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ARAŞTIRMA / RESEARCH

Prediction of mortality with Charlson Comorbidity Index in super-elderly patients admitted to a tertiary referral hospital

Üçüncü basamak bir hastaneye başvuran çok yaşlı hastalarda Charlson Komorbidite İndeksi ile mortalite tahmini

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Abstract

Purpose: In most countries, there is an ever-increasing admission rate of the elderly population into emergency departments (EDs). In particular, these elderly patients differ from younger patients because they have multiple comorbidities that affect the functionality and quality of life. The goal of this study is to reveal whether the Charlson comorbidity index (CCI) foresee the short- and long-term prognosis of the super-elderly patient population.

Materials and Methods: The study was a descriptive, retrospective analysis of emergency department (ED) admissions by patients over 85 years of age and admitted to the Canakkale Onsekiz Mart University (COMU) Hospital between 2013 and 2018. The demographic data of the patients were analyzed according to CCI. Cox-regression analyses were conducted to determine whether the variables affected mortality.

Results: A total of 1142 patients aged 85 and older (507 men, 635 women) with a mean age of 86.96±2.49 were included in the study. According to the multivariable Cox regression analysis male gender, CCI ≥6 and ICU admission were significantly associated with increased mortality rates

Conclusion: The CCI predicts short and long-term prognosis in acutely ill, hospitalized super-elderly patients. The CCI could be used to select super-elderly patients at admission as an indicator of improvement at hospital discharge.

Keywords:. Charlson comorbidity index, emergency department, hospitalization, mortality, aged 80 and over

Öz

Amaç: Çoğu ülkede, yaşlı nüfusun acil servislere (AS'ler) giderek artan bir başvuru oranı vardır. Özellikle bu yaşlı hastalar, fonksiyonel ve yaşam kalitesini etkileyen birden fazla komorbiditeye sahip oldukları için genç hastalardan farklıdır. Bu çalışmanın amacı, Charlson komorbidite indeksinin (CCI) çok yaşlı hasta popülasyonunun kısa ve uzun vadeli prognozunu tahmin edip etmediğini belirlemektir.

Gereç ve Yöntem: Çalışma, 2013 ve 2018 yılları arasında Çanakkale Onsekiz Mart Üniversitesi (ÇOMÜ) Hastanesine başvuran 85 yaş ve üstü hastaların acil servis (AS) ziyaretlerinin tanımlayıcı, retrospektif bir analiziydi. Hastaların demografik verileri CCI'ye göre analiz edildi. Değişkenlerin mortaliteyi etkileyip etkilemediğini belirlemek için Cox-regresyon analizleri yapıldı.

Bulgular: Yaş ortalaması 86,96±2,49 olan 85 yaş ve üzeri (507 erkek, 635 kadın) toplam 1142 hasta çalışmaya dahil edildi. Çok değişkenli Cox regresyon analizine göre erkek cinsiyet, CCI ≥6 ve yoğun bakım ünitesine yatış, artan mortalite oranları ile anlamlı şekilde ilişkiliydi.

Sonuç: CCI akut hasta olarak hastaneye yatırılan çok yaşlı hastalarda kısa ve uzun dönem prognozu tahmin eder. CCI, hastaneden taburculukta iyileşmenin bir göstergesi olarak, kabulde, çok yaşlı hastaların seçilmesinde kullanılabilir.

Anahtar kelimeler: Charlson komorbidite indeksi, acil servis, hospitalizasyon, mortalite, 80 ve üstü yaş

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INTRODUCTION

Emergency department (ED) crowding is a major healthcare problem throughout the world[1]. Due to the rapid growth of the oldest portion of the elderly population (≥ 85 years), this effect is assumed to increase in the near future[2]. Thus, the ageing of the population and the increased prevalence of chronic diseases lead to the elderly to be regular users of the ED[3]. Moreover, the elderly are more likely to have comorbid diseases, and the clinical presentations significantly differ from those in younger patients with the same disorder[4,5]. They remain for a prolonged period in the ED and are more likely to be hospitalized. The top diagnoses for older adults admitted to the ED include acute cerebrovascular and cardiac diseases, syncope, cardiac dysrhythmias, pneumonia, urinary tract infections, and fall-related injuries[6].

In hospital settings, prognostic models can serve as an adjunctive tool for decision-making. Moreover, the recognition of high- or low-risk patients can be used for triage for distinct care trajectories or for risk stratification of in-hospital complications. Studies demonstrated that, in these elderly patient group, factors related to increased age, but not age per se, are predictive of mortality, including diagnosis, comorbidities, and premorbid functional status[7]. Multiple comorbidity scores have been developed and tested to predict in-hospital mortality among different populations and settings[8,9]. Of these scoring systems, the Charlson comorbidity index (CCI) is one of the most well-known and used scoring system developed and validated in a population of women of all ages treated for primary breast cancer[10]. The CCI is primarily established on a history of accompanying disorders for instance renal and cardiac diseases, diabetes, and malignant conditions[7,10]. After its introduction in 1987, the index has been commonly used to predict short-term outcomes in a number of disease states[11,12].

As the number of super-elderly people admitting to overcrowded EDs will continue to grow in the future, taking care of these patients is extremely important in both quantitative and qualitative manners. Accordingly, we need to seriously reconsider organising care in ED settings, leastwise for these patient group. Therefore, this study was conducted to determine the clinical and demographic features of super-elderly population admitted to the ED and whether CCI can predict morbidity and mortality in acutely ill patients over 85 years of age.

MATERIALS AND METHODS

Patient population and design

This study was designed as a retrospective study and includes a descriptive characteristics of all ED admissions by patients over 85 years of age that were admitted to the Canakkale Onsekiz Mart University (COMU) Medical Center between 2013 and 2018. The COMU Medical Center is located in the North-Western region of Turkey and serves as a third-level referral medical center for approximately 540000 inhabitants in the Canakkale province. The ED of the COMU Medical Center offers primary, secondary, and tertiary emergency care facilities.

Patients admitted to the COMU-ED are first triaged by a research assistant. In this study, we used a classical triage system to quickly classify into categories, with colors such as red, yellow, and green[13]. Each individual color correspond to a level of severity and the maximum waiting time allowed for the provision of healthcare. The red color represents the need for emergency care, in which medical care should be provided immediately. The yellow color represents urgent cases, with a waiting time not longer than sixty minutes. The green color symbolizes cases with less urgent conditions or non-urgent cases.

COMU ethics committee granted ethics approval of the present study (Date of Approval: 24.07.2019 Approval number: 2011-KAEK-27/2019-E.190008997).

Data collection

Clinical and demographic characteristics of the patients were collected from the COMU Hospital digital patient registry system. The information gathered from hospital electronic archives lead us to study the subsequent parameters: demographic information of patients, triage categories, date and hour of admission to the hospital, average period of stay in the ED, average period of stay in the ED by triage categories, parameters associated with mortality, comorbid diseases, parameters related to CCI, discharge status, readmission to ED within thirty days after ED discharge, disposition at discharge (home, hospital admission, intensive care unit admission, death), and distribution of diagnoses

by body systems defined according to the International Classification of Diseases, Tenth Revision (ICD-10) diagnosis coding algorithm.

In patients with multiple ED admissions, the data of the first visit was included in the final analysis. The ED length of stay (LOS) in hours was calculated as the time spent by patients in the ED until they were discharged. The length of hospital stay in days was ascertained by determining the difference between the date and time of admission at and discharge from the hospital. Patients readmitting to the ED within 30 days after their hospital discharge were recognized by their patient file number.

National Death Certificate System (NDCS) was used to determine if the patients are still alive or dead. The follow-up duration for deceased patients was determined as the time between ED admission and the time of death according to the NDCS. For alive patients, 15 October 2019 was settled as the endpoint for survival appraisal.

Measure

Charlson Comorbidity Index

The CCI was firstly suggested by Charlson et al. (10) three decades ago in order to predict the long-term survival of patients with malignant diseases by assigning weights to specific disease conditions. By using the ICD-10 coding system, we recognized the Charlson comorbidities in any of the secondary diagnosis coding fields, excluding conditions that occurred or were diagnosed during hospital stay on the basis of the diagnosis type indicator. All comorbid conditions were identified from hospital medical records.

Comorbidities were defined as pre-existing diseases and medical conditions present at the time of admission. According to this classification, comorbid conditions with a weight of one include congestive heart failure, cerebrovascular disease, dementia, myocardial infarction, peripheral vascular disease, chronic pulmonary disease, mild liver disease, ulcer disease, and diabetes mellitus. Diabetes with end organ damage and any malignancy, leukemia, and lymphoma have a weight of two. Moderate or severe liver disease has a weight of three. Metastatic solid tumors and AIDS have a weight of six. The total score is then calculated by adding the weights.

Statistical analysis

The baseline clinical, demographic and other descriptive variables were given as mean ± standard deviation, median and interquartile range, or counts and proportions, where appropriate. Normality assumption for continuous variables were tested by using Shapiro–Wilk test. All continuous variables were normally distributed and are reported as means ± SD. Differences between two groups for normally distributed variables were tested using an independent t-test and ANOVA test. The categorical variables were compared using the Chi-squared test.

Receiver operating characteristic (ROC) curve analysis was used to identify the optimal cut-off values of CCI with maximum sensitivity and specificity for survival. Kaplan-Meier analyses, with log-rank tests, were used to analyze the overall survival with different clinical conditions and other variables. Student's t test was used to compare parameters related to mortality. Statistically significant variables were further included in the Cox regression analysis. A multivariate logistic regression analysis was built by performing stepwise variable selection on those variables with a univariate p-value < 0.025. Results of the analysis were presented in terms of the estimated hazard ratios (HR) and 95% confidence intervals (95% CI). A p-value < 0.05 was considered statistically significant. Data was analyzed by using SPSS Statistics for Windows, Version 20.0 (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp).

RESULTS

We identified 3842 ED admission by 1329 patients aged over 85 years from January 2013 to December 2018. Overall, 187 patients accounting for 455 visits were excluded, owing to incomplete medical records. Of the remaining 1142 patients with 3387 visits, 635 (56%) were female and 507 (44%) were male. The mean age of the study participants was 86.96±2.49 years. Table 1 shows the clinical and demographic characteristics of the study participants. Figure 1 presents the most common ED admission causes of the study population. The top most five common diagnoses reported were chest pain, abdominal pain, soft tissue injury, ischemic stroke, and chronic obstructive lung disease (COPD) exacerbation.

Table 1. Characteristics of study participants

Characteristic		**Mean±SD**
Age (years)		86.96±2.49
Length of ED stay (hours)		4.21±4.09
Hospital stay (days)		5.80±5.70
CCI		5.86±1.77
		n (%)
Gender	Male	507 (44.4)
	Female	635 (55.6)
Triage category	Red	615 (53.9)
	Yellow	250 (21.9)
	Green	277 (24.3)
Disposition	Home discharge	652 (57.1)
	Hospitalization	299 (26.2)
	ICU admission	140 (12.3)
	Transferred	43 (3.8)
	in-ED death	8 (0.7)

ICU: Intensive care unit; ED: Emergency department; CCI: Charson comorbidity index

Patients with a red triage had significantly increased CCI levels compared with the yellow and green triage categories ($p < 0.0001$ for both). Patients who were discharged from emergency medicine after initial evaluation had the lowest CCI scores (CCI: 5.6±1.7) compared with other patients (6.12±1.9 for hospitalized, 6.21±1.6 for ICU-admitted, and 6.74±1.9 for patients transferred to other wards.). The CCI scores of patients, according to distinct clinical and demographic characteristics, including overall survival and ED outcome, are presented in Table 2. The ROC curve analysis demonstrated that the ideal CCI cut-off value for survival was 6 points (sensitivity, specificity, positive predictive value, and negative predictive value of 57%, 61%, 65%, and 53%, respectively).

Table 2. Charlson Comorbidity Index (CCI) scores of patients, according to clinical and demographic characteristics.

Variable	**CCI (mean±SD)**	**p**
Gender		
Female	5.71±1.6	0.002
Male	6.04±1.9	
Triage category		
Red	6.19±1.9	< 0.001[a]
Yellow	5.65±1.6	
Green	5.31±1.5	
ED outcome		
Discharge	5.60±1.7	< 0.001[b]
Hospitalization	6.12±1.9	
ICU admission	6.21±1.6	
Transferred	6.74±1.9	
Exitus	6.12±1.5	
Survival		
Alive	5.41±1.3	< 0.001
Deceased	6.22±2.0	

ED: Emergency department; ICU: Intensive care unit; CCI: Charlson comorbidity index

[a]Yellow versus red and green versus red $p < 0.0001$

[b]Discharge versus hospitalization, discharge versus ICU admission, and discharge versus transferred

The LOS in the ED and hospital was found to be shorter in patients with a cut-off point of a CCI score of less than 6 points (Table 3.). A statistically higher number of patients in the red triage category had a CCI score greater than 6 (58.2% versus 41.8% for CCI ≥ 6 versus CCI < 6, respectively). At the end of the study period, 60.8% of patients with a CCI score less than 6 upon first admission to the ED were found to be alive (p < 0.0001).

Table 3. Comparison of clinical characteristics of patients with a cut-off CCI score of 6 points

Variables	**CCI < 6**	**CCI ≥ 6**	**p**
Age (years)	87.2±2.7	86.7±2.2	< 0.001
Length of ED stay (hours)	3.8±3.7	4.7±4.5	< 0.001
Length of hospital stay (day)	5.6±4.35	5.8±6.7	0.697
Gender (n, %)			
Female	336 (52.9)	299 (47.1)	0.094
Male	243 (47.9)	264 (52.1)	
Triage category (n, %)			
Red	257 (41.8)	358 (58.2)	< 0.001
Yellow	142 (56.8)	108 (43.2)	
Green	180 (65.0)	97 (35.0)	
ED outcome (n, %)			
Discharge	380 (58.3)	272(41.7)	< 0.001**
Other than discharge *	199 (40.6)	291 (59.4)	
Survival (n, %)			
Alive	306 (60.8)	196 (39.2)	< 0.001**
Deceased	273 (42.7)	367 (57.3)	

CCI: Charson comorbidity index; ED: Emergency department
* Group included hospitalized, intensive care unit admission, in-ED death.

Table 4. Cox regression analysis for prediction of mortality according to demographic and clinical characteristics

	Univariable Hazard Ratio			**Multivariable Hazard Ratio**		
	Hazard ratio	95% CI	p	Hazard ratio	95% CI	p
Gender						
Female (Ref.)						
Male	1.197	1.024-1.398	0.024	1.184	1.013-1.383	0.033
Triage category						
Green (Ref.)	-	-	-			
Yellow	1.100	0.857-1.413	0.455			0.375
Red	1.789	1.466-2.185	<0.001			0.152
CCI						
<6 (Ref.)						
≥6	1.703	1.455-1.992	<0.001	1.374	1.194-1.567	<0.001
ED outcome						
Discharge (Ref.)						
Hospitalized	1.591	1.324-1.912	<0.001	1.460	1.150-1.855	<0.001
ICU admission	2.287	1.831-2.857	<0.001	2.040	1.539-2.703	<0.001
Transferred	3.873	2.739-5.475	<0.001	3.411	2.316-5.025	<0.001

CI: Confidence Interval; ICU: Intensive Care Unit; Ref: Reference; CCI: Charlson comorbidity index; ED: Emergency Department.

According to the Kaplan Meier survival estimation, patients with CCI < 6 had an estimated survival time of 41.0±3.2 months, while patients with CCI ≥ 6 had an estimated survival time of 22.0±2.3 months. Patients with CCI ≥ 6 had significantly decreased estimated survival time compared with those with CCI < 6 ($p < 0.001$). Patients with a red triage category had a significantly lower life expectancy compared with the other triage categories ($p < 0.001$, Figure 2). Uni-and multivariable Cox regression analysis for prediction of mortality according to demographic and clinical characteristics are demonstrated in table 4. The male gender, red triage category, CCI≥6 and ICU admitted patients had high risk for mortality in univariable cox regression analysis. In multivariable analysis male gender, CCI ≥6 and ICU admission were significantly related with increased death rates (Table 4).fv.

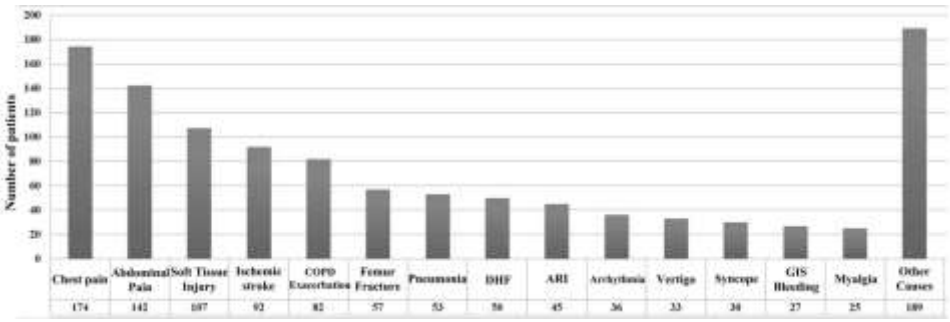

Figure 1. Causes of emergency department admissions in our study population

COPD; Chronic Obstructive Pulmoner Disease, DHF; Decompensated Heart Failure, ARI; Acute Renal Injury, GIS; Gastrointestinal System.

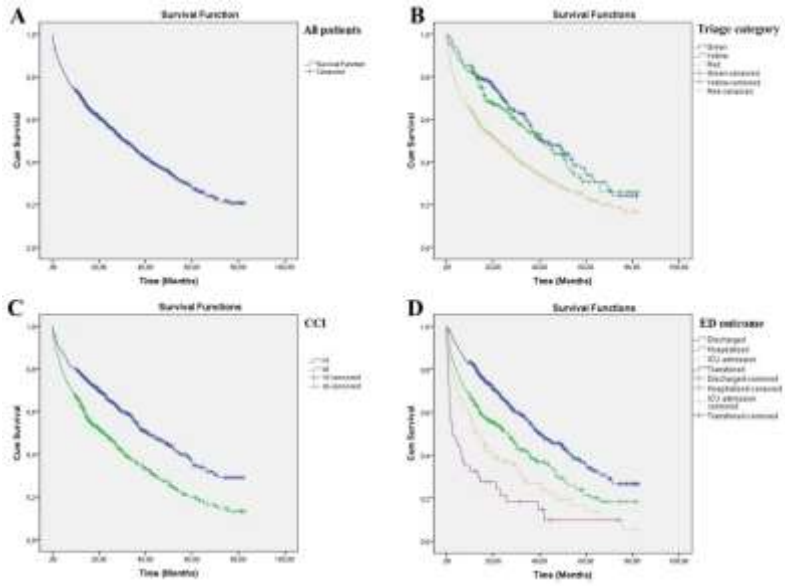

Figure 2. Kaplan-Meier survival curves for overall survival (A) in all patients, (B) based on emergency triage categories, (C) based on CCI levels, (D) based on ED outcomes.

DISCUSSION

The prevalence of multimorbidity increases substantially with age, and a consequent increase in the need for polytherapy and medical resources was observed, resulting in economic and social costs. In this study, we provided original information on current ED use and documented the increasing trend in ED admission rates in the super-elderly population. In addition, we revealed that with a simple index of measurement, it could be easy to assess the seriousness of the emergency and the response needed. Moreover, we demonstrated that super-elderly patients with a CCI higher than 6 have a lower life expectancy compared with those with a CCI lower than 6, irrespective of discharge or hospitalization.

It is not surprising to detect that older adults admit to emergency departments at a higher rate compared with younger persons and have longer LOS in the ED. Furthermore, they are more likely to have repeat ED admissions, and they experience elevated rates of adverse health outcomes after emergency discharge[2]. Due to the increase in life expectancy, this fact becomes more visible and leads to great challenges in making diagnosis and treatment decisions after ED admission. Although considerable research has been devoted to older adults (< 65 years) who have been admitted to EDs, a lack of sufficient knowledge still exists regarding the super-elderly patient population.

Initially developed for and validated with a population of women of all ages treated for primary breast cancer, the Charlson comorbidity index[10] is currently considered a reliable method for predicting short-term outcomes in distinct disease states, including renal and liver diseases, malignant conditions, rhinosinusitis, and neurological disorders[14–19]. Although there is no study in the literature specifically designed to evaluate the prognostic role of CCI in super-elderly patients, several studies validate the prognostic role of CCI in elderly adults [7, 20]. In a recent prospective cohort study by Frenkel et al.[7], the prognostic capability of CCI in 1313 acutely hospitalized elderly adults (> 65 years) was studied, and the CCI was found to predict the risk of short- and long-term mortality in elderly adults acutely admitted to the hospital. Moreover, after one year, the mortality in participants with a CCI of 3, 4, or 5 points or greater was significantly greater than in those with a CCI of 0 points. The authors also noted that the five-year mortality of elderly patients was greater for participants with a CCI of 1 or 2 (OR = 6.2, 95% CI = 2.0–18.8), 3 or 4 (OR = 10.6, 95% CI = 3.5–32.7), and 5 or greater (OR = 52.4, 95% CI = 13.3–206.4) than for the reference group. In the current study, a cut-off level of 6 for CCI demonstrated higher median survival times (41±3.2 months) compared with patients who had CCI scores higher than 6 (22±2.3 months). Although CCI cut-off levels of our study population were different from Frenkel et al.[7], this might be attributed to the age differences between study groups. Therefore, this finding supports the view that CCI is a valuable index to predict mortality in elderly patients admitted to the ED.

This study again provides evidence that admission patterns differ by age, especially in emergency department settings. We demonstrated that the top five common causes of ED admission among our special patient population were chest pain, abdominal pain, soft tissue injury, ischemic stroke, and COPD exacerbation, whereas the study by Ouchi[21] found that shortness of breath (7.3%), chest pain (3.2%), fever (2.8%), altered mental status (2.1%), and syncope or collapse (1.9%) were the top five causes of hospital admission among super-elderly patients. In a recent study by Covino et al.[6], it was reported that neurological deficit (9.1%), trauma (8.3%), abdominal pain (7.5%), wounds (7.2%), and chest pain (6.0%) were the top five most common causes of hospital admission in their > 85 years patient cohort.

Emergency triage is a systematic process of determining patients' priority for medical management based on the severity of their current condition[22]. To prioritize healthcare for severely ill patients, medical centers have instituted triage systems in recent decades, with the aim of identifying patients with more severe conditions and increased risk of death, thereby ensuring faster service with shorter waiting times[23]. The main factors determining patient priority must be rapid, accurate, and reliable. There exist a number of triage categorization systems, and most Turkish hospitals are still using a classical triage system to create a quick categorization with colors such as red, yellow, and green, according to principles referring to airway openness, breating status, and circulatuary condition. In this study, we found that more than half of our study population was categorized as red, which is quite different from the data acquired from other studies that focused on the general population admitted to the ED[24]. For this

reason, it is reasonable to suggest a different approach toward super-older patients to determine the severity of the patient's situation during the admission process. We found that super-elderly patients with admission triage categories of red had significantly elevated CCI levels compared with patients classified in the other two triage zones. In this context, we believe that CCI can be regarded as a novel and attractive tool for the triage of acutely ill super-elderly adults, due to its feasibility and easy evaluation.

This study has limitations that must be identified. First, the data presented in this study comes from a single institution, and the resulting generalizations are therefore questionable. Second, being a referral center, it must be noted that patients with less severe illnesses initially might be directed to the local hospitals. Third, readmission rates were calculated if the patient was re-admitted to our hospital; admission to any other hospital was not calculated in the final analysis.

In conclusion, the population aged 85 years and older will be the fastest-growing demographic segment of the world over the next 10 years. Compared with the general population, super-elderly patients demonstrate poorer outcomes, diminished survival rates, and increased return visits to the ED. Therefore, our findings could be considered attractive because they highlight the importance of simple prognostic markers while evaluating super-elderly patients in emergency department settings. Future studies should focus on different diagnostic cohorts of super-elderly adults admitted to the ED and the potential use of the CCI in ED settings. A scoring system dedicated specifically to super-elderly patients admitted to the ED is desirable.

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Author Contributions: Concept/Design : MD, OB; Data acquisition: OB, MD, GA; Data analysis and interpretation: : MD, CB; Drafting manuscript: YB, MD; Critical revision of manuscript: OA, YB, İK; Final approval and accountability: MD, OB, GA, İK, CB, OA, YB; Technical or material support: İK; Supervision: OA; Securing funding (if available): n/a.

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