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Parameters for Prediction of ICUs Mortality using Organ Dysfunction and Diseases Severity Scoring System

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ABSTRACT

Objectives: The aim of this article is to find the mortality rate of the critical patient admitted in ICU depends on how severe or acute of their diseases and how actively are there organ functioning.

Methods: There are various surgeries are critical in nature among them one such surgery is CABG which requires a few days of ICU stay. The type of ICU stay recommended for various CABG patients depends on the nature of operation done and the type of observation, care needed for them. Like for some patients ICU is recommended, for some ICU along with ventilation is suggested.

Findings: Approximately 1000 patients suffering from different types of disease severity or organ dysfunctions were taken into consideration and the increment of SOFA scores ≥ 2 were considered for the comparison. After that a follow up period, 300 patients regarding death and discharge from the care unit are considered. It was found that 46% were discharged after recovery and remaining 54% are suffering from their sickness in the possibility of hospital stay. It is found that calculated mean for age is 46.9 ± 19.4 years with seniority 52% of patients older than 46 years. Peoples who suffer from illness in care unit were significantly (ρ=0.0352) mature 48.2 ± 18.4 years than peoples who were properly released. In this study a greater number of male patients 56% are identified compared to female patients. The LOS in the ICU after critical surgery is an important variable with other major factors for effective use of the critical resources.

Novelty: The main aim of this study is to find a better and more effective scoring system, at a low cost, so that the patients admitted in hospitals get better treatment along with accurate diagnosis. Last but not the least the author wishes everyone a healthy and happy life.

Keywords: Mortality rate; ICU; Disease; Organ dysfunction

ABBREVIATIONS

(ODIN) Organ Dysfunction and Infection System; (OSF) Organ System Failure; (GCS) Glasgow Coma Scale; (SOFA) Sequential Organ Failure Assessment; (SAPS) Simplified Acute Physiology Score; (MODS) Multiple Organ Dysfunction Score; (MAP) Mean Arterial Pressure; (APACHE) Acute Physiology and Chronic Health Evaluation; (DP) Diastolic Blood Pressure; (ICU) Intensive Care Unit; (LOS) Length of Stay; (SP) Systolic Blood Pressure; (MPM) Mortality Probability Model

INTRODUCTION

Providing proper treatment to the critical patient admitted in ICU is very challenging due to unstable clinical status and physiological capacity. Theses lack of proper resources, at time results in, having an incomplete or inaccurate analysis regarding patient recovery. To meet up this shortage prognostic prediction and therapeutic decision is important. To meet up

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this shortage and for the wellbeing of the patient and to provide more accurate ICU infrastructure several researches has been conducted. But a perfect model along with various acuity scores for proper assessment is still under process. Proposed model are now prevailing in market show comparison of different scoring system to predict mortally and assessment validity of ICU. This study helps to compare the results of different organ based on their functioning for ICU patients. This proposed model has all the elements of APACHE, SAPS, SOFA and MPM that act as a guide line for the doctors to detect the progress of patients in ICU along with care and medication guide line. Shortage of resources like inadequate ICU bed, lack of trained and experienced intensive care giver, the process of providing relief to these critically sick patient become a challenging task for the medical personnel. In spite of these entire drawback all calculating measure are being taken to reduce the rate of mortality for ICU patients. Collecting the data from the care units are partitioned into two categories. Details of each category are as follows in **Table 1**.

Table 1: Data collection categories

First category	Second category
These techniques are used for the whole day to observe the patient physical condition.	Focuses on organ related issues like organ failure-malfunctioning of multiple organs.

The main concern of any ICU is to provide the best treatment and care to the admitted patient. In such case ratings are used to identify better quality of care. For example if a patient has a prolong stay in ICU's than expected then what other problem the patients suffered in relation to medical term like pneumonia, bed shore etc. are also consider. Along with that after treating the patient in ICU and after curing the patient the next step is the discharge process-from ICU to general bed and to find out if the patient is recovering there. Further need to be resifted in ICU. Different parameters regarding duration of stay performance are much related. Make a general ordering to check the achievement of care units, it does not show a vital variation for which one of the several is used. Main issues are ICUs always searching for the better estimate than another. In case such classifications are used for conclusion regarding individual care unit's purposes such as precautions, promising and find better quality of care. It would be sensible to examine several measures; if they give different results consider which is best suited for the purpose at hand. It is useful to look for the cost stifle initiatives like a care unit concern about its profitable achievement managed by different plans for example if the problem was that patient continued longer than as expected, then plans that affect all patients might be examined. Discharge condition also examined with genuine observation also. Further another important difficulty regarding the shifting from care units to regular bed. The action usually used here weighted duration of stay, because from "calendar time" more high values are obtained that also increase the ICUs cost [1].

Research Gap

Purpose of the study: As mentioned earlier the medical professionals have to work in their field with limited resources, for the increasing cost in the health sector. There is a need for proper decision making, by using a user friendly mortality predictive scoring system for patients suffering from organ dysfunction with other ailments. Generally, two categories of patient get admitted in hospitals-the one is general patient who requires a short stay for some basic treatment and the other external patient who needs to get transfer from one hospital to another (critical patient). For theses later patient characterizing of accurate data proper information are required, as because the nature of the patients, the type of diseases, severity of diseases varies from patient to patient. In such cases major research gap exists that addresses following two issues.

- Effective ICUs to control external patient in terms of duration of their stay in the hospitals. Another is
- Limiting their length of stay by use of various scoring systems like SAPS, APACHE and MPM that helps in proper diagnosis of critically sick patients.

Comparative analysis with the existing literature: To evaluate the outcome of critically ill patient along with the mortality risk is an important part of modern medical science. Some of the scoring systems which are helpful are

- APGAR (1953) assesses the validity rate of the new born.
- Glasgow coma scale (GCS)
- RANSON

A large number of scoring system has developed within the last two decades. Prognostic or general scoring systems are used to diagnose severe diseases. APACHE and SAP are used for risk-based purposes of the ICU patient within 24 hours of their admission. Another key element is SMR which can be calculated by using these systems. In the modern ICU several diseases specific scoring system have developed that helps to detect several diseases like hepatic failure, old age respiratory diseases, single or many organ dysfunction, organ-failure etc., [2].

METHODOLOGY

Organ Dysfunction Scores

The percentage of organ damage cause in a patient can be detected by organ failure scores. The rate of organ damage varies from person to person, an organ dysfunction scores helps to find out both the duration and severity of the damage. Those several organ scores are now in existence, but this study is only limited to Logistic Organ Dysfunction Scores (LODS) and Multiple Organ Dysfunction Scores (MODS).

Logistic Organ Dysfunction Score (LODS)

This evaluation process evolved in the year 1996 with a database which consists of 137 ICUs in 12 countries with 13152 admitted patients. Neurological, cardiovascular, renal, pulmonary, hematologist and hepatic organ were taken into consideration by the help of 12 parameters to find out the functioning of each organ. The scale had a variable ranging from 0 to 5 where 0 means no malfunction showing perfect functioning of the organ, and 5 meaning total dysfunction. This evaluation uses multiple logistic regression techniques for analysis of mortality. For respiratory and agglomeration systems, the perfect scores considered is 13 and for bile-duct is one. LODS is helps to find out the percentage of organ malfunction score and get prediction scores. For more specific and accurate reading glob-

al scoring system is recommended. To predict the chances of death regression equation is preferred. It was found that severe malfunctioning of organ is constantly related with more death rate i.e. 22 of LODS=99.7% death rate [3].

Multiple Organ Dysfunction Score (MODS)

Cardio vascular and respiratory organ fall under the category of MODS whose parameters were selected under define "Define Descriptor." Gastrointestinal function was not included under define expositor, but cardio vascular system fell under the composite variable.

Pressure adjusted heart rate=Heart rate × Central Venous Pressure/Mean Arterial Pressure

In the above equation Mean Arterial Pressure (MAP) value can find as

MAP=DP+1/3(SP-D) Or MAP=DP+1/3(PP)

Here systolic blood pressure is SP, the pulse pressure as PP and DP is the diastolic blood pressure. It is useful to measuring mean arterial pressure in most laboratory arrangements which provide a fast useful ways of measurements when blood pressure is known. In this above equation this variable is considered normal for patients without a central line.

Above mentioned six organs, for each organ, the starting variables of the day are used to measures the evaluation according to the rating scale of a score of 0 (which is a treated as normal) to 4 (which is treated as most dysfunction) is calculated, which is a total maximum score of (6 × 4) 24. MODS score was developed for the one surgical ICU where 336 patients are admitted and subsequently validated by 356 sick patients admitted to the same care unit. MODS score alone is not sufficient to find ICU death rate but check growing MODS results also interrelated with care unit output [4].

Sequential Organ Failure Assessment (SOFA)

This scoring system was developed in 1994. Based on the literature review and functioning of each organ in a human body, there are 6 vital organs were chosen-renal, hepatic, respiratory, cardiovascular, principal nervous and concentration. The scoring chart of each organ range from 0 to 4 where 0 was considered to be regular while 4 was critical/irregular. Related to MODS evaluation each day records are compared with SOFA. The main difference between SOFA and MOD is that SOFA uses treatment related parameter-those of dose of vasopressor agents while MOD uses the composite variables. The MOD system is not an ideal practice because the nature of patient, treatment procedure gets changing frequently. In a combination of, medical-surgical ICU population the SOFA scoring system was initially validated. It was applied to various groups of patients and also validated. A prospective study of 1449 patients it has been calculated that counted SOFA value above 15 which correlated for death rate of 90%. Regarding multiple organ dysfunction syndromes with 1340 patients it is found that 100% death rate for sick peoples with respective age more than 60 years. Below **Table 2** summarizes the general characteristics of three organ dysfunction scores and the uses of variables used to measures organ malfunction relevant to the 6 organ of a human body [5] (**Table 3**).

Table 2: Define descriptor of organ dysfunction in ICU patients

SL No.	Descriptor
1	Is it Simple and inexpensive?
2	Is it Routinely available for all ICUs?
3	Is it Reliable for observation like inter-observer and intra mode?
4	Objective (whether independent in nature)
5	Is it pointing to the workings of the organ in question
6	Whether it is independent nature of therapy?
7	Sequential (regarding admission and recorded for definite periods)
8	Not influenced by transient, abnormalities related to therapeutic or practical interventions
9	Is it reflecting not chronic dysfunction but acute malfunction of the organ in question?
10	Is it Reproducible to different types of care unit patients in large?
11	Is it used for different types of care units from several regions across the globe?
12	Whether not proper in uni-direction only?
13	Is it used regularly rather than two-way variables?

Table 3: General characteristics of mentioned organ malfunction scores

Features	LODS	MODS	SOFA
Availability	1996	1995	1996
Choices of parameters and scores	Statistical MLR techniques are used	Statistical Logistic Regression(LR) techniques are used	Decided by the team of specialists
Variables used to assess organ dysfunction			
Neurologic	Measured by GCS	Compared by the parameter of consciousness or GCS	Measured by GCS
Cardiovascular	Identify the rate of heart and SP	Identify the Pressure-adjusted heart rate	Mean arterial blood pressure, vaso-pressor use
Kidney condition	Observe the urea or urea nitrogen, creatinine, urine output	Observe only the Serum creatinine	Observe Serum creatinine, urine output
Respiratory trouble	Check the oxygen level and ratio, mechanical ventilation	Check the level of oxygen ratio	Check the level of PaO2/FiO2 ratio, mechanical ventilation
Hematologic	Count the presence of blood cell (white) and platelet in the blood	Check the Platelet count	Check the Platelet count
Hepatic	Observe the level of Serum bilirubin, prothrombin time	Identify level of Serum Bilirubin in blood	Identify Serum Bilirubin level in blood

Comparison of Different Organ Dysfunction Scores

Several studies have been performed to find out the causes of organ malfunctioning and it was found that these studies are capable to find out the causes of death rate in hospital. Study was performed among 949 patients admitted to ICU, to find out whether MODS or SOFA, whichever method was applied to theses ailing patient, there was no vast difference in the outcome. But in the cardio vascular system it was found that MODS get better results than SOFA. Regarding uses of the cardio vascular component it was found that as compared to the MODS value found was better regarding the SOFA results at all-time duration. In a multicenter study, for both the scoring system SOFA and LODS it is reported good internal consistency and accuracy. In an observation of 1436 ICU patients it was observed that both the scoring system MODS and SOFA had only good capability to differentiates between no-survivors and survivors. Patients with brain injury, more recently it is observed that SOFA has unfavorable neurological outcome compared to MODS and SOFA also has superior discriminative ability for hospital mortality [6].

Disease Severity Scoring Systems

Not only have various organ dysfunction scoring system helps to find out the mortality rated of the patient even age, nutritional values, co-morbidities, inflammation, artificial respiration support and the range of contamination also plays the major role in deciding the survival rate of ICU patients. Different scoring systems have different parameters for detecting mortality rate. How a patient will get treated for his illness-in terms of total infrastructure like manpower, resources are available from diseases severity scores. The scoring systems like APACHE, SAPS and MPM are helps to improve the process of prognosis and to increase the survival rate of patient admitted in ICU.

Acute Physiology and Chronic Health Evaluation (APACHE I and II)

The original APACHE scores were available in 1981 and have two parts (**Table 4**).

Table 4: Availability of APACHE scores

APACHE	APACHE II
To measure the acute illness a physiological scoring system is developed.	Pre admission equation helps to calculate the health condition of sick peoples.

APACHE has 34 physiological variables to identify how serious is the condition of the sick person. APACHE model was modified in 1985 and APACHE II was developed which is used now a days to detect the degree of illness in ICUs throughout the world. List of characteristic was observed under this model.

- 12 physiological variables corresponds to 34 variables for major parameters
- Age and chronic status of the patients are directly incorporated.
- Records corresponding uses and tries to keep the range limit within 71 for better management.
- Record the overall condition of the patient for 24 hours which gets recorded to the health department to measure physiological parameters.

APACHE III and APACHE-IV

In the year 1991 was constructed and was validated accordingly for further updated in the year 1998 and 20 physiological variables initially selected for severity of disease. In this model additional features are added using the calculation for finding risk regarding evaluated care unit duration of stay. Currently APACHE-IV was introduce which consists of information of more than 1,00,000 patients admitted to more than 100 care units in 45 health care units in the USA during 2002/2003 and also revised APACHE III with the same physiological variables and weights but different usable variables and refined accordingly available statistical models. Like APACHE III the new model APACHE-IV again furnish care unit length of stay prediction equations, which can used as an milestone for the evaluation and differentiation of care unit effectiveness and usable resources. APACHE-IV scoring system is measured depend on 100 and 29 variables which are available during the starting whole day of ICU admission, and are evaluated for 110,588 patients admitted to more than 100 care units over USA [7].

Simplified Acute Physiological Score (SAPS and II)

This system was first invented in France in 1984. This system uses 13 weighted physiological variables and uses “age” as an important parameter to know the number of deaths of sick patients in ICU. Both SAPS and APACHE III are used to calculate the most negative results/outcomes collected from the first day of a patient’s admission in ICU. Further SAPS model has been modified to include variable like SAPS II. Similarly 1993 SAPS II got further modified by the inclusion of logistic regression analysis, which consists of 17 variables like 12 anatomical parameters, age, type of admission and three more parameters two measures basic illness. This system was successfully applied to 137 care units over 12 countries and proves to be effective [8].

SAPS III

SAPS III was introduced in 2005, deals with complicated statistical techniques for providing variables regarding information of 16784 persons of 303 care unit and from 35 countries. Further 20 variable were divided into 3 sub-scores which include patents overall condition before admission, circumstances of entries and velocity of anatomical dimension within one hour of admission where SAPS II model needs 24 hours of time before or after of admission in care units. This model has wide range of variable from 0 to 217 for better monitoring. Customize equation are included in this model which provides better and accurate results in terms of mortality outcome than other model; due to small size specimens. Good selection, uninterrupted continuity and goodness fit are some of the positive characteristic of this model. SAPS III scores pointed out three major things like good selection, proper continuity and goodness of fit. SAPS III used for the areas like

- Examine the inconsistency in resource use between care

units

- Uses of parameter for resource use regarding the Length of Stay (LOS) in the care unit
- Stable parameters regarding seriousness for critical illness

Mortality Probability Model (MPM and MPM II)

In the year 1989-90 MPM model was introduced with the help of data collected from the patents of a single ICU, and comprised of 7 entry variables. Later in 1993 are revised MPM model came into existence comprising of statistical techniques with a wide range of informative data of 12610 patients from 12 different countries all over the world. This model has to score

- MPM 0 with 15 variables and
- MPM 24 a single day model with 5 admission variables along with 8 extra variables, designed a especially for those patients who have to stay in care units for more than 24 hours.

In this model (excepting Age-which is specified as the actual value in the system), every other parameters is marked as either present or absent by specifying the value of either 1 or 0 while APACHE and SAP are based on weighted parameters.

MPM_0 III

This updated model is based on patient data comprising of 16 parameters including 3 vital physiological parameters collected within 1 hour of patient admission to evaluate the probability of death rate. This evaluation is largely based on patient's physical condition from admission to the starting of intensive care treatment. This model has been updated accordingly to the outcome related formula of WHD-94.

Comparisons of Three Disease Severity Scoring Systems

The validity or acceptance of any measuring systems depends on many factors among which the most vital are

- The quality of input provided to that particular system
- Following of operating steps according to the specified instructions
- Maintaining of proper definitions
- Maintain exact and correct time of time of data collections
- Percentage of accuracy during data collection
- Specified norms to be followed properly during the absence of data and its proper matching at the time of model building
- Most importantly authenticity of system including intra and inter observer must be considered. Another important factor that must be taken into account while using this scoring system is the limitation in terms of local customization and daily update [9].

First, in many derived equations are inherent biases used to calculate the death rate from the selected samples of sick peoples in ICU which helps in to evaluating the performances of the care unit.

Second, in all the scoring systems the outcome used is the vital status of release from the hospital. Subsequently, use of other parameters like the condition of the patients at the time of release may neglect the validity of prediction. Several scoring system have more evaluation option like use of resources, counted as hazard regulated, encumbered hospital days for further analysis.

Third, the calibration of a prognostic model are measured by various statistical techniques like Hosmer-Lemeshow statistic, which is regulated by various factors like; numbers of covariates used to process the monitoring results of similar probabilities along with its unit size-small or big are also considered. More over accuracy interpretation based on prediction includes use of mathematical tests.

Fourth, prognostic models are designed, keeping in consideration of big population. When this model is predicted on a big population only detoriation in calibration was found, while other parameters remain the same.

Based on the scoring systems APACHE IV provides information regarding its respective range. APS score, estimated percentage (%) of death rate and duration of stay in terms of number of days.

Technical Analysis

As mentioned earlier duration of stay in hospital of various patients varies in terms of disease severity, and clinical characteristics plays a major role on the duration of stay for patients admitted in ICUs. An informative statistical model is helpful for predicting the length of stay, which to some extent helps for different case mix. Different prediction based on the length of stay generally reflects a ICUs operative style management, use of resources, availability of skilled personnel etc. It is found that various prediction regarding the length of stay statistically shows approximately 80% to 85% variation among patients regarding in total cost of a hospitalization. By using severity model with other variable attempts have been taken to predict the estimated stay of patient admitted in ICU, but they are not so effective and showed less success than was expected. By using regression analysis more improved predicted weighted length of stay can be determined which has a value for R2 is 0.29. This model is mainly used for it can adjust for case mix and can take into account the expense differences of ICU and non-ICU stays. In such case mix patient include those patients who are undergoing kidney transplant along with general medical/surgical ICU patients.

RESULTS

This paper discusses the economic performance of the ICU in relation to clinical performances. It was observed that cost calculation becomes a huge problem for that patient who gets transfer from ICU to general bed. Prolonged stay in ICU becomes difficult to calculate because ICU is an overall continuous process of hospital care. Better management policies are needed to minimize and control cost for ICU and post ICU sector and also focus on the cooperative approach to control

the cost. Further our results discuss that there was a significant chances exists for controlling of resources that does not affect ICU length of stay with the help of different scoring system. Further calculating difference (between expected length of stay and actual length of stay) for computing excess weighted length of stay value with the intermediate care cost also. The goal of this result is to suggest a good option for the economic dimension of the performance [10].

DISCUSSION

The hygiene and clinical effectiveness of ICUs depends on the infection level as well as its daily cleaning criteria also. Reducing length of stay by bad policies that increases excess mortality is clearly not desirable. Regular update regarding evaluation methodologies must be considered for clinical and economical dimensions. The main aim of this comparative study is to create more effective policies that will provide enough information regarding ICUs economic dimension. This reviews to identify several parameters regarding the treatment provided in ICUs. Various scoring system helps doctor to predict the chances of death rate by taking into consideration, the scoring variables available within 24 hours of ICU admission along with other ailments like other illness (co morbidities, pathological laboratory examination etc.). Age, capacity to intake the level of ventilation also affects the rate of mortality while APACHE II is not directly related to mortality. The different scoring system provided different results in terms of comparing the rate of mortality for patents admitted in ICUs. According authors Evran et al. reported that "age" is the main factor of high rate of mortality. In an another study, it was found that geriatric patients who were undergoing for emergency abdominal surgery assessment of patients health was more effective with the APACHE II system in terms of severity regarding organ malfunction and contamination system (ODIN), SAPS2 and MCI. APACHE II provided enough accuracy in predicting hospital mortality in association with MCI and ICU by Quach et al. APACHE II is a reliable system for predicting death due to sepsis. But APACHE II has few limitations also. It is not suitable or recommended for death associated with trauma for predicting morbidity by the Dosset et al. for cases related to morbidity APACHE II is preferred. In a recent study it was found that LRA analysis is use full for age, blood pressure, APM score, while CRP level helps to analyze the condition of ICU patients. Regarding cost calculation multiple ICU stays were considered. In case of multivariate logistic regression modeling several parameters like age, albumin, platelet and C-reactive protein were considered for fast mortality prediction [11].

CONCLUSION

Prospects

Though many studies have been published regarding the effectiveness of scoring systems, but a more effective and accurate clinical tool is still absent for ICUs. Lack of a good or effective tool may be due to lack of resources unable to select the proper sample size, lack of availability of proper data system on the first day of a patient admission in ICU and lack of requisite time to analyze the daily vital signs of the scoring systems. The main aim of this study is to compare and analyze different scoring system with the help of various parameters to predict effective mortality outcome of a care unit. Mortality prediction in this case was calculated by taking into consideration average individual parameter for each patient. Only 300 patients are included out of 1000 patients meaning only 30% of the total population. The major strength of this research is to identifying the severity of illness and proper prognosis of ICU patients in terms of diagnosis and treatment parameters. During this study ranking system was developed to analyze patient condition for better treatment in terms of proper medicine. Further comparisons of day to day scores or rankings of care unit were helpful to predict mortality and to assess various biochemical markers like protein status, platelet count, blood pressure monitoring etc.

Further combined application of various parameters and scoring system can helps to improve the accuracy of disease detection. Sample size as said earlier is the biggest limitation of the case-study. Increasing of sample size is required for more accurate study. At present majority of the scoring system is widely based on statistical analysis of clinical data but geographical condition of different countries have different treatment level an application of scoring system.

Take-Home Message

For more than 40 years scoring system acts as an important tool to detect the level of ICU performance. A combination of experience with merits and demerits, along with new technologies, big data, deep learning (DL) and ML techniques major improvements will get reflected for health care industry which may lead to wider and accurate implementation along with international comparison with ICUs worldwide.

Recommendations

Lack of proper availability of good nursing care with facility at time will results in different performances in ICUs. ICUs in cardiac patients like CTV, RCU, CCU, and CTVS have different characteristics in terms of management and organization as compared to other patients admitted in ICUs. This work shows major differences regarding several scoring system and their impact on ICU patient. Further various categories of patient like "typical," "critical and external patients" are also an important area of further research. Special cautions should be noted regarding excess length of stay patients. Due to limited study of few patterns are included for predicting mortality in care unit but in future work more parameters are included for investigation on daily basis till the patient gets discharged or shifted to other care unit to predict outcome of care using SOFA, MODS, and LODS.

Future Work

For the high risk patient, the percentage of sick peoples is staying in the care unit for more than 72 hours is very high. Therefore the need of good prediction model for the validation is also required. Further it is recommended that based on the patient demographic details, the hospital can manage its ICU resources, in-crease capacity of the beds and plan to use of the critical ICU resources efficiently.

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CONFLICT OF INTEREST

The authors declare there are no competing interests.

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