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Clinical paper

Are changes in objective observations or the patient's subjective feelings the day after admission the best predictors of in-hospital mortality? An observational study in a low-resource sub-Saharan hospital

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Abstract

Background: The first clinical re-assessment after admission to hospital probably provides the best opportunity to detect clinical deterioration or failure to improve, and decide if care should be intensified.

Aim: Compare changes the day after admission in the patient's subjective feelings and objective findings that included age, gender, the National Early Warning Score (NEWS) on admission, gait stability and mid-upper arm circumference (MUAC) on admission, and changes in NEWS, gait stability and mental alertness.

Setting: Acutely ill medical patients admitted to a low-resource sub-Saharan hospital.

Methods: Prospective observational study.

Results: 1810 patients were reassessed 18 h after hospital admission. Logistic regression identified NEWS and gait stability on admission, a subjective feeling of improvement, the change in NEWS, and MUAC as clinically significant predictors of in-hospital mortality. Stratifying patients according to their NEWS on admission altered the predictive value of the four other predictors: for patients with an admission NEWS <3 a subjective feeling of improvement is the most powerful predictor of a good outcome. For patients with an admission NEWS $>=3$ the change in NEWS, gait stability on admission and MUAC provide additional prognostic information.

Conclusion: NEWS and gait stability on admission, MUAC, a subjective feeling of improvement, and change in NEWS the day after admission are all clinically significant predictors of in-hospital mortality.

Keywords: In-hospital mortality, Early warning scores, Functional capacity, Predictors of mortality, Vital sign trends, Clinical deterioration

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https://doi.org/10.1016/j.resuscitation.2018.10.023
Received 8 August 2018; Received in revised form 17 October 2018; Accepted 25 October 2018

Introduction

The first clinical re-assessment after admission to hospital is often a seminal moment in a patient's hospital admission. This is when the patient's presenting complaints, initial diagnosis and treatment are first reviewed and, often, when the patient is first seen by senior staff.[1] It is probably the time that provides the best opportunity to correct any errors, detect clinical deterioration and/or failure to respond to initial treatment, and decide whether or not the patient should be transferred to a higher level of care.

Although in 2007 the UK National Confidential Enquiry into Patient Outcome and Death recommended that a consultant assessment of all acutely ill patients should take place within 12–24 h of admission[2], there is little evidence available on the optimal time to perform post-admission re-assessment. A previously reported study on 44,531 patients in Canada found vital sign changes during the first 12 h after admission did not predict subsequent outcome[3] However, changes in a clinical score the morning after admission to an Irish hospital were powerful predictors of subsequent in-hospital mortality.[4]

In this study, we examined and compared several established and potential bedside predictors of in-hospital mortality for acute medical patients in sub-Saharan Africa and we believe probably elsewhere: these included age, vital signs on admission both individually and aggregated into the National Early Warning Score (NEWS), the stability of gait on admission, mid-upper arm circumference (MUAC) as a measure of nutritional reserve, and the changes in alertness, gait, NEWS and the patient's subjective feeling of improvement at the first re-assessment after admission.

Methods

Study design

Prospective observational study carried out as part of an audit in an ongoing quality improvement project.

Setting

The 46 bed medical ward of St. Joseph's Kitovu Health Care Complex, a 220 bedded healthcare facility located near Masaka, Uganda, 140 km from the capital city of Kampala. Together with the 330 bed Masaka Regional Referral Government Hospital, it serves Masaka Municipality (population of 79,200) and Masaka District with a rural population of 804,300. The hospital has no intensive care or renal dialysis unit and cannot provide mechanical ventilation, but supplemental oxygen is available from oxygen concentrators.

Participants

All acutely ill medical patients admitted during the study period and re-assessed at least once after admission. Some participants in this study have previously been presented as part of an interim analysis on the predictive value of the subjective feeling of deterioration[5] and MUAC.[6] Data from some participants were used in these previous analyses.

Data collection

From August 9th 2016 to January 5th 2018, the clinical status and vital signs of every patients admitted to the hospital's medical unit were entered on admission and at least daily at the bedside using tablet computers into a clinical data management and decision support system (Rapid Electronic Assessment Data System (READS) Tapa Healthcare DAC). Each patient was assessed at least once a day during their admission.

All the patients admitted were acutely ill, and no patients were excluded from the study. The READS bedside assessment requires that the patient's contemporaneous mental status, functional status and complaints are entered each time the vital signs are measured.[7] In addition, all alert patients were asked if they felt better, no better or worse since their last assessment.[5] Only the patient's subjective opinion and not the clinicians' opinion was recorded. Therefore, for example, it was not assumed that patients who had regained consciousness since admission "felt better". Alertness was determined by a simple bedside assessment of level of consciousness.[8] The National Early Warning Score (NEWS)[9], a well validated predictor of imminent mortality, was automatically calculated by READS from each patient's heart rate, respiratory rate, systolic blood pressure, level of consciousness, temperature, oxygen saturations, and the use of supplementary oxygen. Impaired mobility on presentation, a known predictor of mortality[10], was defined as lack of a stable independent gait when first assessed.[11] Therefore, all patients who had an unstable gait, needed help to walk or were bedbound were deemed not to have a stable independent gait. These patients included all those only responding to voice or were in coma. The final disposition of patients on hospital discharge was also recorded. All data entered into the READS system are automatically time and date stamped: it is impossible to complete a READS assessment without entering all the data required, and to enter values that are outside a plausible range. In addition to the electronic READS assessment each patient's MUAC was recorded on paper. An MUAC < 20 cm has already, in an interim analysis, been shown to be an independent predictor of in-hospital mortality.[6]

Outcomes

In-hospital death.

Data analysis

All variables that could be easily obtained at the bedside at no cost (i.e. vital signs, oxygen saturation, alertness and gait on admission and re-assessment, subjective feeling of improvement on re-assessment, as well as age, gender and MUAC) were analysed. Patients were stratified according to their NEWS on admission. A NEWS < 3 cut-off was selected as all of these patients must be alert, and a NEWS $>= 7$ cut-off because this is the level at which continuous monitoring and transfer to intensive care is often recommended.[9]

Statistical methods

All calculations were performed using Epi-Info version 6.0 (Center for Disease Control and Prevention, USA) and logistic regression analysis using Logistic software.[12] The p value for statistical

significance was 0.05 and was tested using Student's *t*-test and Chi square analysis that applied Yates continuity correction. Data will be presented as mean (standard deviation (SD)) or number (percentage) as appropriate.

Ethical approval

Ethical approval of the study was obtained from the Ethics Committee Kitovu Hospital, which conformed to the principles outlined in the Declaration of Helsinki.[13] Since no interventions were additional to the usual standard of care the need for written consent was waived. The study is reported in accordance with the STROBE statement.[14]

Results

Participants

During the study period 2240 acutely ill medical patients were admitted to the hospital and 1810 (78.0%) were reassessed at a mean of 18.2 SD10.2 h later. Mean age was 50.0 SD 23.2 years and 772 (42.6%) were male. The mean length of stay was 87.4 SD 57.2 h. A total of 104 (5.7%) patients died in hospital (Table 1).

Non-participants

The 430 patients who were not reassessed and thus excluded from the study had a significantly shorter length of hospital stay (26.9 SD 20.9 versus 87.4 SD 57.2 h, $p < 0.00001$) and higher in-hospital mortality rate (10.2% versus 5.7%, $p = 0.001$) than participants (Fig. 1).

Association between in-hospital mortality and continuous variables

Patients who died in hospital had a higher NEWS, heart and respiratory rates, and lower systolic blood pressure, and oxygen saturation on arrival, and were reassessed approximately 3 h earlier than survivors. There was no difference in the age, length of hospital stay or admission temperature between patients who died and survivors (Table 1 and Supplemental data).

Association between in-hospital mortality and changes in NEWS

The in-hospital mortality of patients who decreased their NEWS at re-assessment was lower than those who either had no change or an increase in their NEWS. However, NEWS on admission was a major determinant of outcome: patients with an admission NEWS >=3 who

Table 1 – Continuous and categorical variables examined on 1810 patients on whom there was complete data. Results in italics are those of patients stratified according to their National Early Warning Score (NEWS) on admission.

Continuous variables		All patients N 1810	Survivors N 1706	Died in hospital N 104	P
Age (years)		50.0 SD 23.2	49.7 SD 23.1	54.3 SD 24.8	0.05
Interval between 1st and 2nd assessment (hours)		18.2 SD 10.2	18.3 SD 10.2	15.1 SD 9.8	0.001
Length of hospital stay (hours)		87.4 SD 57.2	86.8 SD 55.7	97.5 SD 77.8	0.06
Admission NEWS		4.1 SD 3.0	3.9 SD 2.9	7.2 SD 3.2	<0.000001
Delta NEWS		−0.20 SD 2.43	−0.23 SD 2.42	0.33 SD 2.67	0.02
Categorical variables	**N (%)**	**In-hospital mortality (%)**	**Odds ratio death in hospital (95% CI)**		**p**
NEWS on admission		104 (5.7%)			
NEWS < 3	609 (33.6%)§	6 (1.0%)	1.0		
NEWS 3–6	831(45.9%)§	36 (4.3%)	4.55 (1.82 – 12.09)		0.0004
NEWS >=7	370 (20.4%)§	62 (16.8%)	20.23 (8.31 – 52.51)		<0.00001
Delta NEWS >=0	1039 (57.4%)§	69 (6.6%)	1.50 (0.96 – 2.33)		0.07
admission NEWS < 3	*488 (80.1%)**	*4 (0.8%)*	*0.49 (0.08 – 3.96)*		*0.75*
admission NEWS 3–6	*424 (51.0%)***	*29 (6.8%)*	*4.20 (1.72 – 10.72)*		*0.0006*
admission NEWS >=7	*127 (34.3%)****	*36 (28.3%)*	*3.30 (1.81 – 6.04)*		*0.00003*
Feeling better	1547 (85.5%)§	52 (3.4%)	0.14 (0.09 – 0.22)		<0.00001
admission NEWS < 3	*578 (94.9%)**	*4 (0.7%)*	*0.10 (0.01 – 0.84)*		*0.03*
admission NEWS 3–6	*724 (87.1%)***	*24 (3.3%)*	*0.27 (0.12 – 0.60)*		*0.0005*
admission NEWS >=7	*245 (66.2%)****	*24 (9.8%)*	*0.25 (0.13 – 0.46)*		*<0.00001*
Room air only	1705 (94.2%)§	87 (5.1%)	0.28 (0.15 – 0.51)		<0.00001
Male gender	772 (42.7%)§	54 (7.0%)	1.49 (0.98 – 2.26)		0.06
Temperature <=36 °C	189 (10.4%)§	19 (10.1%)	2.02 (1.15 – 3.51)		0.01
Temperature >38 °C	90 (5.0%)§	8 (8.9%)	1.65 (0.71 – 3.68)		0.28

* =percentage of 609 patients with admission NEWS < 3.

** =percentage of 831 patients with admission NEWS 3–6.

*** =percentage of 370 patient with admission NEWS >=7.

§ =percentage of 1810 patients with complete data.

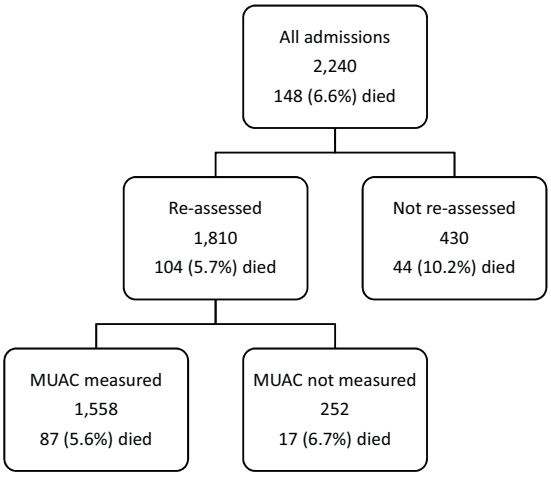

Fig. 1 – Flow diagram of study population and their outcomes – MUAC = mid upper arm circumference.

increased their NEWS on reassessment were 3–4 times more likely to die, whereas for patients with an admission NEWS < 3 a change in NEWS had no influence on outcome (Table 1).

At re-assessment NEWS had increased in 35.1% of patients: there was an increased NEWS in 47.1% of patients with an admission NEWS < 3, in 32.5% of those with an admission NEWS 3–6, and in 20.8% of those with an admission NEWS > = 7. The mean NEWS of all patients with a NEWS < 3 on admission increased, and there was no statistical difference in the increase between those who died and survivors. On the other hand, for patients admitted with a NEWS > = 7 the mean NEWS of both decedents and survivors decreased, but less so for patients who died (Table 2).

Association between in-hospital mortality and changes in alertness and gait

Patients, who were admitted with unstable gait but became stable, were less likely to die in hospital than those who remained unstable, and patients who were not alert on admission but became alert had a lower mortality. Conversely, patients who became unstable were more likely to die in hospital than those who remained stable, as were patients who became non-alert compared to those who remained alert (Table 3).

Association between in-hospital mortality and subjective feeling of improvement

Only one patient claimed to feel worse on re-assessment. Overall, the majority of patients (85.5%) felt subjectively improved and these were less likely to die in hospital, regardless of their NEWS on admission (Table 1). However, the association between feeling improved and reduced mortality was less if the vital signs deteriorated: of patients with a NEWS > = 3 who felt better on re-assessment the mortality of those with an unchanged or increased NEWS was more than twice the mortality of those who felt better and decreased their NEWS (i.e. 7.1 versus 3.3%, odds ratio 2.25, 95%CI 1.19–4.30).

Association between in-hospital mortality and MUAC

MUAC was measured in 1558 (86.1%) of the 1810 reassessed patients. The MUAC of the 87 patients who died (5.6%) was lower than survivors (23.2 SD 4.2 versus 25.7 SD 4.6 cm, $p < 0.0001$). The 131 (8.5%) patients with a MUAC < 20 cm were more likely to die than those with a MUAC > = 20 cm (odds ratio 4.23, 95% CI 2.47–7.37, $p < 0.00001$). However, a MUAC < 20 cm was only associated with increased mortality in patients with an admission NEWS > = 3 (see supplemental data).

Identification of the clinically significant predictors of in-hospital mortality and their relationship to NEWS on admission

Logistic regression analysis of the 1558 patients who had their MUAC measured and therefore had complete data, identified five clinically significant predictors of in-hospital mortality: NEWS on admission, stable gait on admission, a subjective feeling of improvement, change in NEWS, and MUAC as significant predictors of in-hospital mortality (Table 4). Mental alertness on admission, changes in mental status and gait stability after admission, age, male gender, temperature and the use of supplementary oxygen were all excluded. Stratifying patients according to their NEWS on admission altered the predictive value of the four other predictors: for patients with an admission NEWS < 3 the only statistically significant predictor of in-hospital mortality was the patient's subjective feeling of improvement (Table 1), and the mortality associated with the number of other predictors present varied considerably according to the NEWS value on admission (Fig. 2).

Discussion

Key findings

This study shows that the ability of vital signs to predict outcome can be considerably enhanced by considering other information easily obtained at the bedside at no cost. NEWS < 3 on admission identified a large cohort of patients (i.e. a third of all patients) who are unlikely to die, and for whom a subsequent change in their score had no prognostic

Table 2 – Change in NEWS (Delta NEWS) at re-assessment in patients who died in hospital and survivors according to NEWS on admission SD = standard deviation.

NEWS on admission	Delta NEWS				p
	Survivors (n 1706)		Died in hospital (n 104)		
	n	Means SD	n	Mean SD	
NEWS < 3	603	0.79 SD 1.78	6	1.33 SD 2.73	0.46
NEWS 3-6	795	−0.37 SD 2.33	36	1.19 SD 2.65	0.0001
NEWS > = 7	308	−1.87 SD 2.70	62	−0.27 SD 2.55	0.00002

Table 3 – Changes in gait stability and mental alertness and their association with in-hospital mortality.

	Unstable on re-assessment		Stable on re-assessment			
	n	In-hospital mortality	n	In-hospital mortality	Chi-square	P
Unstable on admission (n 909)	698	79 (11.3%)	211	7 (3.3%)	11.16	0.0008
Stable on admission (n 901)	137	7 (5.1%)	764	11 (1.4%)	6.23	0.01
Total	835	86 (10.3%)	975	18 (1.8%)	57.00	<0.000001
	Not alert on re-assessment		Alert on re-assessment		Chi-square	P
	n	In-hospital mortality	n	In-hospital mortality		
Not alert on admission (n 100)	68	20 (29.4%)	32	2 (6.3%)	5.81	0.02
Alert on admission (n 1710)	22	7 (31.8%)	1,688	75 (4.4%)	29.90	<0.000001
Total	90	27 (30.0%)	1,720	77 (4.5%)	98.22	<0.000001

Table 4 – Logistic regression. NEWS = National Early Warning Score. Delta NEWS = change in NEWS between admission and re-assessment.

	Coefficient	Standard error	Odds ratio (95% CI)	P
Constant	−1.5137	0.8416	–	0.0721
NEWS on admission	0.3037	0.0447	1.35 (1.24 – 1.48)	0.0000
Stable gait on admission	−1.0163	0.3248	0.36 (0.19 – 0.68)	0.0018
Feeling better on re-assessment	−1.0358	0.2648	0.35 (0.21 – 0.60)	0.0001
Delta NEWS	0.2008	0.0488	1.22 (1.11 – 1.35)	0.0000
Mid-upper arm circumference	−0.0784	0.0290	0.92 (0.87 – 0.98)	0.0069
Hosmer-Lemeshow statistic: p 0.91				

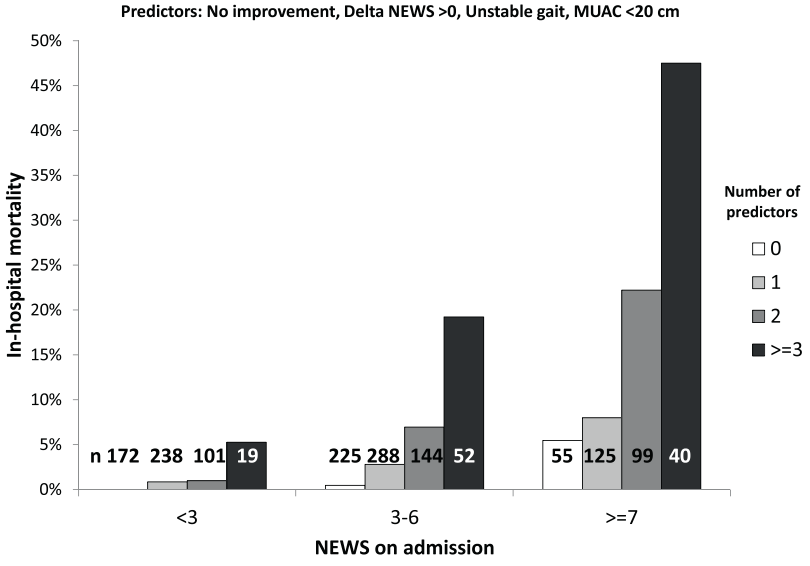

Fig. 2 – In-hospital mortality of the 1558 patients with complete data according to NEWS on admission and the presence of how many of the other four predictors of mortality were present. The other predictors were: no improvement (i.e. the inverse of a subjective feeling of improvement), unstable gait on presentation (i.e. the inverse of a stable independent gait) and MUAC < 20 cm. n = number of patients: 172 patients with an admission NEWS < 3 had no other predictors.

value. For these patients the most valuable predictor of in-hospital mortality when they were re-assessed the day after admission was their subjective feeling of improvement. For the remaining patients with an admission NEWS > = 3 the change in NEWS, along with gait stability on admission and MUAC offered additional prognostic information.

Limitations

Patients who subsequently died were reassessed approximately 3 h earlier than survivors, because the READS software prompted the assessment of the patients with highest admission NEWS first. Since

this study was performed in a resource poor hospital in sub-Saharan Africa, the types of illness and their severity are undoubtedly different from those encountered by hospitals elsewhere, especially in the developed world. The study's major limitation is its small size: a larger study, for example, might also have shown improvement in gait and/or alertness to be more significant predictors of outcome. However, its strength is that the study protocol and the software used ensured that the vital signs and other bedside clinical data (with the single exception of MUAC) were correct, complete and current.[15] All data entered into the READS system were automatically time and date stamped, and it was impossible to complete a READS assessment without entering all the data required, and also impossible to enter values that were outside a plausible range. As a result all the data entered into the READS system was complete. In contrast only 86% of patients had their MUAC recorded.

Interpretation

This study only examined the first re-assessment approximately 18 h after admission to hospital, and found that change in vital signs, when aggregated into an early warning score, was one of five highly significant predictors of outcome. We did not examine if these findings remained true for the rest of the patients' hospital stay. Few studies have examined the value of changes in vital signs, either as individual values or when aggregated into an early warning score. Depending on the definitions used, clinical deterioration rates after admission of from 1.7% to 56.5% have been reported.[4,16–22] A large, recent multicentre study found that vital sign trajectories significantly improved the detection of clinical deterioration compared to current vital sign values alone. However, the difference from the current and previous value was less valuable than the vital sign slope, vital sign variability, and the most deranged values since admission.[23] Canadian data suggests that the prognostic value of early warning score trends during a hospital admission are greatly influenced by the score value on admission.[3] Although it has been suggested that the more normal a patient's vital signs the more likely the patient is to remain clinically stable with little chance of clinical deterioration[24], Henriksen et al found that 30% of patients admitted with normal vital signs deteriorated within 24 h of admission.[16] In our patients although the NEWS increased in nearly 50% of patients with an admission NEWS <3 this increase was not associated with a higher in-hospital mortality.

There have been few reports of the time to clinical deterioration after arrival to hospital, and how often vital sign measurements should be taken is currently based upon existing custom or perceived best practice rather than evidence.[26] Others have reported times to reassessment that are similar to this study: Kennedy et al. found the median time to ICU transfer to be 20 h in patients presenting at the emergency department with an infection[19] and Bleyer et al. found that approximately 25% of all deteriorations in hospitalised patients occurred within 24 h of admission.[22] A 12-hourly minimum frequency for vital sign measurement is used in the UK[25], while hospitals in other countries can measure them more often.[26] More frequent and complete sets of vital sign measurement should detect clinical deterioration earlier. However, Petersen et al found that 8-hourly was no better than 12-hourly measurement for reducing clinical deterioration[27] and van Galen et al have suggested that a 'once a day' early warning score assessment may be sufficient to screen for major adverse events in hospital populations.[28]

Clinical implications of results

Patients with potentially serious conditions can present with normal vital signs. For example, patients with sudden severe headache from a subarachnoid haemorrhage often present with normal vital signs.[29] Most illness starts with the patient having nonspecific feelings of being unwell, at which time their vital signs may be normal. The interval between these subjective nonspecific symptoms and the development of specific symptoms and objective signs may be seconds in acute cardiac disease, minutes in meningococcal sepsis, and hours or even days in other conditions.[30] In the developed world around two-thirds of acutely ill medical patients have been reported to have a NEWS <3 on admission[10], compared with only a third in our cohort. Our results suggest that in these patients replacing frequent vital sign measurement by asking the patients if they feel better, possibly as often as every hour[31] may detect life threatening illness earlier, be preferred by patients[32] and produce considerable cost savings. In contrast, for sicker patients our results show that assessment of nutritional status may also be important: increased body mass index is known to reduce mortality in adults admitted to the ICU with sepsis, severe sepsis, or septic shock[33] Therefore, while a change in NEWS is an important predictor of mortality, it is not the only predictor: how the patient feels, their MUAC and gait stability on admission also provide considerable extra prognostic information.

Conclusion

NEWS and gait stability on admission, changes in NEWS and subjective feeling of improvement approximately18 h after admission and MUAC are clinically significant predictors of in-hospital mortality. For patients with an admission NEWS <3 a subjective feeling of improvement predicts a good outcome. For patients with an admission NEWS $>=3$ the change in NEWS, gait stability on admission and MUAC provide additional prognostic information.

Funding and conflict of interest statement

All costs were borne by the authors. John Kellett is a major shareholder, director and chief medical officer of Tapa Healthcare DAC. The other authors have no potential conflicts of interest.

Acknowledgments

The authors wish to acknowledge and thank Tapa Healthcare DAC (Dundalk, Ireland) for the complimentary use of their Rapid Electronic Assessment Data System (READS). The sponsor played no part in the design or execution of the study, and all other costs were borne by the authors.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resuscitation.2018.10.023.

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