

MELD, APACHE II, SOFA, and Their Combined Scoring Systems for Predicting Postpartum Complications in Acute Fatty Liver of Pregnancy: A Comparative Study

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Abstract

Background

Acute fatty liver of pregnancy (AFLP) is a rare, life-threatening obstetric emergency. Early prediction of its severe postpartum complications remains a significant clinical challenge, optimal risk stratification tools have not been established.

Methods

This retrospective cohort study included 106 patients with AFLP admitted to a tertiary care hospital between 2011 and 2020. Severity scores (MELD, APACHE II, SOFA) were calculated using data from 24 h before delivery or within 24 h of ICU admission. Predictive performance for six major complications—acute kidney injury (AKI), disseminated intravascular coagulation (DIC), sepsis, multiple organ dysfunction syndrome (MODS), postpartum hemorrhage (PPH), and acute liver failure (ALF) was assessed using logistic regression, with discrimination evaluated by area under the receiver operating characteristic curve (AUC-ROC) and clinical utility by decision curve analysis (DCA).

Results

Among 106 patients, the most common complication was AKI (71/106, 67.0%), followed by DIC (30/106, 28.3%), MODS (30/106, 28.3%), PPH (29/106, 27.4%), sepsis (28/106, 26.4%), and ALF (24/106, 22.6%). The combined MELD-SOFA score was the best predictor for DIC (AUC 0.764, 95% CI 0.662–0.856), MODS (AUC 0.757, 95% CI 0.655–0.855), and ALF (AUC 0.797, 95% CI 0.692–0.886), and also demonstrated strong predictive value for AKI (AUC 0.882, 95% CI 0.803–0.943). The combined MELD-APACHE II score demonstrated excellent discrimination for AKI (AUC 0.899, 95% CI 0.815–0.967). APACHE II alone best predicted sepsis (AUC 0.748, 95% CI 0.643–0.848). All models performed poorly for PPH (AUC < 0.7). DCA confirmed greater net clinical benefit for the combined models within relevant threshold probabilities.

Conclusions

A complication-specific approach to score selection optimizes risk stratification in AFLP. While the combined MELD-SOFA score demonstrates broad applicability by showing high effectiveness for predicting DIC, MODS, ALF and AKI, optimal prediction for specific complications requires tailored combinations. the MELD-APACHE II score is superior for AKI, and APACHE II alone for sepsis. These findings support the targeted use of combined scoring models to guide early intervention and improve maternal outcomes.

1. Introduction

Acute Fatty Liver of Pregnancy (AFLP) is a life-threatening condition that typically occurs in the third trimester and persists into the perinatal period, with an incidence of approximately 1 in every 7,000 to 20,000 pregnancies, which is also associated with elevated maternal mortality rates (7% to 18%) and fetal mortality rates (9% to 23%), placing a significant burden on both society and national healthcare systems^[1, 2]. AFLP can lead to various severe complications, including acute liver failure (ALF), acute kidney injury (AKI), postpartum hemorrhage (PPH), disseminated intravascular coagulation (DIC), and multiple organ dysfunction syndrome (MODS)^[3–5]. These severe complications of AFLP necessitated intensive care, mechanical ventilation, continuous renal replacement therapy, and artificial liver support, ultimately leading to prolonged hospital stays, increased hospitalization costs, and a heavier burden on the national healthcare system. Despite some progress in the diagnosis and basic symptom prediction of AFLP, early warning and management of its severe complications remain insufficient. In particular, effective intervention when severe complications have already developed remains a major clinical challenge^[6]. Therefore, it is crucial to strengthen research on the prediction of severe complications of AFLP to provide a scientific basis for early intervention and reduction of maternal and fetal mortality.

The Model for End-Stage Liver Disease (MELD), which quantifies the severity of liver disease using total bilirubin (TBIL), serum creatinine (Cr), and international normalized ratio (INR), has been widely used for prognostic assessment in liver diseases and is effective in predicting outcomes in acute liver failure and pregnancy-specific liver diseases^[7–9]. However, the MELD score has certain limitations in predicting the prognosis of critically ill patients and complications, particularly non-hepatic complications.

The Acute Physiology and Chronic Health Evaluation II (APACHE II) and Sequential Organ Failure Assessment (SOFA) scores are widely used global scoring systems for assessing the severity and prognosis of critically ill patients^[10, 11]. Both of these scoring systems have also been applied in the prognostic prediction of acute liver failure^[12]. However, the comparative effectiveness of these general severity scores versus the MELD score specifically for the patients with AFLP, along with their distinct predictive profiles for different complications, has not been established. More importantly, it is unknown whether a synergistic effect can be achieved by combining these scores to offer clinicians a more accurate and actionable early-warning tool. A systematic investigation to address these gaps is currently lacking.

This study provides the first systematic evaluation of the predictive effectiveness of the MELD, APACHE II, and SOFA scores for postpartum complications of AFLP. Innovatively, it employs both the area under the receiver operating characteristic curve (AUC-ROC) and decision curve analysis (DCA), thereby assessing not only model discrimination but also the net clinical benefit across different decision thresholds. This study employed logistic regression modeling integrated with DCA to overcome the limitations of single-score predictions for postpartum complications of AFLP. Our study demonstrates the distinct risk-stratification advantages of a complication-specific, multi-model combination strategy.

This approach provides an evidence-based framework for establishing individualized intervention thresholds in clinical management.

2. Materials and methods

2.1 Study Population

This retrospective cohort study enrolled 119 patients diagnosed with acute fatty liver of pregnancy (AFLP) and hospitalized at Shandong Provincial Hospital between September 2011 and November 2020. Diagnosis was confirmed using the Swansea criteria (≥ 6 criteria met) ^[13](**Supplementary Table 1**). Inclusion required complete clinical data from the 24 hours before delivery through hospitalization. Key exclusion criteria comprised alternative liver diseases (such as intrahepatic cholestasis, hemolysis, elevated liver enzymes and low platelet (HELLP) syndrome, viral hepatitis, drug-induced hepatitis and autoimmune hepatitis), pre-existing end-stage organ failure, malignant tumors, or missing essential variables for score calculation. After exclusions, 106 patients with a clear prenatal diagnosis of AFLP were included in the final analysis (Fig. 1). In accordance with standard management, pregnancy termination was undertaken upon diagnosis. The study protocol was approved by the Institutional Ethics Committee (Approval No. SWYX:2021-052), and the requirement for informed consent was waived due to the retrospective design.

2.2 Data Collection

All data were extracted from the electronic medical record system, including demographics, clinical characteristics, laboratory results, imaging findings, and major complications and survival outcomes within one month after delivery. A detailed flowchart of patient screening and inclusion is provided in Fig. 1.

2.2.1 Baseline and Clinical Data: This encompassed age, obstetric history (gravidity, parity), gestational age and fetal number, symptom onset-to-delivery interval, mode of delivery, ICU admission, the occurrence of predefined postpartum complications (acute kidney injury [AKI], disseminated intravascular coagulation [DIC], sepsis, postpartum hemorrhage [PPH], multiple organ dysfunction syndrome [MODS], acute liver failure [ALF]), and survival status.

2.2.2 Laboratory Data: Key laboratory parameters—including international normalized ratio (INR), serum creatinine, total bilirubin, platelet count, fibrinogen, and D-dimer—were recorded based on results from the 24 hours preceding delivery or, for ICU-admitted patients, within 24 hours post-admission.

2.2.3 Imaging Data: Abdominal ultrasound or computed tomography (CT) reports were reviewed to document hepatic morphological changes indicative of AFLP, such as fat infiltration or alterations in liver volume.

2.2.4 Severity Scoring: The APACHE II and SOFA scores were calculated using the worst physiological parameters within 24 hours after ICU admission. The MELD score was calculated using the total

bilirubin, INR, and serum creatinine values within 24 hours after ICU admission or, for non-ICU patients, from the 24 hours preceding delivery.

2.3 Diagnostic Criteria

Complication outcomes were defined according to established international criteria as follows:

Acute Kidney Injury (AKI): Defined as an increase in serum creatinine to ≥ 1.5 times baseline within 7 days, an increase of ≥ 0.3 mg/dL within 48 hours, or a urine output of < 0.5 mL/kg/h for 6 hours, according to the Kidney Disease: Improving Global Outcomes (KDIGO) criteria^[14].

Disseminated Intravascular Coagulation (DIC)

Diagnosed using the International Society on Thrombosis and Haemostasis (ISTH) criteria overt DIC score ≥ 5 , based on abnormalities in platelet count, fibrinogen level, prothrombin time, and D-dimer^[15].

Postpartum Hemorrhage (PPH)

Defined as blood loss of ≥ 500 mL after vaginal delivery or ≥ 1000 mL after cesarean section within 24 hours, or the identification of a significant hematoma via imaging or surgery, per World Health Organization (WHO) criteria^[16].

Sepsis

Diagnosed according to Sepsis-3 criteria as life-threatening organ dysfunction (indicated by an increase in the Sequential Organ Failure Assessment (SOFA) score by ≥ 2 points) resulting from a dysregulated host response to infection^[17].

Multiple Organ Dysfunction Syndrome (MODS)

Defined as the acute, potentially reversible dysfunction of two or more organ systems not attributable to the primary disease, occurring within 24 hours of a severe insult^[18].

Acute Liver Failure (ALF)

Defined by the acute onset of hepatic encephalopathy (West-Haven grade $\geq$ II) and coagulopathy (INR ≥ 1.5 or PTA $\leq 40\%$) within 2 weeks in a patient without pre-existing cirrhosis, in accordance with standard diagnostic criteria^[19].

2.4 Statistical Analysis

Continuous variables are presented as mean $\pm$ standard deviation if normally distributed or as median (interquartile range) otherwise. Categorical variables are expressed as frequencies (percentages). Inter-group comparisons were performed using the Student's t-test (or Welch's t-test for unequal variances) for normally distributed continuous variables, the Mann-Whitney U test for non-normally distributed

variables, and the χ^2 test (or Fisher's exact test for expected frequencies < 5) for categorical variables. The predictive value of the MELD, APACHE II, and SOFA scores for postpartum complications was evaluated using logistic regression models, with model performance assessed by the area under the receiver operating characteristic curve (AUC-ROC) and decision curve analysis (DCA). The predictive model is constructed based on logistic regression, and the value of MELD, APACHE II, and SOFA scores in predicting postpartum complications in patients with AFLP is assessed through the AUC-ROC and DCA. A two-sided p-value < 0.05 was considered statistically significant. All analyses were conducted using R software (version 4.1.0) and SPSS (version 21.0).

3. Results

3.1 Demographic Characteristics and Clinical Data of Patients with AFLP

This study included a total of 106 patients with AFLP. The average age at the onset of the first symptoms was 29.8 ± 4.8 years, with an average gestational age of 35.8 ± 2.9 weeks. The MELD, APACHE II, and SOFA scores of the patients with AFLP were as follows: 23.2(16.9, 29.7), 16 (12, 19), and 9.0 (6.0, 10.0), respectively. The baseline data are shown in Table 1.

Table 1
Baseline data of AFLP Patients (n = 106).

Variable	Mean ± SD/n(%)
Maternal age(years)	29.8 ± 4.8
Gravidity	
1	31 (29.2)
2	29 (27.4)
≥ 3	46 (43.4)
Parity	
1	43 (40.6)
2	54 (50.9)
3	9 (8.5)
Delivery	
Cesarean section	98 (92.5)
Vaginal	8 (7.5)
Number of fetuses	
Single	93 (87.7)
Twins	13 (12.3)
Gender of baby	
Female	24 (22.6)
Male	69 (65.1)
Female/male	2 (1.9)
Female/female	1 (0.9)
Male/male	10 (9.4)
Admission to ICU	96 (90.6)
duration from symptom onset to delivery	7.9 ± 7.9
gestational age at symptom onset	250.5 ± 20.2
Score	
ICU: Intensive Care Unit; MELD: Model for End-Stage Liver Disease; APACHE II: Acute Physiology and Chronic Health Evaluation II; SOFA: Sequential Organ Failure Assessment.	

Variable	Mean $\pm$ SD/n(%)
MELD	23.2 [16.9, 29.7]
APACHE II	16 [12, 19]
SOFA	9.0 [6.0, 10.0]
ICU: Intensive Care Unit; MELD: Model for End-Stage Liver Disease; APACHE II: Acute Physiology and Chronic Health Evaluation II; SOFA: Sequential Organ Failure Assessment.	

3.2 Postpartum Complications and Survival Status in Patients with AFLP

Postpartum complications and survival outcomes within one month after delivery were monitored and followed up in patients with AFLP. Among 106 patients, the most common complication was AKI (71/106, 67.0%), followed by DIC (30/106, 28.3%), MODS (30/106, 28.3%), PPH (29/106, 27.4%), sepsis (28/106, 26.4%), and ALF (24/106, 22.6%). Additionally, 10 (9.4%) died within one month after delivery, with 9 (90%) dying from MODS and 1 (10%) from PPH, as shown in Table 2.

Table 2
Postpartum Complications and Survival Status Within One Month in AFLP Patients (n = 106).

Variable	n(%)
Maternal complications	
Acute kidney injury (AKI)	71 (67.0)
Disseminated Intravascular Coagulation(DIC)	30 (28.3)
Multiple Organ Dysfunction Syndrome(MODS)	30 (28.3)
Postpartum hemorrhage(PPH)	29 (27.4)
Sepsis	28 (26.4)
Acute Liver Failure(ALF)	24 (22.6)
Maternal outcomes	
Death	10 (9.4)
MODS	9 (90.0)
Postpartum Hemorrhage(PPH)	1 (10.0)

3.3 Comparison of the MELD, APACHE II, and SOFA Scores in Patients with Complications

Compared with those patients without postpartum complications, patients with AFLP accompanied by AKI, DIC, MODS, PPH, and ALF had significantly higher MELD, APACHE II, and SOFA scores ($p < 0.001$) (Table 3).

Table 3
Analysis of MELD, APACHE II, and SOFA scores in AFLP patients with different postpartum complications.

Variables	Total (n = 106)	No (n)	Yes (n)	p-value
AKI		(n = 35)	(n = 71)	
MELD	23.2 [16.9, 29.7]	15.1 [11.1, 19.1]	27.1 [22.7, 33.2]	< 0.001
APACHEII	16 [12, 19]	12 [10, 15]	17 [14, 20]	< 0.001
SOFA	9.0 [6.0, 10.0]	6.0 [4.5, 7.5]	9.5 [8.0, 11.0]	< 0.001
DIC		(n = 76)	(n = 30)	
MELD	23.2 [16.9, 29.7]	21.4 [15.7, 25.4]	30.7 [25.4, 39.6]	< 0.001
APACHEII	16 [12, 19]	14 [11, 17]	18 [15, 24]	< 0.001
SOFA	9 [6, 10]	7.5 [5.8, 9.0]	11 [9, 13]	< 0.001
Sepsis		(n = 76)	(n = 30)	
MELD	23.2 [16.9, 29.7]	21.8 [15.9, 27.1]	27.3 [24.0, 34.1]	0.001
APACHEII	16.0 [12.0, 19.0]	14.5 [11.2, 17.0]	18.0 [13.8, 21.0]	0.068
SOFA	9.0 [6.0, 10.0]	8.0 [6.0, 10.0]	10.0 [8.2, 12.8]	0.002
MODS		(n = 76)	(n = 30)	
MELD	23.2 [16.9, 29.7]	21.3 [15.7, 25.4]	30.7 [25.3, 39.6]	< 0.001
APACHEII	16 [12, 19]	14 [11, 17]	18 [15.8, 23.2]	< 0.001
SOFA	9 [6, 10]	8 [6, 9]	11 [9, 13]	< 0.001
PPH		(n = 77)	(n = 29)	
MELD	23.2 [16.9, 29.7]	22.2 [15.8, 27.1]	28.9 [22.4, 36.1]	0.001
APACHEII	16.0 [12.0, 19.0]	14.0 [11.0, 17.0]	18.0 [16.2, 23.8]	0.001
SOFA	9.0 [6.0, 10.0]	8.0 [6.0, 10.0]	10.0 [9.0, 13.0]	< 0.001
ALF		(n = 82)	(n = 24)	
MELD	23.2 [16.9, 29.7]	21.9 [16.1, 26.0]	29.8 [26.4, 38.3]	< 0.001
APACHEII	16 [12, 19]	15 [12, 17]	19.5 [13.8, 24.2]	0.001
SOFA	9 [6, 10]	8 [6, 9]	11 [9, 13]	< 0.001
AKI: Acute kidney injury; DIC: Disseminated Intravascular Coagulation; MODS: Multiple Organ Dysfunction Syndrome; PPH: Postpartum hemorrhage; ALF: Acute Liver Failure.				

3.4 Analysis of the Predictive Value of MELD, APACHE II, and SOFA Scores for Postpartum Complications

3.4.1 Prediction of AKI

For predicting AKI in patients with AFLP, the combined MELD-APACHE II score achieved the highest predictive accuracy (AUC 0.899, 95% CI 0.815–0.967) with excellent specificity (0.963) and high sensitivity (0.833), outperforming all individual models (MELD AUC 0.823) and other combinations (MELD-SOFA AUC 0.882). Of note, the combined MELD-SOFA score also showed strong predictive utility for AKI (AUC 0.882), second only to the combined MELD-APACHE II score, suggesting its broader applicability across multiple organ dysfunctions (Fig. 2A, **Supplementary Table 2**). The DCA confirmed its superior clinical utility, demonstrating the greatest net benefit across a wide threshold range (0.1–0.8), particularly above a threshold of 0.4 (net benefit > 0.6) (Fig. 2B).

3.4.2 Prediction of DIC

For predicting DIC in patients with AFLP, the combined MELD-SOFA score demonstrated the best overall performance, achieving the highest AUC (0.764, 95% CI 0.662–0.856) with balanced sensitivity (0.759) and specificity (0.750). Although the SOFA alone had the highest sensitivity among individual models (AUC 0.745; sensitivity 0.862), its specificity was lower. Adding APACHE II to create a combined three-model score did not improve performance, resulting in a lower AUC (0.740) and reduced sensitivity (0.690) (Fig. 2C, **Supplementary Table 3**). DCA confirmed the superior clinical utility of the combined MELD-SOFA score, which provided the greatest net benefit at threshold probabilities between 0.2–0.6, approaching 0.45 when the threshold exceeded 0.4 (Fig. 2D).

3.4.3 Prediction of Sepsis

For predicting Sepsis in patients with AFLP, the APACHE II score demonstrated the highest individual predictive ability, with an AUC of 0.748 (95% CI 0.643–0.848), sensitivity of 0.808, and specificity of 0.727. Notably, combining APACHE II with SOFA or with both MELD and SOFA did not improve predictive performance, yielding lower AUCs of 0.727 and 0.703, respectively (Fig. 2E, **Supplementary Table 4**). The DCA further confirmed the standalone clinical utility of the APACHE II score, which provided the greatest net benefit across threshold probabilities of 0.2–0.8, maintaining a stable benefit of 0.5–0.6 between thresholds of 0.4–0.6 (Fig. 2F).

3.4.4 Prediction of MODS

For predicting MODS in patients with AFLP, the SOFA score provided high sensitivity (0.929), while the combined MELD-SOFA score demonstrated the best overall performance, achieving the highest AUC (0.757, 95% CI 0.655–0.855). The combined three-model score (MELD-APACHE II-SOFA) offered an alternative with balanced AUC (0.743) and retained high sensitivity (0.857) (Fig. 3A, **Supplementary**

Table 5). DCA confirmed the superior clinical net benefit of the combined MELD-SOFA score across relevant threshold probabilities (0.2–0.7), with stable performance (0.45–0.50)(Fig. 3B).

3.4.5 Prediction of PPH

For predicting PPH in patients with AFLP, all models demonstrated suboptimal discriminative ability ($AUC < 0.7$). The combined three-model score (MELD-APACHE II-SOFA) yielded the highest AUC (0.685), while APACHE II alone had the highest specificity (0.731)(Fig. 3C, **Supplementary Table 6**). DCA indicated that the clinical utility of all models was limited, with net benefits below a meaningful threshold (< 0.3 vs. ≥ 0.4)(Fig. 3D).

3.4.6 Prediction of ALF

For predicting ALF in patients with AFLP, the combined MELD-SOFA score achieved the highest AUC (0.797, 95% CI 0.692–0.886), superior to all other models, including SOFA alone ($AUC = 0.711$). The combined three-model score (MELD-APACHE II-SOFA) had a slightly lower AUC (0.784) but higher sensitivity (0.917) (Fig. 3E, **Supplementary Table 7**). DCA confirmed that the combined MELD-SOFA score provided the greatest net clinical benefit across threshold probabilities of 0.2–0.7, with a stable benefit (0.45–0.50) at 0.4–0.6(Fig. 3F).

Discussion

This study systematically evaluated the predictive performance of the MELD, APACHE II, and SOFA scores, both individually and in combination, for major postpartum complications of AFLP. Several important observations emerged. First, the MELD score demonstrated the strongest ability in predicting AKI, while the SOFA score performed best in predicting DIC, MODS, and ALF. APACHE II remained the best single model for predicting sepsis. Second, the predictive accuracy of the combined model for severe postpartum complications of AFLP is higher than that of a scoring system, except for sepsis. Specifically, the combined MELD-SOFA score for DIC, MODS, ALF and AKI, and the combined MELD-APACHE II score excelled for AKI. Finally, none of the models offered satisfactory discriminatory power for PPH. These findings highlight the differential advantages of widely used critical illness scoring systems when applied to a pregnancy-specific hepatic disorder, suggesting a targeted score-selection strategy in clinical practice.

Early prognostic evaluation and intervention can significantly improve maternal and fetal outcomes in patients with AFLP^[6]. The MELD score, a classic prognostic tool for cirrhosis, integrates serum total bilirubin, serum creatinine, and the international normalized ratio (INR) of prothrombin, effectively predicting AKI and DIC in patients with AFLP ($AUC > 0.7$). However, its predictive efficacy for MODS, sepsis, PPH, and ALF was limited. The superiority of MELD in identifying AKI risk and DIC risk may be explained by the distinct pathophysiological features of AFLP. Characterized by impaired mitochondrial β -oxidation and hepatic microvesicular steatosis^[20], AFLP induces profound hepatocellular dysfunction and microcirculatory collapse, which simultaneously compromises detoxification pathways, coagulation

synthesis, and renal perfusion. Because of the three variables of MELD tightly linked to the hepatic–renal–coagulopathic axis, the MELD score captures the early transition toward hepatorenal physiology more sensitively than APACHE II, which focuses primarily on systemic physiologic derangements and is less specific for renal injury driven by hepatic dysfunction. This pathophysiological basis also explains why combining the MELD score (reflecting hepatic dysfunction) with the APACHE II score (reflecting the systemic inflammation) significantly improved AKI prediction in our cohort. Li et al.^[21] demonstrated that when the MELD score exceeds 30, it can accurately predict complications such as ascites, hepatic encephalopathy, DIC, and AKI (AUC > 0.8). Murali et al.^[9] also confirmed the effectiveness of the MELD score in predicting 1-month mortality in patients with AFLP, which is consistent with the results of our study.

In this study, the SOFA score demonstrated a good predictive ability for multi-organ complications in patients with AFLP, especially for predicting AKI, DIC, MODS, and ALF (AUC > 0.7), outperforming APACHE II and MELD scores (except for AKI). This result is consistent with the studies by Cholongitas and Rodrigues^[22, 23]. The SOFA score is designed to quantify multi-organ dysfunction, making it inherently suited for capturing the diffuse organ injury characteristic of AFLP, which manifests as AKI, DIC, MODS, and ALF. AFLP-induced coagulopathy is driven by impaired hepatic synthesis of coagulation factors, widespread endothelial injury, and microvascular fibrin deposition^[24]. By integrating the specificity of liver-centered injury (MELD) with the breadth of multi-organ assessment (SOFA), the combined model mirrors the pathophysiological progression of AFLP from a hepatic insult to systemic multi-organ dysfunction, thereby offering broader clinical applicability. Consequently, the MELD-SOFA score integrates the severity of hepatic synthetic failure with the extent of multi-organ physiological deterioration, which accounts for its superior predictive accuracy for AKI, DIC, MODS, and ALF. In contrast, for complications driven primarily by systemic inflammation rather than organ failure, a different scoring system proved more valuable.

Sepsis is a life-threatening condition arising from a dysfunctional host response to infection, frequently causing widespread effects across multiple organ systems^[25, 26]. Dysregulated inflammation is the pathophysiological characteristic of sepsis^[27]. In our study, the APACHE II score demonstrated superior performance in predicting sepsis compared to the other models. This is attributable to its emphasis on systemic inflammatory indicators such as body temperature, white blood cell count, and hemodynamic parameters. This focus on the host's acute physiological derangement renders it more sensitive for early sepsis detection than liver-centered scoring systems. In this study, 28 patients with AFLP developed sepsis, with 71.4% caused by abdominal or pelvic infections and 28.6% by pulmonary infections, which is consistent with related research from Ireland^[28]. However, since the APACHE II score does not incorporate assessments of liver function or coagulation, its predictive value for AFLP-specific complications, such as ALF and DIC, is limited.

Notably, all models in this study demonstrated poor discrimination for PPH in patients with AFLP. This is likely because PPH in AFLP is predominantly driven by obstetric factors—such as uterine atony, placental

abnormalities, and surgical bleeding—which fall outside the pathophysiological domains assessed by the MELD, APACHE II, and SOFA scores. Although the MELD and SOFA scores incorporate parameters of coagulation and liver function, they do not account for uterine contractility or obstetric mechanical factors. These limitations underscore the necessity for future predictive tools to integrate obstetric-specific variables alongside markers of dynamic fibrinogen consumption.

A complication-specific scoring approach optimizes early risk stratification in AFLP. Given the high prevalence of AKI (67.0%) and the excellent discrimination of the combined MELD-APACHE II score (AUC 0.899), clinicians may use this combination for kidney injury monitoring to guide timely renal replacement therapy. Given its strong predictive performance across DIC, MODS, ALF and AKI (AUCs 0.757–0.882), the combined MELD-SOFA score offers broad clinical utility for alerts of coagulation failure and multi-organ dysfunction, prompting early artificial liver support or coagulation therapy. APACHE II alone (AUC 0.748) remains the tool of choice for sepsis surveillance to facilitate early antibiotic initiation. Prospective validation is recommended before routine clinical implementation.

Future studies should validate these complication-specific models in larger, multi-center cohorts. Given the suboptimal prediction for postpartum hemorrhage (AUC < 0.7), incorporating AFLP-specific biomarkers, dynamic scoring, and obstetric variables (e.g., fibrinogen trends, uterine tone) may improve prediction for this outcome. Building upon the broad applicability of the MELD-SOFA combination, the development of an AFLP-specific composite score incorporating the most predictive elements of existing models is warranted.

Strengths of this study include the first systematic comparison and combination of three widely used critical illness scores (MELD, APACHE II, and SOFA) for predicting specific postpartum complications in AFLP. The finding that the combined MELD-SOFA score offers broad applicability across multiple complications, while specific complications require tailored models, underscores the value of a complication-specific analytical strategy. The application of decision curve analysis (DCA) provides a direct assessment of clinical utility beyond traditional discrimination metrics, offering actionable insights for targeted management.

Limitations should also be acknowledged. First, the modest sample size ($n = 106$), constrained by the rarity of AFLP, may limit the stability of the logistic regression models and result in wide confidence intervals. Second, the single-center, retrospective cohort design introduces potential selection bias and limits generalizability. Third, the severity scores were assessed at a single time point; dynamic serial evaluations might better reflect the rapidly evolving clinical course of AFLP. Finally, the models did not incorporate AFLP-specific biomarkers or key obstetric variables, which likely contributed to their suboptimal performance in predicting postpartum hemorrhage (AUC < 0.7).

Conclusions

This study demonstrates that the MELD, APACHE II, and SOFA scores each afford unique predictive advantages for specific postpartum complications of AFLP. While the combined MELD-SOFA score

demonstrates broad applicability by showing high effectiveness for predicting DIC, MODS, ALF, and AKI, optimal prediction for specific complications requires tailored combinations: the combined MELD-APACHE II score is superior for AKI, and APACHE II alone for sepsis. These findings support the targeted use of combined scoring models to guide early intervention and improve maternal outcomes, and underscore the need for more tailored tools that incorporate pregnancy-specific physiology.

Declarations

Consent to publish

Not applicable.

Competing interests

The Authors declare that they have no conflict of interest.

Ethics approval and consent to participate

This retrospective study was reviewed and approved by the Biomedical Research Ethics Committee of Shandong Provincial Hospital (Approval No. SWYX:2021-052). The requirement for informed consent was waived due to the retrospective design. All procedures performed in this study were in accordance with the ethical standards of the institutional research committee and with the 1964 Declaration of Helsinki and its later amendments, or with comparable ethical standards.

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Author Contribution

Z.L.M., Y.H.T., H.M.H., and W.F. conceived and designed the study. T.Y.S., M.C., and Q.Z.W. collected and curated the clinical data. Z.L.M. and Y.H.T. performed the formal analysis, interpreted the results, and drafted the original manuscript. W.F. provided a critical revision of the manuscript for important intellectual content and supervised the entire project. All authors reviewed and approved the final version of the manuscript.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

1. Ch'ng CL, Morgan M, Hainsworth I, et al. Prospective study of liver dysfunction in pregnancy in Southwest Wales. *Gut*. 2002;51:876–80.
2. Knight M, Nelson-Piercy C, Kurinczuk JJ, et al. A prospective national study of acute fatty liver of pregnancy in the UK. *Gut*. 2008;57:951–6.
3. Li L, Huang D, Xu J, et al. The assessment in patients with acute fatty liver of pregnancy (AFLP) treated with plasma exchange: a cohort study of 298 patients. *BMC Pregnancy Childbirth*. 2023;23:171.
4. Liu J, Ghaziani TT, Wolf JL. Acute Fatty Liver Disease of Pregnancy: Updates in Pathogenesis, Diagnosis, and Management. *Am J Gastroenterol*. 2017;112:838–46.
5. Shen Y, Wang X, Yao Y, et al. Acute fatty liver of pregnancy causing multiple organ dysfunction syndrome in a Chinese intensive care unit. *Nurs Crit Care*. 2023;28:1170–5.
6. Knox TA, Olans. LB Liver disease in pregnancy. *N Engl J Med*. 1996;335:569–76.
7. Kamath PS, Kim. WR The model for end-stage liver disease (MELD). *Hepatology*. 2007;45:797–805.
8. McPhail MJ. Improving MELD for use in acute liver failure. *J Hepatol*. 2011;54:1320. author reply 1320-1.
9. Murali AR, Devarbhavi H, Venkatachala PR, et al. Factors that predict 1-month mortality in patients with pregnancy-specific liver disease. *Clin Gastroenterol Hepatol*. 2014;12:109–13.
10. Knaus WA, Draper EA, Wagner DP, et al. APACHE II: a severity of disease classification system. *Crit Care Med*. 1985;13:818–29.
11. Vincent JL, Moreno R, Takala J, et al. The SOFA (Sepsis-related Organ Failure Assessment) score to describe organ dysfunction/failure. On behalf of the Working Group on Sepsis-Related Problems of the European Society of Intensive Care Medicine. *Intensive Care Med*. 1996;22:707–10.
12. Fikatas P, Lee JE, Sauer IM, et al. APACHE III score is superior to King's College Hospital criteria, MELD score and APACHE II score to predict outcomes after liver transplantation for acute liver failure. *Transpl Proc*. 2013;45:2295–301.
13. Kingham JG. Swansea criteria for diagnosis of acute fatty liver of pregnancy. *Gut*, 2010.
14. Mehta RL, Kellum JA, Shah SV, et al. Acute Kidney Injury Network: report of an initiative to improve outcomes in acute kidney injury. *Crit Care*. 2007;11:R31.
15. Audibert F, Friedman SA, Frangieh AY, et al. Clinical utility of strict diagnostic criteria for the HELLP (hemolysis, elevated liver enzymes, and low platelets) syndrome. *Am J Obstet Gynecol*. 1996;175:460–4.

16. Sentilhes L, Merlot B, Madar H, et al. Postpartum haemorrhage: prevention and treatment. *Expert Rev Hematol*. 2016;9:1043–61.
17. Schlapbach LJ, Watson RS, Sorce LR, et al. International Consensus Criteria for Pediatric Sepsis and Septic Shock. *JAMA*. 2024;331:665–74.
18. Bone RC, Balk RA, Cerra FB et al. Definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. The ACCP/SCCM Consensus Conference Committee. American College of Chest Physicians/Society of Critical Care Medicine. *Chest*, 1992, 101:1644-55.
19. Casey LC, Fontana RJ, Aday A, et al. Acute Liver Failure (ALF) in Pregnancy. How Much Is Pregnancy Related? *Hepatology*. 2020;72:1366–77.
20. Natarajan SK, Ibdah JA. Role of 3-Hydroxy Fatty Acid-Induced Hepatic Lipotoxicity in Acute Fatty Liver of Pregnancy. *Int J Mol Sci*, 2018, 19.
21. Li P, Lin S, Li L, et al. Utility of MELD scoring system for assessing the prognosis of acute fatty liver of pregnancy. *Eur J Obstet Gynecol Reprod Biol*. 2019;240:161–6.
22. Cholongitas EB, Betrossian A, Leandro G, et al. King's criteria, APACHE II, and SOFA scores in acute liver failure. *Hepatology*. 2006;43:881. author reply 882.
23. Rodrigues-Filho EM, Fernandes R, Garcez. A SOFA in the first 24 hours as an outcome predictor of acute liver failure. *Rev Bras Ter Intensiva*. 2018;30:64–70.
24. Suzuki H, Ohkuchi A, Horie K, et al. Acute fatty liver of pregnancy may be associated with non-productive coagulopathy of coagulation and fibrinolytic factors as well as disseminated intravascular coagulation with mild or no thrombocytopenia: Review of case reports in Japan. *J Obstet Gynaecol Res*. 2025;51:e16230.
25. Gao X, Cai S, Li X, et al. Sepsis-induced immunosuppression: mechanisms, biomarkers and immunotherapy. *Front Immunol*. 2025;16:1577105.
26. Martin-Loeches I, Singer M, Leone M. Sepsis: key insights, future directions, and immediate goals. A review and expert opinion. *Intensive Care Med*. 2024;50:2043–9.
27. Ding R, Meng Y, Ma X. The Central Role of the Inflammatory Response in Understanding the Heterogeneity of Sepsis-3. *Biomed Res Int*, 2018, 2018:5086516.
28. Knowles SJ, O'Sullivan NP, Meenan AM, et al. Maternal sepsis incidence, aetiology and outcome for mother and fetus: a prospective study. *BJOG*. 2015;122:663–71.

Figures

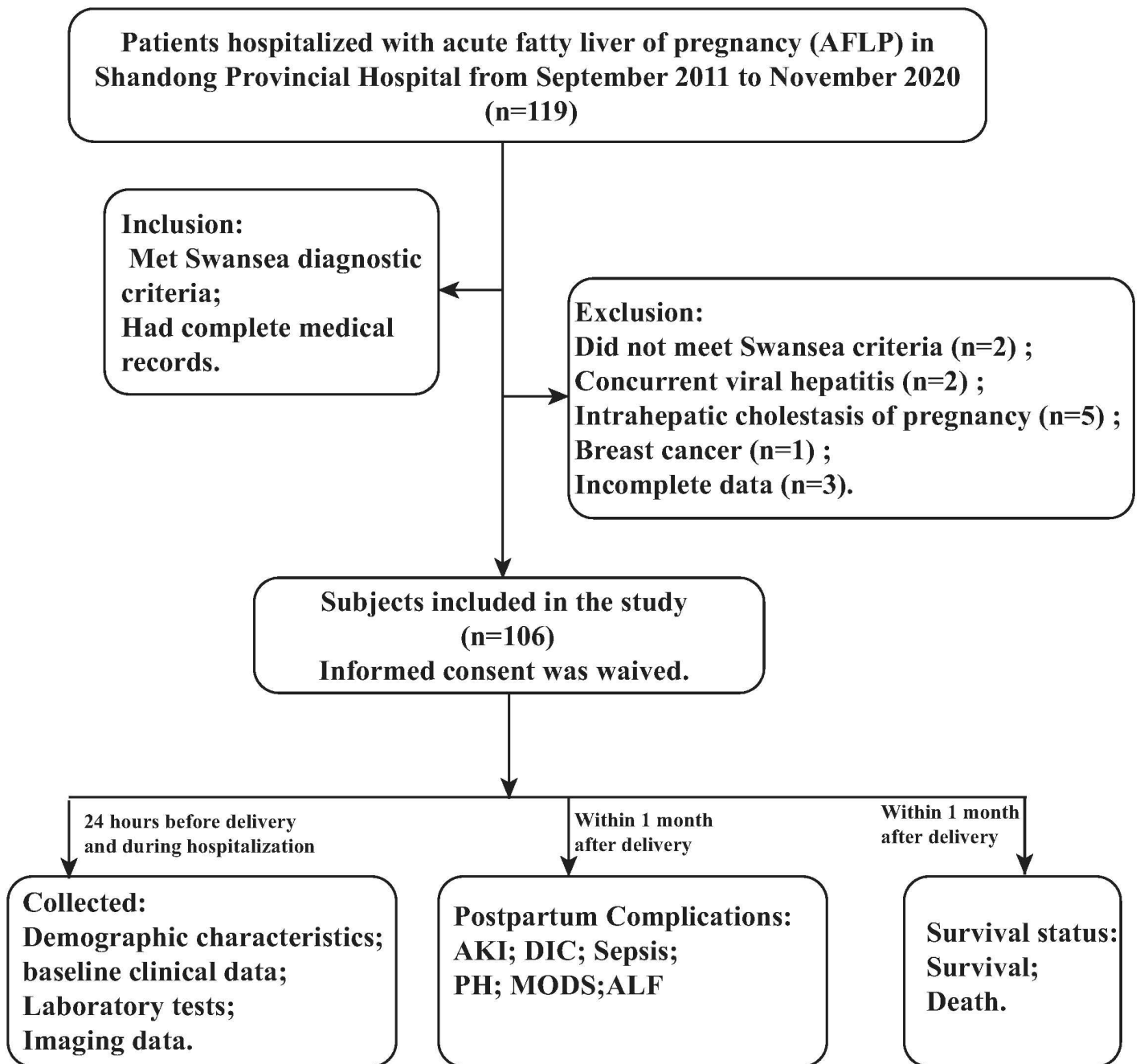


Figure 1

Flow chart of enrollment and data collection in patients with acute fatty liver of pregnancy (AFLP).

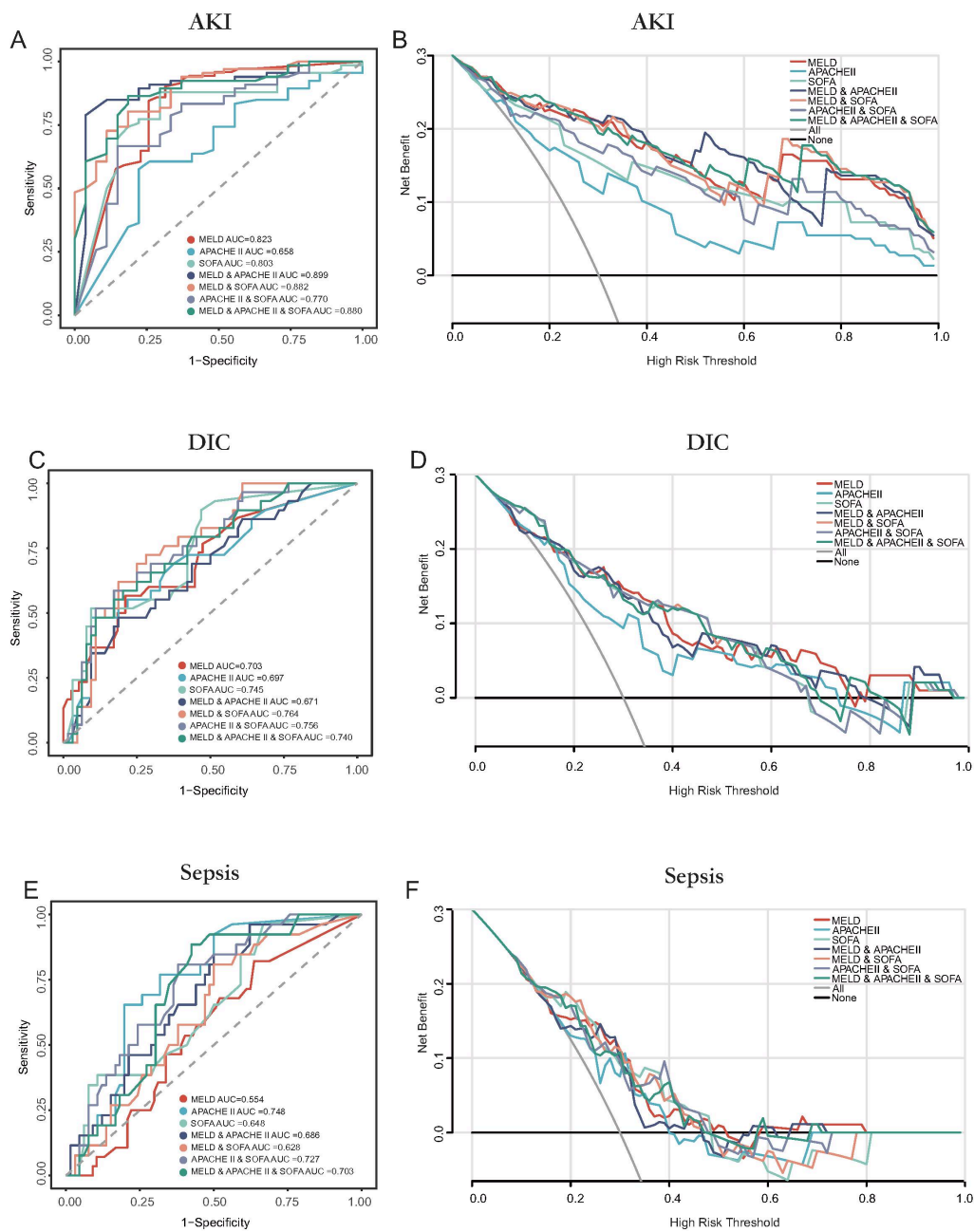


Figure 2

A. ROC analysis for the models to predict AKI in patients with AFLP; B. Decision curve analysis of the prediction model for AKI in patients with AFLP. C. ROC analysis for the models to predict DIC in patients with AFLP. D. Decision curve analysis of the prediction model for DIC in patients with AFLP. E. ROC analysis for the models to predict sepsis in patients with AFLP; F. Decision curve analysis of the prediction model for sepsis in patients with AFLP.

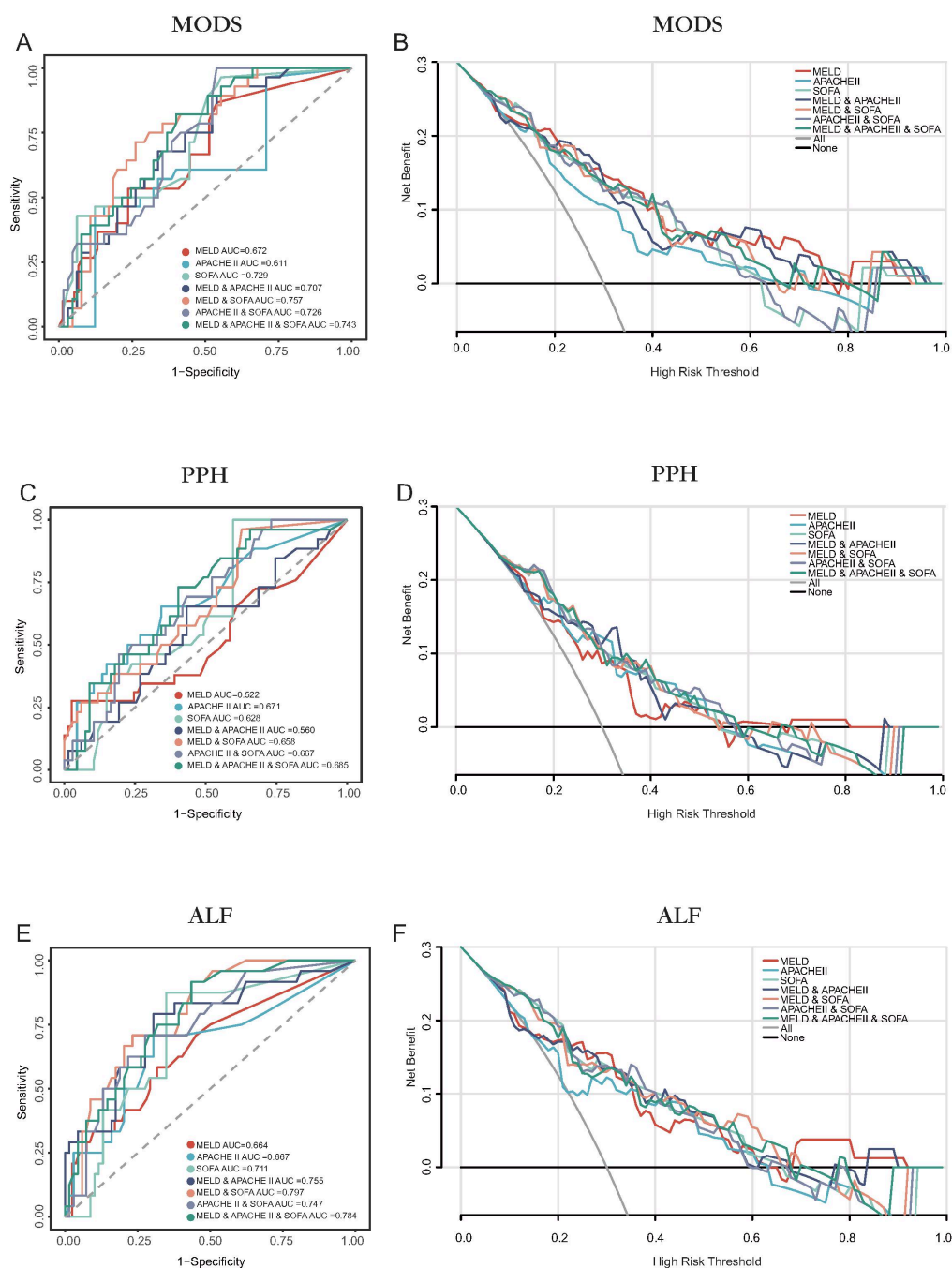


Figure 3

A. ROC analysis for the models to predict MODS in patients with AFLP; B. Decision curve analysis of the prediction model for MODS in patients with AFLP. C. ROC analysis for the models to predict PPH in patients with AFLP; D. Decision curve analysis of the prediction model for PPH in patients with AFLP. E. ROC analysis for the models to predict ALF in patients with AFLP; F. Decision curve analysis of the prediction model for ALF in patients with AFLP.

Supplementary Files

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