



Effect of dynamic light at the coronary care unit on the length of hospital stay and development of delirium: a retrospective cohort study

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Abstract

Background Disturbed circadian rhythm is a potential cause of delirium and is linked to disorganisation of the circadian rhythmicity. Dynamic light (DL) could reset the circadian rhythm by activation of the suprachiasmatic nucleus to prevent delirium. Evidence regarding the effects of light therapy is predominantly focused on psychiatric disorders and circadian rhythm sleep disorders. In this study, we investigated the effect of DL on the total hospital length of stay (LOS) and occurrence of delirium in patients admitted to the Coronary Care Unit (CCU). **Methods** This was a retrospective cohort study. Patients older than 18 years, who were hospitalized longer than 12 h at the CCU and had a total hospital LOS for at least 24 h, were included. Patients were assigned to a room with DL ($n = 369$) or regular lighting conditions ($n = 379$). DL was administered at the CCU by two ceiling-mounted light panels delivering light with a colour temperature between 2700 and 6500 degrees Kelvin. Reported outcome data were: total hospital LOS, delirium incidence, consultation of a geriatrician and the amount of prescribed antipsychotics. **Results** Between May 2015 and May 2016, data from 748 patients were collected. Baseline characteristics, including risk factors provoking delirium, were equal in both groups. Median total hospital LOS in the DL group was 100.5 (70.8–186.0) and 101.0 (73.0–176.4) h in the control group ($P = 0.935$). The incidence of delirium in the DL and control group was 5.4% (20/369) and 5.0% (19/379), respectively ($P = 0.802$). No significant differences between the DL and control group were observed in secondary endpoints. Subgroup analysis based on age and CCU LOS also showed no differences. **Conclusion** Our study suggests exposure to DL as an early single approach does not result in a reduction of total hospital LOS or reduced incidence of delirium. When delirium was diagnosed, it was associated with poor hospital outcome.

J Geriatr Cardiol 2018; 15: 567–573. doi:10.11909/j.issn.1671-5411.2018.09.006

Keywords: Delirium; Dynamic light application; Length of hospital stay

1 Introduction

Delirium is a serious and common mental disorder in older hospitalised patients characterised by a rapid change in mental status and inattention with a fluctuating course.^[1] In older hospitalised subjects, the prevalence of delirium can be as high as 50%, mainly in critically ill patients hospitalised at the intensive care unit.^[2–6] Patients with delirium experience sleep disturbances, prolonged hospitalisations, functional decline, higher antipsychotic drug dosages and high mortality rates up to 14% and 22% at one and six months respectively, and 35%–40% twelve months after hospital admission.^[7–12] The economic burden of delirium is substantial.^[13]

The exact pathophysiology of delirium remains poorly understood. Important risk factors for delirium include older patients, vision impairment, cognitive impairment, severe illness, pre-existing use of antipsychotic medication, sleep deprivation and disturbed sleep-wake rhythm.^[9,14] Both delirium and disturbed sleep-wake rhythm are linked to disorganisation of the circadian rhythmicity in the brain. The major circadian pacemaker, consisting of approximately 20,000 neurones in the suprachiasmatic nucleus (SCN), is located in the anterior hypothalamus and receives information from certain environmental factors, called Zeitgebers.^[14–17] Light activates the SCN through the retinohypothalamic tract.^[17–21] The light-dark cycle is the chief Zeitgeber and thus the most important factor for the human circadian rhythm.^[22]

Since light therapy is able to realign circadian rhythm disturbances, and elderly are less exposed to bright environmental light and photoreception deteriorates with aging,

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Received: May 14, 2018

Revised: August 29, 2018

Accepted: August 29, 2018

Published online: September 28, 2018

we hypothesised that the administration of light with a higher illuminance in a fluctuating course mimicking day and night [so-called Dynamic Light (DL)] should prevent or lessen the impact of delirium.^[20,23] DL has a much higher light intensity compared to regular hospital rooms, namely 1000–2000 and 250 lux, respectively. Knowledge regarding light therapy is nowadays limited to various psychiatric diseases, circadian rhythm sleep disorders and patients hospitalised at the intensive care unit (ICU).^[16,20,24]

The effect of DL on the incidence of delirium has been studied predominantly in ICU patients, i.e., patients at high risk for delirium. The quality of two of these studies was poor,^[4,5] and in one study most patients were sedated and had their eyes closed during the administration of DL.^[6] Patients hospitalised at our Coronary Care Unit (CCU) were not sedated or intubated during the hospital stay.

The aim of the present study was to evaluate the effect of DL on objective outcome measures, i.e., the total duration of hospital stay, the incidence of delirium and the reduction of prescription of antipsychotic drugs and other tranquilizers, among patients hospitalised at the CCU. Patients admitted to the CCU are generally less ill compared to ICU patients. However, they suffer from complex cardiac diseases with comorbidities potentially provoking delirium. A delirium incidence of 31.7% has been described in patients with acute decompensated heart failure hospitalised at the CCU.^[25]

To our knowledge, this is the first study evaluating the effect of DL on objective outcome measures in a large cardiac cohort.

2 Methods

The current study was performed in accordance with the ethical principles of the Helsinki Declaration and Good Clinical Practice.^[26] All patients were informed by written briefing. There were no patients who were not willing to take part in the present study. The study was approved by the Local Ethics Committee of the Viecuri Medical Centre.

2.1 Study design and patient selection

This was an observational cohort study among Dutch hospitalised patients at the CCU and cardiology ward. From May 2015 to May 2016, data from all eligible patients aged 18 years and older admitted to the CCU were collected. The minority of the patients transferred to a ward other than the cardiology ward were also included in the present study.

Since there is no evidence about the relation between the duration of DL administration and the effects on hospital outcomes, we included patients with a length of stay at the

CCU (CCU LOS) for at least 12 h. Patients were excluded if the total length of hospital stay (hospital LOS) was less than 24 h.

According to standard hospital procedures, patients were assigned to a room equipped with regular lighting conditions (fluorescent light tubes) or a room with DL. Altogether, fourteen rooms were available. Seven rooms were equipped with DL and seven rooms with regular lightning condition. Seven rooms had windows facing the north and seven facing the south. Since the rooms alternated each other with DL and conventional fluorescent light, the influence of daylight on the study results was minimalized. Other room characteristics, e.g., interior, space and equipment, were similar in all rooms.

Since there is a clear association between delirium and age and the effects of DL were expected to be greater when duration of DL administration increased, subgroup analyses were performed. These predefined subgroups included patients with: (1) CCU LOS 12–24 hours and age 18–70 years, (2) CCU LOS 12–24 h and age ≥ 70 years, (3) CCU LOS ≥ 24 h and age 18–70 years, and (4) CCU LOS ≥ 24 h and age ≥ 70 years.

2.2 DL system

In 2016, seven DL rooms were created in Viecuri Medical Centre and were equipped with an artificial daylight system consisting of a ceiling-mounted LED panel per room providing general lighting with a correlated colour temperature ranging from 2700 K to 6500 K. Due to practical and financial issues not all rooms at the CCU could be provided with the DL system. The vertical illuminance at eye level was measured by a photometer and reached peak values of 750 lux. The nurses were instructed to switch on the light during daytime as long as possible. Patients in the control group were exposed to standard lighting conditions.

2.3 Data collection

Demographic characteristics including patient's age, sex, indication of hospitalisation, various aspects of medical history and risk factors for delirium were obtained. Furthermore, data regarding the duration of hospital stay, consultation of geriatrician, the development of delirium and the amount of prescribed drugs treating delirium were collected.

To diagnose delirium, an in-hospital policy was used (Figure 1). Obtained data according to standard hospital procedure were: a pre-screening tool (Table S1), the Dutch version of the Delirium Observation Screening Scale (DOSS) (Table S2) and the Confusion Assessment Method

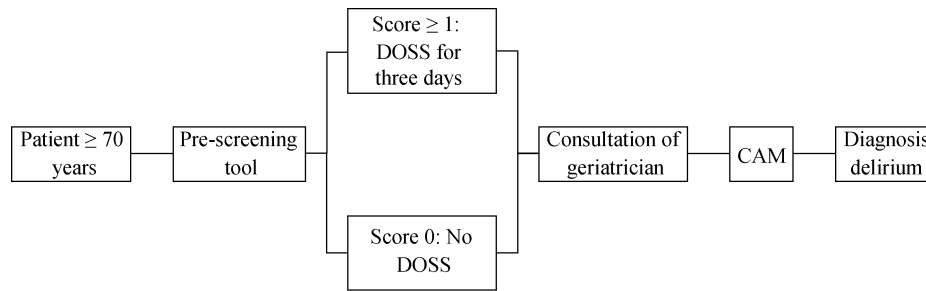


Figure 1. Flow chart in-hospital policy for the assessment of delirium. CAM: confusion assessment method; DOSS: delirium observation screening scale.

(CAM) (Tables S3 and S4). Delirium subtypes (hyperactive, hypoactive, and mixed delirium subtypes) were determined by the geriatrician based on patient's mental state and behaviour.

2.4 Statistical analysis

For our power analysis, we calculated the mean total hospital LOS of patients aged ≥ 18 years and older admitted to the CCU from May 1 2014 to May 1 2015. This was 144.7 ± 131.5 h. Power analysis using this value showed a target sample size of 990 patients with a power of 80% and a two-tailed type I error of 5% to detect a reduction of 24 h in total hospital LOS.

For demographic and clinical variables, descriptive statistics for both the DL as the conventional light group were calculated. Mean \pm SD or medians with interquartile range (IQR) were presented.

Depending on skewness of data, the Pearson's chi-square, Fisher's exact test, Student's *t*-test and Mann-Witney test were used. Odds ratios (OR) were calculated to assess the strength of association of different risk factors for delirium.

All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS version 22).

3 Results

Between May 1 2015 and May 10 2016, a total of 5434 subjects aged 18 years and older were admitted to the hospital via the CCU. Of them, 748 were hospitalised at the CCU for at least 12 h and had a total hospital LOS for at least 24 h. None were excluded. 369 and 379 subjects were allocated to the DL and control rooms respectively. Of all included patients, 460 (61.5%) were male and mean age was 68.9 ± 13.5 years. Reasons for hospitalisation were acute coronary syndrome ($n = 441$; 59.0%), congestive heart failure ($n = 110$; 14.7%), rhythm disorders ($n = 86$; 11.5%), non-specific chest pain ($n = 42$; 5.6%) or other ($n = 69$; 9.2%). Risk factors for delirium, such as dementia, previous cognitive disturbances, comorbidities, substance abuse and

nutritional status were examined. In general, there were no statistical differences for demographic variables and risk factors for delirium between both groups could be found, as stated in Table 1.

We calculated the CCU LOS by subtracting the date and time of admission from the date and time of transfer to the cardiology ward. This gave an impression of the exposure time to DL. The median CCU LOS was 26.4 (20.0–42.7) h. Median total hospital LOS varied widely with a median duration of 100.5 (70.8–186.0) in the DL group and 101.0 (73.0–176.4) in the control group ($P = 0.935$, Table 2). Furthermore, the incidence of delirium (5.4% in the DL group vs. 5.0% in the control group) and in-hospital mortality (3.5% in the DL group vs. 3.4% in the control group) did not differ between both groups. In the DL group, more patients were treated with haloperidol compared to the control group (21 vs. 14). However, there was no difference between the total number of patients that received pharmaceutical treatment for delirium (26 vs. 26). The incidence of QTc prolongation was similar in both groups.

Outcome measures were also calculated for different subgroups (Table 3). These subgroups included: (1) CCU LOS 12–24 h aged 18–70 years ($n = 152$), (2) CCU LOS ≥ 24 h aged 18–70 years ($n = 218$), (3) CCU LOS 12–24 hours aged ≥ 70 years ($n = 134$), and (4) CCU LOS ≥ 24 hours aged ≥ 70 years ($n = 244$). Although the hospital LOS in the last subgroup seemed shorter in the DL group (133.9 vs. 163.2 h), this difference was not statistically significant.

When delirium occurred, it was associated with poor hospital outcomes and increased mortality (Table 4). Of all included patients, 39 were diagnosed with delirium. They were significantly older ($P \leq 0.001$) and delirium occurred more often in patients with a history of dementia (OR = 3.2, 95% CI: 1.0–10.2), cerebrovascular accident or transient ischaemic event (OR = 3.2, 95% CI: 1.6–6.3), cognitive disturbances (OR = 15.0, 95% CI: 7.5–29.9), diabetes mellitus (OR = 3.3, 95% CI: 1.7–6.4) and kidney disease (OR = 6.0, 95% CI: 3.0–11.8). In only 11 (28.2%) patients, the CAM was taken and in one patient the geriatrician was not

Table 1. Baseline characteristics for patients aged ≥ 18 years admitted to the coronary care unit.

	DL (n = 369)	Control (n = 379)	P- value
Patient characteristics			
Age, yrs	68.4 (13.8%)	69.3 (13.1%)	0.382
Male sex	223 (60.4%)	237 (62.5%)	0.555
Reason of admission			
Acute Coronary Syndrome	223 (60.4%)	218 (57.5)	0.889
Congestive heart failure	54 (14.6%)	56 (14.8%)	
Rhythm disorders	41 (11.1%)	45 (11.9%)	
Non-specific chest pain	18 (4.9%)	24 (6.3%)	
Other	33 (8.9%)	36 (9.5%)	
Season at time of admission			
Spring	93 (25.1%)	95 (24.9%)	0.968
Summer	89 (24.0%)	94 (24.7%)	
Autumn	96 (25.9%)	102 (26.8%)	
Winter	93 (25.1%)	90 (23.6%)	
History			
Dementia	7 (1.9%)	12 (3.2)	0.270
Morbus Parkinson	0	2 (0.5%)	0.499
CVA or TIA	66 (17.9%)	64 (16.9%)	0.718
Cognitive disturbances	41 (11.1%)	44 (11.6%)	0.830
Diabetes mellitus	95 (25.7%)	82 (21.6%)	0.188
Kidney disease	94 (25.5%)	94 (24.8%)	0.832
Risk factors at admission			
Hearing impairment	68 (18.4%)	74 (19.5%)	0.702
Alcohol abuse	20 (5.4%)	20 (5.3%)	0.931
Nicotine abuse	76 (20.6%)	70 (18.5%)	0.463
Other drug abuse	0 (0%)	2 (0.5%)	0.499
MUST ≥ 2	19 (5.1%)	23 (6.1%)	0.585
Infection during hospitalisation	65 (17.6%)	79 (20.8%)	0.263
Diagnostic tools			
Pre-screening tool was taken	302 (81.8%)	320 (84.4%)	0.344
Elevated delirium score	60 (16.3%)	63 (16.6%)	0.638
Delirium score			
0	242 (65.6%)	257 (67.8%)	0.529
1	37 (10.0%)	38 (10.0%)	
2	15 (4.1%)	21 (5.5%)	
3	8 (2.2%)	4 (1.1%)	
DOSS was taken	72 (19.5%)	66 (17.4%)	0.460

Data are *n* (%) unless stated otherwise. COPD: chronic obstructive pulmonary disease; CVA: cerebrovascular accident; DL: dynamic light; DOSS: Delirium Observation Screening Scale; MUST: Malnutrition Universal Screening Tool; TIA: transient ischaemic event.

consulted. In addition, their median CCU and hospital LOS was significantly longer ($P = 0.027$ and $P < 0.001$, respectively), they more often received pharmaceutical treatment for delirium ($P < 0.0001$) and in-hospital mortality was higher (OR = 6.3, 95% CI: 2.4–16.6).

Table 2. Clinical outcomes for patients aged ≥ 18 years admitted to the coronary care unit.

	DL (n = 369)	Control (n = 379)	P- value
Delirium	20 (5.4%)	19 (5.0%)	0.802
Consultation of geriatrician	30 (8.1%)	31 (8.2%)	0.980
Prescribed medication			
Total	26 (7.0%)	26 (6.9%)	0.920
Haloperidol	21 (5.7%)	14 (3.7%)	0.039
Lorazepam	8 (2.2%)	11 (2.9%)	0.388
Lorazepam	0 (0.0%)	2 (0.5%)	0.490
CCU LOS, h	27.0 [20.4–43.1]	25.8 [19.8–41.6]	0.497
Hospital LOS, h	100.5 [70.8–186.0]	101.0 [73.0–176.4]	0.935
In-hospital mortality	13 (3.5%)	13 (3.4%)	0.945

Data are *n* (%) or median [IQR] unless stated otherwise. CCU: coronary care unit; DL: dynamic light; LOS: length of stay.

Table 3. Overview of clinical outcomes in four predefined subgroups.

Outcome measures	Subgroups	DL	Control	P- value	
Hospital					
LOS, h	CCU LOS 12–24 h	Age 18–70 yrs	88.5	84.5	0.55
		Age ≥ 70 yrs	116.3	121.5	0.641
	CCU LOS ≥ 24 h	Age 18–70 yrs	95.1	94.3	0.853
		Age ≥ 70 yrs	133.9	163.2	0.513
Delirium	CCU LOS 12–24 h	Age 18–70 yrs	0	0	-
		Age ≥ 70 yrs	3	6	0.500
	CCU LOS ≥ 24 h	Age 18–70 yrs	2	1	1.00
		Age ≥ 70 yrs	15	12	0.571
Prescribed medication	CCU LOS 12–24 h	Age 18–70 yrs	0	0	-
		Age ≥ 70 yrs	4	8	0.320
	CCU LOS ≥ 24 h	Age 18–70 yrs	2	1	1.00
		Age ≥ 70 yrs	20	17	0.630
Haloperidol	CCU LOS 12–24 h	Age 18–70 yrs	0	0	-
		Age ≥ 70 yrs	3	6	1.00
	CCU LOS ≥ 24 h	Age 18–70 yrs	2	1	-
		Age ≥ 70 yrs	16	7	0.015

Data are number or median represented with *P* values. CCU: coronary care unit; DL: dynamic light; LOS: length of stay.

4 Discussion

In this study, we were not able to find significant shortening of hospitalisation and reduction of delirium incidence when patients at the CCU were exposed to DL.

To our knowledge, this is the first study that gives insight into the effect of DL on the length of hospitalisation, the incidence of delirium and the prescription of antipsychotic medication and tranquilizers in a large cardiac cohort. Our hospital offered a unique setting at the CCU where all

Table 4. Patient characteristics and outcome measures in delirium versus no delirium group.

	Delirium (n = 39)	No delirium (n = 709)	P- value
Age, yrs	82.4 (7.8%)	68.2 (13.3%)	< 0.001
Reason of admission			
Acute coronary syndrome	21 (53.8%)	420 (59.2%)	0.008
Congestive heart failure	13 (33.3%)	97 (13.7%)	
Rhythm disorders	2 (5.1%)	84 (11.8%)	
Non-specific chest pain	0	42 (5.9%)	
Other	3 (7.7%)	66 (9.3%)	
History			
Dementia	10 (25.6%)	9 (1.3%)	< 0.001
CVA or TIA	15 (38.5%)	115 (16.2%)	< 0.001
Cognitive disturbances	23 (59.0%)	62 (8.7%)	< 0.001
Diabetes mellitus	19 (48.7%)	158 (22.3%)	< 0.001
Kidney disease	25 (64.1%)	163 (23.0%)	< 0.001
Risk factors at admission			
Hearing impairment	18 (46.2%)	124 (17.5%)	< 0.001
MUST ≥ 2	4 (10.3%)	38 (5.4%)	0.268
Infection during hospitalisation	25 (64.1%)	119 (16.8%)	< 0.001
Diagnostic tools			
Pre-screening tool was taken	37 (94.9%)	585 (82.5%)	0.045
Elevated delirium score	28 (71.8%)	95 (13.4%)	< 0.001
DOSS was taken	38 (97.4%)	100 (14.1%)	< 0.001
CAM was taken	11 (28.2%)	12 (1.7%)	< 0.001
Outcome measures			
CCU LOS, h	38.8 [24.1–68.2]	26.2 [19.9–42.5]	0.027
Hospital LOS, h	307.6 [140.9–435.5]	98.6 [70.8–169.8]	< 0.001
Prescribed medication	39 (100%)	13 (1.8%)	< 0.001
In-hospital mortality	6 (15.4%)	20 (2.8%)	0.001

Data are n (%) or median [IQR] unless stated otherwise. CAM: confusion assessment method; CCU: coronary care unit; CVA: cerebrovascular accident; DOSS: delirium observation screening scale; IQR: interquartile range; LOS: length of stay; MUST: malnutrition universal screening tool; TIA: transient ischaemic event.

rooms were fully identical apart from the type of illumination. Currently, there is a lack of evidence concerning the effect of Dynamic Light on hospital outcomes, occurrence of delirium and other secondary objective endpoints. Knowledge regarding the effects of light therapy on clinical outcomes remains mostly limited to psychiatric diseases, circadian rhythm disorders and ICU patients.

The lack of significant results on hospitalisation duration could be partly explained due to the low occurrence rate of delirium and the relatively short exposure time to DL. Also, measured lux levels were lower than expected.

Interestingly, a reduction of total hospital LOS was seen

favourable for the DL group in elderly patients who were prolonged exposed to DL, but was not statistically significant in subgroup analysis possibly due to too small subgroup sample sizes.

An unexpected finding was that haloperidol was prescribed more often in the DL group. However, the total number of pharmaceutically treated patients did not statistically differ between both groups. In other secondary endpoints no differences were demonstrated.

We demonstrated the high impact of delirium on hospital outcomes even in a cohort with a small incidence of delirium. Apart from the association between delirium and poor hospital outcomes, delirium also leads to an increased morbidity and mortality, institutionalisation and functional decline contributing to greater health care costs. Although we were not able to present positive effects of DL as a single therapy, other strategies to prevent delirium should be investigated, such as multi-strategy approaches combining noise reduction, light administration, the improvement of sleep and orientation. Probably light therapy is more effective in patients who already have a disrupted circadian rhythm, rather than to use it as a preventive therapy. However, this speculative since it is unclear if there is a direct relation between disturbed circadian rhythm and delirium.

Previous research regarding light therapy administration to hospitalised patients mainly focussed on subjective outcome measures, i.e., sleep parameters, depression scales and functional outcomes or was focused on the treatment of delirium rather than the prevention.^[9,10,27,28] These studies showed small improvements in sleep, functional outcomes and depression scores through bright light therapy in delirious hospitalised elderly. In previous unpublished in-hospital research, the effect of DL on mood and sleep quality in 45 patients was evaluated. Full data of 39 subjects (mean age 68.7 years old, male to female ratio 3: 1) was available. Sleep quality measured by the Richards-Campbell Sleep Questionnaire and mood disorder measured by the Hospital Anxiety and Depression Scale (HADS) were not statistically different between both the DL and control group.

The efficacy of light therapy on the incidence of delirium was evaluated by Taguchi, *et al.*^[4] and Ono, *et al.*^[5] in small sample sized intensive care unit patients (11 and 22 included patients, respectively). The incidence of delirium was reduced, but was not statistically significant (RR = 0.29, 95% CI: 0.07–1.25).

Recent research found no effect of DL on the incidence of delirium in 734 critically ill adult patients.^[6] In the DL group delirium occurred in 137 (38%) of 361 patients and 123 (33%) of 373 in the conventional light group (OR = 1.24, 95% CI: 0.92–1.68). However, the majority of the

included patients were sedated and had their eyes closed during a substantial duration of exposure to DL. Since the activation of the suprachiasmatic nucleus (SCN) is triggered through retinal ganglion cells,^[20] patients' eyes should be open to fully benefit from DL. In addition, the use of sedatives and anaesthesia can lead to circadian rhythm disturbances and is associated with delirium.^[29,30] In the current study, no patients were sedated and intubated during their total duration of hospitalisation. Still, we found no statistical beneficial effects of the solitary use of DL.

It should be noted that there are more factors influencing the risk of developing a delirium besides improving the sleep-wake cycle, such as efforts to minimize immobility, poor nutrition or dehydration, urinary retention, constipation, suboptimal pain management and alcohol withdrawal. Also, orientation should be improved by encouraging the use of glasses, hearing aids and other assistive devices.

Several limitations should be discussed. First, this was an observational cohort study. However, our patients were assigned to a room, irrespectively of health status and lighting condition. Blinding of the DL group was due to practical issues not possible.

Secondly, the exposure time to DL was short and could only be derived from the total duration of hospitalisation at the CCU. The amount of exposure to DL was not measured, which is a shortcoming of our study. The presented CCU LOS overestimates the total exposure time to DL, since patients were also admitted in the late evening and night when DL was switched off.

Third, the study did not include the intended amount of 990 patients during the proposed one-year duration of this study. Since only small and clinically not relevant differences between both groups were found after analysis, we decided not to prolong the study.

Fourth, observer bias could not be excluded since only one researcher included the patients and analysed the study results. However, we tried to be as objective as possible since most outcome measures were objectively measurable.

Lastly, delirium was verified by the CAM in only 11 of the 39 patients suffering from delirium and thus the CAM was hardly used in confirming delirium. Mostly, the geriatrician diagnosed delirium based on clinical features.

In conclusion, the administration of DL as a single strategy approach did not result in reduced total hospital LOS, a lower incidence of delirium or less prescribed antipsychotic medication and tranquilizers. A non-significant reduction of almost 30 h in elderly patients who were prolonged exposed to DL was found. The significant impact of delirium justifies further research to multi-strategy approaches to prevent delirium and prolonged hospitalisation of the increasing

admittance of fragile elderly to the hospital, such as improving sleep-wake rhythm, immobility, orientation in time and place, treatment of poor nutrition or dehydration, and noise reduction.

Acknowledgements

We thank Pedro Janssen for the data extraction from the Electronic Patient Record System, Reka Csepán-Magyar and the staff of the Division of Geriatric Medicine for the acquisition of geriatric related data. None of the acknowledged persons received any compensation.

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Table S1. Pre-screening tool of delirium.

The pre-screening tool of delirium is an instrument to assess the risk of developing delirium. At admission all patients 70 years and older were asked three questions routinely by bedside nurses. These questions included:

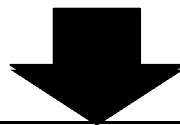
- Are you suffering from memory loss?
- Did you need help with personal care over the past 24 h?
- Were you confused during previous hospitalisations or during a previous period of illness?

Each positive answer was scored with 1 point, resulting in a delirium score from 0 to 3 (higher score indicates higher risk of developing delirium). In case of a delirium score ≥ 1 the DOSS was completed three times a day for three consecutive days.

DOSS: delirium observation screening scale.

Table S2. Thirteen-item delirium observation screening scale.

The patient	Day shift			Evening shift			Night shift			
	Never	Sometimes - always	Unable	Never	Sometimes - always	Unable	Never	Sometimes - always	Unable	
1 Dozes of during conversation or activities	0	1	-	0	1	-	0	1	-	Total score today (0–39)
2 Is easy distracted by stimuli from the environment	0	1	-	0	1	-	0	1	-	
3 Maintains attention to conversation or action	1	0	-	1	0	-	1	0	-	
4 Does not finish question or answer	0	1	-	0	1	-	0	1	-	
5 Gives answers that do not fit the question	0	1	-	0	1	-	0	1	-	
6 Reacts slowly to instructions	0	1	-	0	1	-	0	1	-	
7 Thinks to be somewhere else	0	1	-	0	1	-	0	1	-	
8 Knows which part of the day it is	1	0	-	1	0	-	1	0	-	
9 Remembers recent event	1	0	-	1	0	-	1	0	-	
10 Is picking, disorderly, restless	0	1	-	0	1	-	0	1	-	
11 Pulls iv-tubes, feeding tubes, catheters etc.	0	1	-	0	1	-	0	1	-	
12 Is easy or sudden emotional	0	1	-	0	1	-	0	1	-	
13 Sees/hears things which are not there	0	1	-	0	1	-	0	1	-	
Total score per shift (0–13)										
Doss final score = total score today / 3										



DOSS final SCORE	< 3	Not delirious
	≥ 3	Probably delirious

DOSS: delirium observation screening scale.

Table S3. The confusion assessment method instrument.

Acute onset

1. Is there evidence of an acute change in mental status from the patient's baseline?

Inattention^a

2. A. Did the patient have difficulty focusing attention, for example, being easily distractible, or having difficulty keeping track of what was being said?

Not present at any time during interview.

Present at some time during interview, but in mild form.

Present at some time during interview, in marked form.

Uncertain.

B. (If present or abnormal) Did this behavior fluctuate during the interview, that is, tend to come and go or increase and decrease in severity?

Yes.

No. Uncertain

Not applicable.

C. (If present or abnormal) Please describe this behaviour.

Disorganized thinking

3. Was the patient's thinking disorganized or incoherent, such as rambling or irrelevant conversation, unclear or illogical flow of ideas, or unpredictable switching from subject to subject?

Altered level of consciousness

4. Overall, how would you rate this patient's level of consciousness?

Alert (normal).

Vigilant (hyperalert, overly sensitive to environmental stimuli, startled very easily).

Lethargic (drowsy, easily aroused).

Stupor (difficult to arouse). Coma (unarousable). Uncertain.

Disorientation

5. Was the patient disoriented at any time during the interview, such as thinking that he or she was somewhere other than the hospital, using the wrong bed, or misjudging the time of day?

Memory impairment

6. Did the patient demonstrate any memory problems during the interview, such as inability to remember events in the hospital or difficulty remembering instructions?

Perceptual disturbances

7. Did the patient have any evidence of perceptual disturbances, for example, hallucinations, illusions, or misinterpretations (such as thinking something was moving when it was not)?

Psychomotor agitation

8. Part 1.

At any time during the interview, did the patient have an unusually increased level of motor activity, such as restlessness, picking at bedclothes, tapping fingers, or making frequent sudden changes of position?

Psychomotor retardation

8. Part 2.

At any time during the interview, did the patient have an unusually decreased level of motor activity, such as sluggishness, staring into space, staying in one position for a long time, or moving very slowly?

Altered sleep-wake cycle

9. Did the patient have evidence of disturbance of the sleep-wake cycle, such as excessive daytime sleepiness with insomnia at night?

^aThe questions listed under this topic were repeated for each topic where applicable.

Table S4. The confusion assessment method diagnostic algorithm.

Feature 1. Acute onset and fluctuating course

This feature is usually obtained from a family member or nurse and is shown by positive responses to the following questions:

Is there evidence of an acute change in mental status from the patient's baseline? Did the (abnormal) behavior fluctuate during the day, that is, tend to come and go, or increase and decrease in severity?

Feature 2. Inattention

This feature is shown by a positive response to the following question:

Did the patient have difficulty focusing attention, for example, being easily distractible, or having difficulty keeping track of what was being said?

Feature 3. Disorganized thinking

This feature is shown by a positive response to the following question: Was the patient's thinking disorganized or incoherent, such as rambling or irrelevant conversation, unclear or illogical flow of ideas, or unpredictable switching from subject to subject?

Feature 4. Altered Level of Consciousness

This feature is shown by any answer other than "alert" to the following question: Overall, how would you rate this patient's level of consciousness? (alert [normal], vigilant [hyperalert], lethargic [drowsy, easily aroused], stupor [difficult to arouse], or coma [unarousable])

The diagnosis of delirium by confusion assessment method requires the presence of features 1 and 2 and either 3 or 4.