BRITISH JOURNAL OF HOSPITAL MEDICINE

ARTICLE

The Value of Bedside Ultrasound Evaluation of Intravenous Ultrasound Grading System Combined with TyG Index in Predicting Acute Renal Injury in Patients with Acute Hyperlipidemic Pancreatitis

Lingling He[1], Tinglong Huang[1], Long Xie[2,*]

[1]Department of Intensive Care Unit, The Second Affiliated Hospital of Fujian Medical University, Quanzhou, Fujian, China
[2]Department of Nuclear Medicine, The Second Affiliated Hospital of Fujian Medical University, Quanzhou, Fujian, China
*Correspondence: xiec0709@163.com (Long Xie)

Abstract

Aims/Background Bedside ultrasound evaluation of venous excess ultrasound (VExUS) combined with the triglyceride-glucose (TyG) index plays an important role in predicting acute kidney injury (AKI) in patients with acute hyperlipidemic pancreatitis. VExUS can effectively evaluate the degree of venous congestion, while the TyG index is valuable in predicting severe pancreatitis. The combination of these two methods is expected to provide a more accurate AKI risk assessment tool for clinical practice. This study explores the value of combining bedside ultrasound evaluation using the VExUS grading system with the TyG index in predicting acute renal damage in patients with acute hyperlipidemic pancreatitis.

Methods From January 2021 to December 2023, 110 patients with acute hyperlipidemic pancreatitis were selected. The patients were divided into two groups based on whether they were complicated with acute kidney injury (AKI): the AKI group (n = 23) and the non-AKI group (n = 87). The general data of the two groups were compared, and the risk factors for AKI in patients with acute hyperlipidemic pancreatitis were analyzed using multivariate logistic regression. The predictive value was assessed using receiver operating characteristic curve (ROC) analysis.

Results There were no statistically significant differences in age, gender, outcome, triglyceride (TG), total cholesterol, low-density lipoprotein (LDL) levels at admission, blood nutrition at discharge, creatinine (CREA) at discharge, underlying diseases, start time of enteral nutrition, complications, length of stay, Intensive Care Unit (ICU) days, Acute Physiology and Chronic Health Evaluation II (APACHE II) score, blood glucose level, blood amylase level, CREA, blood urine nitrogen (BUN), blood purification treatment ($p > 0.05$). However, there were significant differences ($p < 0.05$) between the TyG index and the VExUS score, with variables including the TyG index and the VExUS score (included in the logistic regression analysis as variables), and AKI (AKI = 1, non-AKI = 0) as dependent variables. Multiple logistic regression results showed that the TyG index and VExUS score were independent predictors of AKI in patients with acute hyperlipidemia pancreatitis ($p < 0.05$). The standard error, sensitivity and specificity of the TyG index, VExUS score and combined model for predicting AKI in these patients were 0.064, 73.91 and 87.45; 0.036, 78.16 and 95.65; 0.010, 100.00 and 95.65, respectively ($p < 0.05$).

Conclusion The VExUS score combined with the TyG index is highly valuable in predicting AKI in patients with acute hyperlipidemic pancreatitis.

Key words: bedside ultrasound; intravenous ultrasound grading system; triglyceride-glucose index; acute hyperlipidemic pancreatitis; acute renal injury

Submitted: 22 May 2024 Revised: 27 June 2024 Accepted: 3 July 2024

How to cite this article:
He L, Huang T, Xie L. The Value of Bedside Ultrasound Evaluation of Intravenous Ultrasound Grading System Combined with TyG Index in Predicting Acute Renal Injury in Patients with Acute Hyperlipidemic Pancreatitis. Br J Hosp Med. 2024. https://doi.org/10.12968/hmed.2024.0283

Introduction

Acute hyperlipidemic pancreatitis is a severe pancreatic disorder primarily caused by abnormally high lipid levels in the blood, leading to inflammation and damage to pancreatic tissue. This damage releases a large amount of enzymes, triggering a systemic inflammatory response (Zhou et al, 2024). The kidneys are particularly affected, as inflammation and other factors can impair the function of glomeruli and renal tubules, ultimately leading to acute kidney injury (AKI) (Syc and Kujawski, 1973). Incomplete statistics (Wu et al, 2014) indicate that approximately 25% to 59% of patients with severe acute pancreatitis will develop AKI during the progression of the disease, which significantly contributes to a poor prognosis.

Currently, the clinical diagnosis of AKI largely relies on changes in serum creatinine (Scr) and urine output within 7 days. However, these levels are easily influenced by factors such as age, diet, and blood volume, resulting in low sensitivity and specificity. Insulin resistance can cause elevated blood sugar levels, and prolonged hyperglycemia can damage kidney function, thereby increasing the risk of AKI (Cai et al, 2024).

The triglyceride-glucose (TyG) index is an indicator calculated based on triglyceride and blood glucose levels. It has been proven to be closely associated with insulin resistance (Qin et al, 2020) and is therefore considered an important metric for assessing and diagnosing insulin resistance. Effective renal circulation is crucial for maintaining kidney function, and a previous study (Koratala et al, 2022) has shown that systemic venous congestion is closely associated with the occurrence of AKI in critically ill patients. The venous excess ultrasound (VExUS) grading system is a comprehensive ultrasound classification method for describing venous load states. Recent studies (Rihl et al, 2023) have confirmed that the VExUS grading system has significant application value in predicting and treating AKI. However, no literature has reported the predictive value of combining the TyG index with the VExUS system for AKI in patients with acute hyperlipidemic pancreatitis. This study primarily investigates the application value of combining the VExUS grading system and the TyG index in predicting AKI in patients with acute hyperlipidemic pancreatitis, providing a reference for early prevention and treatment in clinical settings.

Methods

Study Subjects

Patients with acute hyperlipidemic pancreatitis from January 2021 to December 2023 were selected retrospectively. The inclusion criteria were as follows:

(1) All patients met the clinical diagnosis of acute hyperlipidemic pancreatitis (Banks et al, 2013; Wang et al, 2017). (a) Serum triglyceride (TG) level: serum TG $\geq$11.3 mmol/L (or more than 3 times the normal value), or TG between 5.65 and 11.3 mmol/L and serum chylous; (b) Serum lipase or amylase level: increased by at least 3 times the upper limit of the normal range; (c) Excluding other causes of acute pancreatitis, such as cholelithiasis, ethanol, biliary infectious diseases, tumours, ischemia, Oddi sphincter dysfunction, drugs, and bacterial or viral infection.

(2) Age $\geq$18 years old.

(3) The time from onset to admission was less than 24 hours.

(4) In line with the Helsinki Declaration.

Exclusion criteria:

(1) Patients with chronic kidney disease.

(2) Patients with malignant tumours.

(3) Patients with severe infection or physical trauma.

According to the inclusion and exclusion criteria, patients with loss of follow-up and patients with incomplete clinical data were excluded. Patients were divided into two groups based on whether they were complicated with AKI: the AKI group (n = 23) and the non-AKI group (n = 87).

AKI diagnostic criteria (Bellomo et al, 2012):

① Creatinine level increased by more than 50% or more during the interval.

② The level of creatinine increased by 0.3 mg/dL (or 26.5 μmol/L) or higher within a known time (e.g., within 48 hours).

③ The elevated value of serum creatinine was more than 1.5 times the baseline value and occurred within 7 days.

④ Urine volume within less than 6 hours was lower than that of 0.5 mL/kg/h.

⑤ Urine volume in less than 12 hours was lower than that of 1 mL/kg/h.

This study was conducted in accordance with the Ethics Committee's guidelines.

Data Collection

Patient data were collected through the electronic medical record system. The data were entered independently by two doctors using a double-blind method. The collected data included gender, age, length of hospital stay, days in the Intensive Care Unit (ICU), outcomes, Acute Physiology and Chronic Health Evaluation II (APACHE II) score, blood glucose, blood amylase, triglyceride (TG) at admission, total cholesterol (TC) at admission, low-density lipoprotein (LDL) at admission, creatinine (CREA) at admission, blood urea nitrogen (BUN) at admission, days with TG above 5.65 mmol/L, BUN at discharge, CREA at discharge, start day of enteral nutrition (days post-admission), underlying diseases, complications, blood purification treatment, and peritoneal puncture drainage.

Detection reagent introduction: Glucose oxidase method [glucose kit] (Shanghai Huzheng Biotechnology Co., Ltd., Catalogue No.: Hhzt-4570, Product Specification: 20 mL × 5, Shanghai, China); Enzymatic triglyceride (TG) colourimetric Test Kit (Bofeimico, Catalog No.: PM13359, Product Specification: 100 T/package, Shanghai, China); Enzymatic testing Reagent (Shanghai Yaji Biotechnology Co., Ltd., Catalogue number: 11-932, Shanghai, China). The kit includes enzyme reagent glucose oxidase (GOD) ≥1200 U/L, etc., phenol reagent (phenol 3.5 mmol/L), glucose standard solution (5.55 mmol/L), and more. Main performance indicators include reagent blank absorbance ≤0.08, accuracy ≤7%, linear range within 0.22 mmol/L–22 mmol/L, and sensitivity with a minimum detection limit of 0.022 mmol/L.

Blood amylase was determined by enzyme activity assay, reflecting amylase activity level in serum, based on its ability to hydrolyze starch into glucose. Triglyc-

eride (TG) was detected using the enzymatic triglyceride (TG) colourimetry kit (202106033, Shanghai Enzyme Union Biological Company, Shanghai, China, double reagent colourimetric method): lipoprotein lipase (LPL) hydrolyzes triglyceride into glycerol and fatty acids, followed by enzymatic reactions producing hydrogen peroxide, finally determined by colourimetry. The kit includes extraction buffer, various enzyme reagents (e.g., glycerol kinase, glycerol phosphate oxidase, peroxidase), and standards. Total cholesterol (TC) was detected by enzymatic method (endpoint colourimetry): cholesterol is converted into hydrogen peroxide by cholesterol esterase and cholesterol oxidase, then determined by colourimetry. The kit includes R1 (Shanghai Rongsheng Biopharmaceutical Co., Ltd., Shanghai, China) (phenol, 4-aminoantipyrine, cholesterol esterase) and R2 (Shanghai Rongsheng Biopharmaceutical Co., Ltd., Shanghai, China) (cholesterol oxidase, peroxidase).

Low-density lipoprotein (LDL), creatinine (CREA), and blood urea nitrogen (BUN) were separated by ultracentrifugation or gel electrophoresis, and then determined by enzymatic or colourimetric methods.

APACHE II Score: The APACHE II score comprises three components: acute physiological score (APS), age score, and chronic health score (Cuenca Fito et al, 2023).

(1) Acute physiological score (APS): This includes 12 physiological parameters, with each parameter scored from 0 to 4 based on deviation from normal values, where 0 indicates normal. Parameters include body temperature, mean arterial pressure (MAP), heart rate, respiratory rate, partial pressure of arterial oxygen (PaO_2), pH, potassium, sodium, creatinine, urea nitrogen, white blood cell count, and platelet count. Typically, the most abnormal value within the first 24 hours of ICU admission is used for scoring.

(2) Age score: Higher scores are assigned to older patients.

(3) Chronic health score: This evaluates chronic conditions such as organ dysfunction or immunosuppression. Scores vary based on the severity of these conditions. If no chronic conditions are present, the score is 0.

The final APACHE II score = acute physiology score (APS) + age score + chronic health score, ranging from 0 to 71. A higher score indicates a more severe condition and a poorer prognosis.

VExUS Grading System Assessment Method

Instrument: The ultrasound examinations were conducted using the portable colour Doppler ultrasound diagnostic system (2011~3231663, Mindray M9, Shenzhen, China) equipped with a 5 MHz convex probe. Experienced radiologists performed all ultrasound operations.

Method: Patients were positioned supine or on their side to expose the abdomen and bilateral subcostal areas for comprehensive ultrasound evaluation. This included assessment of the hepatic veins, portal vein, renal veins, and the inferior vena cava (IVC). The respiratory variability of the IVC, located 2 cm from the right atrium, was quantified using the formula [(end-expiratory diameter – end-inspiratory diameter)/end-expiratory diameter]. This measurement was graded from 0 to 4: Grade 1: end-expiratory diameter <5 mm with respiratory variability; Grade

Table 1. VExUS grading system scoring criteria.

Grade	Criteria
0 point	IVC grade $\leq$ Grade 3, and Grade 0 for hepatic vein, portal vein and intrarenal vein
1 point	IVC grade 4, 0 or (and) 1 in hepatic vein, portal vein and intrarenal vein
2 points	IVC grade 4, 1 grade 2 in hepatic vein, portal vein and intrarenal vein, 2 grade 0 or (and) 1
3 points	IVC grade 4, 2 or 3 grades in hepatic vein, portal vein and intrarenal vein, the rest 0 or (and) 1

VExUS, venous excess ultrasound; IVC, inferior vena cava.

2: end-expiratory diameter 5–9 mm with respiratory variability; Grade 3: end-expiratory diameter 10–19 mm with respiratory variability; Grade 4: end-expiratory diameter >20 mm, without respiratory variability. Additionally, spectral pattern abnormalities of the hepatic vein, portal vein, and renal veins were evaluated and graded from 0 to 2, with higher grades indicating more significant deviations in blood flow velocities. Detailed scoring criteria for the VExUS grading system are provided in Table 1.

Statistical Methods

Data analysis was performed using SPSS version 27.0 (IBM Corp., Armonk, NY, USA). Normally distributed quantitative data are presented as mean ± standard deviation and compared using the *t*-test. Categorical data were expressed as counts or percentages and analyzed using the chi-square test, with or without Yates's Continuity Correction, and Fisher's exact test where appropriate.

Multifactorial logistic regression analysis was employed to identify risk factors for AKI in patients with acute hyperlipidemic pancreatitis. The predictive value of the VExUS score was assessed using receiver operating characteristic curve (ROC), drawn with GraphPad 8.0 software (GraphPad Software Crop., San Diego, CA, USA). A p-value < 0.05 was considered statistically significant.

Results

Comparison of Clinical Data between AKI and Non-AKI Groups

Differences in age, gender, outcome, triglyceride (TG) at admission, total cholesterol, low-density lipoprotein (LDL) levels, blood nutrients at discharge, CREA at discharge, underlying diseases, start time of enteral nutrition, complications, length of stay, ICU days, APACHE II score, blood sugar levels, blood amylase levels, CREA, BUN, blood purification therapy, there were no statistically significant differences ($p > 0.05$). However, significant differences ($p < 0.05$) were observed in the TyG index and VExUS score, details are provided in Table 2.

Multifactorial Logistic Regression Analysis of Risk Factors for AKI in Patients with Acute Hyperlipidemic Pancreatitis

Variables including hospital stays, ICU duration, APACHE II scores, blood Variables included the TyG index and VExUS score, which were included in the logistic regression analysis as variables, and AKI (AKI = 1, non-AKI = 0) as dependent variables. Multivariate logistic regression results showed that TyG index

Table 2. Comparison of clinical data between AKI group and non-AKI group.

Indicator	AKI group (n = 23)	Non-AKI group (n = 87)	$t/\chi^2/z$ value	p-value
Age (years)	36.78 ± 5.01	39.16 ± 10.35	1.066	0.289
Sex			1.673	0.196
Male	19	60		
Female	4	27		
Length of hospitalization (d)	35.13 ± 8.14	34.91 ± 6.94	0.130	0.897
Days of stay in ICU (d)	27.09 ± 9.91	27.09 ± 8.62	0.001	0.999
Outcome			-	>0.999
Improved	21	80		
Automatic discharge	2	7		
APACHE II (min)	18.09 ± 4.40	17.21 ± 4.23	0.880	0.381
Blood glucose (mmol/L)	21.73 ± 7.04	19.05 ± 7.60	1.527	0.130
Blood amylase (U/L)	806.10 ± 141.91	807.98 ± 119.84	0.064	0.949
Admission triglyceride TG (mmol/L)	18.67 ± 6.70	17.79 ± 5.56	0.646	0.520
Admission TC (mmol/L)	8.89 ± 1.82	9.04 ± 2.19	0.306	0.760
Admission LDL (mmol/L)	1.48 ± 0.53	1.56 ± 0.32	0.853	0.396
Admission CREA (μmol/L)	199.69 ± 28.00	204.05 ± 30.64	0.617	0.538
Admission urea nitrogen BUN (mmol/L)	12.95 ± 2.14	12.57 ± 2.19	0.743	0.459
Discharge BUN (mmol/L)	5.24 ± 1.80	4.81 ± 1.38	1.232	0.221
Discharge CREA (mmol/L)	68.96 ± 12.14	70.01 ± 9.49	0.444	0.658
Start time of enteral nutrition (d)	5.30 ± 1.46	5.70 ± 1.17	1.369	0.174
Underlying disease			1.963	0.161
Yes	10	52		
N/A	13	35		
Complications			0.037	0.847
Yes	17	66		
N/A	6	21		
Blood purification therapy			0.134	0.715
Yes	16	57		
N/A	7	30		
Abdominal puncture drainage			-	-
Yes	0	0		
N/A	23	87		
TyG index	10.35 ± 1.19	9.45 ± 0.99	3.722	0.000
VExUS (min)	1 (1, 2)	2 (2, 2)	–6.749	0.001

AKI, acute kidney injury; ICU, Intensive Care Unit; APACHE II, Acute Physiology and Chronic Health Evaluation II; TG, triglyceride; TC, total cholesterol; LDL, low-density lipoprotein; CREA, creatinine; BUN, blood urea nitrogen; TyG, triglyceride-glucose.

and VExUS score were independent predictors of AKI in patients with acute hyperlipidemia pancreatitis ($p < 0.05$), as shown in Table 3.

ROC Curve Analysis of Predictive Value

ROC analysis showed that the area under the curve (AUC) used to predict AKI in patients with acute hyperlipidemia pancreatitis was 0.706 (standard error (SE) =

Table 3. Multifactorial logistic regression analysis of risk factors for AKI in patients with acute hyperlipidemic pancreatitis.

Influencing factors	β value	SE value	Wald value	OR value	95% CI	*p*-value
TyG index	0.960	0.393	5.974	2.611	1.209–5.636	<0.015
VExUS	4.351	1.084	16.119	77.562	9.272–648.820	<0.001

SE, standard error; OR, odds ratio; CI, confidence interval.

Table 4. ROC analysis of predictive value.

Indicator	Lower area	Standard error	95% CI	Sensitivity	Specificity
TyG index	0.706	0.064	0.581–0.830	73.91	87.45
VExUS score	0.889	0.036	0.818–0.958	78.16	95.65
Joint application model	0.991	0.010	0.972–1.000	100.00	95.65

ROC, receiver operating characteristic curve.

0.064, 95% confidence interval (CI) 0.581–0.830). The sensitivity was 73.91%, and the specificity was 87.45%. Similarly, the AUC of the VExUS score was 0.889 (SE = 0.036, 95% CI 0.818–0.958), with a sensitivity of 78.16%, and a specificity of 95.65%. When combined, the area under the curve for this model was 0.991 (SE = 0.010, 95% CI 0.972–1.000). The sensitivity and specificity of the combined model were 100.00%, and 95.65%. Detailed results are shown in Table 4 and illustrated in Fig. 1.

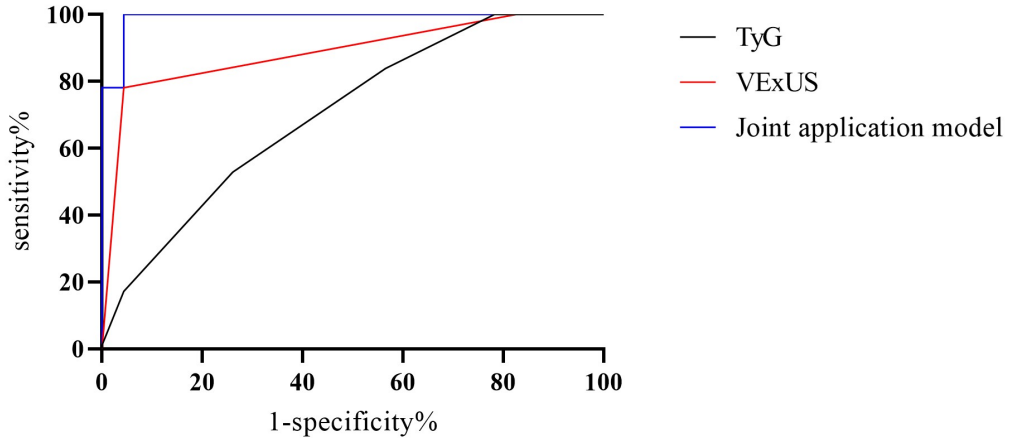

Fig. 1. ROC curve. Note: The area under the curve of the joint model is closest to 1, indicating that the prediction value of the joint model is the highest.

Discussion

Effective management of acute hyperlipidemic pancreatitis hinges on early identification and prevention of complications to enhance patient outcomes. Acute kidney injury (AKI) stands out as a frequent complication, significantly prolonging

hospital stays, increasing mortality rates, and straining healthcare resources. Therefore, identifying reliable methods for predicting AKI risk in acute hyperlipidemic pancreatitis (AHLP) patients is crucial.

In recent years, various assessment tools, notably the VExUS score and the TyG index, have gained prominence for AKI prediction. This study aims to investigate the combined predictive value of the VExUS score and the TyG index in forecasting AKI onset in AHLP patients. The findings seek to provide comprehensive insights into their clinical utility and implications.

This study revealed that the TyG index and VExUS score are independent predictors of AKI in patients with acute hyperlipidemia pancreatitis. The TyG index, a novel marker assessing insulin resistance and metabolic syndrome, has emerged as a valuable predictor of AKI risk in recent studies. Insulin resistance and metabolic disorders exacerbate systemic inflammation and oxidative stress, further impairing renal function (Jin and Zhang, 2023; Yang et al, 2023). Thus, the significant association between the TyG index and AKI underscores the role of insulin resistance and metabolic disorders in AKI development. Lastly, the VExUS score, a bedside tool assessing venous blood flow to predict complication severity, indicates microcirculatory dysfunction and systemic inflammatory response extent in acute hyperlipidemic pancreatitis (Andrei et al, 2023). Elevated VExUS scores reflect pathophysiological states intensifying disease complexity and potentially leading to multi-organ dysfunction, including renal impairment (Natraj et al, 2024). Therefore, as an independent predictor of AKI, the VExUS score highlights microcirculatory disorders and systemic inflammation's impact on renal function in these patients.

ROC analysis demonstrates the TyG index as an excellent predictive tool for AKI, with an area under the curve (AUC) of 0.706, indicating high accuracy. The standard error of 0.064 underscores the reliability of these results. With a sensitivity of 73.91% and specificity of 87.45%, the TyG index effectively identifies AKI and non-AKI patients.

Similarly, the VExUS score performs exceptionally well, achieving an AUC of 0.889, slightly higher than the TyG index, confirming its value in AKI prediction. The standard error of 0.036 indicates stable performance. At the optimal cut-off, the VExUS score demonstrates 78.16% sensitivity showing its ability to identify AKI patients is slightly lower than the TyG index, but remarkably 95.65% specificity, excelling in ruling out non-AKI patients.

Combining the TyG index and VExUS score significantly enhances predictive efficacy, yielding an AUC of 0.991, nearing perfection. The combined model exhibits 100.00% sensitivity and improved 95.65% specificity, surpassing individual indicators in predicting non-AKI patients. Current AKI risk assessment tools often rely on single biological markers or clinical parameters like serum creatinine and urea nitrogen. These metrics are influenced by various factors such as age, sex, and underlying diseases, limiting their accuracy and reliability. Most tools offer static, one-time assessments, lacking dynamic monitoring crucial for AKI management.

The proposed combination method integrates bedside ultrasound evaluation using the venous ultrasound grading system with the TyG index, enabling compre-

hensive AKI risk assessment. This approach considers static and dynamic patient indicators, enhancing prediction accuracy. Bedside ultrasound provides real-time, non-invasive monitoring, crucial for timely adjustment of treatment plans and AKI prevention.

The TyG index, reflecting insulin resistance and dyslipidemia, correlates closely with AKI occurrence. Combined use with bedside ultrasound allows personalized evaluation and precise treatment planning tailored to individual patient conditions. Retrospective and multivariate logistic regression analyses affirm the high predictive value of this combined approach in patients with acute hyperlipidemic pancreatitis complicated by AKI, minimizing diagnostic errors and optimizing patient care.

This study has several limitations that warrant consideration. Firstly, its retrospective design means data were collected retrospectively, potentially leading to incomplete coverage of important variables or information, thereby impacting study accuracy and completeness. Additionally, retrospective research can introduce selection bias due to factors such as data availability and subjective researcher judgment, potentially resulting in samples that do not fully represent the target population. Secondly, the study's sample size is small, which may lack sufficient statistical power to detect subtle differences or effects between variables, compromising the stability and reliability of research findings. Moreover, smaller samples increase the likelihood of random errors influencing results, making them more susceptible to chance factors. Lastly, relying solely on hospitalization data limits the study. Hospitalization records typically reflect disease severity or situations requiring immediate intervention, but may not capture early-stage or comprehensive disease progression. Furthermore, hospital-specific processes and policies can introduce biases or inconsistencies in the data.

Future studies should address these limitations to develop more accurate tools for predicting acute kidney injury in patients with acute hyperlipidemic pancreatitis. The recommendation is that a prospective design with a larger and more diverse sample combined with a comprehensive data collection method will enhance the robustness and applicability of findings in clinical practice.

Conclusion

In conclusion, combining the bedside ultrasonographic venous grading system with the TyG index proves highly predictive for acute kidney injury in patients with acute hyperlipidemic pancreatitis. This integrated approach enhances diagnostic accuracy and reliability, offering comprehensive guidance for clinical diagnosis and treatment decisions. Future research should delve deeper into the mechanisms and application potential of this combined assessment method to develop more effective strategies for diagnosing and managing acute hyperlipidemic pancreatitis.

Key Points

- TyG index were identified as independent factors influencing AKI in patients with multiple traumas.
- VExUS were identified as independent factors influencing AKI in patients with multiple traumas.
- The combination of the VExUS score and TyG index demonstrated high application value in predicting AKI in patients with multiple traumas.

Availability of Data and Materials

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

Author Contributions

LX conceived and designed the experiments; LX, LLH, and TLH performed the experiments; LX and LLH drafted the manuscript. All authors contributed to the important editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study protocol was approved by the Second Affiliated Hospital of Fujian Medicine University (2023-310). The entire experimental procedure adhered to the principles of informed consent, with patients or their family members being provided with information about the study.

Acknowledgement

Not applicable.

Funding

The research was supported by the Startup Fund for Scientific Research, Fujian Medical University (2020QH1124) and the Natural Science Foundation of Fujian Province, China (Grant No.2021J01277).

Conflict of Interest

The authors declare no conflict of interest.

References

Andrei S, Bahr PA, Nguyen M, Bouhemad B, Guinot PG. Prevalence of systemic venous congestion assessed by Venous Excess Ultrasound Grading System (VExUS) and association with acute kid-

ney injury in a general ICU cohort: a prospective multicentric study. Critical Care. 2023; 27: 224. https://doi.org/10.1186/s13054-023-04524-4

Banks PA, Bollen TL, Dervenis C, Gooszen HG, Johnson CD, Sarr MG, et al. Classification of acute pancreatitis—2012: revision of the Atlanta classification and definitions by international consensus. Gut. 2013; 62: 102–111. https://doi.org/10.1136/gutjnl-2012-302779

Bellomo R, Kellum JA, Ronco C. Acute kidney injury. Lancet. 2012; 380: 756–766. https://doi.org/10.1016/S0140-6736(11)61454-2

Cai D, Xiao T, Chen Q, Gu Q, Wang Y, Ji Y, et al. Association between triglyceride glucose and acute kidney injury in patients with acute myocardial infarction: a propensity score-matched analysis. BMC Cardiovascular Disorders. 2024; 24: 216. https://doi.org/10.1186/s12872-024-03864-5

Cuenca Fito E, González-Castro A, Gómez Acebo I. Predictive value of the APACHE II and SOFA scales in the mortality of cancer patients in intensive care. Medicina Clinica. 2023; 161: 547–548. https://doi.org/10.1016/j.medcli.2023.07.016

Jin Z, Zhang K. Association between triglyceride-glucose index and AKI in ICU patients based on MIMICIV database: a cross-sectional study. Renal Failure. 2023; 45: 2238830. https://doi.org/10.1080/0886022X.2023.2238830

Koratala A, Ronco C, Kazory A. Multi-Organ Point-Of-Care Ultrasound in Acute Kidney Injury. Blood Purification. 2022; 51: 967–971. https://doi.org/10.1159/000522652

Natraj R, Bhaskaran AK, Rola P, Haycock K, Siuba MT, Ranjit S. Venous Congestion Assessed by Venous Excess Ultrasound (VExUS) and Acute Kidney Injury in Children with Right Ventricular Dysfunction. Indian Journal of Critical Care Medicine. 2024; 28: 447–452. https://doi.org/10.5005/jp-journals-10071-24705

Qin Y, Tang H, Yan G, Wang D, Qiao Y, Luo E, et al. A High Triglyceride-Glucose Index Is Associated With Contrast-Induced Acute Kidney Injury in Chinese Patients With Type 2 Diabetes Mellitus. Frontiers in Endocrinology. 2020; 11: 522883. https://doi.org/10.3389/fendo.2020.522883

Rihl MF, Pellegrini JAS, Boniatti MM. VExUS Score in the Management of Patients With Acute Kidney Injury in the Intensive Care Unit: AKIVEX Study. Journal of Ultrasound in Medicine. 2023; 42: 2547–2556. https://doi.org/10.1002/jum.16288

Syc S, Kujawski J. Przypadek ostrej niewydolności nerek w przebiegu ostrego zapalenia trzustki u osobnika z rodzinna hiperlipoproteidemia [Case of acute renal failure during pancreatitis in a patient with familial hyperlipoproteinemia]. Wiadomosci Lekarskie. 1973; 26: 243–245.

Wang Q, Wang G, Qiu Z, He X, Liu C. Elevated serum triglycerides in the Prognostic Assessment of Acute Pancreatitis: a systematic review and Meta-analysis of Observational studies. Journal of Clinical Gastroenterology. 2017; 51: 586–593. https://doi.org/10.1097/MCG.0000000000000846

Wu C, Ke L, Tong Z, Li B, Zou L, Li W, et al. Hypertriglyceridemia is a risk factor for acute kidney injury in the early phase of acute pancreatitis. Pancreas. 2014; 43: 1312–1316. https://doi.org/10.1097/MPA.0000000000000180

Yang Z, Gong H, Kan F, Ji N. Association between the triglyceride glucose (TyG) index and the risk of acute kidney injury in critically ill patients with heart failure: analysis of the MIMIC-IV database. Cardiovascular Diabetology. 2023; 22: 232. https://doi.org/10.1186/s12933-023-01971-9

Zhou W, Liu Q, Wang Z, Yao L, Chen J, Yang X. Analysis of the clinical profile and treatment efficiency of hyperlipidemic acute pancreatitis. Lipids in Health and Disease. 2024; 23: 70. https://doi.org/10.1186/s12944-024-02057-5