

Improving health care for stroke patients.

Reorganizing a stroke unit applying Lean methodology.

MED-3950 5.-årsoppgave - Profesjonsstudiet i medisin ved Universitetet i Tromsø

Medisinstudent Ane Igland Nissen, MK-09

Veiledere:

Svein Ivar Bekkelund, avdelingsoverlege dr. med. Nevrologisk og Nevrofysiologisk
avd. UNN/Professor II IKM

Stein Harald Johnsen, overlege dr.med. Nevrologisk og Nevrofysiologisk avd.
UNN/Førsteamanuensis II IKM

Tromsø, 04.06.14



Contents

Summary	2
Background	2
Stoke - definition and epidemiology.....	2
Time is crucial in acute stroke treatment.....	3
Stroke care at the University Hospital of Northern Norway (UNN).....	4
LEAN.....	6
LEAN in the implementation of the new stroke unit.....	7
The new stroke unit.....	9
Purpose	10
Methods	10
Results	14
Discussion	18
Conclusion	22
References	23
Tables	25
Table 1: Social and clinical characteristics of 600 stroke patients.....	25
Table 2: In-hospital management of stroke patients.....	26
Table 3: Correlations between age and delay times.....	27
Table 4: End point parameters before and after reorganization.....	28
Table 5: Characteristics for patients with a patient delay > 24 t.....	29
Table 6: Characteristics for patients receiving thrombolytic therapy.....	30
Appendix	31
Appendix 1: “Prospektiv forløpsundersøkelse”	31
Appendix 2: Outline of processes of stroke care at UNN’s stroke unit.....	32

Summary

In 2009 stroke care in the University Hospital of Northern Norway was reorganized. Until that year the hospital provided stroke care in two separate locations: patients 75 years and older were treated in the Geriatric Unit of the Medical Department while those younger were treated in the Neurological Department. Waiting times in the emergency unit were long, especially for the older patients. With the objective of reducing waiting times and offering equal service to all patients, reorganization by merging the two stroke units into one acute stroke unit was carried out. Lean methodology was applied in this process. This thesis presents and evaluates the effect of the reorganization. A medical record review of patients admitted before and after the reorganization was performed. The main findings were reductions in waiting time for CT scans and for first doctor's visit for the geriatric patients. Furthermore, the proportion of patients receiving thrombolytic therapy increased. No major differences could be found concerning duration of hospitalization or discharge location. Thus, some of the objectives for the reorganization were achieved, while others were not.

Background

Stroke – definition and epidemiology

Stroke is the third most common cause of death and a leading cause of disability in the adult population [1]. In Norway, 15000 people suffer stroke annually, yielding an incidence of 3/1000 [2]. About three quarters experience their stroke for the first time while 25 % have previously been treated for stroke [2].

Ischemic strokes constitute the majority of strokes (85-90 %) while intracerebral haemorrhages account for 10-15 % and subarachnoid haemorrhages 3-5 % of cases [1]. Age is the single most important risk factor for stroke [3]. Other non-modifiable risk factors are gender, ethnicity and heredity. Modifiable risk factors are cardiac disease (atrial fibrillation), stenosis of the carotids, diabetes, high serum cholesterol, physical inactivity, hypercoagulopathies, smoking and high blood pressure, the two latter being the most important at population level [3-5].

Stroke mortality has decreased the last decade [6]. The decline has been attributed to a reduction in incidence and in case fatality as well as improved stroke treatment. Reduced incidence and case fatality are in turn related to better prevention of cardiovascular disease, such as blood pressure control and treatment for diabetes and dyslipidemia [6]. However, with an aging population total stroke incidents are estimated to increase by 50 % during the next 20 years [7]

Stroke is an emergency where treatment options are highly time dependent. Acute medical treatment for ischemic stroke is reperfusion (thrombolysis), which might reverse symptoms completely. Quick access to hospital is a prerequisite for being offered this treatment. Other modalities of stroke care include management of complications, rehabilitation, and prevention of recurrence (secondary prophylaxis). For better long-term outcome, decreased mortality rates and disability, the patients should be treated in a stroke unit (SU) as soon as possible [8] (Class I level a). Although the exact mechanism is not fully understood, the way of organizing the SU seems important for the improved outcome [9 10]. Randomized trials point to early and systematic diagnostic approach, involvement of multidisciplinary team and early mobilization as important factors [11]. Stroke units combining acute treatment and rehabilitation have shown to be the most efficient [12].

Time is crucial in acute stroke treatment

During an acute ischemic stroke the untreated patient loses approximately 1,9 million neurons each minute [13]. For comparison, the forebrain-consists of about 22 billion neurons [13]. These estimates accentuate the urgency of stroke treatment. Early reperfusion using intravenous recombinant tissue plasminogen activator (rt-PA) improves outcome in patients with acute cerebral ischemia [14]. Benefit of reperfusion decreases as time from onset of symptoms to treatment (OTT) increases [15]. The time window for treatment with rt-PA was firstly established at 3 hours from onset of symptoms, but was later expanded to 4.5 hours [14-16]. It is important to stress that an expansion of the time window does not imply that time waste can be allowed. The earlier the treatment is given, the better the outcome – justifying the slogan “time is brain”. In a pooled analysis of several trials of thrombolytic treatment in acute stroke (3700 patients) the authors found that “...approximately five

patients need to be treated 0–90 min, nine patients 91–180 min, or 15 patients 181–270 min after symptom onset for one of them to have an excellent outcome attributable to treatment.” [14].

The time window is still relatively narrow and this has restricted thrombolytic treatment since many patients do not arrive at the hospital within 4.5 hours. Stroke patients arriving at the University Hospital of Northern Norway (UNN) in 2011 had an average time from onset of symptoms to arrival at the hospital of 15 h and 45 minutes for men and 9 h and 56 minutes for women [17]. A major part of this is patient’s delay, i.e. the time from onset of symptoms to contact with health services. Also, long distances and at times challenging weather in the catchment area of UNN may cause further time delays. As time is the most crucial factor in acute stroke treatment, it is vital to reduce time delay in all steps of the acute treatment chain. For patients arriving hospital within the treatment window for thrombolytic therapy, efficiency in patient care is essential. The hospital must have a standardised process, well known to all relevant staff, for the assessment of stroke patients potentially eligible for reperfusion therapy.

Stroke care at the University Hospital of Northern Norway (UNN)

UNN receives 500-600 suspected stroke patients per year. The number with verified stroke is about 300. This number is estimated to rise by 50 % by 2030 [7].

Stroke care before May 2009:

Until May 2009, UNN had two different locations for stroke treatment: Patients aged 75 and older were treated in the Geriatric Unit at the Medical Department while patients under 75 years were treated in the Neurological Department. There were 7 beds reserved for stroke patients in the Geriatric unit, and 8 in the Neurological Department. These beds were located within the larger geriatric and neurological wards and were not in wards for stroke patients exclusively. Admitted patients under 75 years were examined by the neurological junior registrar on call, while the older were examined by the junior registrar internal medicine on call. Stroke treatment was based on local guidelines. Patients in need of further in-hospital rehabilitation after the acute phase were transferred to the Department of

Physical Medicine and Rehabilitation if under 75 years. Those 75 years and older remained in the Geriatric unit for rehabilitation.

In 2008, the hospital management decided to reorganize the stroke treatment at UNN and to establish a new common unit for all the stroke patients.

Why merge the stroke units?

There were several reasons for merging the two stroke units. Given the size of the hospital and the catchment area, more than one stroke unit was not considered expedient. It was by many considered unnecessary that a relatively small hospital should develop expertise in the same field in two different locations. Furthermore, it was felt unnatural to offer separate care for the same condition based on differences in age alone. In a 6-months prospective house-internal trial ("Prospektiv forløpsundersøkelse", Appendix 1) in 2007/2008, it was found that time from hospital admittance to arrival at treating ward (Time to treatment, TT) and duration of hospitalization varied substantially between the two wards (median TT 1 h 45 minutes for neurological and 2 h 40 minutes for geriatric patients). Figure 1 illustrates transfer time from emergency unit to stroke unit from 2008 to 2012.

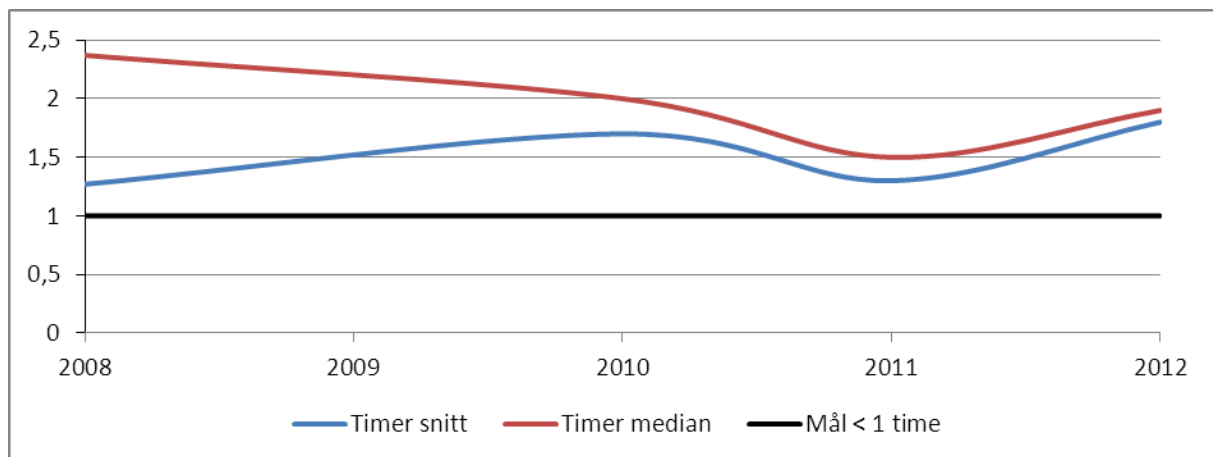


Figure 1. Transfer time from emergency unit to stroke unit

Moreover, the proportion of patients receiving thrombolytic therapy was low. In 2008, only 2-3 % of the patients were given this treatment (Figure 2). Enhancing the efficiency in reception of patients, clinical assessment, thrombolysis, and transfer to the stroke unit for qualified stroke care were central objectives for reorganizing the stroke care at UNN.

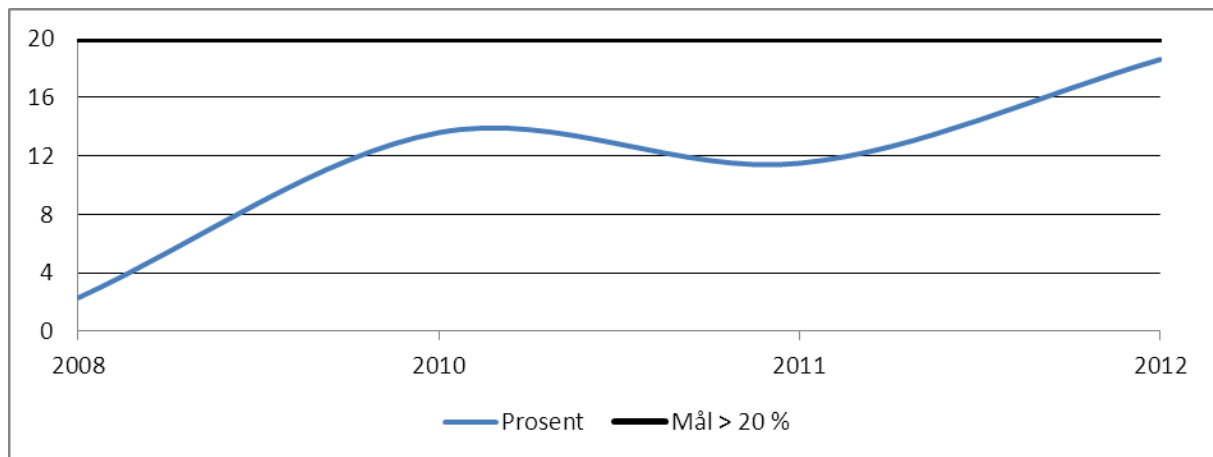


Figure 2. Proportions of ischemic stroke patients < 80 years given thrombolysis

To secure implementation of the new stroke unit (SU) and achieve the predefined goals, UNN used the Lean methodology. In 2008, the hospital management had decided to employ Lean method in projects of quality improvement. Reorganizing the stroke care became the first project at UNN applying the Lean method.

Lean

Lean is a method employed from the Toyota Production System. The “philosophy” of the method is to develop a system for learning of mistakes by identifying the problems, solve them and finally, standardizing the solutions. During the last 10 years, the method has been used to improve different health care units [18].

Lean method uses a number of tools in order to understand, evaluate and identify problems in a process, to manage problems and develop an improved and efficient process, standardize this process and later to improve error detection. In a first preparatory phase tools such as value stream mapping, process mapping and others are used to map and evaluate current status and thereby identify “bottlenecks” and unnecessary use of resources. This helps to set goals for the project. In the next phase of improvement work, the value stream map and other lean tools contribute to develop an outline of the ideal process/flow. The next step is implementation of the improved process, for example a

changed flow chart for treatment of a certain group of patients, and measures necessary to reach and maintain the ideal practice. This may include education of staff, training in use of new procedures and routines, and flow charts. Furthermore, Lean tools may be used to improve error detection after implementation of a project.

Lean method emphasizes the involvement of both staff and management in a team approach to problem solving. This contributes to a better shared understanding of the process and better engagement and collaboration of staff of different professions in the quality improvement work [18].

In health care Lean method is used to streamline and assure quality in a “patient value flow”, with a main focus on improving quality but also attempting to eliminate inappropriate use of resources. A literature review of 33 studies of lean application to healthcare by Mazzocato et al found that “areas of improvement included time-savings and timeliness of service, cost reduction or productivity enhancement, and several quality aspects including reduction in errors or mistakes, improved staff and patient satisfaction and reduced mortality” [18].

Lean in the implementation of the new SU

It was decided to focus on the intra-hospital part of the patient flow, and leave the pre-hospital and post-hospital stroke care to separate projects.

Objectives for this project were:

1. Better quality of stroke treatment:
 - a. by standardizing patient flow and pathways
 - b. by increasing the percentage given thrombolytic treatment
 - c. by reducing transfer time from arrival at the EU to the stroke unit
 - d. by reducing duration of hospitalization
2. More appropriate and less demanding work processes and better organization of work.
3. Increased shared responsibility and satisfaction among managers and employees.

Hospital employees of all professions involved in stroke care participated in the project. In a first phase a value stream map was made in order to map the current patient and process flow and identify problems, for example inefficiency. The value stream maps can be found

on the hospitals internal web pages [19]. Problems in the patient flow and areas of improvement that were highlighted were:

- In the EU: long waiting time for vacant examination rooms, for the doctor, for the lab to take blood samples and for bladder scanning (because of lack of this machine).
- In the Radiology Department: long waiting time for description of CT-images (not rt-PA candidates).
- In the stroke unit: lack of speech and language therapist, varying execution of early mobilization, swallowing test and nutritional screening.

After identifying problems/areas of improvement, these were prioritized according to what would have most impact and be easiest to change. It was decided to take the following measures in attempt to achieve the previously mentioned objectives:

- In order to improve quality of treatment to patients with acute stroke:
 - Standardising patient flow for stroke patients, implement one common flow for both geriatric and neurological patients.
 - Documenting parameters using check-lists.
 - Early mobilization (within the first 24 h)
 - Early start-up of multidisciplinary rehabilitation: first day meetings with doctor, nurse and therapists.
 - Daily “previsit/visit” with geriatrician, neurologist and care personnel.
 - At least one multidisciplinary meeting per week.
 - Raising the expertise in stroke care:
 - Multidisciplinary education once a week.
 - “Slagskolen” – a course in stroke care.
 - Implementing national guidelines (in 2010)
 - Establishing an outpatient clinic for TIA-patients. (This would liberate resources in the ward).
- In order to reduce transfer time from arrival at the EU to the stroke unit:
 - Implement a “prehospital stroke alert”
 - All patients should be examined by the neurological doctor on call

- Oxygen saturation, blood sugar and temperature should be examined already in the ambulance (from 01.10.09)
- In order to reduce duration of hospitalization:
 - Inform the communal health care services about the admitted patient on day 1 (“tidligmelde”, “early notice”).

The new stroke unit (May 2009):

It was decided to locate the new SU in the Neurological Department and organise it according to recommendations for stroke units in the literature. Local guidelines for treatment were replaced by national guidelines when these were available in April 2010. Acute stroke patients were from now on examined by the neurologic doctor on call. When notified about arriving patients, the doctor on call decided whether the “prehospital stroke alert” should be activated, alarming all staff involved in receiving patients eligible for thrombolytic therapy.

The SU had 15 beds. It was staffed by a multidisciplinary team consisting of 3 doctors (2 neurologists and 1 geriatrician), nurses, nursing assistants, physiotherapists, occupational therapists and a speech and language therapists. Nurses and nursing assistants received specialized education in stroke treatment (“Slagskolen”). Formal multidisciplinary meetings took place once a week. At these meetings, doctors, nurses and the involved therapists for the patient in question discussed the objectives for treatment and rehabilitation, and made plans for further follow-up and discharge. In addition, multidisciplinary “first day meetings” were held every day following admission of a new stroke patient. The objective of these meetings was to appoint the responsible doctor, nurse and therapists for the newly arrived patient. Checklists for treatment and care were applied as part of the quality assurance. Early mobilization and screening for swallowing problems was emphasized and was two of several parameters that care personnel started documenting in checklists.

Patients in need of further in-hospital rehabilitation after their stay in the acute stroke unit were transferred to the Department of Physical Medicine and Rehabilitation if younger than 75 years, and to the Geriatric unit if 75 years or older.

A table showing the outline of processes of stroke care at UNN's stroke unit is found in the appendix (Appendix 2).

Purpose

The main purpose of this thesis was to evaluate the effects the reorganization had on stroke care at UNN after 2009. This was done by studying a set of predefined Lean parameters as well as other parameters considered as useful indicators of efficiency in stroke care.

Methods

Sample selection:

This study comprised 600 patients with acute stroke hospitalized at UNN. A total of 300 patients hospitalized in the old stroke units at the Geriatric and Neurology departments up to May 2009 (Group 1) were compared with 300 patients hospitalized in the new and reorganized stroke unit (SU) after September 2009 (Group 2). Patients were identified through discharge diagnosis lists by using the current International Classification of Diseases (ICD-10). Diagnoses I63 (ischemic stroke), I64 (stroke, not specified as ischemic or haemorrhagic) and I61 (haemorrhagic stroke) were included in the search. Anonymised lists of stroke patients were provided by the hospital's center for analysis and the author (AIN) thereafter conducted a medical record review.

Exclusion criteria were as follows: having been transferred from other hospitals, getting the stroke diagnosis while hospitalized in departments other than the Geriatric or Neurologic and not being transferred to these departments for stroke treatment, being hospitalized post stroke only for medical work-up, and being hospitalized at the intensive care unit or the department of neurosurgery. For patients with several strokes during the study period only data from the first hospitalization were registered.

The new stroke unit was established in May 2009. The four-month period from May 1st till Sept 1st was an instable run-in period. Patients admitted in this interim period were not

included. The 300 patients in Group 1 are the latest admitted before 01.05.09 and the 300 in Group 2 are the firstly admitted after 01.09.09. To reach 300 registrations in each group the time spans for admissions were: 12.03.08-01.05.09 and 01.09.09-14.03.11, i.e. 14 and 16 months respectively.

Throughout this paper patients are dichotomized by age since those 75 years and older by UNN's convention are defined as geriatric and those under 75 are defined as neurological patients.

Data collection:

Variables:

A number of demographic variables were abstracted from the patients' medical records, including baseline and clinical characteristics.

Demographic characteristics included age, sex and marital status. The following risk factors for stroke were registered if they were documented either as codes on discharge or enlisted as present or previous disease in the admission record for the relevant hospitalization: previous stroke, hypertension, smoking, diabetes, hypercholesterolemia and heart disease (atrial fibrillation, coronary heart disease, other). Other risk factors such as over-weight were omitted because information about patients' weight seldom was registered in the medical record.

The route of admission was registered as one of the following: through the emergency medical service (ambulance services), through the patient's regular general practitioner, through a district out-of-hours emergency primary health care or through Tromsø out-of-hours emergency primary health care.

Patient delay was registered if symptoms had occurred more than 24 hours prior to arrival at the emergency department.

The following were defined as Lean parameters and were registered to allow evaluation of the reorganization project:

- As measures of efficacy/improvement of patient flow: process times such as
 - Time from arrival at EU to transfer to SU

- Percentages being received by the doctor within 1 and 2 hours after arrival at the EU
- Duration of hospitalization
- As measures to evaluate improvement of quality:
 - Percentages receiving thrombolytic therapy

However, not all of these parameters were possible to obtain through a retrospective medical record review only. Therefore the study is supplemented by the hospital's statistics, provided by the project coordinator, specialist nurse Ola Iversen.

Transfer time from EU to SU and time to first mobilization was not possible to obtain for the Group 1 patients, since this information was not registered and could not be retrieved from the medical records. These variables were however registered prospectively after establishment of the new SU (Group 2 patients) and some statistics are presented in the study. Since Transfer time from EU to SU could not be found retrospectively, and using the hospital's statistics for the time after reorganization would not have allowed comparison, we chose to register two time measures that we consider indicative of time use in the EU - *Doctor's visit delay time* and *CT delay time*.

Doctor visit delay time was calculated by subtracting the recorded time of arrival in the EU from the time of first doctor's visit (registered in the medical record, by the doctor or a nurse) when both times were available. Doctor's visit delay time could be calculated in 70 % of the patients.

CT delay was defined as the time from the patient presented in the EU, registered in the medical record by the nurse, to the time registered on the CT images. The radiology program Impax was used to find a reliable time for image investigations. CT delay time could be calculated for 81 % of the patients.

For patients with in-hospital strokes the delay times were not registered.

Thrombolytic therapy was registered. In calculations of percentages of patients receiving thrombolytic therapy, patients with haemorrhages are excluded. Likewise are patients > 80 years of age since these were not candidates for thrombolytic therapy until 2012 when the results of the IST-3 study were presented.

Duration of hospitalization was registered as the number of days patients were hospitalized in the stroke units at the Geriatric or Neurological Department (Group 1) before, and in the new SU after reorganization (Group 2). In Group 1, patients hospitalized in the Neurological Department were transferred to other departments for rehabilitation if further in-hospital rehabilitation was needed, while geriatric patients in need of rehabilitation received this in that same unit.

Discharge location was registered as one of the following: a. return to previous location (home or institution), b. return to previous location with ambulatory rehabilitation or with measures, for example facilitation of the home, c. discharge to a new institution for rehabilitation or d. discharge to a new institution for care. The geriatric patients in Group 1 (before 2009) who received rehabilitation in the geriatric unit were not registered as discharged to a rehabilitation institution, as they were after 2009 (Group 2).

Statistical analysis:

Statistical analysis was performed using SPSS version 21. A probability value less than 0.05 was considered statistically significant.

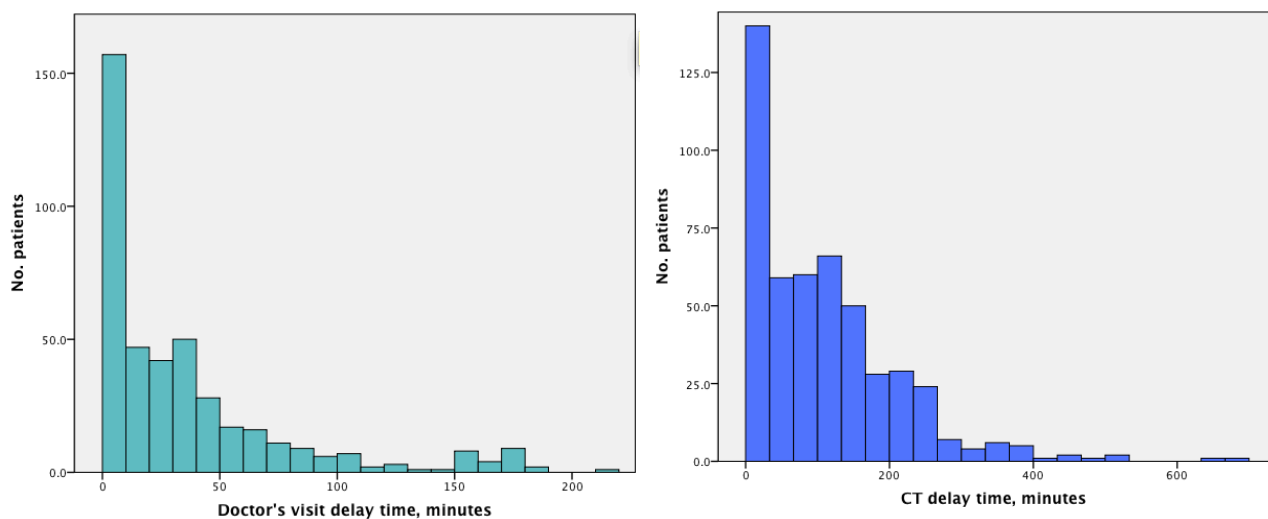


Figure 3: Distributions of CT and doctor’s visit delay time for the total of patients.

CT delay time, doctor’s visit delay time and duration of hospitalization were not normally distributed and the data contained extreme outliers. This is illustrated in Figure 3 for the delay parameters. Comparison of distributions between groups was therefore performed

using the Mann-Whitney U test. The non-parametric Levine's test was used to compare variance between groups. Variables with categorical values were analyzed using chi square test. Spearman's rank-order correlation was used in analysing associations between age and delay times. Regression analysis was used in adjusting for age and gender.

Approval for the project was granted by the UNN's Data Protection Official (Personvernombudet).

Working with this project

My supervisor had the idea for the project. Together we started working out the details of the project in spring 2013. First my supervisor and I designed the study and made a plan for how to carry out the project. During the preparatory phase, the literature was searched for relevant articles. I searched PubMed and the Google Scholar databases. After gaining a fair overview of the subject, a plan for review of medical records was made. Before the summer, the hospital's Department of Analysis (Økonomi og Analyse) provided us with a list of patients. I developed a SPSS work sheet. During the summer and autumn I reviewed the 600 medical records. In this phase there was a lot of trial and error. E.g. the first list of patients contained a wrong sample. This caused a delay. Altogether about 850 medical records were reviewed, of which 600 were relevant for this study. The relevant clinical data from these 600 patients were punched in the SPSS work sheet. I carried out the statistical analysis in SPSS during winter 2013 and spring 2014. After having worked out the results, the elaborate writing process was started.

Throughout the process I received good guidance and help from my supervisor dr. Svein Ivar Bekkelund. We met several times and communicated by e-mail. One month before deadline I got a new supervisor, dr. Stein Harald Johnsen. I do appreciate him stepping in on short notice.

Results

Table 1 presents social and clinical characteristics for the 600 stroke patients included in the study.

Men predominated in the group of neurological patients (64.7%) and women in the geriatric (54.8%). Median age was 62 years in neurological, and 83 years in geriatric patients.

The prevalence of dyslipidemia and hypertension was higher among neurological patients ($p < 0.005$ and $p = 0.002$). There were more smokers among the neurological patients ($p < 0.005$). However, information about smoking status was missing for 30 % of the geriatric and for 11 % of the neurological patients. Coronary heart disease, atrial fibrillation and the combination of these was present in more geriatric than neurological patients ($p < 0.005$). There were a higher proportion of infarctions among the neurological patients (90 % vs. 83 % in the geriatric).

37 % of patients were admitted directly to the hospital after dialling 113 (emergency medical service (AMK)). A considerable proportion of patients (11 % of the neurological and 18 % of the geriatric) were referred by their regular general practitioner (GP). 17.3 % were admitted more than 24 hours after onset of symptoms. Among those with a patient delay > 24 hours, there were more solitaire, more women, less haemorrhages, more referred by their GP, longer CT delay and Doctor's visit delay times, shorter duration of hospitalization and 30 days case fatality and duration of hospitalization was slightly lower (Table 5).

Table 2 displays in-hospital management of stroke patients before and after the reorganization process. The percentage being met by the doctor within 1 hour after arrival in hospital increased from 76.1 % to 85.8 % after the reorganization ($p = 0.012$). The largest increase was seen in the geriatric patients where 83.6 % of patients were met within 1 hour, compared to previous 67.6 % ($p = 0.004$). Also the proportion met by the doctor within 2 hours after arrival increased from 89.4 % to 96.6 % after reorganization ($p = 0.004$).

Doctor's visit delay time:

Neurological patients had shorter doctor's visit delay than the geriatric patients before ($p = 0.002$) and after ($p = 0.021$) establishment of the new SU (Table 2).

For all the stroke patients, *Doctor's visit delay time* was reduced from 25 to 14 minutes after the reorganization ($p = 0.002$). For the geriatric patients, the median delay time was reduced from 31 to 16 minutes ($p = 0.003$). For the neurological patients, the reduction was from 20 to 7 minutes.

CT delay time:

Neurological patients had shorter delay times for CT scans compared to geriatric before ($p < 0.0005$) and after ($p = 0.003$) reorganization of the new SU (Table 2). However, for geriatric patients, there was a significant reduction in median CT delay time of 40 minutes (142 vs. 102 minutes, $p = 0.001$) after reorganization. For neurological patients, CT delay time increased from 40 to 50 minutes, but this difference was not statistically significant ($p = 0.083$).

Women had a 40 minutes longer median CT delay time than men ($p = 0.001$). As shown in Table 1, there were more women among the geriatric patients and more men among the neurological. Female patients had a mean age of 76 years, median 80, while men had a mean age of 71 years, median 73.

Association age and delay times

A Spearman's rank-order correlation was run to assess the relationship between age and delay times for CT and doctor's visit. Preliminary analysis showed the relationships to be monotonic, as assessed by visual inspection of scatterplots. As shown in Table 3, there were small positive correlations between age and delay times, indicating a weak association. The correlations between age and delay times were lower after reorganization (Group 2).

Admission route and delay times:

Patients arriving at hospital after making contact directly with the AMK, were more promptly assessed than patients arriving via doctors (GP or an out-of-hours emergency primary health care). Median CT and doctor's visit delay times for those arriving directly were 60 and 5 minutes, respectively, vs. 111 and 31 minutes for those not calling 113 ($p = 0.001$ and $p < 0.0005$).

Duration of hospitalization:

Durations of hospitalization were not normally distributed and the data contained extreme outliers. We therefore present the median and not the mean. The durations of hospitalization were shorter among the neurologic than the geriatric patients. It was reduced for the geriatric and increased for the neurological patients after reorganization.

However, these numbers are not directly comparable since the durations for some of the geriatric patients prior to reorganization included rehabilitation and are therefore falsely high.

In order to make Group 1 and 2 somewhat comparable, days spent in in-hospital rehabilitation-wards were included in the duration of hospitalization. Inclusion of rehabilitation stay increased median duration of hospitalization in Group 2. What was found was in essence no significant change in durations of hospitalization.

Thrombolytic therapy:

Before reorganization (Group 1), 9.6 % (n = 13) of the neurological and 4.1 % (n = 2) of the geriatric patients received thrombolytic therapy. After reorganization, these numbers were 15.8 % (n = 18) and 7.8 % (n = 4), respectively.

The group of patients receiving thrombolytic therapy was younger than those not receiving it (mean age 67 vs. 74 years, $p = 0.001$). Median CT delay time for these patients was 28 minutes and median doctor's visit delay time 0 minutes. A higher proportion of these patients arrived directly at the hospital (76.9 %) compared to non-thrombolized patients (37.5 %), $p < 0.0005$. Furthermore, they were more often married or lived together with a partner. Further characteristics for patients receiving thrombolysis is given in Table 6.

Case fatality:

Case fatality rates after 30 days and 3 months were similar in Group 1 and 2 with a higher case fatality in the geriatric patients.

Discharge location:

More neurological than geriatric patients were discharged to "favourable locations", that is they returned to their previous location with or without ambulatory rehabilitation or measures. After reorganization, fewer neurological patients were discharged to their previous location (home or institution) without ambulatory rehabilitation or measures. For the geriatric patients, there was an increased proportion discharged to institutions for rehabilitation.

Discussion

The findings from this study imply that the Lean tools were useful in describing two patient flows, identifying bottlenecks, and were successful in designing one new patient flow. One standardized common flow for all stroke patients was implemented. A reduction in delay times was achieved for the geriatric patients. However, after reorganization they still had longer delay times than the neurological patients. The percentage receiving thrombolytic therapy improved. Objectives that were not achieved were reduced hospitalization length and increased proportion discharged to previous location.

The reorganization process, however, entailed changes beyond what we could measure through a medical record review. These include a more systematic approach in stroke care by doctors and care personnel, better routines, a better professional environment etc. Specific examples of better routines resulting in improved quality of care are early mobilization, swallow testing and nutritional screening that are now carried out systematically for all stroke patients. These parameters could not be registered in the medical record review. Therefore this study is far from being a complete evaluation of the reorganization. Its main focus has been on effects on time use.

It is important to emphasize that the aim of the Lean project was not to create an improvement only there and then, but on long term. This study evaluates a limited time period before and after the reorganization. There has been further improvement in several of the Lean parameters since, for example in thrombolytic therapy. Another important parameter, like mobilization within 24 hours, has now been fully implemented. According to the hospital's statistics mean time to mobilization was 5 hours in 2011. Unfortunately, these numbers do not exist for patients admitted before the reorganization.

Time use

The SU had an objective of a maximum time use in the EU of 60 minutes for stroke patients, and 30 minutes for candidates for thrombolytic therapy. The parameters registered in this study, CT delay and doctor's visit delay, do not give us an exact measure of time use in the emergency department, but are fair indicators. Before reorganization geriatric stroke patients waited about twice as long as the neurological patients, both for the doctor and for

the CT scan. After the reorganization, the geriatric patients' delay times were reduced, but were still significantly higher than for the neurological patients.

What caused the differences between neurological and geriatric patients in delay time? The reduction in differences after the reorganization indicates that organizational factors were part of the cause. Even though the service then was identical for geriatric and neurological patients, a difference in delay times persisted after the reorganization. It is pertinent to question why.

It seems natural to assume that the difference in delay time is related to age. The Spearman rank order correlation analysis indicated that increasing age was slightly associated with increasing delay time. However, this analysis does not adjust for other factors. The regression analysis showed that only 8 % of variation in delay time could be explained by age and gender. Therefore age alone seems not to be decisive. Probably there are differences in the two patient groups, other than age, but still related to age, which influence delay times. A natural and justifiable explanation that comes to mind is that younger patients have less co-morbidity and it is therefore reasonable to think that the "prehospital stroke alert" more often is set off before these patient's arrivals, than for elderly patients with contraindications to thrombolytic therapy often known already before arrival at the hospital. A previous student thesis analyzing stroke patients admitted in 2011 [17] found a trend towards younger patients having shorter transit time from the emergency unit to the stroke unit than older patients regardless of stroke severity. Possible explanations could be doctors perceiving it as more critical when young people suffer strokes, or young patients and/or their relatives appealing more strongly for prompt intervention and thereby assuring a faster advance in the acute treatment chain. Furthermore, older people more often present themselves with acute frailty and cognitive symptoms like confusion and delirium as well as other comorbidities like fever and infections, which makes the stroke diagnosis harder to get in the EU.

Women had a 40 minutes longer median CT delay time than men ($p = 0.001$). Female stroke patients were also older than the male patients. Regression analysis showed a small, but statistically significant correlation between gender and CT delay time. There are several factors believed or proved to affect delay time, for example severity of the stroke, amount of

work for the doctor on call and patient's co-morbidity [17]. A study on time use in stroke patients admitted at UNN in 2011 found that stroke severity was highly significant for transfer time from EU to SU [17]. When adjusting for this, there was no gender difference. It would be ideal also in this study to adjust for stroke severity, but unfortunately this variable was not registered. However, in the regression analysis, age and gender explained only 8 % of the variance in CT delay time, so it is more likely that factors like stroke severity explains the variability.

Patients who received thrombolytic therapy were efficiently assessed, judged by median CT delay (28 minutes) and doctor's visit delay (median 0 minutes). The objective of maximum time use in the emergency department of 30 minutes for candidates for thrombolytic therapy seem to have been achieved for the whole study period. The proportion of patients receiving thrombolytic therapy increased after reorganization. As a "prehospital stroke alert" was implemented and clinicians had become more proactive in giving thrombolytic therapy without delay, we feel certain that the increase is clinically significant although the statistics only indicate a trend ($p = 0.116$). The Stroke Register that was established in 2011 keep records of a large number of variables for all stroke patients consenting to be enrolled, and has precise statistics on thrombolytic therapy. These statistics show that the percentage of patients < 80 years receiving thrombolytic therapy has increased to 17 % in 2013, i.e. a slight increase since 2009-2011 (Group 2).

Patient delay

Although not a purpose of this thesis, we find it important to comment on the alarmingly high percentage of acute stroke patients with a patient delay > 24 hrs, i.e. contacting health services more than 24 hours after debut of symptoms. Furthermore, 10-20 % of admitted patients with acute stroke were referred by their GP, i.e. they did not contact emergency services directly. These findings indicate a major potential for improvement by educating the population in recognising stroke and seeking immediate medical help through the emergency services. Among those with a patient delay > 24 hours, many were solitaire, there were more women, many were referred by their general practitioner, and there was a trend toward less haemorrhages, lower 30 days case fatality and duration of hospitalization. This might indicate that these patients suffered less severe strokes. These characteristics are

consistent with other authors' findings [20-23]. Studies have shown that factors delaying hospital arrival are: Route of admission other than through the emergency services, lower level of consciousness or milder strokes, stroke during night-time, disability prior to stroke and living alone [20-23]. One study found increasing age being associated with delay, but this finding has been invalidated as due to confounding [22]. Distance to hospital did not have an influence on delay. These studies have, however, been conducted in areas of different demographical profiles than the region covered by UNN (Leicestershire, Minnesota, Houston and Milan). It would therefore be interesting to compare results if similar studies are conducted in our region in the future.

Discharge locations:

Fewer neurological patients were discharged to their previous location after the reorganization. A definite explanation is not at hand. It might be a consequence of better availability of rehabilitation facilities. On the other hand, it could be a consequence of a worse clinical outcome.

Also, more geriatric patients were discharged to institutions for rehabilitation after the reorganization. Likewise, this could be caused both by improved availability and by increased need, i.e. lower level of functioning. The most immediate explanation is however the differences in logistics before and after the reorganization. Before reorganising, geriatric patients in need of further in-hospital rehabilitation received this in the same Geriatric Unit, while they after the reorganization were transferred there from the SU and therefore are registered as discharged to rehabilitation.

Strengths and limitations

This study is limited by its retrospective nature. Errors of misclassification are expected to occur in both groups. Some variables that would have been useful, such as NIHSS-score as a measure of stroke severity, were not possible to retrieve in retrospect for patients admitted in the time period studied in this project.

The study focuses on differences between two groups separated in time, but registrations are spread over several months. Others events may have occurred in parallel and influenced our measures. For example, the time window for thrombolytic therapy was expanded from 3

to 4.5 h in January 2009. Another influencing factor could be changes in care delivered by the communal rehabilitation services.

Doctor's visit delay time could only be calculated for 70 % of patients, and CT delay for 81 %. When interpreting the CT delay times it is important to take into account that the CT delay is the time passed until the CT scan had *been performed*. This is because the most reliable time for the radiology investigation that was traceable in retrospect was the time found on the CT images. A CT delay time of 0 minutes should therefore be impossible. When several patients despite this were registered with a CT delay time of 0 minutes, this is because they were directly transported to the radiology department on arrival, and time of arrival at the EU was registered after or at the same time as the CT scan was performed. For some patients it is described in the doctor's admission journal that the patient went straight to the radiology department, and CT delay time is still 15 minutes. This indicates that it takes a certain time to transport the patient, move him or her to the CT bench and perform the investigation. CT delay times are in other words for most patients longer than what would have been registered in a prospective study. However, this accounts for both patient groups, i.e. they are comparable.

On certain parameters the groups were not directly comparable. This applies to duration of hospitalization and discharge location. The reason for this was differences in organization before and after the reorganization that affected registration of these parameters. We could not find any considerable changes in these variables over time, but neither can we exclude such changes.

Conclusion:

Stroke care was on several areas improved after reorganization in 2009. One standardized flow for all stroke patients was implemented. Geriatric patient's delay times were reduced. The difference in delay time between neurological and geriatric patients was reduced. Still there is potential for further improvement. Candidates for thrombolytic therapy were efficiently assessed, while the objective of time from EU to SU of maximum 60 minutes for those not candidates for rt-PA was not achieved. The percentage given thrombolytic therapy showed an increasing trend, but must still be improved in order to reach national goals of 20 %.

References

1. Helsedirektoratet. Nasjonale retningslinjer for behandling og rehabilitering ved hjerneslag, 2010.
2. Ellekjær H, Holmen J, Indredavik B, et al. Epidemiology of Stroke in Innherred, Norway, 1994 to 1996: Incidence and 30-Day Case-Fatality Rate. *Stroke* 1997;28(11):2180-84 doi: 10.1161/01.str.28.11.2180[published Online First: Epub Date]].
3. Panel, Sacco RL, Benjamin EJ, et al. Risk Factors. *Stroke* 1997;28(7):1507-17 doi: 10.1161/01.str.28.7.1507[published Online First: Epub Date]].
4. Mathiesen E, Njølstad I, Joakimsen O. Risikofaktorer for hjerneslag. *Tidsskr Nor Lægeforen* 2007 2007(127):748-50
5. Truelsen T, Begg S, Mathers C. The global burden of cerebrovascular disease, 2006.
6. Lackland DT, Roccella EJ, Deutsch AF, et al. Factors Influencing the Decline in Stroke Mortality: A Statement From the American Heart Association/American Stroke Association. *Stroke* 2014;45(1):315-53 doi: 10.1161/01.str.0000437068.30550.cf[published Online First: Epub Date]].
7. Statens Helsetilsyn. Scenario 2030. Sykdomsutvikling for eldre fram til 2030. www.helsetilsynet.no, 1999.
8. Stroke Unit Trialist's Collaboration. Organised inpatient (stroke unit) care for stroke. *Cochrane Database of Systematic Reviews* 2007;Art. No.: CD000197. DOI: 10.1002/14651858.CD000197.pub2.(4)
9. Gilligan AK, Thrift AG, Sturm JW, et al. Stroke Units, Tissue Plasminogen Activator, Aspirin and Neuroprotection: Which Stroke Intervention Could Provide the Greatest Community Benefit? *Cerebrovascular Diseases* 2005;20(4):239-44
10. Askim T, Bernhardt J, Løge AD, et al. Stroke patients do not need to be inactive in the first two-weeks after stroke: results from a stroke unit focused on early rehabilitation. *International Journal of Stroke* 2012;7(1):25-31 doi: 10.1111/j.1747-4949.2011.00697.x[published Online First: Epub Date]].
11. Langhorne P, Pollock A, Collaboration iCwTSUT. What are the components of effective stroke unit care? *Age and Ageing* 2002;31(5):365-71 doi: 10.1093/ageing/31.5.365[published Online First: Epub Date]].
12. Indredavik B. En effektiv slagenhet - hva er det? *Tidsskr Nor Lægeforen* 2007;9(127):1214 – 8
13. Saver JL. Time Is Brain—Quantified. *Stroke* 2006;37(1):263-66 doi: 10.1161/01.STR.0000196957.55928.ab[published Online First: Epub Date]].
14. Lees KR, Bluhmki E, von Kummer R, et al. Time to treatment with intravenous alteplase and outcome in stroke: an updated pooled analysis of ECASS, ATLANTIS, NINDS, and EPITHET trials. *The Lancet*;375(9727):1695-703 doi: [http://dx.doi.org/10.1016/S0140-6736\(10\)60491-6](http://dx.doi.org/10.1016/S0140-6736(10)60491-6)[published Online First: Epub Date]].

15. Hacke W, Donnan G, Fieschi C, et al. Association of outcome with early stroke treatment: pooled analysis of ATLANTIS, ECASS, and NINDS rt-PA stroke trials. *The Lancet* 2004;363(9411):768-74 doi: [http://dx.doi.org/10.1016/S0140-6736\(04\)15692-4](http://dx.doi.org/10.1016/S0140-6736(04)15692-4)[published Online First: Epub Date]].
16. Steiner A, Lyden P. Evolution of the Thrombolytic Treatment Window for Acute Ischemic Stroke. *Curr Neurol Neurosci Rep* 2010;10(1):29-33 doi: 10.1007/s11910-009-0076-8[published Online First: Epub Date]].
17. Kirste SN. Pre- og intra-hospital tidsbruk hos pasienter med akutte hjerneinfarkt innlagt ved Slagenheten UNN-Tromsø i 2011. Universitetet i Tromsø, 2012.
18. Mazzocato P, Savage C, Brommels M, et al. Lean thinking in healthcare: a realist review of the literature. *Quality and Safety in Health Care* 2010;19(5):376-82 doi: 10.1136/qshc.2009.037986[published Online First: Epub Date]].
19. :<http://intranett.unn.no/pilotprosjekt/category21923.html>
20. Harper GD, Haigh RA, Potter JF, et al. Factors delaying hospital admission after stroke in Leicestershire. *Stroke* 1992;23(6):835-8
21. Maestroni A, Mandelli C, Manganaro D, et al. Factors influencing delay in presentation for acute stroke in an emergency department in Milan, Italy. *Emergency medicine journal : EMJ* 2008;25(6):340-5 doi: 10.1136/emj.2007.048389[published Online First: Epub Date]].
22. Smith MA, Doliszny KM, Shahar E, et al. Delayed hospital arrival for acute stroke: the Minnesota Stroke Survey. *Annals of internal medicine* 1998;129(3):190-6
23. Menon SC, Pandey DK, Morgenstern LB. Critical factors determining access to acute stroke care. *Neurology* 1998;51(2):427-32

-

Tables

Table 1: Social and clinical characteristics of 600 stroke patients

	<75 years (neurological) n = 275	≥ 75 years (geriatric) n = 325	Total N = 600
Age, years, median	62.0	83.0	73.0
Men	178 (64.7)	147 (45.2)	325 (54.2)
Previous stroke	57 (20.7)	90 (27.7)	147 (24.5)
Hypertension	165 (60.0)	153 (47.0)*	318 (53.0)
Diabetes	51 (18.5)	63 (19.4)	114 (19.0)
Dyslipidemia	92 (33.5)	32 (9.8)*	124 (20.7)
Current smoker	100 (36.3)	41 (12.6)*	141 (23.5)
Coronary heart disease	55 (20.0)	123 (37.8)*	178 (29.7)
Atrial fibrillation	33 (12.0)	104 (32.0)*	137 (22.8)
Coronary heart disease and atrial fibrillation	8 (2.9)	35 (10.8)*	43 (7.1)
Other heart disease	32 (11.6)	41 (12.6)	73 (12.2)
Stroke type			
Infarction	247 (89.8)	271 (83.4)*	518 (86.3)
Hemorrhage	26 (9.5)	40 (12.3)	66 (11.0)
Not specified	1 (0.4)	13 (4.0)	14 (2.3)
Stroke onset outside of hospital	252 (91.6)	306 (94.2)	558 (93.0)
Stroke onset inside hospital	23 (8.4)	19 (5.8)	42 (7.0)
Patient delay > 24 h	53 (19.3)	51 (15.7)	104 (17.3)
Direct admission	101 (36.7)	123 (37.8)	224 (37.3)
Admission via doctor	150 (54.5)	183 (56.3)	333 (55.5)

Numbers (%) are presented.
* p < 0.05

Table 2. In-hospital management of stroke patients before (Group 1) and after (Group 2) reorganization of the new stroke unit

	<75 years (n=275)		≥75 years (n=325)		Total (N=600)	
	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
	n=151	n=124	n=149	n=176	n=300	n=300
Median CT delay time, min	40.0	50.0	142.0	102.0*	97.0	87.0
Median doctors visit delay time, min	20.0	7.0	31.0	16.0*	25.0	14.0*
Doctors visit delay time < 1 h, %	85.0	89.0	67.6	83.6*	76.1	85.8*
Doctors visit delay time < 2 h, %	95.3	97.6	83.8	95.9*	89.4	96.6*
Thrombolysis, n (%) ¹	13 (9.6)	18 (15.8)	2 (4.1)	4 (7.8)	15 (8.2)	22 (13.3)

*p < 0.05

¹ %: Patients with hemorrhages and patients > 80 years are excluded

Table 3. Correlation between age and delay times

	CT delay time and age	Doctors visit delay time and age
All patients	0,312*	0,171*
Group 1	0,397*	0,225*
Group 2	0,211*	0,155*

*p < 0.05 (Spearman)

Group 1 is previous to reorganizing stroke units

Group 2 is after reorganization

Table 4. End point parameters before (Group 1) and after (Group 2) reorganization of the SU

	< 75 years (n = 275)		≥ 75 years (n = 325)		Total (N= 600)	
	Group 1	Group 2	Group 1	Group2	Group 1	Group2
Duration of hospitalization in days, median (mean)	6 (10.0)	7 (9.3)	12 (19.8)	9 (12.2)	7 (14.9)	8 (11.0)
Duration of hospitalization including rehabilitation, median (mean)	6 (12.7)	7.5 (12.5)	12 (19.8)	10.5 (19.1)	7 (16.3)	9 (16.4)
30 days case fatality, n (%)	5 (3.3)	5 (4.0)	28 (18.8)	27 (15.3)	33 (11.0)	32 (10.7)
3 months case fatality, n (%)	8 (5.3)	6 (4.8)	35 (23.5)	32 (18.3)	43 (14.3)	38 (12.7)
Discharge location, n (%)						
Return to previous location	74 (49.0)	45 (36.6) ¹	40 (26.8)	40 (22.9)	114 (38.0)	85 (28.5) ²
Return with ambulatory rehabilitation	24 (15.9)	31 (25.2)	32 (21.5)	31 (17.7)	56 (18.7)	62 (20.8)
Institutional rehabilitation	45 (29.8)	43 (35.0)	29 (19.5)	66 (37.7) ³	74 (24.7)	109 (36.6) ⁴
Institution for care	5 (3.3)	1 (0.8)	21 (14.1)	17 (9.7)	26 (8.7)	18 (6.0)

¹p = 0.039 ²p = 0.014 ³p < 0.0005 ⁴p = 0.002

Table 5: Characteristics for patients with a patient delay > 24 h

	Patients with > 24 h delay n = 104	Patients with < 24 h delay n = 451	p-value
Age, years	73.0	74.0	0.406
Men	43.3	56.3	0.016
Single	60.2	51.1	0.095
Previous stroke	30.8	24.3	0,175
Admission through EMS	8.7	47.5	<0,0005
Stroke type			
Infarction	90.4	84.9	0.149
Hemorrhage	7.7	12.6	0.157
CT delay time, median, min	117	86	0.034
Doctor's visit delay time, median, min	43	15	<0,0005
Duration of hospitalization, median, days	8	13.3	<0,0005
30 days case fatality	3.8	12.6	0.010
3 months case fatality	7.7	14.8	0.055

% are presented.

Table 6: Characteristics of patients receiving thrombolytic therapy.

	rt-PA administered n = 39	rt-PA not administered n = 518	p-value
Age, years, mean	67	74	0.001
Men	65.1	53.3	0.135
Single	27.9	54.4	0.001
Admission through EMS	76.9	37.5	<0.0005
CT delay time, median, min	28	100	<0.0005
Doctor's visit delay time, median, min	0	25	<0.0005
Duration of hospitalization, median, days	11	7	0.211

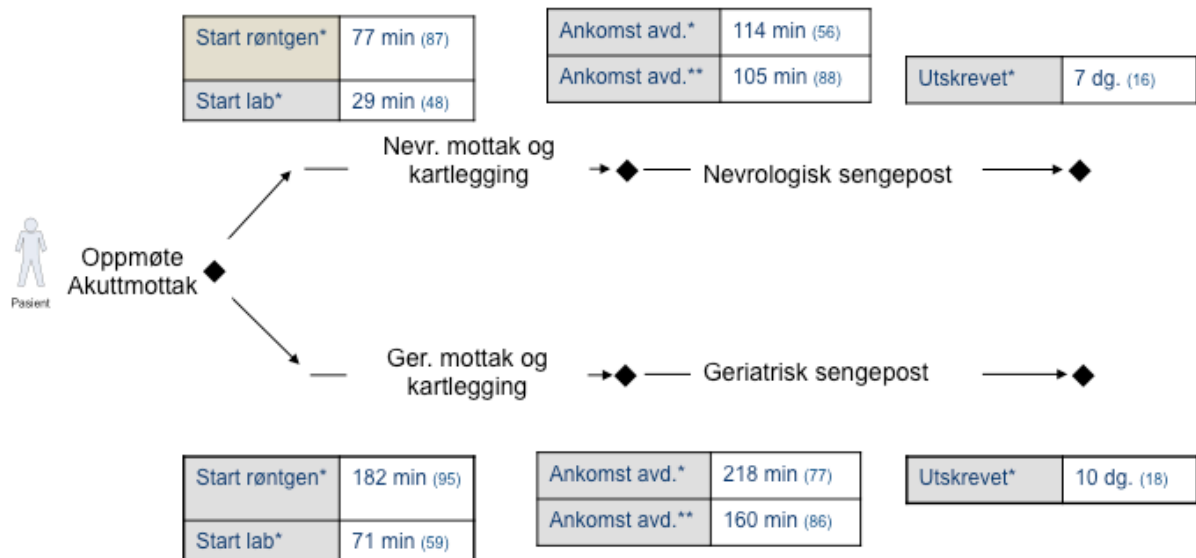
% are presented.

Appendix 1:

Statistics from the house internal trial "Prospektiv forløpsundersøkelse", registrations from 26.08.08 to 26.02.08. Source: the hospital's internal web pages.

Figure showing delay times before 2009:

Tidsbruk akuttmottak til slagenhet - nevrologiske (< 75 år) vs. geriatriske (≥ 75 år) slagpasienter



* Journalaudits: n=10 nevrologisk, n=9 geriatrisk
 ** "Prospektiv forløpsundersøkelse" 26.8.07 – 26.2.08: n=144 nevrologisk, n=95 geriatrisk

1

Regional nettverkssamling Bodø 09-10.06.11/SHJ

Table of transfer time from EU to SU:

	n	Median	SD	Min	Max
Nevrologisk	144	1:45	1:28	:00	9:30
Geriatrisk	95	2:20	1:26	:39	7:20

Appendix 2

Outline of processes of stroke care at UNN's stroke unit: diagnostics, observation, treatment and rehabilitation.

Time	Diagnostics	Observation	Medical treatment	Rehabilitation
Acute phase (0-24 h)	<ul style="list-style-type: none"> - Doctor examination - Radiology (CT) - ECG - Biochemistry 	<ul style="list-style-type: none"> - Repeating or continuously: BP, Pulse, SatO2, Temp, RR - Observation scale (NIHSS, GCS)/repeating assessment of consciousness and neurological disabilities - Assessment of swallow-function - Bladder scan 	<p>Maintain physiological homeostasis:</p> <ul style="list-style-type: none"> - Fluid balance/hydration - Optimal oxygen-saturation - Stable blood pressure - Avoid fever - Optimal blood glucose levels - Antithrombotic treatment: ASA (thrombolytic treatment for some patients) 	<ul style="list-style-type: none"> - Early mobilization - Stimulation - Repeated awakening/stimuli if reduces consciousness.
Sub-acute phase 1 (1st to 3rd day)	<ul style="list-style-type: none"> - Biochemistry - Carotid doppler US* - Echocardiogram* - MRI* - Other examinations* <p>* selected patients</p>	<ul style="list-style-type: none"> - Repeating or continuously: BP, Pulse, SatO2, Temp, RR - Assessment of swallow-function - Observation scale - Assessment of functioning in ADL - Looking for eventual complications 	<ul style="list-style-type: none"> - Continuation of medical treatment started the first day. - Commence secondary prophylaxis and optionally prophylaxis for DVT. - Nutrition per os or tube - Treat complications, ex bowel and bladder care. 	<ul style="list-style-type: none"> - Pressure area care - Mobilization adapted patients functioning: sit, stand, walk. - Rehabilitation training in daily activities, in movements, walking. - Multidisciplinary "First day meeting": appoint patient responsible staff, outline a plan.
Sub-acute phase 2 (3rd to 21st day)	<ul style="list-style-type: none"> - Further work-up if necessary - Identifying risk-profile 	<ul style="list-style-type: none"> - Assessment of functioning in ADL - If needed: assessment of cognitive functioning, speech/language - Awareness of complications 	<ul style="list-style-type: none"> - Further secondary prophylaxis - Continue treatment - Treat complications 	<ul style="list-style-type: none"> - Further rehabilitation training - Intensify training - Assess further rehabilitation potential and needs - Set goals for rehabilitation - Possibly home visits - Plan discharge - Establish collaboration with rehab-ward/primary health care services.