

# Complications in immediate postoperative recovery from elective cardiac surgery: a cross-sectional study based on Roy's theory

Complicações do pós-operatório imediato de cirurgia cardíaca eletiva: estudo transversal à luz de Roy

Complicaciones del período posoperatorio inmediato de la cirugía cardíaca electiva: un estudio transversal según Roy

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## Abstract

**Background:** Postoperative complications can be understood as an ineffective response of the Roy adaptation model to the coping process generated by elective cardiac surgery.

**Objectives:** To identify the complications in the immediate postoperative period of adults and elderly patients submitted to elective cardiac surgery with extracorporeal circulation; To categorize immediate postoperative complications as ineffective responses of the physiological mode of the human adaptive system.

**Methodology:** Retrospective, cross-sectional, exploratory, and descriptive observational study. The immediate postoperative records of 230 patients who underwent surgery with extracorporeal circulation performed between January and December 2013, 2014, and 2015 were analyzed.

**Results:** In the immediate postoperative period, 423 complications were identified, mostly related to fluid, electrolyte, and acid-base balance and endocrinal function.

**Conclusion:** The reading of postoperative complications as ineffective adaptive responses extends the need for evaluation and intervention of the nursing team during the postoperative period, ensuring unique disciplinary management.

**Keywords:** thoracic surgery; cardiovascular surgical procedures; postoperative complications; nursing theory; nursing

## Resumo

**Enquadramento:** Complicações verificadas no pós-operatório podem ser compreendidas como respostas ineficazes do modelo de adaptação de Roy frente à estratégia de coping gerada pela cirurgia cardíaca eletiva.

**Objetivos:** Identificar as complicações do pós-operatório imediato de adultos e idosos submetidos a cirurgias cardíacas eletivas com uso de circulação extracorpórea; Categorizar as complicações do pós-operatório imediato identificadas como respostas ineficazes do modo fisiológico do sistema adaptativo humano.

**Metodologia:** Estudo do tipo observacional retrospectivo, transversal, de objetivo exploratório e descritivo. Foram analisados os registros do período pós-operatório imediato de 230 pessoas submetidas à cirurgia cardíaca eletiva com uso de circulação extracorpórea no período de janeiro de 2013 a dezembro de 2015.

**Resultados:** Foram identificadas 423 complicações no pós-operatório imediato, estando relacionadas, na sua maioria, com o equilíbrio de fluidos, eletrólitos e ácido-base e função endócrina.

**Conclusão:** A leitura das complicações pós-operatórias como respostas ineficazes amplia a participação avaliativa e de intervenção da equipa de enfermagem durante o período pós-operatório, garantindo uma direção disciplinar singular.

**Palavra-chave:** cirurgia torácica; procedimentos cirúrgicos cardiovasculares; complicações pós-operatórias; teoria de enfermagem; enfermagem

## Resumen

**Marco contextual:** Las complicaciones postoperatorias pueden entenderse como respuestas ineficaces del modelo de adaptación de Roy al proceso de afrontamiento generado por la cirugía cardíaca electiva.

**Objetivos:** Identificar las complicaciones del postoperatorio inmediato de adultos y años sometidos a cirugías electivas con circulación extracorpórea; Categorizar las complicaciones postoperatorias inmediatas identificadas como respuestas ineficaces del modo fisiológico del sistema adaptativo humano.

**Metodología:** Estudio observacional retrospectivo, transversal, exploratorio y descriptivo.

**Resultados:** Analizamos los registros del postoperatorio inmediato de 230 personas que se sometieron a cirugía cardíaca electiva con derivación cardiopulmonar realizada entre enero y diciembre de 2013, 2014 y 2015. Se identificaron 423 complicaciones en el postoperatorio inmediato, la mayoría de las afiliaciones, el equilibrio de líquidos, electrolitos y ácido-base y la función de endoscopia.

**Conclusión:** la lectura de las complicaciones postoperatorias como respuestas adaptativas ineficaces amplifica la evaluación y la intervención del equipo de enfermería durante el período postoperatorio, garantizando una dirección disciplinaria singular.

**Palabras clave:** cirugía torácica; procedimientos quirúrgicos cardiovasculares; complicaciones posoperatorias; teoría de enfermería; enfermería

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## Introduction

According to estimates of the World Health Organization, 17.9 million people died from cardiovascular disease in 2016, accounting for 31% of all deaths worldwide (World Health Organization, 2017). A significant part of these diseases requires surgical treatment, myocardial revascularization surgery, correction of valve disease, followed by aortic and congenital heart disease correction surgery, which are the most common among adult and elderly patients (Jesus et al., 2016). These patients are usually referred to the surgical center with the highest number of comorbidities, subject to more complications in the intra- and postoperative periods, which results in a more extended hospital stay and monetary and technological costs incurred in treatment and recovery (Jesus et al., 2016).

Despite advances in cardiac surgery and perioperative care, postoperative complications are still prevalent and impact mortality substantially among patients undergoing these surgical procedures (Zheng et al., 2016). A study that analyzed the clinical outcomes of patients undergoing heart surgery highlighted the main complications in the postoperative period, such as hypotension, bleeding, hyperglycemia, acute kidney failure, reoperation, cardiac tamponade, ventricular tachycardia, hypopotassemia, sepsis, stroke, and cardiac arrest (Santos, Silveira, Moraes, & Souza, 2016).

Despite these outcomes, the healthcare team, in particular nurses, is responsible for monitoring, identifying, and acting immediately upon such complications, so that irreversible damage to health does not occur. It is believed that the description and characterization of these complications through studies favor the development of assessment and intervention guides for this critical period of surgical recovery. This study thus aims to identify the complications that adult and elderly patients suffer immediately after elective cardiac surgery with extracorporeal circulation and to categorize the immediate postoperative complications identified as an ineffective response of the physiological mode of the human adaptive system.

## Background

The immediate postoperative period is the moment of critical recovery that requires intensive care to ensure the good recovery of patients (Soares,

Ferreira, & Gonçalves, 2011). In this period, the effects of the procedure on the body and its physiological mechanisms should be monitored, and the potential and actual complications of these processes must be identified. The monitoring of postoperative complications, from a nurse's perspective, will depend on the use of a nursing theory or conceptual model that allows for the description and explanation from a disciplinary perspective. In Roy's Adaptation Model (RAM) in particular, a disciplinary conceptual model, people are regarded as open systems which are continuously interacting with the environment and are exposed to various stimuli that generate a coping process capable of resulting in adaptive or ineffective responses (Roy, 2009). Consequently, these definitions provide an understanding of the complications observed in the postoperative period as an ineffective response to the coping strategy generated by the stimulus of cardiac surgery.

This conceptual model allows nursing professionals to have access to the human adaptation system in the four adaptive modes: physiological, self-concept, interdependence, and role function (Roy, 2009). Adopting a parallel between the postoperative cardiovascular complications and the ineffective responses of RAM, it can be assumed that they are mostly allocated to the physiological adaptive mode, considering the large size and the high level of complexity of these surgeries, which modify physiological mechanisms (Beccaria et al., 2015). Roy's physiological adaptive mode is associated with how the person responds as a physical being to environmental stimuli, and behavior is described through the manifestation of the body's physiological activities (Roy, 2009).

Conceptual approaches and the link between theory and practice are sophisticated and, despite the reputation of RAM-based research (Roy, 2011), studies on the subject of this research have not been recovered, which triggered the research into complications from the perspective of an ineffective response to coping strategies.

## Research question

Which complications, perceived as an ineffective response, are present in the immediate postoperative period of adults and elderly patients submitted to elective cardiac surgery with extracorporeal circulation (ECC)?

## Methodology

A retrospective, cross-sectional, observational, exploratory, and descriptive study, with a quantitative approach, was conducted at a tertiary-level federal military hospital in the city of Rio de Janeiro, Brazil. The sample included patients who underwent elective cardiac surgery with ECC between January 2013 and December 2015. The following criteria had to be met for inclusion in the study: over 18 years of age, both male and female, submitted to elective cardiac surgery with all forms of ECC. The exclusion criteria of participants were: diagnoses of prior neurological alterations (brain tumors, intracranial hypertension, and cognitive-behavioral deficit) and infections acquired before surgery.

Data on postoperative complications and characterization of patients were obtained from 230 medical records, the total number of patients eligible based on the inclusion and exclusion criteria. The collection period was set for 3 years, depending on the data treatment capacity of the nursing team. This period began from the implementation of the electronic medical records and continued until the year before the data collection.

For the selection of variables, the possible postoperative complications described in the study by Soares et al. (2011) were aligned with the respective basic needs and complex processes of the physiological mode, presented in the conceptual

basis of RAM. This alignment supported the development of the data collection instrument that sought to characterize the participants, their clinical status, surgical procedures and to identify possible complications according to the five basic needs and four complex processes of the physiological adaptive mode, namely: oxygenation; nutrition; elimination; activity and rest; protection; senses; fluid, electrolyte and acid-base balance; neurologic function and endocrine function. Complications related to the psychologic and social adaptive modes were not assessed, as this information was found to be incomplete in the patient records of the services. Data collection was performed by one researcher, with a single check, using a data collection instrument with the patient, surgery, and postoperative complication variables. The instrument was applied to the medical and nursing records of the first 24 hours after surgery (immediate postoperative period), which are considered critical to the human adaptation system of these patients. In order to minimize error related to data gathered from medical records, the collection was performed by the researcher who had more experience handling the clinical records of the institution and in the immediate cardiac postoperative care. Data that seemed to be incongruous were reviewed.

The specific conditions of postoperative complications were categorized according to RAM shown in Table 1.

Table 1

*Type of complication and specific complication conditions in the immediate postoperative period after cardiac surgery*

Type of complication	Specific complication conditions
<b>Complications related to the complex process of fluid, electrolyte, and acid-base balance</b>	Thrombotic events, excessive bleeding - greater than or equal to 1.5ml/kg/hour -, changes in serum levels of sodium, potassium, magnesium, calcium, chlorine, phosphate, low cardiac output syndrome - need for vasopressor drugs for more than two hours and/or use of intra-aortic balloon -, systemic arterial hypertension - average arterial pressure above 90 mmHg with the need for infusion of venous vasodilators for pressure control, changes in the acid-base balance, excessive hypoperfusion, hematocrit below 30%.
<b>Complications related to the complex process of endocrine function</b>	Postoperative hyperglycemia (> 180mg/dl) or hypoglycemia (< 60mg/dl).
<b>Complications related to the basic need for activity and rest</b>	Perioperative acute myocardial infarction: elevated CK-MB or new Q waves on ECG; fibrillation or atrial flutter; atrioventricular block, motor, and mobility changes during the immediate postoperative period; cardio-respiratory arrest; changes in sleep pattern.

<b>Complications related to the basic need of elimination</b>	Diarrhea, increased serum creatinine $\geq 0.3\text{mg/dl}$ and/or increase in the percentage of serum creatinine $\geq 50\%$ (1.5 x baseline) and/or reduction of urinary output ( $< 0.5 \text{ ml/kg/h}$ for more than 6 hours) and/or need for dialysis at any time in the immediate postoperative period.
<b>Complications related to the complex process of neurological function</b>	Alteration in the level of awareness or coma occurring in association with neurological injury during surgery; convulsion; delirium; agitation; stroke.
<b>Complications related to the basic need of oxygenation</b>	Tracheal reintubation; atelectasis, bronchoconstriction, hypoxemia, acute respiratory distress syndrome (ARDS), acute respiratory failure (ARF), phrenic nerve paralysis, pleural effusion, ventilation-associated pneumonia (VAP).
<b>Complications related to the basic need of nutrition</b>	Mesenteric ischemia, digestive hemorrhage; vomiting; nausea
<b>Complications related to the basic need for protection</b>	Hyperthermia (temperatures above $37.5^{\circ}\text{C}$ ), hypothermia (temperatures below $35.5^{\circ}\text{C}$ ), pulmonary and urinary infections, of the surgical site (sternal, saphenous, and radial incisions; superficial versus deep).
<b>Complications related to the complex process of the senses</b>	Alterations of the senses or reflexes at any time in the immediate postoperative period; pain.

For sample characterization, the following variables were evaluated: gender, age, height, and body mass index. Surgery types and duration of ECC were also described. The documented complications were identified according to the correlation previously established in Table 1. Descriptive statistics with characterization of absolute values, percentages, means, and standard deviation was used for the analysis. The distribution of complications was also assessed according to the basic needs or complex processes of the physiological adaptive mode. It should be noted that data regarding serum levels of sodium, potassium, magnesium, calcium, chlorine, and phosphate were not included as these clinical data were not fully available in the records.

The study respected the ethical principles of participant protection, ensuring the confidentiality and anonymity of documentary

sources, data dissemination, and reliability. The research project was approved by the Research Ethics Committee under number 5217516.2.0000.5238.

## Results

The social-demographic characterization of the sample pointed to a profile dominated by men corresponding to 153 participants (66.5%), with a mean age above 65 years and body mass index suggesting overweight, as shown in Table 2. The clinical profile of the patients was also characterized according to Table 2, and the characterization of the surgical procedures performed highlights the predominance of myocardial revascularization surgeries, amounting to 158 (69%), and the mean duration of ECC was 95 minutes.

Table 2

*Clinical characterization and types of procedures on participants submitted to cardiac surgery. Rio de Janeiro, RJ, Brazil, 2013 - 2015*

<b>Clinical characterization</b>	<b>Mean</b>	<b>SD*</b>
Age	65.97	$\pm 10.70$
Weight	73.96	$\pm 13.99$
Height	1.65	$\pm 0.08$
Body mass index ( $\text{Kg/m}^2$ )	26.92	$\pm 4.42$

<b>Characterization of surgical procedures</b>	<b>n</b>	<b>%**</b>
Myocardial revascularization	158	69
Valve replacement	46	20
RVM + TV	16	7
Aortic surgery	5	2
Interatrial communication correction	4	2
Resection of Myxoma	1	0
<b>Characterization of extracorporeal circulation</b>	<b>Mean (hours)</b>	<b>SD*</b>
Mean duration of extracorporeal circulation	95	± 31.60

Note. SD\* = Standard Deviation; RMV + TV = Myocardial revascularization + Valve replacement.

\*\* Percentages apply to each category.

In total, 423 complications were identified in the immediate postoperative period of cardiac surgery with ECC. Table 3 presents these complications and classifies them by type based on the basic needs and complex processes of Roy's

physiological mode. The average number of complications occurring per patient was 26, presented by complications with the highest rate, with a standard deviation of 47.865.

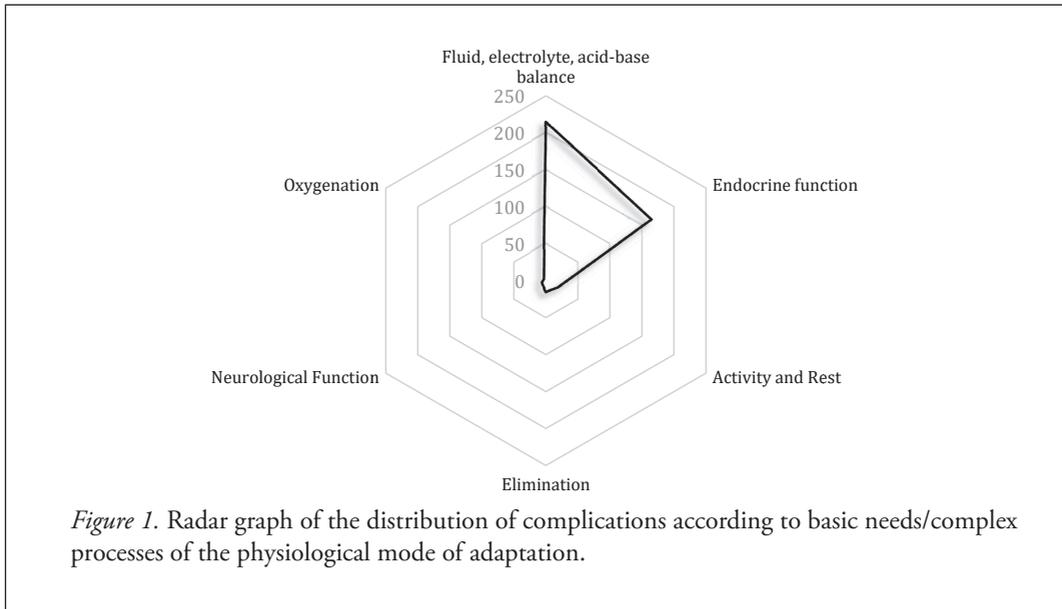
Table 3

*Complications in the immediate postoperative period after cardiac surgery classified according to the physiological mode of RAM*

<b>Complications by basic needs/complex processes</b>	<b>n</b>	<b>%*</b>
<b>of fluid, electrolyte, and acid-base balance</b>		
Changes in acid-base balance	81	35
Excessive bleeding	48	20
Excessive hypoperfusion	33	14
Low cardiac output syndrome	26	11
Low hematocrit levels	26	11
<b>Endocrine function</b>		
Hyperglycemia	165	71
<b>Activity and Rest</b>		
Arrhythmia	19	8
<b>Elimination</b>		
Reduced urinary output (< 0.5 ml/kg/h for more than 6 hours)	16	6
<b>Neurological Function</b>		
Agitation	4	1
Convulsion	2	0
<b>Oxygenation</b>		
Acute respiratory distress syndrome	3	1
<b>TOTAL</b>	<b>423</b>	<b>100</b>

The research sought to identify where the complications of the immediate postoperative period were concentrated according to the basic needs or complex processes of the physiological mode. Thus, the proportion of these ineffective

responses vis-a-vis coping strategies is presented. The evidence is shown in the radar graph of the distribution of complications according to basic needs/complex processes of the physiological mode of adaptation (Figure 1).



## Discussion

The study sought to assess the complications present in adult and elderly individuals immediately after cardiac surgery with ECC. However, it should be noted that the predominant profile obtained from the results is elderly male individuals. Studies also suggest that patients with a mean age of 60.97 years are at increased risk of cardiovascular mortality when they reach the age group of 70 years (Koerich, Lanzoni, & Erdmann, 2016). Aging population and increased life expectancy are also reflected in the studied group, which results in a high rate of chronic degenerative diseases, including cardiovascular disease (Gao et al., 2016).

Cardiac surgery can express a dichotomy in the health conditions of individuals submitted to it because it potentially improves the quality of life of patients, while clinical complications throughout the surgical process may also arise. Progress immediately after surgery represents the critical coping period of the human adaptive system vis-a-vis the surgical procedure because the coping strategies are triggered by the body

during surgery and continue mostly after the end of the stimulus of the surgical procedure. Consequently, during this period, the nursing team is required to continually monitor, assess, and control adaptive and ineffective response, and the possible contextual and residual stimuli of such physiological behavior.

In this study, the most prevalent postoperative complication was hyperglycemia. Although endocrine function was not the complicated process with the highest number of ineffective adaptive responses, hyperglycemia complication was significant considering the total number of research participants. A similar study showed a high rate of glycemic alteration in patients in the postoperative period of cardiovascular surgery with ECC (Oliveira et al., 2015). These changes are triggered by surgical stress associated with the neuroendocrine responses of hormones to insulin regulators, such as glucagon, cortisol, and adrenaline, which cause a state of catabolism, increasing blood glucose levels. Hormonal variations determined by stress are also related to this ineffective response, which triggers a state of tissue resistance to the effect of

insulin with gluconeogenesis and catabolism of lean mass (Akhtar, Barash, & Inzucchi, 2010). Therefore, complications related to the complex process of fluid, electrolyte, and acid-base balance are highlighted, namely, changes in acid-base balance, excessive bleeding, excessive hypoperfusion, low cardiac output syndrome, and low hematocrit. Concerning the identified acid-base balance cases, it is advocated that such results are directly related to the participants chosen to participate in this research. All participants were submitted to ECC, which is recognized in the literature as a precursor of respiratory alkalosis and metabolic acidosis disorders (Liskaser et al., 2009).

Consequently, coping strategies and ineffective response initiated during the operation are ongoing, generated mainly by poor tissue oxygenation and stress endured by the body during the surgical procedure. ECC causes tissue oxygenation to drop by releasing catecholamines and vasopressor compounds through the contact of blood cells with the non-endothelial surface of the extracorporeal circulation circuit, causing acid-base changes as the main postoperative complications of cardiac surgery using ECC (Liskaser et al., 2009).

The identification of excessive bleeding as the third major complication of the immediate postoperative period reinforces the assumption that bleeding continues to be one of the main morbidities in heart surgery, especially with the use of more complex procedures that favor the extension of duration of ECC (Liskaser et al., 2009). This result points to postoperative bleeding as one of the most common complications of heart surgery. Approximately 20% of patients lose significant amounts of blood after surgery, and 5% must be operated on again due to excessive bleeding (Fröjd & Jeppson, 2016). Extensive surgical trauma, prolonged contact with the artificial surface of ECC, heparin-induced systemic anticoagulation, and reduced body temperature at the level of hypothermia are associated as stimuli and factors contributing to the dysfunction of coagulation cascade factors and the inflammatory systems that lead to postoperative coagulopathy (Beccaria et al., 2015).

Excessive hypoperfusion complication can be considered an ineffective response generally associated with severe hypotension and heart

failure syndrome. This association characterizes two significant complications in percentage terms highlighted in the study, which are the fourth and fifth most prevalent complications, respectively, requiring in both situations the administration of inotropic and vasoconstrictor drugs for their reversal. The complications identified are also in line with the literature that characterizes them as common phenomena in postoperative cardiac surgery, increasing their incidence in cases where prolonged ECC was needed, and in 20% of cases, the development of a vasoplegic syndrome may occur, requiring hemodynamic support (Ferraris et al., 2007). Low hematocrit levels were observed, which the study found to be the fifth complication addressed as an ineffective response in the study. Low hematocrit rates are related to increased mortality, bleeding, and renal failure after heart surgery (Choi et al., 2017).

There were also complications related to the basic need for activity and rest, arising from post-surgical arrhythmia complications, followed by the basic need for elimination with the complication of reduced urinary output (< 0.5 ml/kg/h for more than 6 hours). As an ineffective response, arrhythmia is associated with the presence of prior comorbidities of the individual, which may prolong the hospital stay, resulting in costs and postoperative recovery of the individual (Koerich et al., 2016).

It should be noted that the relationship between arrhythmia and prolonged ECC increases the likelihood of metabolic acidosis occurring, causing the oxygen supply to the myocardium to drop, favoring the development of this complication (Aneman et al., 2018). The most common arrhythmia present in the postoperative period of cardiac surgery is atrial fibrillation, which is related to factors present in pre-, peri-, and postoperative periods (Aneman et al., 2018; Koerich et al., 2016).

Reduced urinary output in the immediate postoperative period of cardiac surgery may be related to acute renal failure (ARF). This complication, described in the literature as frequent in the immediate postoperative period of cardiac surgery, is the second cause of hospitalization in intensive care units. The interruption of the heartbeat is related to the use of ECC, which implies the need to use invasive mechanical ventilation, leading in turn to a change in the

hemodynamic stability of the patient, impairing glomerular filtration by reducing blood flow (O'Neal, Shaw, & Billings, 2016).

Less likely are complications in the complex process of the neurological function and the basic need for oxygenation. Neurological complications after heart surgery can be divided into stroke, neuropsychiatric changes, and peripheral neuropathies (Torres, Duarte, & Magro, 2017). Neurological complications associated with heart surgery presented in this study and characterized as ineffective neuropsychiatric responses were agitation and seizure. In a recent comprehensive literature review study, delirium is pointed out as an alteration prevailing in 3% to 32% of cases, possibly as a result of the procedure itself or the use of drugs. Seizures, on the other hand, are found in 0.5% to 3.5% of individuals and may be related to hypoxemia, metabolic disorders, drug toxicity, and structural brain injury (Torres et al., 2017).

The complication of the basic need for oxygenation was characterized in the study as acute respiratory distress syndrome. It presented low prevalence, which was expected, as this syndrome, that features inflammation of the alveoli, generally causes respiratory failure up to one week after the injury (Nascimento, Aguiar, Silva, Duarte, & Magro, 2015). Considering that the data refer to the immediate postoperative period, it is not common in this period to establish this respiratory syndrome, which demonstrates that, albeit in small proportion, some patients may present an ineffective response.

The radar graph represents this flow of distribution of complications according to basic needs/complex processes of the physiological mode of adaptation, which starting with complications in the fluid, electrolyte, and acid-base balance progresses clockwise, in particular activity and rest. This result is believed to represent new insight emerging from this research, which fosters a useful structure for prioritizing problems and guiding clinical judgment and decision-making in nursing. Complications concentrated in three basic needs/complex processes change the way of dealing with problems as separate and unrelated entities and drive reasoning towards a more systemic perspective of gathering and relating evidence from a nursing perspective. It is also worth noting that these results are in line with other similar research studies. However,

they are presented as innovative from the standpoint of nursing theory. The study's limitations include the retrospective documentary design, which depends significantly on the quality of the records kept and the inability to research other adaptive modes.

## Conclusion

This study identified hyperglycemia, changes in the acid-base balance, and excessive bleeding as the main complications in the period immediately after elective cardiac surgery with ECC. It was found that the coping strategy during the immediate postoperative period presents a more significant number of ineffective responses in the complex process of fluid, electrolyte, and acid-base balance, followed by endocrine function.

The concentration of complications in the basic needs/complex processes of fluid, electrolyte, and acid-base balance, endocrine function, activity and rest, elimination, neurological function, and oxygenation underscores the areas that require closer monitoring by nurses and the healthcare team, in general.

Therefore, these findings may pave the way to the development and standardization of assessment and intervention protocols for nursing care during surgical recovery in the immediate postoperative period.

Refocusing postoperative complications on the ineffective responses of the coping process changes the approach to the phenomenon-concept relationship and the integration of nursing theory and practice. To a certain extent, the use of categorization for nursing knowledge validates the conceptual elements of the discipline in clinical practice, which may have a positive impact on data interpretation and decision-making by nurses.

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