Heart Surgery Forum 2024; 27(10): E1182–E1192
doi: 10.59958/hsf.7813

Article

Impact of Applying PDCA Circulation Method on Surgical Care Interventions in the Operating Room on Patients Undergoing Cardiothoracic Surgery: A Retrospective Study

Yingying Wang[1], Lijun Wei[1,*]

[1]Operating Room, Ningbo No.2 Hospital, 300270 Ningbo, Zhejiang, China
*Correspondence: weilijun202405@126.com (Lijun Wei)

Submitted: 19 June 2024 Revised: 17 July 2024 Accepted: 16 August 2024 Published: 16 October 2024

Abstract

Background: The Plan-Do-Check-Act (PDCA) cycle is a widely recognized methodology for continuous quality improvement. This study evaluated the impact of applying the PDCA cycle on surgical care interventions in the operating room for patients undergoing cardiothoracic surgery. **Methods**: A retrospective study was conducted on the treatment of patients who underwent continuous cardiothoracic surgery in our Hospital from July 2020 to June 2023. Participants were divided into control and PDCA groups on the basis of the application of the PDCA cycle in their surgical care. Various outcomes were assessed, including psychological well-being (Hospital Anxiety and Depression Scale [HAMA] and Hamilton Depression Rating Scale [HAMD] scales), quality of life (using the QLQ-C30 tool), patient satisfaction, incidence of adverse accidents, clinical parameters, and laboratory measures. **Results**: The study comprised 133 patients, with 62 in the control group and 71 in the PDCA group. The psychological well-being, as measured by the HAMA and HAMD scales, of the PDCA group showed significant improvements compared with that of the control group ($p < 0.05$). The Quality-of-Life scores were higher in the PDCA group than in the control group ($p < 0.05$). In the PDCA group, the patient satisfaction scores related to hospital satisfaction were significantly higher than that in the control group, and the incidence of adverse accidents was lower (all $p < 0.05$). No significant differences were noted in clinical parameters (ejection fraction and B-type natriuretic peptide levels) nor laboratory measures (serum protein and C-reactive protein (CRP) levels) between the groups ($p > 0.05$ for all). **Conclusion**: The implementation of the PDCA cycle in the operating room for patients undergoing cardiothoracic surgery significantly improved psychological well-being and patient satisfaction and reduced the incidence of adverse accidents in the operating room, indicating that this quality improvement approach can enhance patient care experience. Although no significant differences were observed in clinical and laboratory parameters, the findings suggest that the PDCA cycle's strengths lie in its systematic approach to care process optimization and patient-centered outcomes.

Keywords

cardiothoracic surgery; PDCA cycle; quality improvement; patient outcomes; surgical care interventions; patient satisfaction

Introduction

Improvements in surgical care processes are pivotal in enhancing patient outcomes, particularly in high-stake environments such as cardiothoracic surgery [1]. The surgical environment is inherently complex, with numerous variables that can significantly impact patient safety, recovery, and overall satisfaction [2]. Among the myriad of strategies aimed at optimizing surgical care, the Plan-Do-Check-Act (PDCA) cycle has gained prominence due to its structured approach to continuous quality improvement [3,4].

The PDCA cycle, originally conceptualized by Walter Shewhart and later popularized by W. Edwards Deming, is a methodological approach that emphasizes iterative progress through four stages: planning, doing, checking, and acting [5,6]. This cycle is particularly relevant in healthcare settings where ongoing evaluation and refinement of processes are essential to meet the dynamic needs of patients and the healthcare system [7]. The PDCA cycle's systematic nature ensures that quality improvement is not a one-time effort but a continuous journey towards excellence [8–10].

Cardiothoracic surgery encompasses a range of complex procedures, including coronary artery bypass grafting (CABG), heart valve replacement, and heart transplants [11–13]. These procedures require meticulous coordination among multidisciplinary teams, including surgeons, anesthesiologists, nurses, and other healthcare professionals. Given the complexity and high-risk nature of these surgeries, any fluctuations in care processes can have profound implications for patient outcomes. Implementing a robust quality management strategy, such as the PDCA cycle, is therefore essential to ensure the highest standards of care.

The quality improvement methodologies in healthcare have good clinical application effects. For instance, the implementation of checklists and standardized protocols has

been shown to reduce surgical complications and improve patient outcomes [14]. However, research specifically evaluating the impact of the PDCA cycle on surgical care interventions in the cardiothoracic context is lacking. The PDCA approach, with its focus on iterative improvement, offers a unique opportunity to address specific challenges within the operating room environment, potentially leading to enhanced patient safety and satisfaction [15].

This retrospective study aimed to fill this gap by assessing the impact of applying the PDCA circulation method on surgical care interventions in the operating room for patients undergoing cardiothoracic surgery. Various outcomes, including psychological well-being, quality of life, patient satisfaction, clinical parameters, and laboratory measures, were investigated.

Materials and Methods

Study Design

In this retrospective cohort study, patients undergoing cardiovascular surgery at our institution from July 2020 to June 2023 were selected. They were divided into a control group and a PDCA group on the basis of their preferred nursing approach. Patient selection was conducted with full respect and consideration, with healthcare decisions made collaboratively between physicians and patients after a comprehensive understanding of the care plans, ensuring the preservation of patient autonomy and informed consent. This study conformed to the Declaration of Helsinki [16], and it has been approved by the Ethics Committee of Ningbo No.2 Hospital (approval no.: 2024-048-01). The informed consent was obtained from all patients.

Eligibility Criteria

Patients were required to meet the following criteria for inclusion: (1) underwent cardiothoracic surgery due to cardiac disease; (2) aged between 18 and 80 years; and (3) classified as American Society of Anesthesiologists (ASA) class I–III, displaying normal mental and cognitive functions and possessing complete clinical data. The study focused on patients eligible for day surgery.

The exclusion criteria encompassed the following: (1) patients with pre-existing infections; (2) those with severe systemic illnesses; and (3) patients with immunodeficiency or heightened infection risk factors, severe liver or kidney dysfunction, cardiovascular or cerebrovascular conditions, or severe infectious diseases; those who experienced unconsciousness; individuals diagnosed with mental health disorders; patients lacking comprehensive medical records; and those who were unable to actively participate in the study due to cooperation limitations.

Post-hoc analysis based on *t*-tests was performed using G*Power 3.1.9.7 software (University of Düsseldorf, dusseldorf, north rhine-westphalia, Germany). The analysis was configured in two-tailed mode with an effect size of d = 0.5 and a significance level of α error probability = 0.05. The calculation of power (1-β error probability) yielded a result of 0.815.

Treatment Approach

In the control group, standard nursing protocols were adhered to during operations, consisting of managing procedures in the operating room, vigilantly monitoring vital signs, ensuring correct body position, educating patients about postoperative nursing, addressing nursing issues in a timely manner, and organizing surgical equipment.

In the PDCA group, the PDCA cycle was implemented as follows:

Plan: (1) A quality control team was established and theoretical knowledge and skill operations of team members were assessed. (2) The situations of the operating room in the recent stage were investigated to seek the problems and potential safety hazards. Wrong recording of operation sites, the occurrence of pressure injury, medication error in the operating room, improper drug distribution and equipment management, and foreign body retention in the operating room were summarized by the team leader. A preliminary assessment of the current actions was carried out in accordance with current investigation situations, and the causes of the above problems were analyzed, such as operating room nurses having insufficient operational skills, outdated theoretical knowledge, and poor implementation of core nursing system. Improvement plans of nursing quality control were formulated in accordance with the reasons analyzed by the quality control team.

Do: (1) The strengthening of training related to skills and theoretical knowledge of operating room nurses ensured that the personnel in operating room mastered the skills of cardiothoracic surgery, the risk factors of surgical infection and corresponding control measures, strictly implemented aseptic operations during operations, and followed the relevant rules and regulations of the operating room. Increasing practical opportunities and experience reserves of nursing staff with moderate and junior qualification were necessary, and opportunities for nursing staff with moderate qualification for advanced studies must be provided. (2) About the possible preoperative safety hazards, before the patients entered the operating room, the rounding nurses in operating room strictly checked patients' medical records, basic information, surgical marking sites, and intraoperative medication to ensure that the patients entered the operating room without error. Before surgery, two or more operating room nurses checked the number of surgical items and instruments to ensure correct preparation and distribution of surgical instruments and drugs, thereby reduc-

ing the possibility of medication errors and improper management of instruments. The rounding nurses explained the rationality of cardiothoracic surgery to patients before surgery to relax patients' tension and win their trust and cooperation, explained the operation steps, and promised that the operation will be carried out in strict accordance with the operation procedures, which could improve the operational effect and reduce the psychological burden of patients. (3) In view of the possible intraoperative safety hazards, the operating room nurses should closely monitor patients' vital signs during operation to timely detect and deal with abnormalities, pay attention to the disinfection of personnel and surgical instruments in the operating room, and prepare first-aid items to ensure rapid and effective intervention in emergency situations. In addition, the operating room nurses needed to maintain close communication with surgeons and other medical team members to ensure smooth operation processes. Intraoperative specimens were carefully preserved and then fixed and labeled for inspection, and nursing records were made. For patients with an operation time >3 h, antibiotics were given in accordance with doctors' advice. (4) In view of possible postoperative safety hazards, checking postoperative instruments, articles, and materials, maintaining the temperature of patients, and reminding surgeons to speed up skin disinfection to minimize skin exposure were necessary. Nursing staff should be mindful of the collection and treatment of medical waste and carefully clean and disinfect the operating room. In the process of returning patients to the ward, attention should be paid to protecting the drainage tube and preventing it from falling off. Meanwhile, the nursing staff carefully explained the relevant precautions to the family members. During return visit after operation, the operating room nurses informed the patients and their families about the operational success and objectively elaborated the operation in accordance with patients' actual situations to reduce the psychological burden in the follow-up treatment and actively cooperate with the follow-up nursing and treatment.

Check: (1) The quality control team regularly carried out quality inspections in the operating room, including the cleanliness of the operating room, the disinfection of surgical instruments, and the implementation of rules and regulations in the operating room. Simultaneously, the skill operations and theoretical knowledge of the nursing staff in the operating room were assessed. (2) After surgery, the nursing staff in the operating room conducted self-reflection and summary to determine the problems and deficiencies in the operation process and put forward improvement measures. (3) The quality control team summarized and analyzed the problems raised by the nursing staff in the operating room, determined the root causes of these problems, and formulated corresponding improvement measures.

Act: (1) About the problems found in the quality inspection, the quality control team formulated specific improvement measures and urged the operating room nurses to implement these measures. (2) The quality control team also analyzed the problems raised in the self-reflection of the operating room nurses one by one and provided corresponding solutions. (3) For recurrent problems, the quality control team conducted an in-depth investigation to determine the root causes of the problems and formulated corresponding preventive measures to avoid similar problems from occurring again.

General Information

Participants' baseline information was collected through a Demographic Questionnaire, covering age, gender, Body Mass Index (BMI), smoking and drinking history, hypertension, diabetes, employment and marital status, educational level, and physical activity. Clinical data, such as previous cardiac surgery, chronic obstructive conditions, vascular and myocardial infarctions, ASA grade, family history of cardiovascular disease (CVD), atrial fibrillation, left ventricular mass, surgery specifics (duration, blood loss, type, cardiopulmonary bypass, cross-clamp time, and transfusion needs), were obtained from medical records.

Parameters like Intensive Care Unit (ICU) stay duration, ventilation hours, hospital stay length, mortality rate, and occurrence of adverse events were documented and compared across the two groups.

Cardiac Function Assessment

Cardiac function was evaluated using a digital color Doppler ultrasound diagnostic device (Voluson E8, GE, Boston, MA, USA) to measure peak systolic pressure and calculate ejection fraction (EF) by using the biplane Simpson method and monitor cardiac output and mean arterial pressure through echocardiography pre-operatively and at 1 month post-operation.

Blood Tests

The blood parameters of patients were assessed preoperatively and 1 month post-operatively. A fasting venous blood sample of 3 mL was obtained from the median cubital vein in the early morning. The serum obtained after centrifugation was analyzed using an automated biochemistry analyzer (BS-280, Mindray, China) to determine the levels of hemoglobin, serum albumin, serum creatinine, white blood cell count (WBC), and B-type natriuretic peptide (BNP). Troponin I levels were measured using electrochemiluminescence, and C-reactive protein (CRP) levels were assessed using ELISA.

Pain Score

The postoperative pain levels of patients were assessed using the Visual Analog Scale, a standard tool for

pain evaluation ranging from 0 to 10, where 0 represents the absence of pain and 10 indicates severe pain. This objective pain assessment method showed high internal consistency, with a Cronbach's alpha of 0.94 [17].

Emotion Score

The negative emotions of both groups were assessed using Hospital Anxiety and Depression Scale (HADS) and Hamilton Depression Rating Scale (HAMD) scores, where higher scores signified a more pronounced negative emotional state. The internal consistency of HADS was notably strong at 0.92, complemented by a high inter-rater reliability of 0.91. Similarly, the Chinese version of HAMD demonstrated a Cronbach's alpha of 0.91, with a retest reliability intra-group correlation coefficient of 0.81 [18].

Quality of Life

The quality of life was postoperatively evaluated through the EORTC QLQ-C30 assessment tool. This tool encompasses functional domains such as physical, mobility, emotional, social, and cognitive functions. Each domain item was evaluated on a scale of 1 to 7 (Likert scale), with aggregated scores falling between 0 and 100. Higher scores on this scale indicated an increased quality of life. The reliability analysis yielded a Cronbach's alpha of 0.927 [19].

Patient Satisfaction

In the day surgery department, satisfaction was evaluated on the basis of interactions with staff, pain control, hospital surroundings, and general contentment. A 10-point scale determined the level of satisfaction: very satisfied ($\geq$ 9 points), satisfied (7–9 points), and unsatisfied ($\leq$7 points).

Incidence of Adverse Accidents

The incidences of adverse accidents in the two groups were collected from the medical record system. Adverse accidents referred to the incidents that did not cause harm to patients or caused minor/serious harm and induced or did not induce complaints and disputes due to the lack of responsibility of nursing staff and failure to implement the operational norms or core system.

Statistical Analysis

The clinical data collected in this study were processed using SPSS (version 26.0) software (IBM; Armonk, NY, USA). Categorical variables were expressed as [n (%)], and the corresponding test methods were adopted in accordance with the characteristics of the data. (1) Fourfold table test. (i) Pearson's chi-square test was used for all theoretical numbers T $\geq$5 and total sample size n $\geq$40. (ii) Chi-square test with continuous correction was used for theoretical numbers $1 \leq T < 5$ and n $\geq$40. (iii) Fisher's test was used for theoretical numbers T $<$1 or n $<$40. (2) R$\times$C table test. Cells with theoretical numbers $<$5 not exceeding 20% or theoretical numbers T $\geq$1 were tested by Pearson chi-square test. Conversely, Fisher's test was used (cells with theoretical numbers $<$5 exceeded 20% or theoretical numbers T $<$1). The Shapiro–Wilk test was used to test whether all continuous variables conformed to normal distribution. The data that conformed to normal distribution were expressed as (mean $\pm$ SD), and *t* test was performed. The data that did not conform to normal distribution were expressed as M (P_{25}, P_{75}), and the Mann–Whitney U test was performed. Two-sided $p < 0.05$ indicated statistical significance.

Results

Demographic and Basic Data

In this retrospective study investigating the impact of implementing the PDCA circulation method on surgical care interventions in patients undergoing cardiothoracic surgery, a total of 133 patients were analyzed, with 62 in the control group and 71 in the PDCA group. The demographic characteristics showed no statistically significant differences in age, sex, Body Mass Index (BMI), smoking history, drinking history, hypertension history, diabetes history, employment status, marital status, educational level, previous cardiac surgery, chronic obstructive pulmonary disease, previous vascular surgery, previous myocardial infarction, ASA grade, family history of CVD, atrial fibrillation, and left ventricular mass between the two groups ($p >$ 0.05 for all, Table 1).

Surgical Variables

Within the scope of surgical variables, the comparison of surgical parameters, such as surgery duration (control: 165.34 $\pm$ 12.67 *vs*. PDCA: 163.21 $\pm$ 11.98 minutes), blood loss (control: 340.18 $\pm$ 45.21 *vs*. PDCA: 334.97 $\pm$ 42.89 mL), type of surgery (CABG, heart valve, heart transplant, and others), cardiopulmonary bypass time, cross-clamp time, and transfusion requirements, did not reveal statistically significant differences between the two groups ($p > 0.05$ for all, Table 2).

Cardiac-related Measures

The examination of cardiac-related measures showed analyses of ejection fraction, BNP, troponin I levels, peak systolic pressure, cardiac output, and mean arterial pressure at pre- and post-treatment time points indicated no statistically significant differences between the two groups ($p >$ 0.05 for all comparisons, Table 3). The results suggest that

Table 1. Patient Demographics.

Parameter	Control group (n = 62)	PDCA group (n = 71)	t/χ^2	*p*-value
Age (years)	56.43 ± 5.67	55.89 ± 6.21	0.525	0.601
Gender (M/F)	40 (64.52%)/22 (35.48%)	44 (61.97%)/27 (38.03%)	0.092	0.762
BMI (kg/m^2)	22.16 ± 3.42	22.91 ± 2.98	1.354	0.178
Smoking history	20 (32.26%)	18 (25.35%)	0.773	0.379
Drinking history	23 (37.10%)	23 (32.39%)	0.323	0.570
Hypertension	22 (35.48%)	22 (30.99%)	0.302	0.582
Diabetes	18 (29.03%)	17 (23.94%)	0.442	0.506
Employment status (full-time/part-time/unemployed/retired)	25 (40.32%)/25 (40.32%)/6 (9.68%)/6 (9.68%)	28 (39.44%)/26 (36.62%)/9 (12.68%)/8 (11.27%)	0.468	0.926
Marital status			0.747	0.688
Single	5 (8.06%)	4 (5.63%)		
Married	45 (72.58%)	56 (78.87%)		
Divorced/Widowed	12 (19.35%)	11 (15.49%)		
Educational level			0.065	0.968
Primary school (%)	16 (25.81%)	17 (23.94%)		
Secondary school (%)	36 (58.06%)	42 (59.15%)		
University (%)	10 (16.13%)	12 (16.9%)		
Physical activity (h/week)	3.51 ± 1.28	3.84 ± 1.35	1.434	0.154
Previous cardiac surgery	2 (3.23%)	1 (1.41%)	0.014$^{\#}$	0.905$^{\#}$
Chronic obstructive pulmonary disease	5 (8.06%)	4 (5.63%)	0.044$^{\#}$	0.833$^{\#}$
Previous vascular surgery	8 (12.90%)	7 (9.86%)	0.307	0.580
Previous myocardial infarction	26 (41.94%)	32 (45.07%)	0.132	0.716
ASA grade (I/II/III)	18 (29.03%)/32 (51.61%)/12 (19.35%)	20 (28.17%)/34 (47.89%)/17 (23.94%)	0.421	0.810
Family history of CVD (%)	7 (11.29%)	6 (8.45%)	0.303	0.582
Atrial fibrillation	2 (3.23%)	4 (5.63%)	0.062$^{\#}$	0.804$^{\#}$
Left ventricular mass (g)	185.62 ± 15.27	184.89 ± 14.94	0.275	0.783

$^{\#}$ represented the results of chi-square test with continuous correction. BMI, Body Mass Index; CVD, cardiovascular disease; PDCA, the Plan-Do-Check-Act; ASA, American Society of Anesthesiologists.

Table 2. Surgical Variables.

Parameter	Control group (n = 62)	PDCA group (n = 71)	t/χ^2	*p*-value
Surgery duration (min)	165.34 ± 12.67	163.21 ± 11.98	0.990	0.324
Blood loss (mL)	340.18 ± 45.21	334.97 ± 42.89	0.680	0.498
Type of surgery			2.041	0.728
CABG	20 (32.26%)	26 (36.62%)		
Heart valve	19 (30.65%)	20 (28.17%)		
CABG	16 (25.81%)	15 (21.13%)		
Heart transplant	6 (9.68%)	6 (8.45%)		
Others	1 (1.61%)	4 (5.63%)		
Cardiopulmonary bypass (min)	88.75 ± 7.92	87.39 ± 8.77	0.941	0.348
Cross-clamp time (min)	56.81 ± 5.67	55.92 ± 6.12	0.871	0.386
Transfusion requirements	12 (19.35%)	10 (14.08%)	0.666	0.414

CABG, coronary artery bypass grafting.

the PDCA circulation method did not demonstrate a notable impact on these cardiac parameters compared with standard care, emphasizing the need for further investigations to elucidate the potential benefits of this method on cardiac performance in the context of cardiothoracic surgical interventions.

Laboratory Examination

The evaluation of laboratory parameters between the control group and the PDCA group showed that the serum creatinine levels, hemoglobin concentrations, platelet counts, serum albumin levels, and CRP levels before and after treatment did not yield statistically significant

Table 3. Cardiac-related measures.

Parameter	Time point	Control group (n = 62)	PDCA group (n = 71)	t	*p*-value
Ejection Fraction (%)	Before treatment	51.34 ± 4.21	51.89 ± 4.38	0.729	0.467
	After treatment	56.18 ± 6.36	57.27 ± 6.19	1.002	0.318
BNP (pg/mL)	Before treatment	180.86 ± 35.42	170.79 ± 39.81	1.544	0.125
	After treatment	103.26 ± 30.37	105.49 ± 28.56	0.436	0.664
Troponin I (ng/mL)	Before treatment	0.13 ± 0.05	0.14 ± 0.05	1.151	0.252
	After treatment	0.08 ± 0.04	0.07 ± 0.03	1.612	0.110
Peak systolic pressure (mmHg)	Before treatment	132.54 ± 15.67	131.89 ± 17.48	0.227	0.821
	After treatment	121.49 ± 10.27	120.28 ± 10.52	0.669	0.504
Cardiac output (L/min)	Before treatment	4.41 ± 0.46	4.39 ± 0.42	0.257	0.797
	After treatment	5.22 ± 0.34	5.23 ± 0.32	0.175	0.862
Mean arterial pressure (mmHg)	Before treatment	95.73 ± 8.65	93.45 ± 9.28	1.466	0.145
	After treatment	86.18 ± 6.24	84.69 ± 6.10	1.388	0.168

BNP, B-type natriuretic peptide.

Table 4. Laboratory examination.

Parameter	Time point	Control group (n = 62)	PDCA group (n = 71)	t	*p*-value
Serum creatinine (mg/dL)	Before treatment	1.08 ± 0.14	1.06 ± 0.12	0.847	0.399
	After treatment	0.95 ± 0.09	0.94 ± 0.08	0.687	0.493
Hemoglobin (g/dL)	Before treatment	12.24 ± 0.97	12.10 ± 0.85	0.907	0.366
	After treatment	14.95 ± 1.87	15.26 ± 2.14	0.867	0.387
Platelet count ($\times 10^3/\mu L$)	Before treatment	255.78 ± 38.56	258.46 ± 37.91	0.404	0.687
	After treatment	240.42 ± 30.24	242.68 ± 32.16	0.417	0.677
Serum albumin (g/dL)	Before treatment	4.82 ± 0.32	4.75 ± 0.27	1.368	0.174
	After treatment	4.03 ± 0.43	4.08 ± 0.36	0.730	0.467
CRP (mg/L)	Before treatment	5.28 ± 1.15	5.34 ± 1.06	0.303	0.762
	After treatment	3.85 ± 1.29	4.02 ± 1.68	0.678	0.499

CRP, C-reactive protein.

differences ($p > 0.05$ for all comparisons, Table 4). These results suggest that the implementation of the PDCA circulation method did not exhibit a substantial impact on the assessed laboratory parameters compared with standard care.

Postoperative Outcomes

The examination of variables, such as the length of ICU stay, ventilation hours, hospital stay duration, and mortality rates, did not reveal statistically significant differences between the two groups ($p > 0.05$ for all comparisons, Table 5). These findings suggest that the implementation of the PDCA circulation method did not significantly affect the postoperative outcomes.

Quality of Recovery Scores

While the pain scores did not show statistically significant differences between the two groups ($p = 0.413$), significantly lower HAMA scores ($p = 0.004$) and HAMD scores ($p = 0.006$) and higher Quality-of-Life (QoL) scores were observed in the PDCA group than in the control group ($p = 0.002$, Table 6). These results suggest that the application of the PDCA circulation method may have a notable impact on emotional well-being and quality of life post-cardiothoracic surgery, warranting further investigation into the potential benefits of this method on psychological and QoL outcomes in surgical patient recovery.

Adverse Events

The analysis of adverse events, including surgical site infections, cardiac complications, respiratory complications, renal complications, and neurological complications, did not exhibit statistically significant differences between the two groups ($p > 0.05$ for all comparisons, Table 7). These findings suggest that the application of the PDCA circulation method did not significantly impact the occurrence of adverse events following cardiothoracic surgery compared with standard care.

Patient Satisfaction Scores

While no statistically significant differences were noted in both groups in terms of pain management satisfaction scores ($p = 0.380$), significantly higher scores of communication with staff ($p = 0.002$), hospital environment satisfaction ($p = 0.045$), and overall satisfaction ($p = 0.033$)

Table 5. Postoperative Outcomes.

Parameters	Control group (n = 62)	PDCA group (n = 71)	t/χ^2	*p*-value
Length of ICU stay (days)	2.91 ± 0.87	2.66 ± 0.92	1.601	0.112
Ventilation hours	12.47 ± 3.91	12.11 ± 3.67	0.544	0.587
Hospital stay (days)	9.34 ± 1.89	9.18 ± 1.76	0.491	0.624
Mortality rate (%)	4 (6.45%)	3 (4.23%)	0.034#	0.854#

represented the results of chi-square test with continuous correction. ICU, Intensive Care Unit.

Table 6. Quality-of-Recovery Scores.

Parameters	Control group (n = 62)	PDCA group (n = 71)	t	*p*-value
Pain score (0–10)	2.76 ± 1.23	2.58 ± 1.19	0.822	0.413
HADS	13.21 ± 4.32	10.89 ± 4.76	2.946	0.004
HAMD	14.74 ± 3.81	12.91 ± 3.67	2.811	0.006
Quality-of-Life score	76.95 ± 11.76	83.28 ± 10.89	3.201	0.002

HADS, Hospital Anxiety and Depression Scale; HAMD, Hamilton Depression Rating Scale.

Table 7. Adverse Events.

Parameters	Control group (n = 62)	PDCA group (n = 71)	χ^2	*p*-value
Surgical site infection	3 (4.84%)	1 (1.41%)	0.418	0.518
Cardiac complications	3 (4.84%)	2 (2.82%)	0.024	0.877
Respiratory complications	2 (3.23%)	1 (1.41%)	0.014	0.905
Renal complications	2 (3.23%)	1 (1.41%)	0.014	0.905
Neurological complications	1 (1.61%)	3 (4.23%)	0.138	0.711

Table 8. Patient Satisfaction Scores.

Parameter	Control group (n = 62)	PDCA group (n = 71)	t	*p*-value
Communication with staff	6.87 ± 0.65	7.22 ± 0.62	3.154	0.002
Pain management	6.23 ± 0.74	6.34 ± 0.68	0.881	0.380
Hospital environment	5.68 ± 1.69	6.27 ± 1.63	2.022	0.045
Overall satisfaction	9.02 ± 0.79	9.31 ± 0.73	2.161	0.033

Table 9. Comparison of Incidence of Adverse Accidents.

Groups	Cases	Number	Incidence (%)
Control group	62	5	8.06
PDCA group	71	0	0.00
χ^2	-		3.929#
p	-		0.047#

represented the results of chi-square test with continuous correction.

were observed in the PDCG group than in the control group (Table 8). These results suggest that the implementation of the PDCA circulation method may positively influence aspects related to communication, hospital environment, and overall patient satisfaction in the context of cardiothoracic surgical care interventions.

Incidence of Adverse Accidents

Table 9 shows significantly lower incidence of adverse accidents in the PDCA group than in the control group (p = 0.047).

Discussion

The application of the PDCA cycle as a quality improvement strategy in healthcare settings has been advocated to enhance patient outcomes and operational efficiency [20,21]. This retrospective study aimed to evaluate the impact of the PDCA circulation method on surgical care interventions in the operating room for patients undergoing cardiothoracic surgery. While the results indicated no statistically significant differences in several clinical and laboratory parameters, notable improvements were observed in areas concerning psychological well-being, overall QoL, the incidence of adverse accidents, and patient satisfaction.

Psychological Well-being and QoL

PDCA cycle nursing is a nursing management mode with four cores (i.e., plan, do, check, and act), and its influence is not limited to the normalization and standardization of nursing operations; it has a far-reaching effect on the mental health of patients. From the perspective of men-

tal health, the implementation of PDCA cycle nursing provides patients with a more stable and orderly nursing environment. Patients can feel the care and attention from nursing staff, thus reducing the anxiety and unrest caused by the disease. Especially in the planning stage (i.e., plan), nursing staff formulate personalized nursing plans in accordance with patients' specific conditions and psychological states, and this "people-oriented" nursing concept remarkably improves patients psychological comforts. Before, during, and after operation, nursing staff carry out detailed psychological nursing for patients in accordance with specific fear and tension sources, including explaining the operational steps, informing patients of operational rationality, and notifying operational success after operation, to further reduce their psychological burdens.

The significantly lower HADS and HAMD scores in the PDCA group underscore the potential psychological benefits of implementing the PDCA cycle in the surgical care process. The PDCA method's structured approach likely contributed to reducing anxiety and depression among patients by promoting clarity and communication between healthcare providers and patients. Interventional strategies included pre-and post-operative discussions led by itinerant nurses, meticulous verification of case data, and consistent engagement with patients at various stages of the surgical journey. These measures likely enhanced patients' understanding of their care trajectory, thus alleviating preoperative anxiety and depressive symptoms by fostering a sense of control and reassurance.

Regular training sessions for in-house staff emphasized professional knowledge and operational processes, including equipment management, application, and maintenance, which likely contributed to smoother and more predictable care processes [22,23]. Such predictability and professionalism may have further reassured patients, thus reducing their overall stress response to surgery. Consequently, these systematic interventions harnessed by the PDCA approach appear pivotal in improving emotional outcomes post-cardiothoracic surgery.

The enhanced QoL scores in the PDCA group can be attributed to the method's comprehensive approach to patient care. By addressing specific operating room challenges and developing targeted solutions, the PDCA cycle likely fostered a more conducive postoperative environment, contributing significantly to patients' physical, emotional, and social recovery domains [24]. The systematic and continuous quality checks and peer reviews ensured consistent care standards, positively influencing overall patient outcomes [25].

Patient Satisfaction

Patient satisfaction scores related to communication with staff, hospital environment, and overall satisfaction were significantly higher in the PDCA group. Effective communication is crucial in healthcare settings, particularly in surgical environments where patients often experience heightened stress and uncertainty. The PDCA method, through its detailed planning and execution phases, involved comprehensive preoperative counseling and postoperative discussions [26]. This not only ensured that patients were well-informed about each step of their surgical process but also facilitated a supportive atmosphere where they felt heard and understood.

In the planning stage (i.e., plan), nursing staff develop personalized nursing plans according to patients' specific conditions and psychological states. The PDCA method is "people-oriented", which considerably improves patients' psychological comforts. In the implementation stage (i.e., do), nursing staff strictly follow the plan to carry out nursing operations to ensure that all nursing measures can be effectively implemented to ensure patients' life safety, so that they feel the professionalism and reliability of nursing staff, thus further reducing their psychological burden. During the examination stage (i.e., check), nursing staff regularly evaluate the nursing effect and adjust the nursing plan in time in accordance with the evaluation results to meet patients' nursing needs, and at the same time, patients can feel that their conditions are gradually improving, thereby enhancing their treatment confidence. In the treatment stage (i.e., act), nursing staff formulate corresponding improvement measures in accordance with the examination results and apply these measures to the next nursing work. This continuously optimized nursing process can improve the nursing efficiency and make patients feel the continuous improvement of the nursing work to further improve their nursing satisfaction.

Incidence of Adverse Accidents

PDCA is a humanized scientific management mode. In this study, PDCA was used to comprehensively manage the safety hazards of operating room in cardiothoracic surgery. The results showed lower incidence of adverse accidents in the PDCA group. In this group, the four steps from the PDCA method to the operating room were applied to improve the nursing of cardiothoracic surgery. Through investigating the current situations of routine nursing in cardiothoracic surgery, the causes of adverse accidents were analyzed to formulate corresponding improvement plans and carry out targeted training for nursing staff in accordance with the plans. In the nursing process, team members exert teamwork power and ensure the safety of patients through personnel training and the improvement of nursing quality of nursing staff, ultimately reducing the incidence of adverse accidents in the operating room.

Insignificant Differences in Clinical and Laboratory Parameters

Despite the notable benefits observed in psychological well-being and patient satisfaction, the study found no statistically significant differences in clinical outcomes, laboratory parameters, nor intraoperative measures between the two groups. These results suggest that while the PDCA cycle may not directly influence clinical parameters, such as ejection fraction, BNP levels, troponin I levels, or intraoperative blood loss, its indirect benefits through improved care processes and patient psychological health are evident.

The lack of significant differences in clinical parameters could be attributed to several factors. First, the patient population may be relatively homogeneous in clinical characteristics, and this study had a small sample size, so these improvements of nursing brought by the PDCA cycle may not be sufficient to immediately trigger significant changes in clinical parameters. Second, the improvement of clinical and laboratory parameters often requires long-term treatment and observation, and the timespan of this study may not be enough to reflect long-term effects. Finally, the effect of random errors on the results could not be excluded. The PDCA cycle is essentially committed to identifying, solving, and preventing systemic problems, rather than directly altering clinical intervention strategies or patients' physiological responses, so its benefits may be more obvious in terms of organization, team performance, and patient-centered nursing. Although no significant difference was found in clinical and laboratory parameters, this finding does not diminish the value of the PDCA cycle in improving patients' nursing experience and mental health. In fact, the implementation of this method may provide a low-cost, high-efficiency manner for medical institutions to improve patient satisfaction and nursing quality. Medical institutions should gradually establish a patient-centered and effective nursing mode via continuous monitoring, evaluation, improvement, and standardization. Subsequent studies should consider further expanding the sample size, increasing the observation time, and deeply discussing the effect of PDCA cycle on clinical and laboratory parameters. In addition, more evaluation indicators could be introduced, such as the QoL of patients and the utilization of medical resources, to more comprehensively evaluate the effect of the PDCA cycle in improving the quality of medical services.

Role of a Structured Quality Control Approach

The core principle of the PDCA cycle lies in its iterative and continuous improvement process. By regularly assessing and refining care protocols, the PDCA method ensures ongoing enhancement of surgical care quality. The establishment of a quality control team to address specific operating room challenges and the subsequent implementation of tailored strategies likely played a pivotal role in the overall improved patient outcomes observed in this study.

Random quality checks conducted by the head nurse and the hospital's quality control office ensured that high standards were maintained consistently. These practices, while primarily focused on care process optimization, indirectly contributed to a safer and more efficient operating room environment, which is crucial for patient safety and recovery.

Limitations and Future Directions

While this study provides valuable insights into the benefits of the PDCA cycle, several limitations must be acknowledged. First, this retrospective study could not rule out all confounding factors, such as hospital background and patients' diversity, that may have affected the results. Future research could further control these potential confounding factors through prospective design to more accurately evaluate the application effect of the PDCA cycle nursing in the operating room. Second, this study focused on one hospital, and although this hospital is representative, it may not fully reflect the actual situation of all hospitals adopting PDCA cycle nursing in operating room, so future studies could expand the sample to cover more hospitals and regions to obtain broader and more in-depth data. Third, this study focused on certain aspects of nursing management in the operating room, such as staff training and quality control, but as a complex and multidimensional process, nursing management in the operating room involved numerous aspects such as equipment maintenance, medication management, and patient communication. Therefore, the study scope could be further expanded to comprehensively assess the effectiveness of the PDCA cycle in all aspects. Finally, with the continuous development of medical technology and nursing management in the operating room, the application of the PDCA cycle needs to constantly adapt to new needs and challenges. Future research could further explore how to combine the PDCA cycle with new technologies and new concepts and delve into the long-term effect of the PDCA cycle on patients to promote the continuous improvement and innovation of nursing management in the operating room.

Conclusion

The implementation of the PDCA circulation method in surgical care interventions for patients undergoing cardiothoracic surgery demonstrated significant improvements in psychological well-being, QoL, and patient satisfaction. While no significant differences were observed in clinical and laboratory parameters, the structured and systematic approach of the PDCA cycle likely contributed to a safer and more efficient care process. These findings underscore

the importance of continuous quality improvement strategies in enhancing patient-centered care and highlight the potential of the PDCA method to improve overall surgical care experiences.

Availability of Data and Materials

The datasets used and/or analysed during the current study were available from the corresponding author on reasonable request.

Author Contributions

YW and LW—designed the research study; YW—performed the research; LW— analyzed the data. Both authors contributed to editorial changes in the manuscript. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study has been approved by the ethics committee of Ningbo No.2 Hospital, approval No. 2024-048-01. This study has obtained the informed consent of patients.

Acknowledgment

Not applicable.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

References

[1] Ortega G, Allar BG, Kaur MN, Edelen MO, Witt EE, Fayanju OM, *et al*. Prioritizing Health Equity in Patient-reported Outcome Measurement to Improve Surgical Care. Annals of Surgery. 2022; 275: 488–491.

[2] Marshall SD, Touzell A. Human factors and the safety of surgical and anaesthetic care. Anaesthesia. 2020; 75 Suppl 1: e34–e38.

[3] Chen J, Cai W, Lin F, Chen X, Chen R, Ruan Z. Application of the PDCA Cycle for Managing Hyperglycemia in Critically Ill Patients. Diabetes Therapy: Research, Treatment and Education of Diabetes and Related Disorders. 2022; 1–9.

[4] Liu C, Liu Y, Tian Y, Zhang K, Hao G, Shen L, *et al*. Application of the PDCA cycle for standardized nursing management in sepsis bundles. BMC Anesthesiology. 2022; 22: 39.

[5] Brown RA. Quality Management in Respiratory Care: PDCA ≠ PDSA. Respiratory Care. 2022; 67: 778–779.

[6] He YH, Wang F. PDCA nursing in improving quality management efficacy in endoscopic submucosal dissection. World Journal of Clinical Cases. 2022; 10: 9611–9618.

[7] Wei W, Wang S, Wang H, Quan H. The application of 6S and PDCA management strategies in the nursing of COVID-19 patients. Critical Care (London, England). 2020; 24: 443.

[8] Chen H, Wang P, Ji Q. Analysis of the Application Effect of PDCA Cycle Management Combined With Risk Factor Management Nursing for Reducing Infection Rate in Operating Room. Frontiers in Surgery. 2022; 9: 837014.

[9] Chen Y, Zheng J, Wu D, Zhang Y, Lin Y. Application of the PDCA cycle for standardized nursing management in a COVID-19 intensive care unit. Annals of Palliative Medicine. 2020; 9: 1198–1205.

[10] He LJ, Ma L, Li TT. PDCA cycle management combined with detailed management of postoperative deep vein thrombosis in patients undergoing hip replacement surgery. European Review for Medical and Pharmacological Sciences. 2023; 27: 11535–11542.

[11] Dimeling G, Bakaeen L, Khatri J, Bakaeen FG. CABG: When, why, and how? Cleveland Clinic Journal of Medicine. 2021; 88: 295–303.

[12] Tugaoen Z, Nguyen P, Arora S, Vavalle J. The selection of transcatheter heart valves in transcatheter aortic valve replacement. Trends in Cardiovascular Medicine. 2022; 32: 513–522.

[13] Baran DA. Heart Transplant: Challenge Accepted. Journal of the American College of Cardiology. 2023; 81: 2358–2360.

[14] Pronovost P, Needham D, Berenholtz S, Sinopoli D, Chu H, Cosgrove S, *et al*. An intervention to decrease catheter-related bloodstream infections in the ICU. The New England Journal of Medicine. 2006; 355: 2725–2732.

[15] Li Y, Wang H, Jiao J. The application of strong matrix management and PDCA cycle in the management of severe COVID-19 patients. Critical Care (London, England). 2020; 24: 157.

[16] World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. JAMA. 2013; 310: 2191–2194.

[17] Naunheim MR, Dai JB, Rubinstein BJ, Goldberg L, Weinberg A, Courey MS. A visual analog scale for patient-reported voice outcomes: The VAS voice. Laryngoscope Investigative Otolaryngology. 2019; 5: 90–95.

[18] Wang XM, Ma HY, Zhong J, Huang XJ, Yang CJ, Sheng DF, *et al*. A Chinese adaptation of six items, self-report Hamilton Depression Scale: Factor structure and psychometric properties. Asian Journal of Psychiatry. 2022; 73: 103104.

[19] Jassim G, AlAnsari A. Reliability and Validity of the Arabic Version of the EORTC QLQ-C30 and QLQ-BR23 Questionnaires. Neuropsychiatric Disease and Treatment. 2020; 16: 3045–3052.

[20] Sun J, Cao W, Song Y, Yuan C. Plan, Do, Check, Act (PDCA) Cycle Nursing Model Reduces the Risk of Hemangioma in Hemodialysis Patients. Iranian Journal of Public Health. 2021; 50: 2560–2566.

[21] Zeng X, Huang X, Wang P, Liao J, Wu L, Liu J, *et al*. The application of the PDCA cycle in the nutritional management of patients with nasopharyngeal carcinoma. Supportive Care in Cancer: Official Journal of the Multinational Association of Supportive Care in Cancer. 2023; 31: 251.

[22] Chen H, Tao Z, Zhou C, Zhao S, Xing Y, Lu M. The Effect of Comprehensive Use of PDCA and FMEA Management Tools on the Work Efficiency, Teamwork, and Self-Identity of Medical Staff: A Cohort Study with Zhongda Hospital in China as an Example. Contrast Media & Molecular Imaging. 2022; 2022: 5286062.

[23] Xu Y, Shi C, Liu Y. Application effect of PDCA circulation on nursing quality management and risk control in digestive endoscopy room. Medicine. 2023; 102: e35885.
[24] Zhou J, Xu H, Jiang M, Cao H, Jiang L, Xu T, *et al*. Effect of PDCA-based nursing management model on the quality of life and complications of patients with acute leukemia undergoing chemotherapy. American Journal of Translational Research. 2021; 13: 3246–3253.
[25] Zhao M, Li H, Wang J, Chu L, Huang L, Li H. The effectiveness of motivation-guided PDCA cycle nursing for self-management ability and outcomes of patients with gestational diabetes mellitus. Nursing Open. 2023; 10: 6509–6516.
[26] Bai L, Yang L, Shi X, Huang W. Effect of PDCA circulation nursing intervention on prognosis of patients with severe pneumonia. American Journal of Translational Research. 2022; 14: 252–263.