ORIGINAL RESEARCH

Assessment of Knowledge and Training Needs for the Clinical Management of Warfarin Anticoagulation Among Physicians in China

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Objective: To assess the knowledge level of physicians on anticoagulation management and identify their training needs to ensure the safety and efficacy of warfarin therapy among patients.

Methods: This project adopted convenient sampling and collected survey questionnaires online to investigate physicians' management level in aspects such as basic anticoagulation knowledge, routine adjustment of warfarin dosage, and management of warfarin complications and special situations after mechanical valve replacement.

Results: Among the 232 participants in this survey, 158 were male (68.10%), and 74 were female (31.90%); Grade III hospitals accounted for 61.21%; cardiovascular medicine department accounted for 65.09%; primary, intermediate, and advanced title holders each accounted for about one-third. The respondents had a good foundation in warfarin anticoagulation knowledge, and most physicians could guide patients in anticoagulation treatment. However, there were still many respondents who answered incorrectly on some basic questions. Using the chi-square test, the analysis of the impact of gender, age, hospital level, department, education, and title on the knowledge level of warfarin anticoagulation found that gender had no statistical significance in all items; age, department, and title had statistically significant differences in the impact on the knowledge level of anticoagulation in the respondent (P < 0.05). **Conclusion:** The respondents have good anticoagulation knowledge on basic items, but some healthcare professionals have insufficient understanding of some items, such as the approximate time required for INR to reach a stable value and the use of warfarin in pregnant women, posing significant risks in clinical work. Relevant healthcare professional training should be strengthened

Keywords: anticoagulation management level, heart valve replacement surgery, warfarin, survey questionnaire, training strategies

Introduction

on extended knowledge on warfarin.

Currently, approximately 300,000 patients worldwide require heart valve replacement surgery each year. In China, there are about 80,000 cases of patients needing valve surgery annually.^{1,2} Artificial heart valves mainly come in two types: mechanical valves and bioprosthetic valves. Patients undergoing mechanical valve replacement surgery need to take anticoagulant medications for a lifetime, while those with bioprosthetic valves also require oral anticoagulants for 3–6 months.³ Warfarin, with its convenient administration, long duration of action, low cost, and significant efficacy, has been the only oral anticoagulant used in clinical practice for over 60 years. It is currently the preferred anticoagulant for post-valve replacement surgery.⁴ Warfarin has a narrow treatment window, large individual differences, and common drug interactions, and warfarin can be easily affected by drugs, food, gene polymorphisms and comorbid diseases, resulting in many related complications and life-threatening in severe cases.⁵

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In clinical practice, the anticoagulant intensity of patients taking oral warfarin is monitored using prothrombin time (PT) and the international normalized ratio (INR). Medication is continuously adjusted until the INR reaches the stable target range. It generally takes one to several months to achieve a stable anticoagulant state, and fluctuations are common even after reaching stability, requiring repeated tests. This significantly increases the burden on patients in terms of time and finances. Therefore, patients on warfarin anticoagulation often experience the "three lows" in China: low anticoagulation rates, low success rates, and low compliance. Various factors, including patients' economic status, cultural background, environment, and genotype influence warfarin anticoagulation. Studies have shown that patients with lower education levels and poorer economic conditions tend to have worse anticoagulation outcomes.^{6–8} Does the anticoagulation management level of healthcare providers affect the effectiveness and safety of anticoagulation? Currently, there is a lack of relevant research on the knowledge level of clinical healthcare providers in anticoagulation management in China, and there is limited training specifically for anticoagulation providers. Given that a significant number of patients undergo warfarin dose adjustments at primary hospitals after cardiac surgery, where healthcare doctors may have limited relevant experience, their anticoagulation management level is particularly worthy of attention.⁹ This study aims to investigate the anticoagulation management level of clinical physicians in cardiac surgery department, cardiovascular medicine department, and related departments guiding warfarin anticoagulation in hospitals of different levels. It seeks to propose targeted strategies to enhance the anticoagulation management level of clinical physicians, thereby improving the safety and effectiveness of oral warfarin anticoagulation treatment.

Objectives and Methods

Instruments and Sampling

This project utilized a questionnaire developed independently by the research team for online investigation. The questionnaire was based on the Oral Anticoagulation Knowledge (OAK) Test used in the United States,¹⁰ with modifications tailored to the practical clinical situation in China. The questionnaire added items such as the basic information of the objectives, whether they guide patients on anticoagulation, and different clinical habits for INR standards. The questionnaire consisted of multiple-choice questions, multiple-selection questions, and fill-in-the-blank questions, totaling 27 items. It was divided into four main sections: respondent's basic information, basic anticoagulation knowledge, routine adjustment of warfarin dosage, and management of warfarin complications and special situations. The research received approval from the Medical Ethics Committee of Xiangya Hospital, Central South University (201912452) and all the participants signed informed consent.

Data Collection

For participant selection, a convenient sampling method was employed. The survey was conducted using the online platform "Wenjuanxing", and the questionnaire was accompanied by an introduction outlining the purpose of the study, details about the survey, instructions for completion, and a privacy confidentiality commitment to ensure standardized interpretation of the questionnaire content by respondents. The questionnaire was distributed through WeChat groups of cardiovascular medicine and cardiac surgery departments in hospitals of different levels. Doctors regularly involved in guiding anticoagulation therapy were invited to participate in the survey. Inclusion criteria were clinicians in relevant departments dealing with post-cardiac valve replacement patient follow-ups, those capable of correctly using smartphones to complete the questionnaire, and those volunteering to participate.

When using the Wenjuanxing online survey, all questions were set as mandatory, requiring participants to complete the entire questionnaire before submission. As a result, all 232 participants in the survey successfully completed the questionnaire, achieving a 100% questionnaire completion rate.

Statistical Analysis

After exporting the data online, statistical analysis was conducted using SPSS 24.0 software. Descriptive statistics, such as composition ratios, were employed for categorical data. Chi-square tests were used for statistical analysis. The basic knowledge and extended knowledge of warfarin anticoagulation therapy are scored, and 1 point is assigned to the correct

answer and 0 points are given to the wrong answer. The scores of all items were added up, and the total score was used as the dependent variable, and age, ethnicity, unit level, department, education level and job title were used as independent variables, and multiple linear regression models were used for analysis. Differences with P < 0.05 were considered statistically significant.

Results

General Information

Out of the 232 participants surveyed, 158 were male (68.10%), and 74 were female (31.90%). Further details regarding the basic characteristics of the surveyed participants can be found in Figure 1.

Results of Warfarin Anticoagulation Basic Knowledge Investigation

Out of the 232 participants surveyed, 201 individuals (86.64%) reported frequently guiding patients on oral warfarin anticoagulation after heart valve replacement surgery, while 31 individuals (13.36%) occasionally provided guidance (frequency less than once a week per person). When answering the question about the duration of warfarin anticoagulation after mechanical heart valve replacement surgery, 225 individuals (96.98%) answered correctly, stating that



Figure I Basic Characteristics of Survey Participants.

Notes: Among the 232 participants in this survey, the distribution of demographic and professional characteristics is as follows: Age Distribution: 21–30 years: 65 participants (28.02%). 31–40 years: 111 participants (47.84%). 41–50 years: 46 participants (19.83%). 51–60 years: 10 participants (4.31%). Hospital Classification: Tertiary Grade A hospitals: 142 participants (61.21%). Tertiary Grade B hospitals: 57 participants (24.57%). Tertiary Grade C hospitals: 13 participants (5.60%). Secondary Grade A and other hospital levels: 20 participants (8.62%). Department Distribution: Cardiology (Internal Medicine): 151 participants (65.09%). Cardiothoracic Surgery: 51 participants (21.98%). Other departments: 30 participants (12.93%). Educational Background: Doctoral degree: 99 participants (42.67%). Master's degree: 94 participants (40.52%). Bachelor's degree: 39 participants (16.81%). Professional Title: Junior title: 72 participants (31.03%). Intermediate title: 88 participants (37.94%). Senior title: 72 participants (31.03%). Vears of Work Experience: 5 years or less: 71 participants (30.60%). 6–10 years: 54 participants (23.28%). 11–15 years: 58 participants (25.00%). 16–20 years: 27 participants (11.64%). Over 20 years: 22 participants (9.48%).

patients need to take warfarin or other anticoagulant medications for a lifetime. On the question about the duration of oral warfarin anticoagulation after bioprosthetic valve replacement surgery, 179 individuals (77.16%) answered correctly. However, 22.84% of the surveyed individuals provided incorrect answers.

A total of 174 individuals (75.00%) were aware of common foods that can affect the effectiveness of warfarin anticoagulation. Only 147 individuals (63.36%) knew the approximate time required for INR to reach a stable value. Regarding the optimal target range for INR, there is no unified domestic standard, and the survey results are presented in Table 1.

Knowledge Level on Warfarin Anticoagulation Adjustment and Complications

In the investigation of warfarin anticoagulation knowledge after heart valve surgery, the majority of surveyed individuals demonstrated a high level of knowledge. For instances where INR is not within the standard range, and in cases of missed warfarin doses, correct response rates exceeded 80.00%. However, when it comes to the interval for INR rechecking with unchanged warfarin dosage and INR within the appropriate range, only 86 individuals (37.07%) chose the recommended interval of 2–3 months as the guidelines, while more than half of the surveyed individuals opted for a monthly interval.

Regarding the scenario of minor bleeding during warfarin anticoagulation treatment, where observation or a slight reduction in dosage is appropriate, 94.40% of the surveyed individuals provided accurate responses. When asked about the timeframe for resuming the original dosage after reducing warfarin dosage due to minor bleeding, 84.48% of respondents suggested actively attempting to restore the dosage.

Generally, warfarin should be discontinued for 1 week, with concomitant use of low-molecular-weight heparin as a substitute. The majority of surveyed individuals (97.84%) correctly knew how to handle this situation. Regarding how to restart anticoagulation after other surgeries, 81.03% of respondents knew that overlapping the use of low-molecular-weight heparin and warfarin for 3 days, followed by using warfarin alone for anticoagulation, is the correct approach.

Warfarin has teratogenic effects, and the use of warfarin in pregnant women is a common clinical issue. Generally, it is believed that low-dose warfarin (below 5 mg) can be used without substituting low-molecular-weight heparin. When the warfarin dose is higher, low-molecular-weight heparin can be used as a substitute during early pregnancy (first 12 weeks) and close to delivery (after 36 weeks). For this question, 61.64% of the surveyed individuals provided correct responses.

Analysis of Factors Influencing Warfarin Anticoagulation Knowledge Level

Using the chi-square test, an analysis of the impact of gender, age, hospital level, department, education, and title on the knowledge level of warfarin anticoagulation revealed that gender differences were not statistically significant for all items. However, age, department, and title showed statistically significant differences in the impact on the knowledge level of anticoagulation in the surveyed individuals (P < 0.05). Different age groups had statistically significant differences in knowledge of the anticoagulation duration after heart bioprosthetic valve replacement surgery ($\chi^2 = 12.550$, P = 0.006), knowledge of how to handle missed warfarin doses ($\chi^2 = 17.820$, P < 0.001), and knowledge of the interval for rechecking INR when warfarin dosage remains unchanged and INR is within the appropriate range ($\chi^2 = 17.770$, P < 0.001).

Category	INR Optimal Target Value N (%)								
	1.5–2.5	1.8–2.5	2.0–2.5	2.0–3.0	2.5–3.5	Others			
Aortic Valve Mechanical Replacement	42 (18.10)	50 (21.55)	31 (13.36)	87 (37.50)	22 (9.48)	0 (0.00)			
Mitral Valve Mechanical Replacement	2 (0.86)	54 (23.28)	47 (20.26)	101 (43.53)	28 (12.07)	0 (0.00)			
Tricuspid Valve Mechanical Replacement	2 (0.86)	15 (6.47)	44 (18.97)	142 (61.21)	29 (12.50)	2 (0.86)			
Trial Fibrillation	(4.74)	22 (9.48)	45 (19.40)	151 (65.09)	3 (1.29)	l (0.43)			

Table I International Normalized Ratio (INR) Optimal Target Value Range

The department was statistically significant in differences in knowledge about how to adjust warfarin dosage when patient INR is lower ($\chi^2 = 13.936$, P < 0.001), knowledge of the interval for rechecking INR when warfarin dosage remains unchanged and INR is within the appropriate range ($\chi^2 = 13.373$, P < 0.001), and knowledge of warfarin reversal agents ($\chi^2 = 13.711$, P < 0.001).

Title was statistically significant in differences in knowledge of the anticoagulation duration after heart bioprosthetic valve replacement surgery ($\chi^2 = 8.852$, P = 0.012), knowledge of how to handle missed warfarin doses ($\chi^2 = 9.480$, P = 0.009), knowledge of the interval for rechecking INR when warfarin dosage remains unchanged and INR is within the appropriate range ($\chi^2 = 6.877$, P = 0.032), and knowledge of warfarin reversal agents ($\chi^2 = 12.176$, P = 0.002). Specific details are shown in Table 2.

Analysis of Factors Influencing Extended Knowledge on Warfarin

Regarding the question of how to manage anticoagulation in patients on long-term oral warfarin undergoing other surgical procedures, age differences were statistically significant ($\chi^2 = 10.625$, P = 0.014), as well as differences in department ($\chi^2 = 7.337$, P = 0.026), educational level ($\chi^2 = 9.931$, P = 0.007), and title ($\chi^2 = 8.198$, P = 0.017). Respondents aged 31–40, with a master's degree or higher education, working in the cardiac surgery department, and holding a senior title demonstrated higher correct response rates than other groups.

When it comes to knowing how to restart warfarin anticoagulation in patients on long-term oral warfarin after undergoing other surgical procedures, age ($\chi^2 = 17.306$, P < 0.001) and title ($\chi^2 = 9.850$, P = 0.007) differences were statistically significant.

Regarding knowledge about how to manage warfarin anticoagulation during pregnancy, differences in department (χ^2 = 11.693, *P* = 0.003) and title (χ^2 = 8.727, *P* = 0.0013) were statistically significant. Specific details are shown in Table 3.

Multivariate Analysis

The total score was used as the dependent variable, and age, ethnicity, unit level, department, education level and job title were used as independent variables, multiple linear regression models were used for analysis. The analysis results showed that the *F*-value of the model was 1.034 and the *P*-value was 0.411, indicating that the model was statistically insignificant. The coefficients for each variable are shown in Table 4.

Discussion

Basic Characteristics of the Respondents

After heart valve replacement surgery, long-term or even lifelong oral administration of warfarin is required for patients.¹¹ Among the respondents, 86.64% of the individuals frequently provided guidance on anticoagulation in clinical practice, indicating that anticoagulation management after cardiac surgery plays a significant role in cardiovascular departments and cardiac surgery. The survey aimed to cover hospitals of different levels, but the respondents were predominantly from tertiary hospitals (accounting for 75.43%). This is mainly because patients undergoing heart valve replacement surgery tend to seek follow-up care in larger hospitals and rarely visit township or community hospitals. The majority of the respondents were cardiovascular department doctors, accounting for 65.09%, possibly due to the lack of mature cardiac surgery departments in grassroots hospitals, making cardiovascular department doctors crucial in guiding warfarin anticoagulation. The gender, age, title, and years of work of the respondent were generally consistent with the actual situation in hospitals.

Basic Knowledge of Anticoagulation Among Respondents

31.47% of the respondents believed that stability could be achieved in 2–3 days, with a small percentage providing answers such as "24 hours" or "3–4 weeks", deviating significantly from the correct answer.¹² In the absence of complications and any special circumstances, adjusting warfarin dosage based on blood test results is a common situation faced by patients after valve replacement surgery and is a fundamental aspect of daily warfarin management. Regarding missing one dose of warfarin, 82.33% of the respondents answered correctly, stating that it generally does not require

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Factors	ctors M V:		lge of ulation After Il Heart acement ery	of Knowledge of on Anticoagulation er Duration After eart Bioprosthetic Heart nent Valve Replacement Surgery		Knowledge of How to Adjust Warfarin Dosage When Patient INR is Lower		Knowledge of How to Adjust Warfarin Dosage When Patient INR is Higher		Knowledge of How to Handle Missed Warfarin Doses		Knowledge of Time Required for INR to Reach Stable State After Changing Warfarin Dosage		Knowledge of Interval for Rechecking INR When Warfarin Dosage Remains Unchanged and INR is Within the Appropriate Range	
Age	21-30 years	60 (25.86)	5 (2.16)	54 (23.28)	11 (4.74)	40 (17.24)	25 (10.78)	56 (24.14)	9 (3.88)	43 (18.53)	22 (9.48)	45 (19.4)	20 (8.62)	(4.74)	54 (23.28)
	31–40 years	110 (47.41)	I (0.43)	75 (32.32)	36 (15.52)	60 (25.86)	51 (21.98)	106 (45.69)	5 (2.16)	101 (43.53)	10 (4.31)	66 (28.44)	45 (19.4)	46 (19.83)	65 (28.02)
	41–50 years	45 (19.40)	I (0.43)	40 (17.24)	6 (2.59)	27 (11.64)	19 (8.19)	41 (17.66)	5 (2.16)	38 (16.38)	8 (3.46)	26 (11.21)	20 (8.62)	23 (9.91)	23 (9.91)
	51–60 years	10 (4.31)	0 (0)	10 (4.31)	0 (0)	9 (3.88)	I (0.43)	10 (4.31)	0 (0)	9 (3.88)	I (0.43)	10 (4.31)	0 (0)	6 (2.59)	4 (1.72)
Hospital Level	Grade IIIA hospital	138 (59.48)	4 (1.72)	121 (52.16)	21 (9.05)	82 (35.34)	60 (25.86)	126 (54.31)	16 (6.9)	115 (49.57)	27 (11.64)	94 (40.52)	48 (20.68)	47 (20.26)	95 (40.95)
	Grade IIIB hospital	20 (8.63)	0 (0)	14 (6.03)	6 (2.59)	15 (6.47)	5 (2.16)	20 (8.62)	0 (0)	18 (7.76)	2 (0.86)	15 (6.46)	5 (2.16)	12 (5.16)	8 (3.45)
	Grade IIIC hospital	13 (5.60)	0 (0)	10 (4.31)	3 (1.29)	6 (2.59)	7 (3.02)	(4.74)	2 (0.86)	11 (4.74)	2 (0.86)	6 (2.59)	7 (3.02)	6 (2.59)	7 (3.02)
	Grade IIA hospital and others	54 (23.28)	3 (1.29)	34 (14.66)	23 (9.91)	33 (14.22)	24 (10.34)	56 (24.14)	I (0.43)	47 (20.26)	10 (4.31)	32 (13.79)	25 (10.78)	21 (9.05)	36 (15.52)
Department	Cardiovascular medicine	148 (63.79)	3 (1.29)	112 (48.28)	39 (16.81)	76 (32.76)	75 (32.33)	142 (61.21)	9 (3.88)	127 (54.74)	24 (10.34)	91 (39.22)	60 (25.86)	68 (29.31)	83 (35.78)
	Cardiovascular surgery	47 (20.26)	4 (1.72)	45 (19.40)	6 (2.59)	35 (15.09)	16 (6.9)	43 (18.53)	8 (3.45)	44 (18.97)	7 (3.02)	33 (14.23)	18 (7.76)	14 (6.03)	37 (15.95)
	Others	30 (12.94)	0 (0)	22 (9.48)	8 (3.44)	25 (10.77)	5 (2.15)	28 (12.07)	2 (0.86)	20 (8.62)	10 (4.31)	23 (9.91)	7 (3.02)	4 (1.72)	26 (11.21)
Education	Doctor	38 (16.38)	I (0.44)	34 (14.66)	5 (2.15)	17 (7.33)	22 (9.47)	32 (13.79)	7 (3.02)	33 (14.22)	6 (2.59)	19 (8.19)	20 (8.62)	12 (5.17)	27 (11.64)
	Master	96 (41.38)	3 (1.29)	86 (37.07)	13 (5.60)	35 (15.09)	64 (27.59)	91 (39.23)	8 (3.45)	80 (34.48)	19 (8.19)	68 (29.31)	31 (13.36)	38 (16.38)	61 (26.29)
	Undergraduate and others	91 (39.22)	3 (1.29)	59 (25.43)	35 (15.09)	55 (23.71)	39 (16.81)	90 (38.79)	4 (1.72)	78 (33.62)	16 (6.9)	60 (25.86)	34 (14.66)	36 (15.52)	58 (25)
Title	Primary title	68 (29.31)	4 (1.72)	58 (25.00)	14 (6.03)	40 (17.24)	32 (13.79)	62 (26.72)	10 (4.31)	51 (21.98)	21 (9.05)	47 (20.26)	25 (10.77)	12 (5.17)	60 (25.86)
	Intermediate title	86 (37.07)	2 (0.86)	59 (25.44)	29 (12.50)	55 (23.71)	33 (14.23)	85 (36.64)	3 (1.29)	77 (33.19)	(4.74)	55 (23.71)	33 (14.22)	39 (16.81)	49 (21.12)
	Advanced titles	71 (30.60)	I (0.44)	62 (26.72)	10 (4.31)	41 (17.67)	31 (13.36)	66 (28.45)	6 (2.59)	63 (27.16)	9 (3.88)	45 (19.4)	27 (11.64)	35 (15.09)	37 (15.95)

Table 2 Analysis Results of Factors Influencing Warfarin Anticoagulation Basic Knowledge

Table 3	Analysis	Results	of Factors	Influencing	Extended	Knowledge on	Warfarin
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Factors		Correct Answers for Knowledge of Antidotes for Warfarin Overdose N (%)	Correct Answers for Knowledge of Anticoagulation Management in Long- Term Oral Warfarin Patients After Other Surgical Procedures Following Mechanical Valve Replacement N (%)	Correct Answers for Knowledge of Restarting Warfarin Anticoagulation in Long-Term Oral Warfarin Patients After Other Surgical Procedures Following Mechanical Valve Replacement N (%)	Correct Answers for Knowledge of Warfarin Anticoagulation Management During Pregnancy N (%)
Age	21–30 years	53 (25.24)	54 (34.39)	55 (29.26)	48 (33.57)
	31–40 years	104 (49.52)	66 (42.04)	98 (52.13)	66 (46.15)
	41–50 years	43 (20.48)	30 (19.11)	28 (14.89)	24 (16.78)
	51–60 years	10 (4.76)	7 (4.46)	7 (3.72)	5 (3.50)
Hospital Level	Grade IIIA hospital	127 (60.48)	96 (61.15)	115 (61.17)	96 (67.13)
	Grade IIIB hospital	20 (9.52)	14 (8.92)	13 (6.91)	10 (6.99)
	Grade IIIC hospital	11 (5.24)	6 (3.82)	12 (6.38)	5 (3.50)
	Grade IIA hospital and others	52 (24.76)	41 (26.11)	48 (25.54)	32 (22.38)
Department	Cardiovascular medicine	143 (68.10)	93 (59.23)	124 (65.96)	81 (56.64)
	Cardiovascular surgery	45 (21.43)	40 (25.48)	37 (19.68)	39 (27.27)
	Others	22 (10.47)	24 (15.29)	27 (14.36)	23 (16.08)
Education	Doctor	35 (16.67)	18 (11.46)	34 (18.08)	28 (19.58)
	Master	89 (42.38)	71 (45.22)	77 (40.96)	65 (45.45)
	Undergraduate and others	86 (40.95)	68 (43.32)	77 (40.96)	50 (34.97)
Title	Primary title	58 (27.62)	58 (36.94)	60 (31.91)	52 (36.36)
	Intermediate title	83 (39.52)	56 (35.67)	78 (41.49)	56 (39.16)
	Advanced titles	69 (32.86)	43 (27.39)	50 (26.60)	35 (24.48)

Table 4 Analysis Results of Multiple Linear Regression Model

Model	Unstandardized Coefficient		Standardized Coefficient	t	Р
	B SD		Beta		
Constant	48.561	3.440		14.115	0.000
Sex	-0.943	0.941	-0.067	-1.002	0.317
Age	-1.049	1.176	-0.129	-0.892	0.373
Nationality	-0.715	1.244	-0.039	-0.575	0.566
Hospital Level	-0.055	0.449	-0.01 I	-0.122	0.903
Department	-0.630	0.658	-0.069	-0.957	0.339
Education	0.471	0.807	0.052	0.583	0.561
Title	0.234	1.061	0.028	0.221	0.825
Time to Work	1.012	0.799	0.199	1.267	0.207

additional doses or other interventions due to the long half-life of warfarin, resulting in relatively minor impacts. However, 11.64% chose to "double the dose", posing a certain risk of bleeding, and 6.03% suggested daily blood tests, which are unnecessary and increase trauma. Both the American Heart Association (AHA) guidelines and Chinese expert consensus recommend a follow-up interval of 2–3 months for stable warfarin anticoagulation.¹³ Only 37.07% of the respondents answered correctly, with 51.72% recommending monthly follow-ups, which is acceptable but not ideal. The remaining 11.21% suggested follow-ups every 1–2 weeks or every 6 months, which is less reasonable. Understanding these basic knowledge points is essential for correctly adjusting warfarin dosage. However, this study found that many healthcare professionals lack a correct understanding of these crucial aspects. Any incorrect answer to the above questions could pose significant medical risks.

The optimal target value for INR is a rather controversial topic in China. Both AHA guidelines and ESC guidelines recommend targets of 2.0 to 3.0 after aortic valve replacement, 2.5 to 3.5 after mitral valve replacement, and 3.0 to 4.0 after tricuspid valve replacement.^{13,14} In 2013, the Chinese Association of Cardiovascular Diseases issued the *Chinese Expert Consensus on Warfarin Anticoagulation Therapy*, in which the recommended values for INR after valve replacement are basically similar to the AHA and ESC guidelines, but the guidelines are mainly participated by cardiologists.¹² Cardiac surgeons in China have found that Chinese patients are more likely to develop bleeding complications, so lower anticoagulation standards are commonly used. A Chinese multicenter registry study of 11,769 patients in 34 heart centers, published in 2014, concluded that a target value of 1.5–2.5 in the Chinese population was safe and effective.¹⁵ This view is also supported by a number of other studies from China.^{16,17} In recent years, Chinese cardiac surgeons have improved the standard of anticoagulation after valve replacement, and most surgeons use the following criteria: INR 1.8–2.5 after aortic valve replacement and 2.0–3.0 for other valves. The above standards are not supported by the literature, but they are currently the most widely used.

In this study, the topic of anticoagulation goals is only to understand the preferences of individual physicians, not about right or wrong. From the survey results, it can be seen that the distribution of respondents among the different anticoagulation standard options is quite even, but it can still be seen that the respondents who choose 2.0–3.0 as the anticoagulation standard are the most diverse.

Complications and Special Situations in Warfarin Management

Complications related to warfarin are among the most common conditions encountered in emergency departments.¹⁸ Mastering the measures to address warfarin-related complications is crucial for the safety of anticoagulation patients. When patients reduce warfarin dosage due to minor bleeding, 84.48% of the respondents suggested actively attempting to restore the dosage, which is appropriate. The remaining respondents suggested maintaining a low dosage in the long term, which may pose a risk of thrombosis. Facing other surgeries is a common special situation for anticoagulation patients. Generally, warfarin should be stopped for 1 week, and low-molecular-weight heparin should be used as a substitute. However, 65.52% of the respondents incorrectly believed that when using heparin, INR should be maintained within the range required for anticoagulation. This is a misconception because low-molecular-weight heparin generally does not increase INR.¹⁹ Regarding the use of warfarin in pregnant women, different opinions exist. Warfarin has teratogenic effects, and it is generally believed that low-dose warfarin (below 5 mg) may not require substitution with low-molecular-weight heparin. When the warfarin dose is large, low-molecular-weight heparin can be used as a substitute in early pregnancy (before 12 weeks) and close to delivery (after 36 weeks). For this issue, 61.64% of the respondents had a relatively accurate understanding. However, 24.57% of the respondents believed that even low-dose warfarin should be substituted with low-molecular-weight heparin, which is somewhat reasonable but should consider the complications associated with low-molecular-weight heparin.

Development of Training Programs to Improve Anticoagulation Management Skills

The effect of warfarin knowledge on anticoagulation control among patients with heart valve replacement had been confirmed.¹⁹ Continuing education for healthcare professionals is a long-term process that significantly influences their competency.²⁰ Based on the results, when formulating training programs to enhance the anticoagulation management skills of medical staff, a multidisciplinary collaboration is required. First and foremost, training should target not only

cardiac surgeons but also doctors from cardiology and pharmacists. Especially in grassroots hospitals, cardiologists play a pivotal role in guiding warfarin anticoagulation. Secondly, the training content should cover not only basic anticoagulation-related knowledge but also focus on providing correct response measures when warfarin complications occur. For instance, when patients experience complications of varying severity, it is crucial to know whether to reduce or stop the medication, when to resume treatment, and so on. Lastly, training emphasis should be tailored to different trainees. For surgeons, the focus should be on understanding how to manage warfarin anticoagulation when patients are facing other surgeries. For internists, daily management of warfarin anticoagulation and handling complications are key areas.

Limitations

Limitations of this study include the convenience sampling method used for the online survey via WeChat, therefore, some individuals such as old aged physicians, who have lower access to digital tools, have lower motivation to participate. The individuals may not entirely align with the research objectives. The majority of respondents were concentrated in tertiary hospitals, mainly involving clinical doctors from cardiovascular departments and cardiac surgery departments, leading to a potential sampling bias. Future research should consider using a stratified sampling method and a larger sample size to better reflect the general knowledge level of frontline clinical doctors in warfarin anticoagulation.

Conclusion

This study found that the surveyed individuals had a good understanding of warfarin anticoagulation basics, and most clinical doctors could effectively guide patients in anticoagulation treatment. However, there were still errors in some fundamental questions, indicating significant risks in daily anticoagulation management. Heart valve replacement surgeries are generally performed in large tertiary hospitals by cardiac surgery departments, and there may be insufficient awareness of surgical aspects in cardiovascular departments and primary hospitals. Therefore, there is room for improvement in postoperative anticoagulation management.

Given the substantial risks associated with warfarin, it is essential to enhance the knowledge level of clinical doctors involved in anticoagulation treatment. This study recommends systematic training for all healthcare professionals engaged in anticoagulation treatment. The training should not only focus on warfarin dosage adjustments and complications but also include knowledge about the interval for rechecking INR after reaching a stable target value, the cessation and resumption of warfarin when other surgeries are needed, and similar aspects. This comprehensive approach aims to effectively enhance the knowledge level of healthcare professionals in anticoagulation, thereby improving the safety and effectiveness of warfarin anticoagulation therapy for patients.

Data Sharing Statement

The data-set used and analyzed during the current study are available from the corresponding author on reasonable request.

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Disclosure

The authors declare that there were no competing interests in this work.

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