest, accurate, and transparent account of the study being reported, that no important aspects of the study have been omitted, and that any discrepancies from the study originally planned have been explained.

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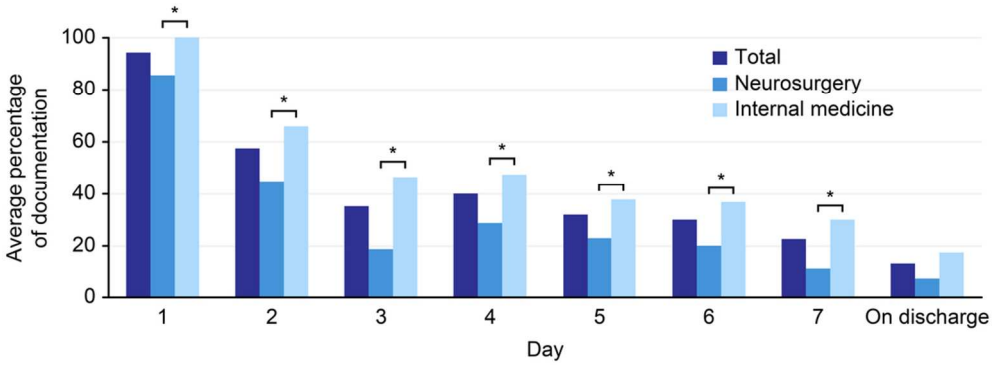
Fig 1. Temporal changes in the documentation rate of any neurological findings in 172 ischaemic stroke patients during hospital stay.

*p-value < 0.05



Temporal changes in the documentation rate of any neurological findings in 172 ischaemic stroke patients during hospital stay.

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STROBE (Strengthening The Reporting of OBservational Studies in Epidemiology) Checklist

A checklist of items that should be included in reports of observational studies. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Section and Item	Item No.	Recommendation	Reported on Page No.
Title and Abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/Rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study Design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-9
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	N/A
		Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls	N/A
		Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants	5-6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed	N/A
		Case-control study—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9

Section and Item	Item No.	Recommendation	Reported on Page No.
Data Sources/ Measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-9
Bias	9	Describe any efforts to address potential sources of bias	5-10
Study Size	10	Explain how the study size was arrived at	9-10
Quantitative Variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10
Statistical Methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9-10
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A N/A N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive Data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome Data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	N/A
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	12-13

Section and Item	Item No.	Recommendation	Reported on Page No.
Main Results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12
		(*b*) Report category boundaries when continuous variables were categorized	12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other Analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12-13
Discussion			
Key Results	18	Summarise key results with reference to study objectives	14-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18-20
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-18
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	22

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups cohort and cross-sectional studies.

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Temporal changes in the documentation of neurological findings among acute ischaemic stroke patients in a single centre in Japan: a retrospective cross-sectional study

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Temporal changes in the documentation of neurological findings among acute ischaemic stroke patients in a single centre in Japan: a retrospective cross-sectional study

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Running title: Documentation rate of neurological findings

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ABSTRACT

Objective: To evaluate temporal differences in the documentation of neurological findings by the same physicians in ischaemic stroke patients while in hospital. We also investigated differences in the rate of documentation of neurological findings in stroke patients between internists and neurosurgeons.

Design: A retrospective medical chart review.

Participants: Hospitalized adult patients with acute ischaemic stroke who stayed seven or more days in our hospital. Neurosurgeons (n=8) and internists (n=19) caring for these patients (including up to 10 patients per physician).

Main outcome measures: The documentation rate of any neurological finding in the patients on each day (from day 1 to 7 and on discharge). The documentation rates of eight neurological finding components (consciousness, mental status, cranial nerves, motor function, sensory function, coordination, reflexes, and gait). We included only documentation by the same physician. Fisher's exact test was used to evaluate differences in outcomes between neurosurgeons and internists.

Results: During the study period, we identified 172 stroke patients who were cared for by 27 physicians. The documentation rates of any neurological findings were 94% (day 1), 58% (day 2), 35% (day 3), 40% (day 4), 32% (day 5), 30% (day 6), and 23% (day 7).

On discharge, all eight neurological finding components were documented in fewer than 10% of all cases. The documentation rate was significantly higher by internists than that by neurosurgeons on each day but not on discharge.

Conclusions: The documentation rate of neurological findings by physicians during usual stroke care decreased to less than 50% after the third hospital day. Given the importance of temporal changes in the neurological symptoms of stroke patients, further study is needed to determine whether this low documentation rate after the third hospital day was due to a lack of physician interest in neurological findings or other factors.

Key words: Documentation, Neurology, Stroke

Strengths and limitations of this study

- This is the first study to evaluate temporal differences in the documentation of neurological findings by the same physicians in acute stroke patients.
- An association between documentation and patient outcomes was not evaluated.
- This study was conducted in only a single hospital in Japan in a small sample of patients.

INTRODUCTION

The renowned stroke neurologist C. Miller Fisher said that we learn about neurology stroke by stroke. The development of imaging tests has improved our ability to localize neurological symptoms, particularly in stroke patients, compared to previous decades.[1] The continuing development of more accurate neurological examination techniques allows us to learn symptomatology from stroke patients. Nonetheless, physicians, particularly non-neurologists, often omit important neurological examinations[2, 3] and tend to depend on brain imaging during routine stroke care.[4] Furthermore, despite an emphasis on observations of temporal changes in neurological findings in stroke patients,[5-8] physicians often lose interest in such neurological signs in these patients, particularly after a definite diagnosis is achieved,[9] potentially reducing the documentation of neurological findings. This is problematic because temporal changes in neurological symptoms are key to predicting a prognosis and a need for intervention.[10-13] Moreover, given the limitations of brain imaging for diagnosing acute ischaemic stroke,[14] it is important to determine the typical clinical course in acute stroke patients. Nonetheless, no studies have evaluated the speed at which the documentation of neurological findings in stroke patients decreases after admission. Hence, we evaluated temporal changes in the documentation rate of

neurological findings by the same physician in ischaemic stroke patients during hospital stays. We also evaluated differences in the documentation rate of any neurological finding in stroke patients between internists and neurosurgeons. Given their specialty training and interest in neurology, neurosurgeons might document neurological findings more frequently than internists.

METHODS

Study design and participants

A retrospective medical chart review was conducted to assess data obtained between September 1, 2014 and June 30, 2017 at Tochigi Medical Center, a 350-bed acute care hospital in the Tochigi prefecture of Japan. Since September 2014, all medical records have been electronic in our hospital. We chose a retrospective study design because prospective research can introduce the Hawthorne effect,[15] which affects physicians' documentation in medical records. All consecutive patients aged 18 years old or older who were admitted with acute ischaemic stroke as a primary diagnosis, survived and stayed in our hospital at least seven days were included. We excluded patients who died because of other factors, such as non-neurological disease

and terminal care, which might affect the documentation of neurological findings. Patients whose principal physicians changed during the hospital stay were also excluded. Up to 10 patients per physician were included. The purpose of the study was to characterize temporal changes in the documentation rate of neurological findings in ischaemic stroke patients by a single principal physician during a hospital stay. We also evaluated differences in the documentation rate of neurological findings between internists and neurosurgeons on each hospital day.

Usual care

In our hospital, consultation with a neurologist (T.K.) from an academic hospital once per week is possible; however, there is no ward neurologist. Therefore, either internists or neurosurgeons care for most acute ischaemic stroke patients without consultation with neurologists. All internists included in this study had received formal training for neurology during one or two months while in their junior residency. No internists included in this study had received additional formal training for neurology. However, all of the internists had cared for stroke patients on a regular basis in usual care. These practices are common in Japan, and approximately half of hospitals in Japan have no neurologists, even in certified training institutions such as the Japan

Neurosurgical Society, the Japanese Society of Neurology, and/or the Japan Stroke Society.[16] Furthermore, non-neurologists often care for acute ischaemic stroke patients even in hospitals with neurologists in Japan. During this study period, the average hospital stay of acute ischaemic patients (excluding those with a transient ischemic attack) was 25.1 days, and their in-hospital mortality was 7.0%. These rates were similar to those in other Japanese hospitals.[16, 17] This mortality in acute ischemic stroke patients was also similar to data from other countries.[18]

In our hospital, acute ischaemic stroke patients are randomly admitted to either the internal medicine or neurosurgical ward. However, stroke patients requiring surgery or interventional radiology are admitted to the neurosurgery ward. In most cases, these stroke patients are treated by a single principal internal medicine or neurosurgery physician without handoffs from admission to discharge. Additional physicians rarely examine or document neurological findings in these stroke patients. Therefore, we could evaluate temporal changes in the documentation rate of neurological findings by a single physician. Furthermore, in Japan, the mean length of hospital stay among acute stroke patients is approximately 30 days,[16, 17] which is longer than in other countries.[18] Thus, in most stroke patients, we could also evaluate temporal changes in the documentation rate of neurological findings during at least seven consecutive days.

We assumed that the documentation rate would dramatically decrease after the second day and would thereafter change at a lower rate. Hence, even a short-term observation period was enough to evaluate the documentation rate of neurological findings. To reduce the effect of the day of the week at admission,[19] we selected a seven-day evaluation period.

Characteristics

Patient information, including age, sex, and duration of hospital stay, was retrieved from medical records obtained at the time of each patient's admission. Physician-related information, including age, sex and specialty, was also retrieved from the database of Tochigi Medical Center.

Outcome measures

One of authors (J.K.) evaluated the medical records of all included patients. The primary outcome was the documentation rate of any neurological finding in ischaemic stroke patients by physicians on each hospital from the day of admission to the seventh day. We also evaluated the documentation rate of neurological findings at discharge (within the 24 hours before discharge). Neurological findings were classified as one of

eight categories (consciousness, mental status, cranial nerves, motor function, sensory function, coordination, reflexes, and gait) based on a previous study.[2] We allowed any documentation of neurological findings regardless of the quality of the examination. However, some documentations, such as "no change in neurological findings" and "no change", were not allowed because they often lacked information regarding which neurological findings were not different and to the extent of the examination. Documentation such as "no change for right hemiplegia" was allowed though it was low quality because it lacked the quantity of neurological findings. Furthermore, documentation of only a total score on the National Institute of Health Stroke Scale (NIHSS) was not allowed, although documentation of the detailed contents of NIHSS was allowed. Documentation of neurological findings by health care providers, including physicians, other than the principal physician was excluded because we sought to evaluate only documentation by a single principal physician.

Statistical analysis

We did not formally calculate sample size because the primary objective was to define the characteristics of neurological documentations by physicians in ischaemic patients. However, we expected a dramatic reduction in the documentation of

neurological findings and therefore selected 10 patients per physician. Assuming that the documentation rate of any neurological finding would be 95% on admission and lower than 40% after the second hospital day, approximately 10 patients per physicians was needed to achieve a significance level of 0.05 with a power of 0.8. To minimize the effect on outcomes of a few physicians caring for many patients, only up to 10 patients per physician were included.

The baseline and demographic characteristics of patients and physicians were summarized using standard descriptive summaries. For the primary objective, we determined the documentation rate of any neurological finding in ischaemic stroke patients on each hospital day. For outcomes on each hospital day, 95% confidence intervals (CIs) were calculated. For the secondary objective, to evaluate the difference in the documentation rate of neurological findings on each hospital day between internists and neurosurgeons, we used Fisher's exact test. These analyses were performed using the Excel statistical software package version 2.11 (Bellcurve for Excel; Social Survey Research Information Co., Ltd., Tokyo, Japan), and the level of significance was set at 5%.

Patient involvement

No patients were involved in determining the research question or outcome measures nor were they involved in developing plans to design or implement the study. No patients were asked for advice during the interpretation or writing up of the results. There are no plans to disseminate the results of this research to study participants or the relevant patient community.

RESULTS

We identified 474 consecutive acute ischaemic stroke patients who were cared for by 29 physicians during the study period. Forty-six patients (9.7%), including nine patients who had died, were excluded due to discharge before the seventh hospital stay. Of the remaining 428 patients, 172 who were cared for by 27 physicians (19 internists and 8 neurosurgeons) met our inclusion criteria. Among these 172 patients, 105 were discharged to home, 40 to rehabilitation facilities, and 27 to other hospitals or long-term care facilities. The baseline characteristics of the patients and physicians are presented in Table 1.

Table 1. Characteristics of patients with acute ischemic stroke and physicians. Values are shown as numbers (percentages) unless stated otherwise.

	Total	Neurosurgery	Internal Medicine
Physicians, n = 27			
Mean (SD) age (years)	35.5 (7.8)	41.9 (11.0)	32.8 (3.8)
Men	22 (81.5)	7 (87.5)	15 (78.9)
Mean (SD) experience of doctor (years)	8.5 (7.5)	14 (10.9)	6.2 (3.3)
Patients, n = 172			
Mean (SD) age (years)	75.1 (11.5)	74.9 (11.6)	75.3 (11.5)
Men	93 (54.1)	38 (55.1)	55 (53.4)
Admission day of week			
Weekday	155 (90.1)	63 (91.3)	92 (89.3)
Weekend	17 (9.9)	6 (8.7)	11 (10.7)
Mean (SD) length of hospital stay (days)	27.1 (18.5)	25.3 (19.0)	28.4 (18.1)

Figure 1 shows the temporal changes in the documentation rate of any neurological finding in all patients according to the specialty of their principal physician. The documentation rate of any neurological finding was 94% (95% CI 91 to 98) at admission and 58% (95% CI 50 to 65) on day 2. However, the average documentation rate of any neurological finding from the third to seventh day was lower than 40%. Furthermore, the documentation rate was only 14% within 24 hours of discharge. The documentation rate of any neurological finding was significantly lower in the neurosurgeon-treated group than in the internal medicine-treated group on each hospital day but not at discharge.

Among the eight neurological finding categories, motor function was the most frequently documented during the initial seven hospital days (Table 2). Mental status,

209 reflexes and gait were documented in fewer than 50% of all patients during the same
210 period. Furthermore, after the third hospital day, these three components were
211 documented in fewer than 10% of all patients. At discharge, all categories of
212 neurological findings were documented in fewer than 10% of all patients.

213

214 **Table 2.** Temporal changes in the documentation rates of 8 categories of neurological
215 findings. Values are shown as percentages (95% confidence intervals).

	Day of hospital stay							
	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**	**On discharge***
Any neurological finding	94 (91 to 98)	58 (50 to 65)	35 (28 to 43)	40 (33 to 48)	32 (25 to 39)	30 (23 to 37)	23 (16 to 29)	13 (8 to 2
Level of consciousness	80 (74 to 86)	23 (16 to 29)	17 (11 to 23)	13 (8 to 19)	13 (8 to 19)	12 (7 to 16)	8 (4 to 12)	5 (1 to 9
Mental status	46 (38 to 53)	12 (7 to 17)	9 (5 to 14)	5 (1 to 8)	6 (3 to 10)	6 (3 to 10)	4 (1 to 7)	3 (1 to 6
Cranial nerves	84 (79 to 90)	35 (28 to 43)	19 (13 to 24)	22 (15 to 28)	15 (9 to 20)	13 (8 to 19)	10 (5 to 14)	6 (2 to 9
Motor function	92 (88 to 96)	45 (38 to 53)	28 (21 to 35)	31 (24 to 38)	22 (16 to 28)	22 (15 to 28)	16 (10 to 21)	7 (3 to 1
Sensory function	58 (51 to 66)	17 (12 to 23)	12 (7 to 17)	10 (6 to 15)	5 (2 to 9)	7 (3 to 11)	7 (3 to 11)	2 (0 to 4
Coordination	51 (44 to 59)	13 (8 to 19)	9 (4 to 13)	6 (2 to 9)	5 (1 to 8)	3 (0 to 5)	5 (1 to 8)	3 (0 to 5
Reflex	45 (37 to 52)	5 (1 to 8)	4 (1 to 7)	2 (0 to 4)	2 (0 to 5)	2 (0 to 5)	1 (-1 to 2)	1 (-1 to 2
Gait	17 (11 to 23)	5 (1 to 8)	3 (0 to 5)	4 (1 to 7)	4 (1 to 7)	4 (1 to 6)	2 (0 to 4)	3 (0 to 6

216 *Within 24 hours of discharge.

217

218 **DISCUSSION**

In this study, the documentation rate of neurological findings by principal physicians decreased to lower than 50% after the third hospital day during stroke care. Furthermore, the documentation of mental status, reflexes and gait was often omitted by principal physicians during routine stroke care, and the documentation rate of these three categories was extremely low after the third day. These results indicate that physician interest in neurological findings in stroke patients dramatically decreases after the third hospital day.

Among 8 categories of neurological findings, motor function was the most frequently documented in this study, is consistent with the results of previous studies.[20-22] Mental status and gait were documented less frequently, as the stroke textbook describes that these important neurological assessments are unfortunately often omitted in routine care.[7] Because cognitive impairment frequently occurs in stroke patients[23] and can be effectively treated with rehabilitation,[24, 25] the low documentation rate of mental status by principal physicians is problematic, although such documentation may not reflect physician awareness.

We did not expect that neurological findings would be more frequently documented in stroke patients in our hospital by internists than by neurosurgeons, and this result should be interpreted cautiously. Unlike in the internal medicine ward,

trained nurses often document NIHSS every day during routine stroke care in the neurosurgery ward of our hospital, and such thorough assessment by other health providers may reduce the need for neurosurgeons to document neurological findings. Furthermore, we did not evaluate the quality or volume of neurological findings. Given their specialty in neurology, neurosurgeons might be more likely than internists to document more detailed and important neurological findings. Further study is needed to investigate whether a physician's specialty affects documentation.

Strengths and weaknesses of the study

To the best of our knowledge, this is the first study to evaluate temporal changes in the documentation of neurological findings by the same physician in stroke patients. In our hospital, in most cases, a single principal physician cares for each acute ischaemic stroke patient. This allowed us to evaluate temporal changes in medical record documentation by the same physicians.

Its major limitation is that the extent of documentation does not necessarily reflect the interest of the recorder. Furthermore, in stroke patients, it is impossible to distinguish an interest in neurological findings from interest in a prognosis. In addition, the role of clinical documentation has changed in the modern era, and billing and

quality indicators affect medical record documentation.[26-28] However, the documentation of neurological findings during stroke care does not affect medical fees and is not considered a quality indicator in Japan. Therefore, billing for inpatient hospital care, litigation, and quality indicators have few effects on the documentation of neurological findings by physicians. Furthermore, documentation itself is also important. As William Osler said, "observe, record, tabulate, communicate".[27] We were unable to retrospectively learn or perform detailed discussions about brain function without access to the sequential documentation of neurological findings, and physicians who are more interested in neurological findings will more thoroughly document them.

Other limitations include the following. First, this study included a small sample size and was limited to a single centre in which stroke patients are admitted to neurosurgeons or internists. Therefore, our findings may not be applicable to hospitals in which stroke patients are admitted to a neurology ward. However, this practice is common in Japan,[16] and a previous German study also reported that acute ischemic stroke patients were admitted in the internal medicine ward in approximately half of 225 acute care hospitals that participated in a stroke registry.[29] Moreover, given that the number of neurologists is not sufficient worldwide,[30] our findings for

non-neurologists are important. Nonetheless, these findings should be confirmed in other settings, such as neurology ward in other countries. Second, it is uncertain whether a higher rate of documentation of neurological findings is associated with higher clinical skill and better patient outcomes. However, interest in stroke is associated with a more accurate clinical diagnosis of lacunar stroke.[31] Furthermore, poor documentation may mean poor monitoring, which causes a delay in awareness of acute changes in patient status. Therefore, poor documentation may result in worse patient outcomes because a delay in the response to an acute change in patient status is associated with increased mortality.[10] Third, we did not evaluate outcomes between the eighth hospital day and discharge, but given the very low rate of documentation of neurological findings within 24 hours of discharge, we are confident that the documentation of neurological findings continued to gradually decrease after the eighth hospital day. Fourth, we did not individually evaluate the documentation of other important neurological signs, such as neuro-ophthalmic findings and visual problems,[7] and we did not evaluate the thoroughness of medical histories, which is important. As C. Miller Fisher showed, in ischaemic stroke patients, the frequency and importance of transient ischaemic attacks can be determined from a thorough history of prodromal symptoms.[32] Fifth, a single observer evaluation might introduce bias and

affect our results. However, past studies reported good inter-rater reliability in audits of neurological finding documentation.[19, 22] Sixth, the prevalence of inappropriate copying and pasting[33] suggests that we may have overestimated clinically meaningful documentation. Seventh, we regarded two or more documentations per day as one documentation per day. Hence, we might have underestimated documentation by physicians. Finally, although a higher patient volume is associated with a lower rate of documentation of important information,[34] we did not consider the effect of work load on outcomes.

Meaning of findings

Several factors could have caused the observed reduction in the documentation of neurological findings after the third hospital day. First, the low documentation rate of neurological findings after the third hospital day might derive from the initial stable course of stroke patients rather than a loss of physician interest in neurological findings.[20] However, because neurological findings often change day by day in the early course of acute stroke,[35, 36] this possibility seems unlikely. Second, fatigue might occur in the documentation of neurological findings by physicians. If so, a similar phenomenon could occur in the documentation of non-neurological findings in

non-neurological disease. Third, spending more time communicating, such as during neurological examinations of patients, is of utmost importance for learning about neurology and might reduce the documentation of neurological findings after the third hospital day. However, a previous study demonstrated acceptable concordance between documentation in medical records and actual performance during direct observations.[37] Furthermore, in previous studies, time spent communicating with patients and direct patient care were not affected by time spent during medical record documentation.[38, 39] Fourth, participation in annual meetings during conferences and holidays could affect medical record documentation.

Although these factors might have affected our findings, physicians interested in neurological findings are more likely to frequently document neurological signs regardless of their fatigue, and the temporal reduction in documentation observed in our study is considered a reflection of loss of physician interest. Nonetheless, further study is needed to determine whether the low documentation rate after the third hospital day is truly due to a lack of physician interest in neurological findings.

Implications for clinical practice

C. Miller Fisher described many syndromes and mechanisms using thorough neurological examinations and observations of stroke patients.[40] One of his significant contributions was an understanding of the relationship between carotid artery disease and ischaemic stroke. Before his work, approximately 55% of ischaemic strokes were thought to be caused by vasospasm.[41] When the first key patient who gave him an initial clue died while he was away for a weekend, the resident on call for the patient did not request an autopsy. When Fisher asked the medical staff why they did not request an autopsy, he was amazed that the resident on call did not consider it necessary.[32] This episode reflects a gap in interest in stroke patients between Fisher and the resident. Unlike Fisher's era, modern imaging tests provide us a more detailed localization of neurological symptoms, especially in stroke patients. Hence, our findings are disappointing even if they truly indicate a rapid loss of post-admission interest in stroke patients by physicians. We propose that now is the time for physicians to relearn about neurology stroke by stroke.[42]

CONCLUSIONS

The documentation rate of neurological findings by physicians in usual stroke care decreased to lower than 50% on the third hospital day and subsequently continued

to decrease. Given the importance of learning and monitoring temporal changes in neurological symptoms in stroke patients, further study is needed to determine whether the low documentation rate after the third hospital day was caused by a lack of physician interest in neurological findings or other factors.

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Competing interests: All authors have completed the ICMJE unified disclosure from competing interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author). All authors declare they have no financial relationships with any organisations that might have an interest in the submitted work and no other relationships or activities that could appear to have influenced the submitted work.

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Ethics approval: This study was approved by the Medical Ethical Committee of Tochigi Medical Center (protocol No. 29-14) and was performed in accordance with the Declaration of Helsinki. This study was also conducted in accordance with the Ethical Guidelines for Epidemiological Research in Japan. We were not required to obtain individual informed consent because we used de-identified data obtained from medical records and did not contact the patients. According to Japanese Ethical Guidelines, we did display a poster in the waiting room of the hospital to provide information about the collection and use of data for this study and the protection of personal information.

Data sharing: Data sharing is not applicable because we did not receive informed consent for data sharing from the participants. The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

Transparency: The lead author (JK) affirms that this revised manuscript is an honest, accurate, and transparent account of the study being reported, that no important aspects of the study have been omitted, and that any discrepancies from the study originally planned have been explained.

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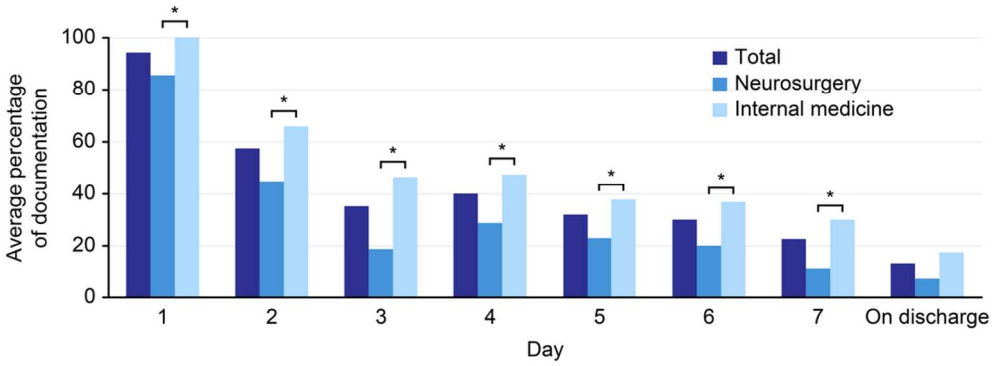
Fig 1. Temporal changes in the documentation rate of any neurological findings in 172 ischaemic stroke patients during hospital stay.

*p-value < 0.05



Temporal changes in the documentation rate of any neurological findings in 172 ischaemic stroke patients during hospital stay.

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STROBE (Strengthening The Reporting of OBservational Studies in Epidemiology) Checklist

A checklist of items that should be included in reports of observational studies. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Section and Item	Item No.	Recommendation	Reported on Page No.
Title and Abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/Rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study Design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-9
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	N/A
		Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls	N/A
		Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants	5-6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed	N/A
		Case-control study—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9

Section and Item	Item No.	Recommendation	Reported on Page No.
Data Sources/ Measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-9
Bias	9	Describe any efforts to address potential sources of bias	5-10
Study Size	10	Explain how the study size was arrived at	9-10
Quantitative Variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10
Statistical Methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9-10
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A N/A N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive Data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome Data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	N/A
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	12-13

Section and Item	Item No.	Recommendation	Reported on Page No.
Main Results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12
		(*b*) Report category boundaries when continuous variables were categorized	12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other Analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12-13
Discussion			
Key Results	18	Summarise key results with reference to study objectives	14-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18-20
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-18
Other Information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	22

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups cohort and cross-sectional studies.

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