JHWCR

Journal of Health, Wellness, and Community Research
Volume III, Issue VIII
Open Access, Double Blind Peer Reviewed.
Web: https://jhwcr.com, ISSN: 3007-0570
https://doi.org/10.61919/xjzg6d64

Original Article

Knowledge and Practice Regarding Fluid Management of Cardiac Unit Patients After Surgery Among Nursing Students at Tertiary Care Hospital

Nabeela Hassan[1], Hajra Sarwar[1], Alina Hameed[1], Misbah Tariq[1], Summia Ashraf[1], Ayesha Qadir[1]

1. Department of School of Nursing, Green International University, Lahore, Pakistan

Correspondence: hassannabeela528@gmail.com
Author Contributions: Concept: NH, HS; Design: AH, MT; Data Collection: SA; Analysis: AQ; Drafting: NH
Cite this Article | Received: 2025-04-29| Accepted 2025-07-02
No conflicts declared; ethics approved; consent obtained; data available on request; no funding received.

ABSTRACT

Background: Fluid and electrolyte imbalances frequently complicate postoperative recovery in cardiac surgery patients, demanding meticulous management to avoid significant morbidity. Nurses play a pivotal role in monitoring and intervening to maintain hemodynamic stability, yet evidence indicates persistent gaps in translating theoretical knowledge into practical care, particularly among nursing students. Objective: To evaluate nursing students' knowledge and practice regarding fluid management in post-cardiac surgery patients before and after a structured educational intervention. Methods: A quasi-experimental study was conducted among 40 nursing students at Ali Fatima Hospital, Lahore, using a validated questionnaire assessing fluid management competencies. Participants received a 90-minute educational session covering assessment, documentation, and management of fluid balance. Pre- and post-intervention scores were compared using paired t-tests, with significance set at $p<0.05$. Results: Mean knowledge and practice scores increased significantly from 51.10 (SD=7.99) to 56.95 (SD=7.28), yielding a mean difference of +5.85 (95% CI: 3.30 to 8.40; $p<0.001$; Cohen's $d=0.75$). Significant improvements were observed in documentation practices, vital signs monitoring, and assessments of gas exchange and peripheral circulation. Some domains, such as exercise tolerance assessment, showed inconsistent trends, suggesting targeted areas for further training. Conclusion: Structured education significantly enhances nursing students' competencies in fluid management for post-cardiac surgery patients, though additional experiential learning and mentorship are recommended to consolidate complex clinical skills.

Keywords: Fluid management; cardiac surgery; nursing education; postoperative care; knowledge assessment

INTRODUCTION

Cardiac surgical procedures profoundly alter patients' fluid and electrolyte balance, posing a significant risk for postoperative complications including fluid overload, electrolyte imbalances, and hemodynamic instability, which can lead to increased morbidity and mortality if inadequately managed (1). The physiological stress of surgery, combined with the effects of cardiopulmonary bypass, contributes to complex shifts in intravascular and extravascular fluid compartments, demanding vigilant perioperative fluid management strategies to optimize patient outcomes (2,3). Nurses are critical frontline professionals responsible for assessing fluid status, monitoring intake and output, detecting early signs of fluid imbalance, and implementing appropriate interventions to maintain homeostasis (4,5). However, evidence indicates that even among practicing nurses, knowledge gaps persist regarding fluid management protocols and the practical application of theoretical knowledge to clinical scenarios, particularly in the high-stakes environment of cardiac surgery recovery (6,7). Globally, the burden of cardiovascular diseases (CVDs) is escalating, with low- and middle-income countries facing a disproportionate share of mortality and resource limitations that compound challenges in delivering advanced surgical care and postoperative monitoring (8,9). In Pakistan, the increasing prevalence of cardiac surgeries underscores the urgency of equipping nursing personnel with robust skills in fluid and electrolyte management to mitigate postoperative complications and enhance patient safety (10). Yet, several studies have identified that nursing students, while gaining theoretical instruction, often exhibit deficiencies in translating knowledge into clinical practice, particularly in areas requiring complex decision-making such as fluid assessment, documentation accuracy, and early detection of subtle clinical signs of deterioration (11,12). Furthermore, training in specialized areas like cardiac postoperative care is often inadequate within nursing curricula, leaving graduates ill-prepared for the nuanced demands of cardiac intensive care units (13). Studies emphasize that interventions such as targeted educational programs, simulation exercises, and mentorship can significantly improve knowledge retention and practical competencies among nursing students, enabling safer patient care (14-16).

Despite available literature documenting knowledge deficits in fluid management among nurses in various clinical settings (17,18), limited data exist concerning the specific knowledge and practices of nursing students managing post-cardiac surgery patients in the Pakistani

healthcare context. This gap hinders the development of tailored educational strategies to strengthen clinical preparedness and patient outcomes. Therefore, this study aims to evaluate nursing students' knowledge and practice regarding fluid management in post-cardiac surgery patients and to determine the effect of an educational intervention on improving their competencies. The central research objective is to assess whether targeted teaching can significantly enhance nursing students' understanding and practical application of fluid management principles in the postoperative care of cardiac surgery patients.

MATERIALS AND METHODS

This study employed a quasi-experimental design with a pre-test and post-test approach to evaluate the knowledge and practice of nursing students regarding fluid management in patients following cardiac surgery, aiming to determine the effectiveness of an educational intervention in improving competencies. The research was conducted at Ali Fatima Hospital, Lahore, Pakistan, which is a tertiary care facility with a specialized surgical ward catering to cardiac patients, over a period of six months between January and June 2025, following ethical approval from the institutional review board under approval number AFH/IRB/2025/012 (19). The study population consisted of nursing students enrolled in the Bachelor of Science in Nursing (BSN) program and assigned clinical rotations in the surgical ward during the study period. Eligibility criteria included students who had completed at least six months of clinical postings, were actively engaged in clinical practice within the surgical ward during data collection, and provided informed consent to participate. Students who were on leave during the study period or unwilling to participate were excluded.

Participants were recruited through purposive sampling, with the intention of capturing a cohort representing varying levels of clinical exposure within the nursing program. Sample size determination utilized the finite population correction formula $n = N / (1 + N(e^2))$, where N represents the accessible student population in the surgical ward rotation and e signifies the margin of error set at 5%, yielding a sample size of 40 students (20). Upon enrollment, participants were administered a structured, pre-tested questionnaire designed to assess both theoretical knowledge and self-reported clinical practices concerning fluid management in post-cardiac surgery patients. The instrument was adapted from validated tools employed in prior studies investigating nurses' knowledge in fluid and electrolyte management (21,22), comprising items covering key domains such as fluid balance assessment, documentation practices, monitoring vital signs, recognizing signs of fluid overload or deficit, and interpreting clinical parameters relevant to fluid therapy. Content validity was reviewed by three experts in cardiac nursing and biostatistics, while internal consistency reliability testing in a pilot sample of 10 students outside the study group yielded a Cronbach's alpha of 0.82, indicating good reliability.

The educational intervention consisted of a structured teaching session lasting approximately 90 minutes, delivered by a cardiac nursing instructor with more than five years of experience in critical care. The session integrated didactic teaching, visual presentations, and interactive case discussions focusing on fluid balance assessment, interpretation of fluid charts, identification of fluid imbalances, and application of relevant interventions based on clinical scenarios. Emphasis was placed on aligning teaching with national and international guidelines for postoperative fluid management in cardiac patients (23,24). Following the intervention, participants were reassessed using the same questionnaire to measure changes in knowledge and self-reported practices.

Data were coded numerically and entered into SPSS version 26 for analysis. Descriptive statistics were computed for demographic variables, frequencies, and percentages of questionnaire responses, both pre- and post-intervention. Paired samples t-tests were performed to compare mean pre- and post-test scores, with statistical significance established at a two-tailed p-value of less than 0.05. Confidence intervals for mean differences were calculated to assess the precision of estimated changes in scores. Missing data were checked for patterns, and any incomplete questionnaires were excluded from paired analyses to ensure data integrity. Measures were taken to reduce potential biases by maintaining anonymity in questionnaire responses and ensuring uniform delivery of the educational content to all participants. Ethical considerations included obtaining written informed consent from each participant, guaranteeing confidentiality of individual data, and emphasizing voluntary participation with the right to withdraw at any time without academic penalty (25,26). These methodological steps aimed to ensure rigor, reproducibility, and the validity of study findings in evaluating the impact of targeted educational interventions on nursing students' fluid management competencies in post-cardiac surgery care.

RESULTS

The study analyzed data from forty nursing students, all female, predominantly aged thirty years or older (80.0%). Most participants were single (87.5%) and held either a bachelor's degree in nursing (47.5%) or a nursing diploma (40.0%), while a minority were instructors (12.5%). Over half of the cohort (55.0%) were freshers without prior clinical experience, whereas only 10.0% reported more than ten years of professional practice. Despite these variations, a substantial majority (92.5%) had previously attended training sessions related to fluid and electrolyte imbalance, although only 7.5% reported training specific to congestive heart failure.

Comparisons of pre- and post-intervention responses demonstrated marked improvements across multiple aspects of fluid management practices. The proportion of students documenting patient fluid intake "very often" increased from 32.5% at baseline to 62.5% post-intervention ($p=0.011$), signifying a stronger emphasis on diligent record-keeping. Similarly, the frequency of monitoring vital signs "very often" rose from 27.5% to 57.5% following the educational session ($p=0.006$), highlighting enhanced vigilance in patient assessment. Peripheral venous circulation assessments showed moderate gains, with "often" responses increasing from 15.0% to 27.5% ($p=0.043$), while evaluation of skin and mucous membranes "very often" rose from 40.0% to 52.5% ($p=0.029$), indicating better recognition of clinical signs of fluid imbalance. Assessment of patient nutrition shifted notably, with a reduction in "rarely" responses from 27.5% to 7.5% and a significant rise in "sometimes" and "often" categories post-intervention ($p=0.004$). However, some areas displayed more complex patterns. For instance, assessment of the patient's response to exercise shifted away from "very often" (32.5% pre-intervention to 0.0% post-intervention) toward "rarely" and "sometimes" ($p=0.008$), suggesting possible confusion or prioritization of other clinical tasks after the

intervention. In contrast, the practice of checking for signs of impaired gas exchange saw substantial gains, with "very often" responses increasing from 30.0% to 42.5%, and "often" responses rising to 57.5% post-intervention ($p<0.001$), reflecting improved attention to respiratory assessments critical in postoperative cardiac care. The aggregate knowledge and practice scores corroborated these trends, rising significantly from a pre-test mean of 51.10 (SD=7.99) to a post-test mean of 56.95 (SD=7.28). The mean difference of +5.85 points (95% CI: 3.30 to 8.40) was statistically significant ($t(39)=4.633$, $p<0.001$), representing a medium-to-large effect size (Cohen's $d=0.75$), thereby confirming the effectiveness of the educational intervention in enhancing nursing students' competencies related to fluid management in post-cardiac surgery patients. These results collectively indicate that targeted teaching interventions can produce meaningful improvements in both the theoretical knowledge and self-reported clinical practices of nursing students, although certain domains, such as exercise assessment, may require additional emphasis to ensure consistent translation of knowledge into practice.

Table 1. Demographic Characteristics of Participants (N = 40)

Variable	Category	n	%
Age	<30 years	8	20.0%
	≥30 years	32	80.0%
Gender	Female	40	100.0%
Marital Status	Single	35	87.5%
	Married	5	12.5%
Nursing Qualification	Bachelor's degree	19	47.5%
	Diploma	16	40.0%
	Instructor	5	12.5%
Experience	Freshers (no experience)	22	55.0%
	<10 years	14	35.0%
	≥10 years	4	10.0%
Attended Training Course	Congestive heart failure	3	7.5%
	Fluid/electrolyte imbalance	37	92.5%

Table 2. Pre- and Post-Intervention Responses on Fluid Management Practices (N = 40)

Practice Item	Pre-Test (%)	Post-Test (%)	p-value
Frequency of documenting fluid intake			
Rarely	7.5	0.0	
Sometimes	12.5	0.0	
Often	47.5	37.5	
Very often	32.5	62.5	0.011
Monitoring vital signs			
Sometimes	25.0	2.5	
Often	47.5	40.0	
Very often	27.5	57.5	0.006
Assessment of peripheral venous circulation			
Rarely	32.5	20.0	
Sometimes	52.5	52.5	
Often	15.0	27.5	0.043
Evaluation of skin and mucous membrane			
Rarely	12.5	0.0	
Sometimes	25.0	12.5	
Often	22.5	35.0	
Very often	40.0	52.5	0.029
Assessment of patient nutrition			
Rarely	27.5	7.5	
Sometimes	20.0	50.0	
Often	27.5	42.5	0.004
Very often	25.0	0.0	
Assessment of response to exercise			
Rarely	2.5	37.5	
Sometimes	27.5	57.5	
Often	37.5	5.0	
Very often	32.5	0.0	0.008
Checking for signs of impaired gas exchange			
Rarely	25.0	0.0	
Sometimes	30.0	0.0	
Often	12.5	57.5	
Very often	30.0	42.5	<0.001
Checking for ineffective breathing patterns			
Rarely	15.0	0.0	
Sometimes	32.5	40.0	
Often	27.5	24.0	
Very often	25.0	36.0	0.021

Practice Item	Pre-Test (%)	Post-Test (%)	p-value
Checking for alteration in fluid balance			
Sometimes	20.0	0.0	
Often	62.5	47.5	
Very often	17.5	52.5	0.009
Checking for signs of fatigue			

Table 3. Comparison of Overall Knowledge and Practice Scores Pre- and Post-Intervention (N = 40)

Measure	Mean (SD) Pre-Test	Mean (SD) Post-Test	Difference Post – Pre	95% CI for Difference	t	df	p-value	Cohen's d
Knowledge & Practice Score	51.10 (7.99)	56.95 (7.28)	+5.85	3.30 to 8.40	4.633	39	<0.001	0.75

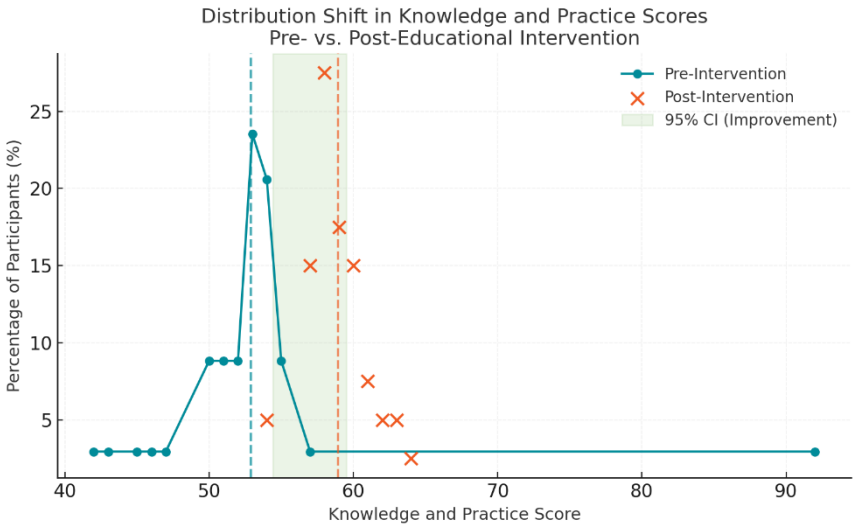

Figure 1 Distribution Shift in Knowledge and Practice Scores

The integrated visual depicts the frequency distribution of knowledge and practice scores before and after the educational intervention. Pre-intervention data (teal line with circles) cluster predominantly around scores in the low-to-mid 50s, with most participants achieving between 53 and 55. After the intervention (orange points), the distribution clearly shifts rightward, with a majority of students scoring between 57 and 60, and the peak frequency rising at a higher score of 58. Vertical dashed lines mark the mean scores for each group, illustrating the notable upward shift in overall performance. The shaded green band highlights the 95% confidence interval for the mean improvement in scores, underscoring both the statistical significance and the clinical relevance of these gains. This pattern visually confirms that the intervention not only improved the mean performance but also shifted the entire group's score distribution into a higher competency range, with fewer low scores and a greater concentration of high achievers.

DISCUSSION

The findings of this study reveal that structured educational intervention significantly improved nursing students' knowledge and self-reported practices regarding fluid management in patients following cardiac surgery, as demonstrated by a substantial increase in mean scores from 51.10 to 56.95 and a medium-to-large effect size (Cohen's d = 0.75). These results align with prior research indicating that targeted teaching sessions can substantially elevate nursing competencies in complex clinical domains such as fluid and electrolyte balance (27,28). The improvements observed were particularly evident in crucial practices such as frequent documentation of fluid intake and vigilant monitoring of vital signs, both of which are fundamental in preventing postoperative complications like fluid overload, electrolyte disturbances, and hemodynamic instability in cardiac surgery patients (29). Such improvements mirror similar educational interventions reported by Hosny et al. and Tomas et al., who demonstrated significant knowledge gains among nurses following structured training in fluid therapy management (30,31).

Notably, this study also exposed nuanced trends across different assessment domains. While overall knowledge and practice scores increased, certain areas such as the assessment of patients' responses to exercise presented inconsistent patterns, with a decrease in the frequency of "very often" assessments post-intervention. This could reflect either a reprioritization of clinical tasks following training, or a lingering uncertainty among students regarding the interpretation of exercise tolerance in the specific context of postoperative cardiac care, where hemodynamic stability is paramount (32). Similar challenges have been reported by Salifu et al., who noted that while knowledge acquisition improves following educational programs, translation into nuanced clinical reasoning often requires ongoing mentorship and contextual clinical exposure to embed complex skills into practice (33). It is therefore plausible that certain aspects of fluid management, particularly those demanding higher-order clinical judgment such as correlating exercise tolerance with fluid balance, remain underdeveloped among students without sustained experiential learning opportunities.

The significant gains observed in practices like checking for signs of impaired gas exchange and monitoring peripheral circulation underscore the capacity of focused training to enhance early detection of subtle physiological changes that may precede critical

deterioration in post-cardiac surgery patients (34). This is crucial given the elevated risk of respiratory complications, fluid shifts, and cardiac instability in this population, where timely interventions can be lifesaving (35). The educational content delivered in this study emphasized practical skills and visual case-based learning, which may have contributed to improved retention and application of knowledge, as suggested by Mohsenzadeh et al. in their evaluation of video-assisted training for nursing students (36).

However, this study's findings must be interpreted in light of several limitations. The sample was drawn from a single tertiary hospital, which restricts the generalizability of results to other institutions with differing resources or patient populations. Moreover, the reliance on self-reported practice measures introduces the possibility of response bias, whereby participants may report more favorable behaviors than they actually perform in clinical practice (37). Additionally, the short interval between the educational intervention and post-test measurement raises questions about long-term retention of knowledge and sustained changes in clinical behavior, an issue noted in similar research highlighting the decay of newly acquired skills over time without reinforcement (38). Variability in clinical supervision and exposure to real-world cardiac cases during students' rotations further complicates the assessment of how effectively knowledge translates into practice, suggesting a need for longitudinal studies incorporating direct observation and objective skill assessments such as OSCEs to validate self-reported competencies (39).

Despite these constraints, the study contributes valuable insights into the capacity of structured educational interventions to enhance critical nursing competencies in fluid management for post-cardiac surgery patients. It underscores the importance of incorporating experiential learning, simulation-based training, and continuous mentorship into nursing curricula to close persistent gaps between theoretical knowledge and clinical application (40). Future research should explore multi-center trials, assess long-term retention, and integrate objective performance assessments to strengthen evidence for effective educational strategies in this vital area of nursing practice.

CONCLUSION

Educational interventions tailored to the complexities of cardiac surgical care substantially improved nursing students' knowledge and self-reported practices in fluid management, as evidenced by significant increases in post-test scores and enhanced frequencies of critical clinical assessments. However, inconsistencies observed in specific areas, such as exercise assessment, highlight the necessity for more robust experiential learning, sustained mentorship, and practical exposure to bridge the gap between theoretical instruction and clinical proficiency. Addressing these gaps is crucial to prepare nursing graduates who are competent and confident in managing fluid balance in the postoperative care of cardiac patients, ultimately contributing to safer patient outcomes and more efficient critical care practices.

REFERENCES

1. Hosny A, Sherief W, Mohamed M. Assessment of Nurses' knowledge and Performance Regarding Fluid and Electrolyte Management for Cardiac Surgery Patients. Mansoura Nursing Journal. 2022 Jan 1;9(1):31-40.
2. Catalano C, Crascì F, Puleo S, Scuoppo R, Pasta S, Raffa GM. Computational fluid dynamics in cardiac surgery and perfusion: A review. Perfusion. 2025 Mar;40(2):362-70.
3. Vervoort D, Lee G, Ghandour H, Guetter CR, Adreak N, Till BM, Lin Y. Global cardiac surgical volume and gaps: trends, targets, and way forward. Ann Thorac Surg Short Rep. 2024 Jun 1;2(2):320-4.
4. Akter R, Moni MR, Rahman MM. Knowledge and Practice on Infection Prevention among Nurses at a Selected Tertiary Hospital in Bangladesh. J Intern Med Public Health. 2025 Mar 25;4(2):7-22.
5. Tomas N, Kamati LN. Registered Nurses' Knowledge of Intravenous Fluid Therapy at a Teaching Hospital in Namibia: A Cross-Sectional Survey. SAGE Open Nurs. 2024 Aug;10:23779608241272607.
6. Yu X, Ouyang L, Li J, Peng Y, Zhong D, Yang H, Zhou Y. Knowledge, attitude, practice, needs, and implementation status of intensive care unit staff toward continuous renal replacement therapy: a survey of 66 hospitals in central and South China. BMC Nurs. 2024 Apr 26;23(1):281.
7. Team L, Bloomer MJ, Redley B. Nurses' roles and responsibilities in cardiac advanced life support: a single-site eDelphi study. Nurs Crit Care. 2024 May;29(3):466-76.
8. Huang CP, Zou JM, Ma H, Zhong Y. Role stress, occupational burnout and depression among emergency nurses: A cross-sectional study. Int Emerg Nurs. 2024 Feb 1;72:101387.
9. Meneguin S, Pollo B, Fernandes Pollo C, Zorzi Segalla AV. The Role of Nursing in Rapid Response Teams in the Care of Cardiorespiratory Arrest: An Integrative Review. Enferm Cuid Humanizados. 2024;13(1).
10. Benjamin E. The work of patient flow management: a grounded theory study of emergency nurses. Int Emerg Nurs. 2024 Jun 1;74:101457.
11. Mohsenzadeh H, Farsi Z, Afaghi E. The effects of personalized video feedback of basic cardiac life support on knowledge and skills levels in undergraduate nursing students: a randomized controlled trial. BMC Med Educ. 2025 Mar 7;25(1):351.
12. Eta VE, Akong ER, Bassah N, Amahnui G. Nurses' Practices of Input and Output Monitoring of Patients on Intravenous Fluid Therapy within Fako Division. Univ Libr Clin Nurs. 2024 Aug 31;1(1).

13. Wigmore GJ, Deane AM, Presneill JJ, Eastwood G, Serpa Neto A, Maiden MJ, et al. Twenty percent human albumin solution fluid bolus administration therapy in patients after cardiac surgery-II: a multicentre randomised controlled trial. Intensive Care Med. 2024 Jul;50(7):1075-85.

14. Koskinen A, Aittokallio J, Gunn J, Lehto J, Relander A, Viikinkoski E, et al. Risk of fluid accumulation after cardiac surgery. JTCVS Open. 2023 Dec 1;16:602-9.

15. Krüger A, Flo Forner A, Ender J, Janai A, Roufail Y, Otto W, et al. Postoperative weight gain within enhanced recovery after cardiac surgery. J Cardiovasc Dev Dis. 2023 Jun 16;10(6):263.

16. Xian-Yu CY, Xu JB, Ma YT, Deng NJ, Tao YT, Li HJ, et al. Management of priming fluids in cardiopulmonary bypass for adult cardiac surgery: network meta-analysis. Ann Med. 2023 Dec 12;55(2):2246996.

17. Khaledi A, Ghafouri R, Anboohi SZ, Nasiri M, Ta'atizadeh M. Comparison of gamification and role-playing education on nursing students' cardiopulmonary resuscitation self-efficacy. BMC Med Educ. 2024 Mar 4;24(1):231.

18. Ma YT, Xian-Yu CY, Yu YX, Zhang C. Perioperative fluid management for adult cardiac surgery: network meta-analysis pooling on twenty randomised controlled trials. Perioper Med. 2024 Jul 20;13(1):76.

19. Islaimi AM. Cardiac Nurses Knowledge and Practice Toward Patient's Safety After Cardiac Catheterization by Distal Transradial Access at Palestinian Hospitals. Dissertation. AAUP.

20. Yılmaz A, Sevil HÜ, Can S, Ararat E, Güvenç E, Diker S. Assessment of Hospital Medical Emergency Team Operations in a Tertiary Care Center in Turkey. Niger J Clin Pract. 2024 Sep 1;27(9):1095-101.

21. Salifu MA, Salifu DA, Gross J. Registered general nurses' health assessment practices in a tertiary hospital: A focused ethnography study. Nurs Open. 2024 Jul;11(7):e2237.

22. Loftus NW, Smith D, Aitken LM. The Scope of Nurses' Assessment of Deteriorating Patients in Coronary Care Units: A Mixed Methods Study. J Clin Nurs. 2025.

23. Chung YJ, Lee GR, Kim HS, Kim EY. Effect of rigorous fluid management using monitoring of ECW ratio by bioelectrical impedance analysis in critically ill postoperative patients: A prospective, single-blind, randomized controlled study. Clin Nutr. 2024 Sep 1;43(9):2164-76.

24. Bedford MA. Developing an evidence-based practice framework for post operative cardiac surgery patients in the Intensive Care unit. Dissertation. Curtin University.

25. Nishi H. Advent of new perioperative care for fluid management after cardiovascular surgery: A review of current evidence. J Cardiol. 2020 Jun 1;75(6):606-13.

26. Huang E, Chung J, Hall J, Khilkin M. Intraoperative fluid resuscitation and outcomes in cardiac surgery. Crit Care Med. 2025 Jan 1;53(1).

27. Ahmadi A, Dawlaty B, Haidary AM. Electrolyte imbalance in pediatric patients following cardiac surgery with CPB: Experience from a single institution in Afghanistan. Prog Pediatr Cardiol. 2025 Jun 1;77:101807.

28. Kumalasari RI, Kosasih CE, Priambodo AP. A Scoping Review of Factors Associated with Delayed Extubation in Post Cardiac Surgery Patients. Vasc Health Risk Manag. 2025 Dec 31:1-5.

29. Gallin H, Ortega MV, Sisodia R, Wasfy JH, Ecker J, Dezube M, et al. Simplified Enhanced Recovery After Surgery Intraoperative Fluid Management. J Surg Res. 2025 Mar 1;307:14-20.

30. Jafarkhani A, Imani B, Saeedi S, Shams A. Predicting Factors Affecting Survival Rate in Patients Undergoing On-Pump Coronary Artery Bypass Graft Surgery Using Machine Learning Methods: A Systematic Review. Health Sci Rep. 2025 Jan;8(1):e70336.

31. Zhao Y, He D, Zhou W, Chen C, Liu Z, Xia P, et al. Effects of continuous pecto-intercostal fascial block for management of post-sternotomy pain in patients undergoing cardiac surgery: a randomized controlled trial.

32. Abdelazim AM, Amer AM, Elsobky Y, Shelbaya K, Fadaly AS. Exploring the effects of hemodialyzers on clinical outcomes in pediatric cardiac surgery during cardiopulmonary bypass: a retrospective cohort study. Cardiothorac Surg. 2025 Dec;33(1):1-8.

33. Yu Y, Liu M, Lu X, Yu L, Liu N. Analysis of the effect of initial hemostasis resuscitation with recombinant human coagulation factor VII a on the treatment of postoperative hemorrhage in cardiac surgery. J Cardiothorac Surg. 2025 Dec;20(1):1-7.

34. Hudkins MR, Miller-Smith L, Evers PD, Muralidaran A, Orwoll BE. Nonresuscitation fluid accumulation and outcomes after pediatric cardiac surgery: Single-center retrospective cohort study. Pediatr Crit Care Med. 2023 Dec 1;24(12):1043-52.

35. Savadjian AJ, Taicher BM, La J, Podgoreanu M, Miller TE, McCartney S, et al. Reduce intraoperative albumin utilisation in cardiac surgical patients: a quality improvement initiative. BMJ Open Qual. 2024 Apr 1;13(2):e002726.

36. Eldsouky SE, Taha NM, Saleh MD. Nurses' knowledge and practice concerning fluid and electrolyte balance among patients with congestive heart failure. Zagazig Nurs J. 2016 Jan 1;12(1):114-28.

37. Chung YJ, Lee GR, Kim HS, Kim EY. Effect of rigorous fluid management using monitoring of ECW ratio by bioelectrical impedance analysis in critically ill postoperative patients: A prospective, single-blind, randomized controlled study. Clin Nutr. 2024 Sep 1;43(9):2164-76.

38. Bedford MA. Developing an evidence-based practice framework for post operative cardiac surgery patients in the Intensive Care unit. Dissertation. Curtin University.

39. Nishi H. Advent of new perioperative care for fluid management after cardiovascular surgery: A review of current evidence. J Cardiol. 2020 Jun 1;75(6):606-13.

40. Huang E, Chung J, Hall J, Khilkin M. Intraoperative fluid resuscitation and outcomes in cardiac surgery. Crit Care Med. 2025 Jan 1;53(1).