ORIGINAL RESEARCH

Risk of Acute Kidney Injury Complications After Aortic Dissection and the Value of Perioperative Cluster Nursing

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ABSTRACT

Background • Emergency aortic dissection affects 5 to 10 per 100 000 individuals with a fatality rate exceeding 30%.
Objective • The study investigates acute kidney injury (AKI) as a complication following acute aortic dissection and the effect of cluster nursing measures.
Methods • Single-factor and multi-factor model analysis screened risk factors for postoperative renal injury complications after acute aortic dissection. Cluster nursing measures were implemented during the perioperative period. Changes in renal function and AKI incidence before and after surgery between the 2 groups were compared.
Results • Logistic regression model analysis identified increased preoperative SCr levels, prolonged cardiopulmonary bypass time, and protracted aortic occlusion time as independent risk factors for AKI following acute aortic dissection surgery ($P < .05$). A high postoperative oxygenation index appeared to be a protective factor ($P < .05$). On day 1 and 3 after surgery, serum SCr and Cys-C levels in cluster nursing group were lower than those in routine nursing group. The incidence of postoperative AKI in the cluster nursing group was 2.86%, significantly lower than that in routine care group (17.14%, $P < .05$).
Conclusion • Perioperative cluster nursing measures for acute aortic dissection patients can reduce renal injury caused by surgery and reduce the incidence of AKI. (*Altern Ther Health Med.* [E-pub ahead of print.])

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INTRODUCTION

Aortic dissection is a pathological change caused by the separation of true and false aortic lumen due to lesions in the layers of the aorta. This results in the formation of a dissection layer, where blood enters the middle layer of the aortic wall.[1] Currently, surgery is the preferred clinical treatment for aortic dissection, which requires deep hypothermic cardiopulmonary bypass. However, this method is more invasive and can lead to various postoperative complications, including a higher incidence of acute kidney injury (AKI) compared to other heart surgeries.[2] Therefore, it is crucial to prioritize the prevention and treatment of AKI during the perioperative period to enhance patient prognosis. However, conventional nursing intervention mode cannot meet these needs.[3]

Cluster nursing is an emerging scientific nursing model that integrates evidence-based nursing measures to address challenging medical conditions and deliver optimal patient care. The cluster nursing model has been implemented in the clinical treatment of numerous diseases.[4] This study focuses on the clinical treatment of aortic dissection and examines the risk of developing complications such as AKI and the impact of employing cluster nursing techniques.[5] The findings are outlined below.

AKI, a dangerous complication that can occur after aortic dissection, has an unfavorable prognosis. This study analyzed the risk factors and found that increased preoperative serum creatinine (SCr), prolonged cardiopulmonary bypass time, and protracted aortic occlusion time were independent risks for AKI after the surgery. On the other hand, a high postoperative oxygenation index was identified as a protective factor. Additionally, the study explored the effectiveness of cluster nursing measures in the perioperative period for patients with acute aortic dissection. The results showed that these measures could effectively reduce the renal injury caused by surgery and decrease the incidence of AKI. These findings have significant clinical application potential.

MATERIALS AND METHODS

General Information

From April 2016 to April 2018, the researchers' hospital treated 31 patients who experienced renal injury after acute aortic dissection. These patients constituted the AKI group in the study. During the same period, 58 patients were selected as the control group to establish a model for analyzing risk factors.

For clinical randomized trials, a group of 70 patients with acute aortic dissection who received surgical treatment in the hospital between June 2018 and June 2021 was randomly divided into a cluster nursing group (with cluster nursing intervention) and a routine nursing group (with routine nursing measures). Each group consisted of 35 cases.

The study enrolled patients aged 18 to 75 to meet the inclusion criteria. The diagnosis of aortic dissection was based on the "Chinese expert consensus on the diagnosis and treatment of aortic dissection" and confirmed through multislice spiral CT angiography,[6] specifically identifying patients with Stanford A aortic dissection. All patients included in the study underwent surgery with cardiopulmonary bypass. Additionally, their stay in the intensive care unit (ICU) exceeded 48 hours. The diagnostic criteria for AKI were based on guidelines outlined in the 2012 edition of the "Clinical Practice Guidelines for Improving the Prognosis of Global Kidney Disease (KDIGO)."[7] Furthermore, the research complied with the ethical standards of the hospital's medical ethics expert group, and all participants provided informed consent.

Patients who have a history of underlying kidney diseases, such as chronic glomerulonephritis, nephrotic syndrome, diabetic nephropathy, etc., were excluded from this study. Additionally, individuals with thyroid disease, malignant tumors, coagulation system diseases, or those who recently used immune system drugs or drugs affecting renal function were also excluded.

Surgical Method

All patients underwent interventional surgery with tracheal intubation performed under general anesthesia. The left brachial artery was punctured to confirm the nature of the lesion through angiography, enabling the selection of an appropriately covered stent. The femoral artery was incised on one side, allowing the covered stent to be inserted and fully cover the proximal incision. Subsequently, a pigtail catheter was implanted through the left brachial artery incision to release the covered stent. Finally, the femoral artery was sutured, and the incision closed.

Intervention Measures

To create a set of nursing intervention measures for individuals with aortic dissection, the researchers thoroughly examined and discussed the implementation of cluster nursing interventions. They also comprehensively reviewed recent medical and nursing literature on this topic domestically and internationally.

To manage heart rate and blood pressure actively, it is crucial to monitor the patient's blood pressure as soon as they are admitted to the hospital. Within 48 hours of the onset of the illness, blood pressure should be measured every 15 minutes. Once the blood pressure stabilizes, the frequency of measurements can be extended.

Before surgery, monitoring and identifying any preoperative complications is important. If the aortic root is affected by dissection, it is important to assess for symptoms of heart failure, myocardial infarction, arrhythmia, and cardiac tamponade. In dissection cases in the large vessels above the bow, it is necessary to evaluate for central nervous system symptoms and spinal cord ischemia.

For individuals with dissection affecting the abdominal artery, it is essential to assess whether they exhibit signs of gastrointestinal ischemia and follow the doctor's advice to abstain temporarily from food and drink. Evaluating urine properties, volume, and water intake is important if the dissection affects the renal artery. Lastly, if the common iliac artery is affected by dissection, it is crucial to assess for signs of lower limb ischemia.

For pain relief and sedation, the doctor will recommend combining pain-relieving opioids with sedatives to improve their effectiveness. To manage postoperative complications for hypoxemia, early postoperative mechanical ventilation is necessary to ensure a clear airway and allow for early extubation. Strict aseptic procedures should be followed during sputum suctioning. Patients with preexisting pulmonary diseases should receive appropriate treatment.

To be vigilant regarding acute kidney injury, close blood pressure monitoring is essential to prevent renal insufficiency caused by low blood pressure and reduced cardiac output. Diuretics should be used judiciously to avoid hypokalemia. Prompt identification of AKI is crucial, and blood purification treatment should initiated when diagnosed.

Detection of delirium requires intensive patient observation, including intensive monitoring of pupil size, consciousness, and limb function, which should be conducted before patients regain full consciousness. A comprehensive plan that provides for optimizing sedation and pain relief methods, maintaining a quiet environment, and facilitating early extubation can help reduce the occurrence of delirium. If necessary, immobilization may be considered for patients.

The routine nursing group followed a regular care routine for patients in bed in quiet, comfortable hospital wards. This routine included administering perioperative medication, providing oxygen therapy, and following the doctor's advice. The patient's vital signs were closely monitored throughout their treatment. Any abnormalities were promptly reported to the doctors.

Observation Indicators and Detection Methods

The study compared the levels of (SCr), blood urea nitrogen (BUN), and cystatin C (Cys-C) before and after the operation, specifically at 1 day and 3 days post-operation, in 2 groups. The incidence of AKI in the 2 groups was statistically

analyzed using the following criteria: SCr level increased to 2-3 times the baseline before surgery or an absolute value greater than 354 mmol/L with a total value greater than 44 mmol/L.

Venous blood samples of 3ml were collected separately from the patients before the operation and 1 and 3 days after the treatment. The collected blood was centrifuged at 3000r/min for 10 minutes at 1 hour after collection. The serum obtained detected SCr and BUN using an automatic biochemical analyzer (Hitachi 7600), while Cys-C was detected using a microplate reader (Merry RT-96A). The ELISA kit used for the analysis was sourced from Nanjing Jiancheng Bioengineering Institute.

Statistical Treatment

The serum levels of SCr, BUN, Cys-C, and other measurement indexes of patients were tested using a normal distribution. These levels were consistent with either an approximate normal distribution or normal distribution, expressed as ($\bar{x} \pm s$). The *t* test was used to compare the 2 groups, while the χ^2 test was used for comparing non-grade counting data between groups. Risk factors were analyzed and modeled using a logistic regression model. The data was processed using professional SPSS21.0 software with a testing level set at α=0.05.

RESULTS

Univariate Analysis

Upon comparing the baseline data of the AKI group and the control group, it was observed that the AKI group had longer preoperative SCr, cardiopulmonary bypass time, aortic occlusion time, operation time, and mechanical ventilation time compared to the control group. Additionally, the AKI group had a larger blood transfusion volume than the control group, with a statistically significant difference ($P < .05$). The postoperative oxygenation index in the AKI group was lower than that in the control group, and this difference was also statistically significant ($P < .05$). (Table 1)

Logistic Regression Model Analysis

A logistic regression model was established to examine the factors associated with AKI following acute aortic dissection. The dependent variable in this model was AKI occurrence. At the same time, preoperative SCr, cardiopulmonary bypass time, aortic occlusion time, blood transfusion volume, operation time, mechanical ventilation time, and postoperative oxygenation index were considered independent variables. Univariate analysis found that higher preoperative SCr levels, longer cardiopulmonary bypass time, and prolonged aortic occlusion time were independent risk factors for AKI after acute aortic dissection ($P < .05$). Conversely, a higher postoperative oxygenation index was identified as a protective factor, reducing the risk of AKI following the surgery ($P < .05$). (See Table 2)

Effect of 2 Nursing Interventions on Patients' Renal Function

Before the operation, there was no significant difference in serum SCr, BUN, and Cys-C between the cluster and routine nursing groups ($P > .05$). However, at 1 day and 3 days after the operation, the cluster nursing group exhibited lower levels of serum SCr and Cys-C compared to the routine nursing group, and this difference was found to be statistically significant ($P < .05$). The detailed results can be found in Table 3.

Two Kinds of Nursing Interventions to Reduce the Incidence of AKI Difference

In the cluster nursing group, postoperative AKI was 2.86%, significantly lower than 17.14 % ($P < .05$) in the routine nursing group. (See Table 4)

Table 1. Univariate Analysis Results

Index	AKI group (n=31)	Control group (n=58)	t/χ^2	*P* value
Age (years)	46.9±8.2	45.5±7.8	0.792	.430
BMI (kg/m²)	24.13±1.58	23.80±1.65	0.912	.364
Gender (%)			0.739	.390
Male	18 (58.06)	39 (67.24)		
Female	13 (41.94)	19 (32.76)		
Smoking (%)	12 (38.71)	25 (43.1)	0.161	.689
Drinking (%)	14 (45.16)	23 (39.66)	0.252	.616
Hypertension (%)	24 (77.42)	36 (62.07)	2.167	.141
Diabetes (%)	9 (29.03)	14 (24.14)	0.253	.615
Hyperlipidemia (%)	14 (45.16)	20 (34.48)	0.976	.323
Preoperative SCr (μmol/L)	113.5±11.0	95.3±8.2	8.832	.000
Preoperative left ventricular ejection fraction (%)	58.63±4.10	59.27±4.77	-0.632	.529
Preoperative albumin (g/L)	41.85±3.30	43.02±2.95	-1.710	.091
Cardiopulmonary bypass time (min)	209.5±12.0	201.4±11.8	3.067	.003
Aortic Occlusion Time (min)	88.7±7.4	83.5±8.0	2.997	.004
Blood transfusion volume (mL)	1463.8±155.3	1205.7±114.8	8.910	.000
Operation time (min)	295.0±25.7	277.4±22.6	3.336	.001
Postoperative oxygenation index (mmHg)	113.8±15.0	130.2±17.0	-4.512	.000
Postoperative ICU				
time (h)	10.5±1.8	9.8±1.7	1.813	.073
Mechanical ventilation time (h)	8.6±1.2	7.7±1.4	3.031	.003
Total arch replacement (%)	18 (58.06)	39 (67.24)	0.739	.390
Emergency surgery (%)	17 (54.84)	28 (48.28)	0.348	.555

Table 2. Logistic Regression Model Analysis

Index	B	SE	Walds	*P* value	OR	95%*CI*	
Preoperative SCr	0.688	0.295	5.439	.021	1.990	1.116	3.547
Cardiopulmonary bypass time	0.669	0.328	4.160	.048	1.952	1.026	3.713
Aortic Occlusion Time	0.594	0.265	5.024	.031	1.811	1.077	3.045
Blood transfusion volume	1.028	0.627	2.688	.114	2.795	0.818	9.554
Operation time	0.339	0.184	3.394	.096	1.404	0.979	2.013
Postoperative oxygenation index	-0.701	0.307	5.214	.026	0.496	0.272	0.905
Mechanical ventilation time	0.674	0.411	2.689	.114	1.962	0.877	4.391
Constant term	1.02	0.482	4.478	.045	2.773	1.078	7.133

Table 3. Influence of 2 Nursing Interventions on Patients' Renal Function ($\bar{x} \pm s$)

Group	n	SCr (μmol/l)			BUN (mmol/L)		
		Preoperative	1 day after surgery	3 days after surgery	Preoperative	1 day after surgery	3 days after surgery
Bundled care group	35	92.4±11.7	122.8±13.0	146.7±10.6	4.89±0.81	6.74±1.02	8.20±1.33
Usual care group	35	94.0±12.4	140.2±12.8	164.4±12.1	5.13±0.86	7.10±0.99	8.66±1.43
t		-0.555	-5.642	-6.510	-1.202	-1.498	-1.394
P value		.581	.000	.000	.234	.139	.168

Group	n	Cys-C (mg/L)		
		Preoperative	1 day after surgery	3 days after surgery
Bundled care group	35	0.74±0.15	0.84±0.18	0.96±0.15
Usual care group	35	0.71±0.12	0.99±0.16	1.26±0.20
t		0.924	-3.685	-7.099
P value		.359	.000	.000

Table 4. Differences in Reducing the Incidence of AKI Between 2 Nursing Interventions

Group	n	AKI	Non-AKI
Bundled care group	35	1(2.86)	34(97.14)
Usual care group	35	6(17.14)	29(82.86)
χ^2		3.968	
P value		.046	

DISCUSSION

Stanford type A represents the most severe form of aortic dissection, exhibiting a more critical condition compared to other types.[8] The affected areas are extensive, spanning from the aortic root to the iliac artery, involving multiple organs and vessels. As a result, the surgical risk and postoperative complications are more complex than those associated with conventional cardiac surgery.[9] Some studies have suggested that postoperative AKI is primarily caused by renal hypoperfusion resulting from deep or moderate hypothermia during surgical repair. Furthermore, multiple physiological and pathological mechanisms are involved, including renal microvascular embolization, abnormal neuroendocrine activation, ischemia-reperfusion injury, endogenous and exogenous toxins, and oxidative stress and inflammatory responses.[10] At present, there is no specific treatment for AKI after aortic dissection in clinical practice. Solely relying on renal replacement therapy not only increases the medical burden and prolongs hospitalization for patients but also increases their postoperative mortality rate.[11]

At present, there is a lack of comprehensive understanding regarding the clinical risk factors for postoperative AKI in patients with acute aortic dissection. Various studies have been conducted on this topic, but the findings lack consistency.[12] Some studies indicate that advanced age, preoperative liver dysfunction, and red blood cell transfusion are risk factors for postoperative AKI in these patients.[13] Other studies suggest that high preoperative creatinine levels and a low postoperative oxygenation index are associated with postoperative AKI in Stanford type A patients.[14]

This study used a logistic regression model to examine independent risk factors associated with AKI after acute aortic dissection. The analysis revealed that increased preoperative serum creatinine levels, prolonged cardiopulmonary bypass time, and protracted aortic occlusion time were independent risk factors for AKI after the operation. Conversely, a higher postoperative oxygenation index was found to provide a protective factor, reducing the risk of AKI after surgery. These findings align with existing research conclusions.[15]

Patients with elevated preoperative SCr typically exhibited compromised renal function and were less able to tolerate harmful stimuli. Prolonged extracorporeal circulation and aortic occlusion time can extend renal ischemia duration and exacerbate local ischemia-hypoxia injury. Conversely, achieving a higher postoperative oxygenation index can enhance blood supply and oxygen delivery to the renal area, thereby protecting the kidneys.[16]

Superior perioperative nursing intervention plays a crucial role in ensuring the success of the surgery and minimizing complications.[17] In this study, cluster nursing intervention was implemented during the perioperative period. The findings revealed that serum SCr and Cys-C levels in the cluster nursing group were lower than those in the routine nursing group at 1 and 3 days post-operation. Additionally, the incidence of postoperative AKI was lower in the cluster nursing group compared to the conventional group. The results indicate that implementing cluster nursing measures for patients with acute aortic dissection can effectively reduce renal injury caused by surgery and decrease the occurrence of AKI.

As a byproduct of human muscle metabolism, SCr is expelled from the body through urine excretion. Therefore, when the glomerular filtration rate decreases, the SCr level in the blood increases.[18] On the other hand, Cys-C is secreted by human nucleated cells, which is excreted through glomerular filtration and remains unaffected by age, diet, exercise, and weight.[19]

The above indicators are sensitive markers that reflect the level of kidney function. The objective results confirm that implementing cluster nursing measures for patients with acute aortic dissection during the perioperative period can effectively reduce the renal injury caused by surgery. When following the cluster nursing approach, doctors and nurses must anticipate potential issues during the perioperative period and develop appropriate intervention strategies. Managing heart rate and blood pressure can help regulate blood pressure and prevent hypotension from aggravating renal injury. Providing sufficient pain relief and sedation and actively avoiding and treating hypoxemia can improve oxygenation and ensure adequate blood supply and oxygen to the kidneys. By closely monitoring patients, any instances of AKI should be promptly detected for blood purification treatment to minimize harm caused by AKI.[20]

In summary, heightened levels of increased preoperative SCr, extended cardiopulmonary bypass time, and prolonged aortic occlusion time were identified as independent risk factors for AKI after surgery. Conversely, a high postoperative oxygenation index was a protective factor. Cluster nursing implementation for patients with acute aortic dissection during the perioperative period was effective in reducing renal injury caused by surgery and decreasing the occurrence of AKI.

ETHICS APPROVALS

The Ethics Committee of the researchers' hospital approved the current study, which was conducted in accordance with the principles of the Declaration of Helsinki.

FUNDING

No funding was received for conducting this study.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

DATA AVAILABILITY

For reasonable requirements, the data related to this study can be requested from the corresponding author.

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