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ABOUT COVER

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WJD mainly publishes articles reporting research results and findings obtained in the field of diabetes and covering a wide range of topics including risk factors for diabetes, diabetes complications, experimental diabetes mellitus, type 1 diabetes mellitus, type 2 diabetes mellitus, gestational diabetes, diabetic angiopathies, diabetic cardiomyopathies, diabetic coma, diabetic ketoacidosis, diabetic nephropathies, diabetic neuropathies, Donohue syndrome, fetal macrosomia, and prediabetic state.

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ORIGINAL ARTICLE

Retrospective Study

Application value of high-pressure-resistant peripherally inserted central catheters in enhanced computer tomography of diabetic patients with malignant tumors

Li Zhang, Hui-Feng Yan

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Abstract

BACKGROUND

Individuals with diabetes mellitus have a higher risk of developing malignant tumors, and diagnosing these tumors can be challenging.

AIM

To confirm the benefits of using peripherally inserted central catheters (PICCs) in contrast-enhanced computerized tomography (CECT) for diagnostic imaging in diabetic patients with malignant tumors and to provide a research basis for follow-up research.

METHODS

This retrospective study analyzed 204 diabetic patients with malignancies treated at The Second Affiliated Hospital, Jiangxi Medical College, Nanchang University, from January 2024 to June 2024. The patients were divided into two groups: A control group (n = 102) with indwelling peripheral intravenous catheters and a research group (n = 102) with high-pressure-resistant PICC. The study compared baseline data, the incidence of iodine contrast extravasation during CECT, the incidence of adverse events (discomfort, redness and swelling at the puncture site, and blood oozing), imaging quality, nursing time, intubation success rate, number of venipuncture attempts, and catheter maintenance cost.

RESULTS

Male patients accounted for 51.96% in the control group and 55.88% in the

research group; the average age was (59.68 ± 11.82) years in the control group and (61.41 ± 12.92) years in the research group; the proportions of lung cancer, colorectal cancer, and gastric cancer patients in the control group were 42.16%, 38.24%, and 19.61%, respectively, while those in the research group were 34.31%, 37.25%, and 28.43%, respectively. Except for the gender distribution, age, and cancer type mentioned above, other general information such as underlying diseases, puncture location, and long-term chemotherapy shows no significant differences as tested ($P > 0.05$). The results showed that the research group had significantly reduced incidence of iodine contrast extravasation (7 *vs* 1, $P = 0.031$), similar incidence of adverse events (11 *vs* 7, $P = 0.324$), reduced nursing time [(18.50 ± 2.68) minutes *vs* (13.26 ± 3.00) minutes, $P = 0.000$], fewer venipuncture attempts [(2.21 ± 0.78) times *vs* (1.49 ± 0.58) times, $P = 0.000$], lower catheter maintenance cost [(1251.79 ± 205.47) China yuan (CNY) *vs* (1019.25 ± 117.28) CNY, $P = 0.000$], increased intubation success rate (16.67% *vs* 58.82%, $P = 0.000$), and better imaging quality (85.29% *vs* 94.12%, $P = 0.038$).

CONCLUSION

High-pressure-resistant PICCs can lessen the physical burden of diabetic patients during nursing, reduce treatment costs, and improve the efficiency and quality of imaging for diagnosis malignant tumors.

Key Words: Diabetes mellitus complicated with malignant tumors; Contrast-enhanced computerized tomography; High-pressure-resistant peripherally inserted central catheters; The incidence of adverse events; Quality of computer tomography imaging

Core Tip: For patients with diabetes mellitus complicated by malignant tumors, there is potential for improving the administration of intravenous contrast agents during contrast-enhanced computerized tomography (CECT). High-pressure-resistant peripherally inserted central catheters (PICCs) may be a better option for this improvement. This study has demonstrated the advantages of using high-pressure-resistant PICC in CECT for such patients, including reducing the physical burden during nursing, lowering treatment costs, and enhancing the efficiency and quality of imaging. These novel findings offer a strong research foundation for future research.

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INTRODUCTION

Diabetes mellitus (DM) is a common chronic metabolic disorder, characterized by chronic hyperglycemia caused by insulin resistance or insulin deficiency[1-3]. Diabetic patients are more prone to developing malignancies. It is estimated that DM patients have a significantly higher risk of colorectal, hepatocellular, gallbladder, breast, endometrial, and pancreatic cancers than non-diabetic individuals[4]. However, diagnosing DM complicated by malignancies is challenging, and some antidiabetic agents may mask the symptoms and features of malignancies. Recent advancements in anatomical imaging techniques have significantly improved the detection of malignant diseases. Among these, contrast-enhanced computed tomography (CECT) shows great advantages because of its high sensitivity, high specificity, and higher quality of imaging. In addition, CECT scans are well-tolerated and artifact-free with rapid imaging[5]. Therefore, CECT is expected to be used for early diagnosis and identification of malignancies in DM patients.

During CECT examination, iodine contrast, an intravenous contrast agent, is injected through a scalp steel needle or an intravenous indwelling needle, which may cause adverse reactions in the patient. Moreover, high-pressure injection may increase the risk of iodine contrast extravasation (ICE) and cause symptoms like pain, fever, and vomiting[6,7]. Therefore, there is potential for improvement in how intravenous contrast media is administered. Clinical data suggest that high-pressure-resistant peripherally inserted central catheters (PICCs) are associated with a significantly reduced risk of deep venous thrombosis, accidental catheter removal, and catheter-related infection compared to indwelling central venous catheters[8,9], indicating a wider application prospect of high-pressure-resistant PICCs in clinical imaging.

Previous studies have used high-pressure-resistant PICCs in diagnosing and detecting malignant tumors and obtained high-quality lesion images[10]. However, there is a lack of research on the application of PICCs in CECT examinations for DM patients with malignant tumors. To address this problem, this study intends to select diabetic patients with malignancies as the research subjects, dividing them into a control group and a research group according to the catheter placement method, to compare their differences in terms of safety during CECT, imaging quality, nursing time, catheter maintenance cost, *etc.*, in order to confirm the advantages of using PICCs in CECT examination of such patients and provide a research basis for future research.

MATERIALS AND METHODS

General information

From January to June 2024, patients with type 2 DM (T2DM) complicated by malignant tumors, who were admitted to The Second Affiliated Hospital, Jiangxi Medical College, Nanchang University, and scheduled for CECT scanning were selected.

Inclusion criteria were as follows: Patients were diagnosed with T2DM by biochemical indicators, *etc.*, and met the Chinese Guidelines for the Prevention and Treatment of T2DM (2020 Edition) (I) diagnostic criteria; patients were diagnosed with malignant tumor by histopathological examination, and were to undergo chemotherapy treatment and CECT scanning; patients met the indications for PICC catheterization and peripheral venous catheterization; patients were 18-75 years old and voluntarily participated in this study with informed consent.

Exclusion criteria were as follows: Contraindications to catheter therapy; contraindications to CECT scanning; history of allergies.

A total of 204 patients strictly following the inclusion criteria were enrolled in this study. The flowchart of specific inclusion and exclusion criteria for patients is shown in Figure 1. They were grouped depending on the difference in the catheter type used: A control group (n = 102) receiving indwelling peripheral intravenous catheters and a research group (n = 102) receiving high-pressure-resistant PICC. The control group consisted of 53 males and 49 females aged (59.68 ± 11.82) years on average, with 43 cases of lung cancer, 39 cases of colorectal cancer, and 20 cases of gastric cancer (imaging results shown in Figure 2). The research group had a male-to-female ratio of 57:45, an average age of 61.41 ± 12.92 years, and 35 cases of lung cancer, 38 cases of colorectal cancer, and 29 cases of gastric cancer.

Endpoints

Primary outcome measures: (1) Occurrence, specific grade, and definition of ICE during CT scanning (Table 1). No extravasation, mild extravasation, moderate extravasation, and severe extravasation were rated as grades 0, 1-2, 3, and 4, respectively; (2) Image quality of CECT: Table 2 for specific grades and definitions; and (3) Daily care time: The time spent in daily nursing refers to the total duration of nursing services provided by nurses every day. Nursing services mainly included preoperative assessment, pre-catheterization life care, health education, psychological care, catheterization care, post-catheterization limb care and complication prevention care, dietary care, blood glucose management, medication guidance, *etc.*

Secondary outcome measures: (1) Adverse events: Discomfort, redness and swelling at the puncture site, and blood oozing; (2) Number of venipuncture attempts; (3) First-attempt intubation success rate; and (4) Catheter maintenance cost after 6 months.

Statistical analysis

Statistical analysis was conducted using SPSS software (version 21; IBM Corp., Armonk, NY, United States), while image rendering was performed with GraphPad 9.0 software. Categorical variables, expressed as the number of cases (percentage), were analyzed using χ^2 tests. Continuous variables, represented as the mean ± variance, were compared using independent samples t-tests. The sample size of this study adhered to the inclusion and exclusion criteria for screening, while meeting the minimum requirement of approximately 55 participants for each group, as determined by the binomial proportion sample size estimation formula. All statistical analyses were two-tailed and relied upon a $P < 0.05$ statistical criterion.

RESULTS

Comparison of general data

By independent sample t-test or χ^2 test analysis, it was found that the sex distribution (χ^2 = 0.316, P = 0.574), age (t = 0.995, P = 0.321), cancer type (χ^2 = 2.487, P = 0.288), hypertension (χ^2 = 0.179, P = 0.673), coronary heart disease (χ^2 = 0.666, P = 0.186), puncture site (χ^2 = 0.766, P = 0.682), and long-term chemotherapy (χ^2 = 0.091, P = 0.763) were not statistically different, with comparability between groups (Table 3).

Comparison of the occurrence of ICE during CT scanning

Regarding the safety of high-pressure-resistant PICCs, this study first counted the ICE of two groups of patients. As shown in Table 4, there were seven cases of ICE in the control group and one case in the research group. The incidence of extravasation was significantly lower in the research group than in the control group (χ^2 = 4.684, P = 0.031).

Comparison of the incidence of adverse events

This study further examined the incidence of adverse events to assess the safety of high-pressure-resistant PICCs (Table 5). In the control group, 5 patients experienced discomfort, 2 redness and swelling at the puncture site, and 4 blood oozing. In the research group, 3 experienced discomfort, 1 redness and swelling at the puncture site, and 3 blood oozing. There was no statistically significant difference in the incidence of adverse events between the research and control groups (χ^2 = 0.975, P = 0.324).

Table 1 Symptoms and grades of iodine contrast extravasation

Symptom	Grade
No obvious symptoms	0
Edema diameter < 2.54 cm	1
2.54 cm < edema diameter < 15.24 cm	2
Translucent edema (diameter > 15.24 cm)	3
Edema diameter > 15.24 cm, combined with blood oozing, circulatory disturbance, and moderate to severe pain	4

Table 2 Contrast-enhanced computed tomography imaging quality grading

Image	Grade
Clear vascular display and no artifacts or only a few artifacts, which does not affect the diagnosis	Good
Blurred development of important blood vessels or interrupted display of blood vessels, with a large number or all artifacts in arteries, which cannot be used for diagnosis	Poor

Table 3 Comparison of general information, *n* (%)

	Control group (*n* = 102)	Research group (*n* = 102)	χ^2/t	*P* value
Sex			0.316	0.574
Male	53 (51.96)	57 (55.88)		
Female	49 (48.04)	45 (44.12)		
Age (years)	59.68 ± 11.82	61.41 ± 12.92	0.995	0.321
Cancer type			2.487	0.288
Lung cancer	43 (42.16)	35 (34.31)		
Colorectal cancer	39 (38.24)	38 (37.25)		
Gastric cancer	20 (19.61)	29 (28.43)		
Underlying diseases				
Hypertension			0.179	0.673
With	55 (53.92)	58 (56.86)		
Without	47 (46.08)	44 (43.14)		
Coronary heart disease			0.666	0.186
With	38 (37.25)	41 (40.20)		
Without	64 (62.75)	61 (59.80)		
Puncture site			0.766	0.682
Median cubital vein	14 (13.73)	11 (10.78)		
Basilic vein	84 (82.35)	85 (83.33)		
Cephalic vein	4 (3.92)	6 (5.88)		
Long-term chemotherapy			0.091	0.763
With	69 (67.65)	71 (69.61)		
Without	33 (32.35)	31 (30.39)		

Comparison of CECT imaging quality

In this study, CECT scan quality was assessed to evaluate the benefits of using high-pressure-resistant PICCs. As shown in Table 6, there were 87 cases with good image quality and 15 cases with poor image quality in the control group, and 96 cases with good image quality and six cases with poor image quality in the research group. The research group had significantly higher image quality than the control group (χ^2 = 4.300, P = 0.038).

Table 4 Occurrence of iodine contrast extravasation during computed tomography scanning, *n* (%)

	Control group (*n* = 102)	Research group (*n* = 102)	χ^2	*P* value
No extravasation	95 (93.14)	101 (99.02)		
Mild extravasation	4 (3.92)	1 (0.98)		
Moderate extravasation	1 (0.98)	0 (0.00)		
Severe extravasation	2 (1.96)	0 (0.00)		
Incidence of extravasation	7 (6.86)	1 (0.98)	4.684	0.031

Table 5 Adverse events in the two groups, *n* (%)

	Control group (*n* = 102)	Research group (*n* = 102)	χ^2	*P* value
Discomfort	5 (4.90)	3 (2.94)		
Redness and swelling at the puncture site	2 (1.96)	1 (0.98)		
Blood oozing	4 (3.92)	3 (2.94)		
Incidence rate of adverse events	11 (10.78)	7 (6.86)	0.975	0.324

Table 6 Imaging quality of contrast-enhanced computed tomography scanning, *n* (%)

	Control group (*n* = 102)	Research group (*n* = 102)	χ^2	*P* value
			4.300	0.038
Good	87 (85.29)	96 (94.12)		
Poor	15 (14.71)	6 (5.88)		

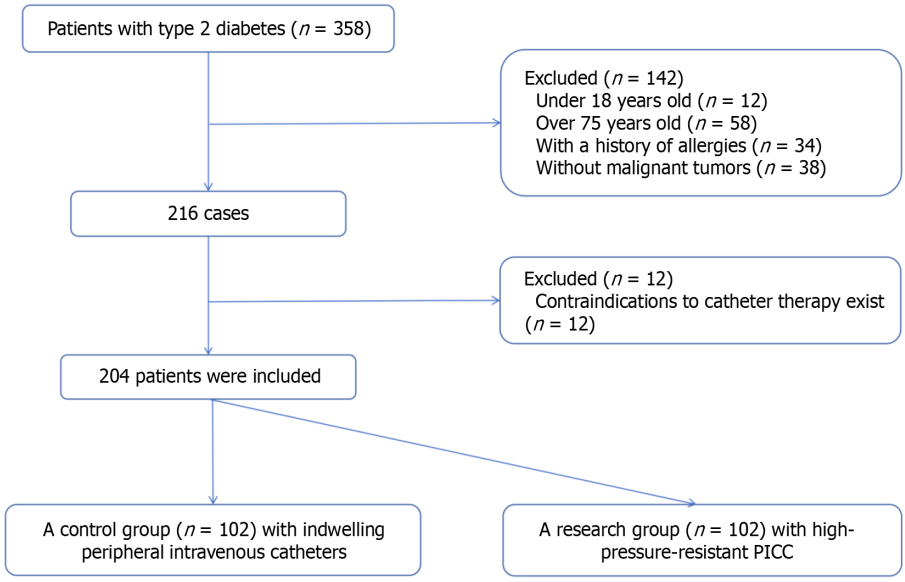

Figure 1 Flowchart of specific patient inclusion and exclusion criteria. PICC: Peripherally inserted central catheters.

Comparison of care time

Figure 3 shows the time spent on each nursing session by two patient groups. The duration of each nursing session was 18.50 ± 2.68 minutes in the control group and 13.26 ± 3.00 minutes in the research group. The independent sample *t*-test showed that the research group had significantly less nursing time than the control group (t = 13.148, P = 0.000).

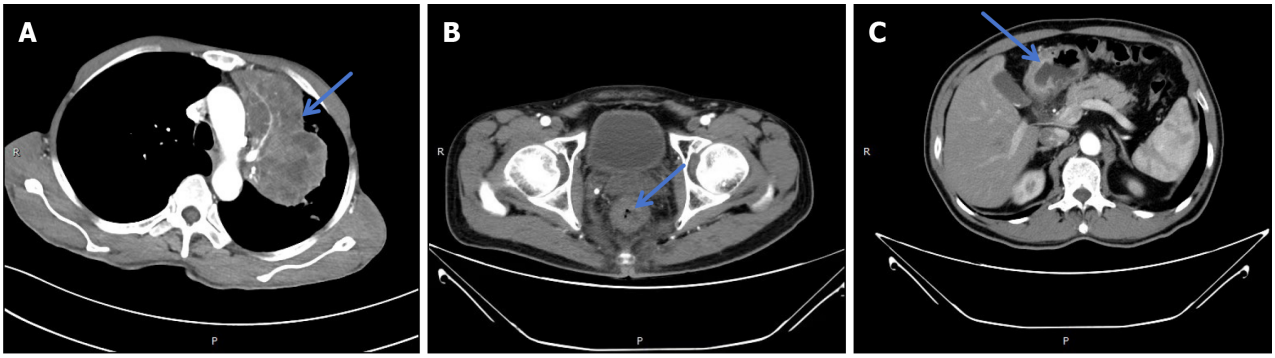

Figure 2 Computerized tomography imaging findings. A: Lung cancer; B: Colorectal cancer; C: Gastric cancer. The arrow indicates the location of the tumor.

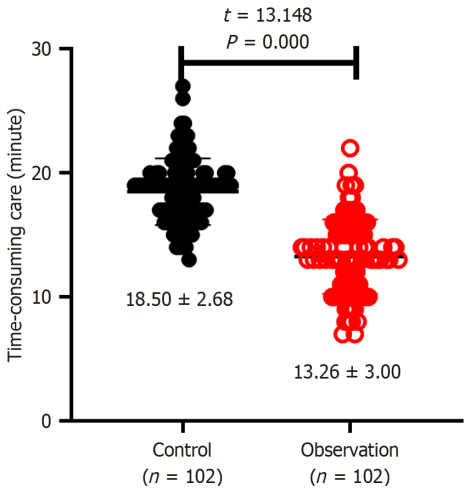

Figure 3 Comparison of nursing time of two groups of patients.

Comparison of the intubation time, number of venipuncture attempts, intubation success rate, and catheter maintenance cost

Table 7 shows the number of venipuncture attempts, intubation success rate, and catheter maintenance cost for the two groups. The intubation success rate was higher in the research group than in the control group (χ^2 = 38.570, P = 0.000). The research group had fewer venipuncture attempts (t = 7.486, P = 0.000) and lower catheter maintenance costs after 6 months (t = 9.927, P = 0.000) than the control group.

DISCUSSION

DM patients are at significantly increased risk of developing malignancies[11-14]. Meanwhile, the survival rate of diabetic cancer patients is significantly lower compared to non-diabetic cancer patients[15-18]. Early cancer screening can help reduce mortality and prolong survival, but the consistency in cancer screening appears to be lower in DM patients than in non-diabetic patients[19], suggesting that DM can impact the effectiveness of early cancer diagnosis. Advancements in imaging technology offer solutions for improving cancer screening in diabetic patients, in which CECT plays a crucial role.

However, the traditional needle placement method used in CECT be burdensome for patients. Clinical data suggests that continuous and repeated venipunctures may lead to ICE. PICCs, on the conversely, offer an alternative to central venous catheterization *via* the jugular vein, providing central venous access with a reduced risk of intraoperative complications, lower maintenance costs, and fewer catheter-related bloodstream infections[20]. In a retrospective study of 374 cancer patients, PICC was demonstrated to provide simple and easy-to-use intravenous access to enhance out-of-hospital intravenous symptomatic management[21], making it clinically feasible. High-pressure-resistant PICC is further modified on the basis of PICC, with the characteristics of high-pressure resistance and multi-channel, which is suitable for rapid infusion[22]. This type of PICC allows the iodine contrast medium to enter the superior vena cava directly through the catheter, thereby avoiding irritation and damage to the peripheral blood vessels caused by the contrast medium. The results of this study also showed that high-pressure-resistant PICC significantly reduced the incidence of ICE compared

Table 7 The intubation time, number of venipuncture attempts, intubation success rate, and catheter maintenance cost of the two groups, *n* (%)

	Control group (*n* = 102)	Research group (*n* = 102)	χ^2/t	*P* value
Number of venipuncture attempts	2.21 ± 0.78	1.49 ± 0.58	7.486	0.000
Success intubation			38.570	0.000
Yes	17 (16.67)	60 (58.82)		
No	85 (83.33)	42 (41.18)		
Catheter maintenance cost after 6 months (CNY)	1251.79 ± 205.47	1019.25 ± 117.28	9.927	0.000

CNY: China yuan.

to traditional intravenous indwelling needles. This indicates that high-pressure-resistant PICC is associated with a reduced risk of ICE. In addition, there was no statistical difference between the two groups in the incidence of adverse events (including discomfort, redness and swelling at the puncture site, and blood oozing), indicating that the safety of high-pressure-resistant PICC is comparable to that of traditional venous catheters. From the perspective of ICE and adverse events, high-pressure-resistant PICC has a good safety profile, effectively reducing ICE and minimizing serious clinical symptoms in patients. This aligns with findings from Washio *et al*[23], who reported that high-pressure-resistant PICC had a higher safety profile than conventional intravenous indwelling needles, which is mainly due to the absence of complications associated with dynamic injection and significantly lower radiation density values.

This study also explored the impact of high-pressure-resistant PICC on CECT imaging quality. The findings indicate that high-pressure-resistant PICC significantly improved CECT imaging quality compared to conventional catheterization, which may be due to the direct entry of iodine contrast agent into the superior vena cava under high-pressure-resistant PICC, reducing the likelihood of extravasation. Iodine contrast agents contain iodine atoms, which are more susceptible to photoelectric absorption and produce image contrast, making them widely used for intravenous and intra-arterial X-ray imaging[24,25]. The application of high-pressure-resistant PICC significantly reduced ICE, which can greatly meet the injection requirements for iodine contrast agents and ensure the contrast conditions. This allows the iodine contrast agent to quickly reach the target organ and participate in CT imaging, ultimately improving CT imaging quality. These results also indicate the advantages of high-pressure-resistant PICC in CECT diagnosis. By improving imaging quality, high-pressure-resistant PICC enables clinicians to have a clearer understanding of lesion information and make targeted treatment decisions.

This study also found the economic advantages of using high-pressure-resistant PICC. An economic evaluation of PICC compared to other venous access devices pointed out that PICC may be more cost-effective[26]. Based on the results of this study, this type of PICC also helps improve the efficiency of care and reduce catheter maintenance costs. In this study, the use of high-pressure PICC shortened the time spent on each nursing session compared to conventional catheters, thereby reducing the clinical pressure on medical staff. This method also reduced the number of venipuncture attempts and improved the intubation success rate, effectively lessening the physical burden on patients during CECT. The results also showed a reduction in catheter maintenance costs with high-pressure-resistant PICC, suggesting it may help alleviate the economic burden. These findings align with the report by Wang *et al*[27], which also demonstrated that high-pressure-resistant PICC is more cost-effective than totally implanted venous access devices (ports) within a 3-9-month dwell time.

This study has some limitations. First, the sample size is limited because it was conducted at a single trial. Second, more detailed information on the types and severity of adverse events would have provided a better understanding of PICC safety. Third, the lack of long-term follow-up prevented exploration of factors affecting CECT imaging. Finally, for future research, a large-scale, multicenter prospective study and long-term follow-up are necessary to provide a research foundation for follow-up studies, which is crucial for evaluating long-term outcomes such as infection rates, long-term catheter-related complications, and patient satisfaction. The significance of this study lies in confirming the application advantages of high-pressure-resistant PICC in CECT examinations of DM patients complicated by malignant tumors, mainly manifested in minimizing the risk of ICE events to reduce the physical burden on patients and improving the imaging quality of CECT scans while reducing nursing time and catheter maintenance costs over a six-month period, which is of great value for reducing the medical and economic burdens of patients and society.

CONCLUSION

In summary, this study confirms that high-pressure-resistant PICC can reduce the physical burden of patients during nursing, reduce treatment costs, and improve the efficiency and quality of CECT imaging. These findings reveal the value of using high-pressure-resistant PICC in DM patients with malignant tumors, which provides a strong research basis for future research.

FOOTNOTES

Author contributions: Zhang L and Yan HF designed the research and wrote the first manuscript; Zhang L and Yan HF contributed to conceiving the research and analyzing data; Zhang L and Yan HF conducted the analysis and provided guidance for the research; All authors reviewed and approved the final manuscript.

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