

Analysis of Cardiovascular Function Stability in Anesthesia Patients in High-Altitude Areas

Chunyong Tang¹, Jing Sui¹, Dingpan Deng² & Pengcuo.SL²

¹ Deyang People's Hospital, Deyang, Sichuan, China

² Aba County People's Hospital, Aba, Sichuan, China

Correspondence: Chunyong Tang, Deyang People's Hospital, Deyang, Sichuan, 618000, China. E-mail: tangchunyong16@163.com

Received: November 23, 2025; Accepted: December 12, 2025; Published: December 15, 2025

Abstract

Objective: To explore the stability of cardiovascular function and influencing factors in anesthesia patients in high-altitude areas. **Methods:** Select anesthesia patients who meet the inclusion criteria in high-altitude areas of Aba County, record their basic information in detail, and use a multifunctional monitor to continuously monitor cardiovascular function indicators, including heart rate, blood pressure, cardiac output, etc., before surgery, after anesthesia induction, at different stages of surgery, and after surgery. Analyze the impact of different factors on the stability of cardiovascular function. **Results:** It was found that the cardiovascular function indicators of patients showed dynamic changes during anesthesia surgery, and factors such as age, gender, surgical type, and anesthesia method all affected their stability. **Conclusion:** This study provides theoretical basis and practical guidance for cardiovascular risk management in anesthesia surgery in high-altitude areas.

Keywords: high-altitude areas, Anesthesia patients, Cardiovascular functional stability, influence factor

1. Introduction

Due to the decrease in atmospheric pressure and oxygen partial pressure in high-altitude areas, the human body is in a state of hypoxia, which poses a huge challenge to the cardiovascular function of anesthesia patients. Anesthesia surgery itself can also have an impact on the patient's cardiovascular system, and the combination of the two makes the stability of cardiovascular function in high-altitude anesthesia patients a focus of clinical attention. This study focuses on anesthesia patients in high-altitude areas, and explores in depth the status and influencing factors of their cardiovascular function stability, in order to provide valuable references for clinical practice and improve the safety and quality of anesthesia surgery in high-altitude areas.

2. Material and Method

2.1 Research Object Selection

Accurately selecting research subjects in the vast field of medical research is the cornerstone of ensuring research quality and reliability. This study focuses on the in-depth analysis of cardiovascular function stability in anesthesia patients in high-altitude areas, and precisely targets the selection of research subjects in Aba County, a region with unique geographical and climatic characteristics. Aba County is located in the altitude range of 3100 to 4400 meters, with an urban area altitude of about 3290 meters. Its atmospheric pressure is about 67.46 Kpa, oxygen partial pressure is 14.13 Kpa, and effective oxygen concentration is about 13.94%, which is only 66.56% of the oxygen content at 0 altitude. Such a unique low oxygen environment provides a natural 'laboratory' for studying the effects of high altitude on cardiovascular function in anesthesia patients.

The subjects included in this study must strictly meet a series of conditions. The patient age range is set between 18-70 years old, which covers the majority of the adult population undergoing surgical treatment. This ensures the representativeness of the study subjects and avoids the interference of physiological differences caused by being too young or too old on the research results. The surgical types widely cover common departments such as general surgery, orthopedics, obstetrics and gynecology, aiming to comprehensively explore the effects of different surgical operations on cardiovascular function in anesthesia patients in high-altitude areas. Not all patients who meet the age and surgical type criteria can be included in the study. Strict exclusion criteria have been set, and patients with severe cardiovascular diseases (such as coronary heart disease, heart failure, etc.) and respiratory diseases (such as chronic obstructive pulmonary disease, asthma, etc.) have been excluded because their

cardiovascular or respiratory functions have been impaired, and the high-altitude environment further exacerbates their condition, resulting in research results that cannot accurately reflect the simple impact of high altitude on the cardiovascular function of anesthetized patients. Patients with a history of anesthesia drug allergies and those with severe preoperative infections or liver and kidney dysfunction were also excluded due to interference with the study results.

2.2 Research Method Description

Conduct a detailed and comprehensive evaluation of each patient included in the study before surgery. This not only includes detailed medical history collection, covering multiple aspects such as past disease history, family history, allergy history, etc., but also involves comprehensive physical examination, from vital signs to the functional status of various system organs, conducting detailed examinations one by one. Conduct a series of laboratory tests, such as blood routine, coagulation function, liver and kidney function, to obtain objective data on the patient's physical condition and provide important baseline information for subsequent research. After fully informing patients and their families of the research objectives, methods, and risks, sign an informed consent form to ensure the legality and ethics of the study^[1]. During the anesthesia implementation process, the appropriate anesthesia method is carefully selected based on the type of surgery and the individual condition of the patient. For general anesthesia, drugs such as propofol and sufentanil are used during the induction phase to utilize their rapid and effective sedative and analgesic effects, allowing patients to smoothly enter the anesthesia state; During the maintenance phase, inhaled anesthetics such as sevoflurane and intravenous anesthetics such as remifentanil are used in combination. The drug dosage is precisely adjusted according to the surgical process and changes in the patient's vital signs to ensure stable anesthesia depth. Intraspinal anesthesia involves precise selection of puncture sites based on the surgical site, and the use of local anesthetics such as ropivacaine to achieve good nerve block effects. Cardiovascular function monitoring is the core component of this study. Using a multifunctional monitor to monitor the patient's heart rate (HR), blood pressure (including systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) in real-time and continuously. Heart rate, as an important indicator reflecting the frequency of heartbeats, can intuitively reflect the stress state of the cardiovascular system; the fluctuation of blood pressure reflects the comprehensive changes in cardiac pumping function and peripheral vascular resistance^[2]. Continuously monitor electrocardiogram (ECG) to capture subtle changes in cardiac electrical activity and promptly detect abnormal conditions such as arrhythmia. By using advanced cardiac output monitoring devices such as thermal dilution or pulse indication continuous cardiac output monitoring technology, precise measurement of cardiac output (CO) is achieved, and the pumping function of the heart is comprehensively evaluated. The monitoring time points are carefully set as 30 minutes before surgery, 5 minutes after anesthesia induction, 30 minutes before the start of surgery, 30 minutes before the end of surgery, 1 hour after surgery, and 6 hours after surgery to dynamically observe the changes in cardiovascular function throughout the anesthesia surgery process.

2.3 Data Collection and Processing

The accurate collection and scientific processing of data are key steps in mining the value of research results. During the data collection process, assign a dedicated person to ensure that heart rate, blood pressure, electrocardiogram changes, cardiac output, and other data at each monitoring time point are recorded in a timely and accurate manner. Detailed records of patients' basic information, such as age, gender, type of surgery, anesthesia method, and dosage of anesthetic drugs, serve as important variables for research and provide rich materials for subsequent data analysis^[3]. The collected data is initially organized, classified, sorted, and subjected to simple statistical analysis to check its completeness and accuracy. Any errors or omissions are promptly identified and corrected. Subsequently, professional statistical software (such as SPSS) was used for in-depth data analysis. The measurement data is expressed as mean \pm standard deviation ($\bar{x} \pm s$), and t-tests or analysis of variance are used to compare the differences between different time points and groups, in order to clarify whether factors such as high-altitude environment and anesthesia surgery have a statistically significant impact on cardiovascular function indicators. Count data is presented as a rate and compared using chi square test to analyze the relationship between different factors and the incidence of cardiovascular dysfunction. Through this series of rigorous data processing methods, we strive to extract valuable information from massive amounts of data, providing solid data support for the study of cardiovascular function stability in anesthesia patients in high-altitude areas.

3. Results

3.1 Statistical Results of Patient Basic Information

In this study on the cardiovascular stability of anesthesia patients in high-altitude areas, the included patient population showed diverse characteristics. The following is the patient basic information statistical table (Table 1):

Table 1. Basic Patient Information Statistics

project	classification	Number of people	account for
age	18-40 years old	30	25%
	40-60 years old	60	50%
	60-70 years old	30	25%
gender	male	60	50%
	female	60	50%
Surgical type	General surgery	50	41.70%
	orthopedics	40	33.30%
	ob-gyn	30	25%
Type of anesthesia	general anesthesia	70	58.30%
	Intrathecal Block	50	41.70%

From the perspective of age distribution, patients aged 40-60 are the majority, accounting for 50%. Patients in this age group gradually experience changes in their physical functions and may also have underlying underlying diseases. Patients aged 18-40 are relatively rare, accounting for 25%, and their physical function is relatively good. Patients aged 60-70 also account for a certain proportion, accounting for 25%, and their organ function declines more significantly.

In terms of gender, the proportion of male and female patients is roughly equal, each accounting for 50%. Male patients have certain differences in the physiological structure of their cardiovascular system regulation mechanisms compared to females; Female patients, on the other hand, have unique cardiovascular responses due to factors such as physiological cycles and hormone levels.

In terms of surgical types, there are a large number of patients undergoing general surgery, accounting for 41.7%, orthopedic surgery patients accounting for 33.3%, and relatively few patients undergoing gynecological surgery, accounting for 25%.

In terms of anesthesia methods, both general anesthesia and spinal anesthesia are used, accounting for 58.3% and 41.7% respectively.

3.2 Results of Changes in Cardiovascular Function Indicators

During anesthesia surgery, there are significant dynamic changes in heart rate, blood pressure, and cardiac output. The following is a statistical table of changes in cardiovascular function indicators (Table 2):

Table 2. Changes in cardiovascular function indicators

Monitoring time point	Heart rate (beats/minute)	Systolic blood pressure (mmHg)	Diastolic blood pressure (mmHg)	Mean arterial pressure (mmHg)	Cardiac output (L/min)
30 minutes before surgery	78	120	80	93	5
5 minutes after anesthesia induction	68	100	65	78	4.5
30 minutes from the start of the surgery	82	110	75	88	4.8

30 minutes before the end of the surgery	76	105	70	83	4.7
1 hour after surgery	74	115	78	90	4.9
6 hours after surgery	79	122	81	94	5.1

Heart rate changes: Prior to surgery, the patient's average heart rate was 78 beats per minute. After 5 minutes of anesthesia induction, the heart rate dropped to 68 beats per minute. At the beginning of the surgery, 30 minutes later, the heart rate returned to 82 beats per minute. 30 minutes before the end of the surgery, the heart rate dropped again to 76 beats per minute. One hour after surgery, the heart rate gradually increased to 74 beats per minute. Six hours after surgery, the heart rate basically returned to the preoperative level, which was 79 beats per minute.

Blood pressure changes: Prior to surgery, the average systolic blood pressure was 120mmHg, the average diastolic blood pressure was 80mmHg, and the average arterial pressure was 93mmHg. After anesthesia induction, blood pressure significantly decreased, with systolic pressure dropping to 100mmHg, diastolic pressure dropping to 65mmHg, and mean arterial pressure dropping to 78mmHg. During the surgery, blood pressure fluctuated slightly, but the overall trend remained relatively stable. After the surgery, blood pressure gradually increased.

Changes in cardiac output: The average preoperative cardiac output was 5.0 L/min. After anesthesia induction, the cardiac output decreased to 4.5L/min. During the surgery, cardiac output fluctuates with the progress of the surgery and changes in the patient's physiological state. After surgery, cardiac output gradually recovered and reached 5.1L/min 6 hours postoperatively.

3.3 The Impact of Different Factors on the Stability of Cardiovascular Function

The following is a statistical table of the impact of different factors on cardiovascular function stability (Table 3):

Table 3. Effects of Different Factors on Cardiovascular Function Stability

factor	grouping	Heart rate variation amplitude (beats/minute)	Blood pressure change amplitude (mmHg)	Change amplitude of cardiac output (L/min)
age	18-40 years old	10	15	0.5
	40-60 years old	12	20	0.6
	60-70 years old	15	25	0.7
gender	male	12	20	0.6
	female	13	22	0.7
Surgical type	General surgery	10	18	0.5
	orthopedics	14	24	0.7
	ob-gyn	12	21	0.6
Narcotic drugs	propofol	13	22	0.6
	Ropivacaine	11	19	0.5

Age factor: There are significant differences in the impact of cardiovascular function stability among patients of different age groups. The heart rate of young patients (18-40 years old) changes by 10 beats per minute, the blood pressure changes by 15mmHg, and the cardiac output changes by 0.5L/min. The heart rate of elderly patients (60-70 years old) changes by 15 beats per minute, the blood pressure changes by 25mmHg, and the cardiac output changes by 0.7L/min.

Gender factors: There are also certain differences in cardiovascular stability between male and female patients. The heart rate of male patients changes by 12 beats per minute, the blood pressure changes by 20mmHg, and the cardiac output changes by 0.6L/min. The heart rate of female patients changes by 13 beats per minute, the blood pressure changes by 22mmHg, and the cardiac output changes by 0.7L/min.

Surgical type factors: The impact of different surgical types on cardiovascular function stability also varies. The heart rate of patients undergoing general surgery changes by 10 beats per minute, the blood pressure changes by 18mmHg, and the cardiac output changes by 0.5L/min. The heart rate of orthopedic surgery patients changes by 14 beats per minute, the blood pressure changes by 24mmHg, and the cardiac output changes by 0.7L/min.

Anesthetic drug factors: The effects of different anesthetic drugs on cardiovascular function also vary. The patient using propofol had a heart rate change of 13 beats per minute, a blood pressure change of 22mmHg, and a cardiac output change of 0.6L/min. The heart rate change amplitude of patients using ropivacaine is 11 beats per minute, the blood pressure change amplitude is 19mmHg, and the cardiac output change amplitude is 0.5L/min.

By analyzing the above results, we can gain a preliminary understanding of the cardiovascular function stability of anesthesia patients in high-altitude areas, as well as the impact of different factors on cardiovascular function stability. Young patients, male patients, general surgery patients, and patients using ropivacaine show relatively good cardiovascular stability. However, elderly patients, female patients, orthopedic surgery patients, and patients using propofol face greater challenges in terms of cardiovascular function stability. These results provide important reference for subsequent research and clinical practice.

4. Discuss

4.1 The Impact Mechanism of High-Altitude Environment on Cardiovascular Function in Anesthesia Patients

From the perspective of the core factor of decreasing oxygen partial pressure, as altitude increases, atmospheric pressure gradually decreases and oxygen partial pressure also significantly decreases. This reduces the amount of oxygen inhaled by the human body, leading to a decrease in arterial oxygen saturation and a state of hypoxia in tissues and organs. For anesthesia patients, this hypoxic state can trigger a series of compensatory reactions^[4]. The sympathetic nervous system is activated, causing an increase in heart rate and myocardial contractility in an attempt to increase cardiac output and meet the body's demand for oxygen. However, this compensatory mechanism is often difficult to fully compensate for the adverse effects of hypoxia in high-altitude environments. Hypoxia can also cause pulmonary vasoconstriction. In high-altitude areas, low oxygen stimulates pulmonary vascular smooth muscle cells, leading to increased pulmonary vascular resistance and subsequently causing pulmonary arterial hypertension. Pulmonary arterial hypertension not only increases the burden on the right ventricle, but also leads to long-term right heart hypertrophy and even right heart failure.

4.2 Comparison of Research Results with Previous Studies

Comparing the results of this study with previous research, it can be found that there are both similarities and certain differences. In terms of the trend of changes in cardiovascular function indicators, this study is consistent with some previous studies, which have found that anesthesia patients experience significant fluctuations in heart rate, blood pressure, and other indicators in high-altitude environments^[5]. For example, after anesthesia induction, both heart rate and blood pressure will decrease, which is consistent with previous research on the inhibitory effects of anesthetic drugs on the cardiovascular system.

This study also made some unique discoveries. In terms of the stability of cardiovascular function in patients of different age groups, this study found that the cardiovascular function indicators of elderly patients fluctuated more significantly, while some previous studies did not fully reflect this characteristic due to differences in sample size or research methods. This study also delved into the effects of different surgical types and anesthesia methods on cardiovascular function, and found that orthopedic surgery and general anesthesia have a relatively significant impact on cardiovascular function. This result enriches previous research to a certain extent.

4.3 The Innovation and Limitations of this Study

The research site was chosen in high-altitude areas with unique geographical and climatic characteristics, providing a natural experimental venue for further exploring the effects of high-altitude environments on cardiovascular function in anesthesia patients. This study comprehensively considered multiple factors, including patient basic information, surgical type, anesthesia method, etc., and comprehensively analyzed the impact of these factors on cardiovascular function stability, making the research results more convincing.

However, this study also has certain limitations. The sample size is relatively limited and cannot fully represent the situation of all anesthesia patients in high-altitude areas, which limits the generalizability of the research results. This study only observed changes in cardiovascular function during anesthesia surgery and lacked follow-up research on long-term postoperative cardiovascular function recovery. Due to limitations in research conditions, the molecular mechanisms underlying the effects of high-altitude environments on cardiovascular function have not been thoroughly explored, which is also a direction that needs to be further expanded in future research.

5. Conclusion

This study focuses on the key issue of cardiovascular function stability in anesthesia patients in high-altitude areas. Through rigorous and comprehensive research design, many valuable discoveries have been made. At the level of patient basic information, factors such as age, gender, type of surgery, and anesthesia method all affect the

performance of cardiovascular function during anesthesia surgery to varying degrees. Due to the decline of physical function, elderly patients have significantly reduced tolerance of the cardiovascular system to high-altitude hypoxic environments and anesthesia surgeries, and their cardiovascular function indicators fluctuate more violently; The differences in hormone levels, physiological structures, and other aspects among patients of different genders also lead to varying cardiovascular responses during anesthesia surgery; The type of surgery and anesthesia method directly affect the patient's body, triggering a series of stress changes in the cardiovascular system.

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