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The Model of End-Stage Liver Disease (MELD) Score Predicts the Survival Period of Patients with Liver Failure

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Abstract

The liver is the largest essential internal organ in the body. A healthy liver is necessary for survival that can regenerate most of its own cells when these are damaged. The Model of End-Stage Liver Disease (MELD) is a numerical scale that is reported as a whole number, and is used to predict survival in patients with cirrhosis and liver failure. It is an objective measure incorporating three quantitative values, such as serum creatinine, international normalized ratio (INR), and serum bilirubin that are readily available, reproducible, and objective. It is used to prioritize and allocate adult patients with liver cirrhosis waiting for a liver transplantation (LT). The transplant teams should take decision of LT for patients with higher MELD scores. Liver failure patients with MELD score≥20 should be regarded as high risk for mortality. Although, MELD is an ideal score, it cannot provide accurate information of survival in 15–20% cases. In this study an attempt has been taken to highlight the importance of MELD score for LT patients.

Keywords: MELD, liver cirrhosis, liver transplantation, prediction of survival, mortality

1. Introduction

The Model of End-stage Liver Disease (MELD) is a scoring system that provides the severity of the end-stage liver disease when the liver is almost completely damage due to liver cirrhosis, liver failure, and hepatocellular carcinoma (HCC). It is developed to predict survival following transjugular intrahepatic portosystemic shunt (TIPS) was subsequently found to be accurate predictor of mortality amongst patents with end-stage liver disease (Malinchoc et al., 2000). It accurately predicts most patients' short-term risk of death without a liver transplant. It is calculated from laboratory values of serum bilirubin, serum creatinine, and the International Normalized Ratio (INR) for prothrombin time (Khan et al., 2009). It is most accurate predictor of short-term mortality amongst patents with end-stage liver disease. The waitlist mortality among women is by 13% more compared to men due to the given renal function, women tend to have lower serum creatinine compared to men for lower muscle mass in women (Zhang et al., 2012).

The MELD was originally developed at the Mayo Clinic of the USA around 2000 through the effort of a group of researchers lead by Dr. Patrick Kamath, professor of gastroenterology and hepatology; and at that time, it is called the "Mayo End-Stage Liver Disease" score (Malinchoc et al., 2000). It was developed to predict mortality within three months of surgery in patients who had undergone a transjugular intrahepatic portosystemic shunts (TIPS), acute liver failure, alcoholic hepatitis, acetaminophen-induced liver injury, and hepatorenal syndrome to assess the surgical mortality risk in patients with liver cirrhosis (Schmidt & Larsen, 2007). In February 27, 2002, the MELD score is adopted and approved as the core system for organ allocation and implementation by the United Network for Organ Sharing (UNOS) that is a score to allocate organs for patients awaiting liver transplantation (LT) in the USA (Kamath & Kim, 2007). In January 2016, the MELD scoring system for donor allocation in the USA was further modified to incorporate serum sodium, using the MELD-Na equation. It is

incorporated in only for persons with a MELD score greater than 11 (Kalra et al., 2016).

2. Literature Review

Literature review is an introductory section where research works of previous researchers are highlighted to make familiar with the new researchers in the research world (Polit & Hungler, 2013). It helps the researchers to understand the core concept of the subject that serves as an indicator of the subject that has been carried out previously (Creswell, 2007). Patrick S. Kamath and his coauthors have investigated that the MELD scale is a reliable measure of mortality risk in patients with end-stage liver disease and is suitable for use as a disease severity index to determine organ allocation priorities (Kamath et al., 2001). Ashwani K. Singal and Patrick S. Kamath have stated that the MELD score is initially developed to predict survival following transjugular intrahepatic portosystemic shunt (TIPS) that is an accurate predictor of mortality amongst patents with end-stage liver disease (Singal & Kamath, 2013).

Rustam Khan and his coauthors have tried to determine the relationship of MELD scores to the outcome of post-viral hepatitis cirrhosis with infection and to compare it with Child-Turcott-Pugh (CTP) score. However, better improved models need to be developed for prioritization of patients in the waiting list (Khan et al., 2009). Nasim Rahimi-Dehkordi and his coworkers have compared the ability of the CTP score and the MELD score to predict mortality or removal from the waiting list due to poor medical conditions (Rahimi-Dehkordi et al., 2014). Patrick G. Northup and his coworkers have tried to determine the ability of the MELD score to predict 30-day postoperative mortality for patients with cirrhosis undergoing non-transplant surgical procedures (Northup et al., 2005). Isioma Emenena and her coauthors have taken attempt to find the value of the MELD score in assessing the mortality of patients with decompensated liver cirrhosis over one month period (Emenena et al., 2023).

Prathvi Nandalike and her coauthors have observed that chronic liver disease (CLD) is one of the common non-communicable diseases that is related to significant morbidity and mortality in developing countries. The MELD-Na score is higher among the patients with outcome of death compared to the MELD score among the patient (Nandalike et al., 2022). Uri Kartoun and his coworkers have stressed on accurate assessment of the risk of mortality following a cirrhosis-related admission can enable healthcare providers to identify high-risk patients and modify treatment plans to decrease the risk of mortality. They are hopeful that the improvement of current standard models, such as MELD and MELD-Na that can guide clinicians in better targeting treatment to improve cirrhosis care and outcomes for high-risk patients (Kartoun et al., 2017). W. Ray Kim and his coworkers have found that the MELD has been established as a reliable indicator of short-term survival in patients with end-stage liver disease. Their objective was to optimize MELD further by taking into account additional variables and updating coefficients with contemporary data. The final model MELD 3.0 affords more accurate mortality prediction than MELD-Na and addresses determinants of wait list outcomes, including the sex disparity (Kim et al., 2021).

3. Research Methodology of the Study

Research is an essential part for academicians to develop their academic world (Pandey & Pandey, 2015). Methodology is a guideline to prepare a good research (Kothari, 2008). Therefore, research methodology is the collection of a set of principles for planning, designing, organizing, and conducting a successful research (Legesse, 2014). To prepare this article, I have dependent on the secondary data sources related to MELD score for the prediction of the mortality of the liver failure patients (Mohajan, 2017, 2018, 2020). I have consulted books of famous authors, national and international journals, e-journals, handbooks, theses, etc. to enrich the study (Mohajan, 2024a-r).

4. Objective of the Study

Main objective of this article is to discuss the basic concept of MELD score that is a good predictor of mortality among patients with decompensated liver cirrhosis. It is developed by a group of researchers at the Mayo Clinic initially as a model to predict survival following transjugular intrahepatic portosystemic shunt (TIPS) for refractory variceal bleeding or refractory ascites. It gives each patient a ‘score’ or number based on how urgent s/he needs a liver transplant in the next three months (Malinchoc et al., 2000). Other minor objectives of the study are as follows:

- to focus on overview of liver and liver transplantation,
- to highlight on MELD scores, and
- to discuss the importance of MELD scores.

5. An Overview of Liver

The liver is the largest and the most complex internal organ of the body that weighs approximately 1500 gm. It has a remarkable capacity to regenerate its injured tissues (Mohajan, 2024b). It is a wedge or cone shaped with the base on the right and the apex to the left (Ramachandran & Kumar, 2019). It is an essential organ in the

human body that performs up to 5,000 different vital functions in combination with other organs and systems, such as supporting digestion, immunity, proteins synthesis, amino acid metabolism, blood coagulation, detoxification, vitamin storage, etc. (Hettiaratchi, 2022). In an adult human it weighs between 1.5 and 2 kg. It is divided into right and left lobes; the right lobe being larger than the left. It is located in the right upper quadrant of the abdomen and spans across the midline to the left upper quadrant (Mohajan, 2024j).

6. An Overview of LT

Complications of end-stage liver disease (ESLD) are ascites, variceal hemorrhage, hepatic encephalopathy, and renal impairment primarily that account for numerous deaths. LT is a valid treatment option for these patients (Cox-North et al., 2013). LT is a life-saving treatment option of a diseased liver through the replacement with a healthy liver from a deceased donor or a portion of a healthy liver from a living donor. It is the second most common solid organ transplantation after kidney transplantation worldwide (Lucas, 2021). It is a well-recognized life-saving treatment option for people when liver cannot regenerate and the damage becomes about life-threatening due to liver cirrhosis, decompensated disease, liver cancer, acute liver failure, and hepatocellular carcinoma (HCC) (Mohajan, 2024q). The first attempted of human LT was performed in the world in 1st March 1963 by American physician, researcher, and expert on organ transplants Thomas Earl Starzl (1926-2017) who has often been referred to as "the father of modern transplantation" (Starzl et al., 1963). The LT can be orthotopic (same place) or heterotopic (other place), and can be performed in patients of all ages (Freeman et al., 2002).

A LT is a complex process that requires hundreds of steps before, during and after LT. The LT centers match donors with recipients based on compatible liver size and blood type. In 2021, there were about 34,694 LTs performed globally that is an increase of 6.5% from 2020 and a 20% increase from 2015 (Terrault et al., 2023). However, donor organ shortage and lifelong need for immunosuppression are the main restrictions to LT (Adam et al., 2018). Most of the LT persons are able to return to a normal and healthy lifestyle, and can enjoy an improved quality of life. They are able to start normal exercise after their recuperation, and women are able to conceive and have normal post-transplant pregnancies and deliveries. Proper nutrition maintenance is necessary after LT to control the changes in the body (Lewis & Howdle, 2003). However, with increased waiting times for organ transplantation, some listed patients die annually while waiting for LT, and many other patients with ESLD are not candidates for LT (Montgomery et al., 2005).

7. MELD Scores

The MELD scoring has been applied as a new liver organ allocation system for LT since 2002 in the USA and since 2006 in Europe, and at present it is using worldwide (Aiello et al., 2017). Decompensated liver disease is developed at the end-stage of the disease, such as liver cirrhosis, liver cancer, liver failure, and hepatocellular carcinoma (HCC). LT is the only life-saving treatment option of these patients that can be performed by a diseased liver through the replacement with a healthy liver from a deceased donor or a portion of a healthy liver from a living donor (Lucas, 2021).

The MELD scoring has three objective variables: serum bilirubin, serum creatinine, and institutional normalized ratio (INR). It has been used worldwide for listing and transplanting patients with end-stage liver disease allowing transplanting sicker patients first irrespective of the wait time on the list (Singal & Kamath, 2013). It is defined by American hepatologist Michael Malinchoc, and is calculated according to the following formula (Malinchoc, et al., 2000):

$$\text{MELD} = 3.78 \times \ln(\text{serum bilirubin (mg/dL)}) + 11.2 \times \ln(\text{INR}) + 9.57 \times \ln(\text{serum creatinine (mg/dL)}) + 6.43 \quad (1)$$

Of the three variables of equation (1), serum total bilirubin is the most important that has a linear relationship with 90-day mortality in patients waiting for LT in clinical practice. The INR reflects coagulopathy associated with synthetic dysfunction in patients with end-stage liver disease. After the adjustment of serum bilirubin and serum creatinine, the INR is associated with a steep increase in mortality risk (Leise et al., 2011).

The MELD uses a continuous scale from 6 to 40, based on serum bilirubin, international normalized ratio (INR) of prothrombin time, and serum creatinine (Kamath et al., 2001). The MELD<16 indicates low-risk patients and the MELD≥16 indicates high-risk patients (Angermayr et al., 2009). It has proven to be a robust predictor of short-term mortality in patients with cirrhosis, including candidates for LT (Wiesner et al., 2003). Mortality and MELD score are linearly correlated, and 3-month mortality estimated to be 4%, 27%, 76%, 83%, and 100% for MELD scores are of <10, 10-19, 20-29, 30-39, and 40 or more respectively. The MELD score of greater than 30 is the significant predictor of the mortality (Singal & Kamath, 2013).

The MELD-Na scale is defined as (Kartoun et al., 2017),

$$\text{MELD} - \text{Na} = \text{MELD} + 1.32 \times (137 - \text{Na}) - [0.033 \times \text{MELD} \times (137 - \text{Na})] \quad (2)$$

where the serum sodium concentration (Na) is bound between 125 and 137 mmol/L, as defined by the Organ Procurement and Transplantation Network (OPTN). In the USA, the MELD-Na is applied only if MELD is greater than 11. During 2005 to 2006, using MELD-Na instead of MELD has save 90 more lives (Kim et al., 2021). The model (2) has four objective variables: serum bilirubin, serum creatinine, and institutional normalized ratio (INR), and sodium. It has been used to determine organ allocation priorities for LT in the USA since 2016 (Nagai et al., 2018).

8. Importance of MELD Scores

Chronic liver failure affects multiple vital organs of the body that shortened life expectancy. As a result, the disease increases perioperative morbidity and mortality in patients with cirrhosis. Mortality and MELD score are linearly correlated amongst patients with end-stage liver disease listed for LT. For the survival of the patients; a surgical procedure, such as LT is necessary when there is no other option (Northup et al., 2005).

After the introduction of MELD score for organ allocation in the USA in the very first year have reduced about 12% in waitlist mortality. For example, the deaths on waitlist in the USA from 2,046 in 2001 to 1,364 in 2005 with the reduction in waiting time from 656 days to 416 days. On the other hand, the numbers of liver donors have increased from 4,671 in 2001 to 5,160 in 2005 (Wiesner et al., 2006).

The liver disease is increasing alarmingly worldwide and some of them are in end-stage liver disease. There are many patients waiting for LT. But only few living and deceased donors are providing the organs (Rahimi-Dehkordi et al., 2014). The criteria of LT have changed due to the development of CTP and MELD scores. At present LT are arranged through the changing allocation, immunosuppression, and liver failure etiologies, as well as better supportive therapies (Gotthardt et al., 2014). The MELD score has been widely validated in different populations of cirrhotic patients. Despite some concerns, it is currently useful for guiding LT allocation (Aiello et al., 2017).

9. Conclusions

From this study, we have observed that the MELD score is highly sensitivity and specificity, and predict the mortality among the patients with decompensated liver cirrhosis. It can accurately predict mortality, morbidity and long-term survival in patients with HCC and cirrhosis. It has been found to be well-suited for prioritizing patients who would be benefitted from LT. About the last three decades of discovery many efforts have been made by the scientific researchers for further improvement and refinement of MELD score. We should confidently depend on MELD score for liver transplantation until a better score is developed.

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