Treatment Strategy of Hemorrhagic Traumatic Shock Patients in High Altitude Area: A Systematic Review

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Research

Keywords: Hemorrhagic traumatic shock; High altitude; Treatment strategy; Systematic review

Posted Date: May 20th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-29150/v1

Abstract

Background

Because of the influence of hypoxia, the degree of shock of patients with traumatic hemorrhagic shock (HTS) in high altitude area will be aggravated in a short period of time. There is a difference in treatment strategy compared with the low altitude area. At present, the relevant literature reports are growing. However, there is no systematic review of these clinical evidences. Therefore, this study aims to synthesize existing literature on the treatment strategy of HTS patients in high altitude area.

Methods

By searching PubMed, Medline, Embase, CNKI, CBMdisc, VIP and the Cochrane Database of Systematic Reviews, searched from inception until March 1, 2020. The clinical trial of HTS patients at high altitude, which was conducted by qualitative analysis to extract data, classify, summarize and arrange information.

Results

Overall, 254 articles were identified, of which 13 relevant articles were identified following screening. Clinical practice and rationale for treatment decisions mainly involve the following 6 aspects: (1) effective prehospital treatment (hemostasis, bandaging, ventilation and establishment of venous access, etc.); (2) long time and low concentration oxygen supply; (3) limited rehydration, the amount of rehydration being 1–2 times of the patient's blood loss; (4) the microcirculation of patients was improved by drug intervention and rewarming; (5) lanatoside C or cedilanid was used to improve the cardiopulmonary function of patients; (6) 5% sodium bicarbonate was used to improve the acid-base balance of patients. In addition, ARDS, MOF and PTPI are the main complications leading to death.

Conclusions

The level of oxygen supply, rehydration and other treatment strategies for HTS patients in high altitude area are different from those in low altitude areas. The dynamic changes of physiological indexes in the process of treatment are important signs of adjusting the treatment plan. Effective prehospital first aid and rapid medical transport have a positive effect on patients' later rehabilitation.

Introduction

Traumatic hemorrhagic shock (HTS) is a kind of syndrome caused by many factors such as sharp decrease of effective circulation blood volume, insufficient microcirculation perfusion, disorder of cell metabolism, severe pain and fear [1]. When the altitude is more than 2,500 m, the partial pressure of

oxygen in the environment is significantly reduced; under the combined effect of hypoxia and blood loss, the degree of shock is significantly increased, the course of disease is rapid, and it is easy to cause hypoxemia [2]. At the same time, complex pathological changes will reduce the body's stress ability and tolerance of shock patients, resulting in their ability to bear the liquid, and in the process of resuscitation, pulmonary edema and brain edema are very easy to occur, even with right heart failure [3]. Therefore, the treatment of HTS patients in high altitude area is more difficult than that in low altitude area, and the treatment strategy is different from that in low altitude area.

As the number of people entering high altitude area for work, business and tourism increases year by year, the risk of HTS also increases. As of 2015, the permanent population of Tibet Autonomous Region in the south of the Qinghai Tibet Plateau in China has reached 3.24 million; in 2017, the number of foreign inflow population was 3.26 million [4]. Due to the frequent occurrence of natural disasters, traffic accidents, violent conflicts and other public emergencies, HTS has become the main cause of trauma death in high altitude area. Qu Jifu's investigation of hospitals in Shannan District of Tibet found that the mortality rate of 1,453 patients was 9.15%, and hemorrhagic shock ranked the first among all post-traumatic death factors, accounting for 36.76% [5].

At present, a large number of clinical studies on the treatment of HTS patients in high altitude area have been published in Chinese journals, while the number of such studies published in international journals is relatively small. In addition, due to the limitations of injury characteristics, treatment experience and medical conditions, different researchers have different treatment strategies for HTS patients, resulting in different treatment effects. Therefore, this systematic review aims to provide reliable evidence-based basis for the clinical treatment process of HTS patients in high altitude area by analyzing the clinical treatment measures of HTS patients at this stage, evaluating and summarizing effective treatment strategies.

Methods

The methods of this study are to refer to the systematic review and meta-analysis in the Cochrane guidelines, and refer to the PRISMA checklist for our writing report [6, 7].

Inclusion criteria

I. Study: Clinical trial, which included randomized controlled trial (RCT) and non-randomized controlled trial (non-RCT).

II. Patients: the HTS at high altitude.

III. Intervention: no restrictions.

IV. Control: no restrictions.

V. Outcomes: prehospital or in hospital treatment measures.

Exclusion criteria

I. Lack of treatment effect information.

II. Poor data reliability.

Search strategy

A systematic search of databases included PubMed, Medline, Embase, CNKI, CBMdisc, and the Cochrane Database of Systematic Reviews, searched from inception until March 1, 2020. The search keywords include: high altitude, traumatic shock, hemorrhagic shock, hemorrhagic traumatic shock. For PubMed, the search strategy is as follows: high altitude [Title/Abstract] AND ((traumatic shock [Title/Abstract] OR hemorrhagic shock [Title/Abstract]) OR hemorrhagic traumatic shock [Title/Abstract]).

Data extraction and analysis

Two evaluators independently selected literature, extracted data and cross checked them. If there are differences, the third evaluator should be consulted to assist in judgment. Through reading the title and the abstract, the preliminary selection of the literature is carried out; after excluding the obviously unrelated literature, the full text is further read to determine whether it is finally included. Data extraction includes: the principle, plan and result of the treatment of HTS at high altitude.

Risk of bias

The quality of the study was evaluated by MINORS (Methodological Index for Non-Randomized Studies): 1. A stated aim of the study; 2. Inclusion of consecutive patients; 3. Prospective collection of data; 4. Endpoints appropriate to the study aim; 5. Unbiased assessment of the study endpoint; 6. Follow-up period appropriate to the aim of the study; 7. Loss to follow up not exceeding 5%; 8. Prospective calculation of the study size [8].

Statistical analysis

Through qualitative analysis, the basic information, treatment principles, measures and effects of the included study were classified, summarized and described.

Results

Study selection

349 studies were obtained through electronic retrieval of literature database and manual retrieval of conference materials in the library of the institution. After reading the titles and abstracts, 23 studies were obtained; after reading the full text, 13 studies that met the standards were finally included in the systematic review (Fig. 1).

Study characteristics

In Table 1, 12 retrospective studies [9-21] were included in this study. The total sample size was 1,059. The injury factors included traffic accident, falling accidents, crush injury, fall damage, stab wound or cuts, firearm injury, and explosion injury. The degree of damage includes abdominal viscera, thoracic viscera, limbs fracture, craniocerebral injury and others. The subjects are all from the high altitude area of Western China (Sichuan, Qinghai and Tibet, etc.), and the majority of them are immigrants. The average altitude of the treatment site is above 2,200 meters. In addition, the results of quality evaluation show that 8 studies are A and 5 studies are B.

Treatment Strategy

In Table 2, the clinical intervention measures for HTS patients in high altitude area included in the study are summarized into 6 categories, including *prehospital emergency care*, *improving oxygen supply*, *replenish circulating blood volume*, *improving microcirculation*, *improving cardiopulmonary function* and *correcting acid-base balance*. The specific implementation measures are as follows:

I. In terms of prehospital emergency care, 9 treatment measures were reported in the included studies, among which 8 measures were reported with a frequency of n ≥ The most commonly reported measures were *hemostasis*, *transport of patients*, and *establish venous access* (n = 5). The second was *ventilation* and *bandaging* (n = 4); and the other measures included *fracture fixation* and *heat preservation* (n = 2~3).
II. In terms of improving oxygen supply, 3 treatment measures were reported in the included studies, among which 2 measures were reported with frequency of n ≥ *Long time and large flow oxygen supply* is the main intervention measure; the most reported flow range is 4-6 L / min (n = 6); the next is 6-8 L / min (n = 2).
III. In terms of replenishing circulating blood volume, 8 treatment measures were reported in the included studies, among which 6 measures were reported with a frequency of n ≥ The most reported measures include *the establishment of two or more vein channels*, *the volume of fluid infusion is 1-2 times of the volume of blood loss*, *the supplement of whole blood or self-return blood*, and *the regulation of fluid infusion speed by timely monitoring physiological data (blood pressure, pulse, urine volume and pulse pressure)* (n>5). Secondly, 7.5% sodium chloride solution + 6% hydroxyethyl starch solution (or 6% dextran solution) was injected intravenously (n = 3).
IV. In terms of improving microcirculation, 8 treatment measures were reported in the included studies, among which 4 measures were reported with a frequency of n ≥ The mostly reported measures were intravenous *dopamine* and *rewarming* (n=4-5), followed by *hydroxylamine* and *phentolamine* (n=2).
V. In terms of improving cardiopulmonary function, 2 treatment measures were reported in the study, which were intravenously injected into *Lanatoside C* (n=2) and *cedilanid* (n=2).

VI. In terms of correcting acid-base balance, the treatment measures reported in the study were intravenous injection of *5% sodium bicarbonate* (n=4).

Outcome of treatment

In Table 3, the average death rate of patients with HTS at high altitude was 10.84 ± 9.97% (excluding case report [18]; in the study, a total of 10 causes of death were reported, 80% (8/10) of which were caused by post shock complications; the highest reported complications were Adult Respiratory Distress Syndrome (ARDS) (11.00%), Multiple Organ Failure (MOF) (7.00%) and Pulmonary Infection (PTPI) (6.00%).

Discussion

Summary of the findings

This systematic review comprehensively analyzed the clinical treatment decision-making of HTS patients in high altitude area, and found that the low temperature and low oxygen environment had an important impact on the whole treatment process of patients, including oxygen supply, rehydration and medication. Based on the qualitative analysis of the included literature, this article summarizes the basic treatment measures and fatal complications of HTS patients in high altitude area at this stage, which provides evidence-based basis for the early treatment of severe trauma patients at high altitude.

Prehospital Emergency Care

Effective on-site emergency measures help to reduce the risk of shock deterioration in trauma patients [22, 23]. In the included studies, the measures with high frequency were hemostasis, bandage, ventilation, and establishment of venous access [9–10, 14–15, 18]. Due to the influence of environmental factors in high altitude area, trauma patients have poor ability of stress and compensation for trauma and blood loss. When the blood flow is 300–500 ml, it may lead to severe shock [19]. In addition, hypoxia can also lead to rapid pathological damage of hemodynamics, endocrine and oxygen free radical metabolism [24]. Therefore, once hemorrhagic shock occurs in high altitude area, not only is the condition serious, but also many complicated and refractory complications will be caused under the catalysis of hypoxia partial pressure. According to Mingfang Guo's study [9], the patients used pressure bandage, clamp and tourniquet to perform temporary hemostasis during prehospital emergency care; early ventilation and oxygen supply were carried out through cricothyroidotomy; at the same time, vein channel was established to carry out early rehydration treatment. In addition, the geographical situation of China's high altitude area is dominated by mountains and gullies, with limited transportation capacity and rapid development of the disease, effective prehospital emergency care measures have become an important basic link affecting the success of HTS patients' treatment [11]. Especially in the earthquake or war and other disasters, HTS patients are limited by the condition of medical evacuation. The treatment technology (recovery, operation) moves forward to the site of rescue, which may be an effective measure to improve the treatment effect of patients in special environment [18].

Improving hypoxia

Low oxygen partial pressure is the main factor that leads to the rapid development of HTS in high altitude area; the treatment measures to improve the patients' hypoxia status run through the whole process of anti-shock treatment [25]. In Qing Zhao's study, 14 patients with severe shock and 40 patients with moderate shock were reported to have an average oxygen inhalation time of 80.25 hours and 32.5 hours respectively [16]. According to Jizhi Ma's research, oxygen should be given at a flow rate of 6-8L /min in the early stage of HTS patients' treatment, because the high concentration, large flow and continuous oxygen supply in the early stage of HTS patients' treatment can improve the arterial oxygen tension, increase the differential pressure of blood and tissue oxygen, promote the diffusion of blood oxygen to the tissue, so as to achieve the purpose of improving tissue hypoxia in varying degrees [17]. Because the high oxygen supply concentration is easy to lead to oxygen poisoning [26], it is necessary to adjust the oxygen supply flow according to the recovery of shock symptoms. In the study of Fengju Tian and Yumei Ma, when the patient's condition improves, the oxygen flow can be reduced to 2-4L/ min, and the oxygen concentration is still maintained at 80% [20, 21]. In addition, most researchers believe that [10, 17, 20, 21], the effect of oxygen inhalation by mask is better than that by nasal catheter or nasal plug.

Replenishing circulating blood volume

The pathological basis of shock is the microcirculation obstacle caused by the sharp decrease of effective circulation blood volume and insufficient tissue perfusion; the "limited fluid replenishment" has become the main measure to deal with the circulatory blood volume replenishment of HTS patients in high altitude area [3]. When patients were transferred to hospital for treatment, usually 2–3 vein channels would be established for fluid infusion and anesthesia at the same time [20]. At the same time, in the process of rehydration, it is necessary to monitor the patient's physiological indicators (blood pressure, pulse, urine volume and central venous pressure), and adjust the rehydration speed according to the monitoring situation [9]. According to Hongmin Lv's study, the volume of infusion within 24 hours is lower than that of patients in low altitude areas; in order to prevent the occurrence of pulmonary edema, brain edema and heart failure, it is appropriate to input 1-1.5 times of the volume of blood loss in the balance salt solution, no more than 2 times at most [15]. Previous study found that there was no significant difference between HSD and isotonic solution in reducing the mortality of HTS patients during resuscitation [27].

However, when patients with high altitude HTS receive 7.5% hypertonic saline/6% dextran (HSD) treatment, they can expand capillaries, reduce peripheral resistance, adjust body fluid distribution, improve microcirculation, maintain blood pressure, resist shock, and reduce the risk of pulmonary and brain edema [15]. In addition, some studies suggest that 2,000–2,500 ml glucose solution should be added in the process of rehydration, which can provide necessary energy for tissues and enhance the therapeutic effect of myocardial contractility [12, 14, 16, 18]. In terms of blood transfusion demand, Zhongjiang Yu believed that in the process of fluid replenishment, the effective blood replenishment amount should be judged according to the blood loss and the specific volume of blood cells; the

hematocrit should be maintained at more than 30%, so as to improve the oxygen carrying capacity of blood and improve the hypoxia of tissues [16].

Improving microcirculation

The rational use of vasoactive drugs is the main treatment measure to improve the microcirculation of HTS patients [28]. During the treatment of HTS patients, we can judge whether the blood vessels of the patients are spasmodic or dilated according to the information of skin color, temperature, fundus, blood pressure and urine volume. We can choose a reasonable drug to enhance the myocardial contractility and maintain the blood perfusion of important organs. Dopamine is the most reported vasoactive drug in the study; as a β receptor agonist, it can effectively enhance the cardiac contractility, improve cardiac output, selectively expand the visceral blood flow, especially the renal vascular perfusion [29]. It should be noted that HTS patients at high altitude are more sensitive to vasoactive drugs, and the drug concentration and input flow should be adjusted at any time according to the specific situation [10]. In addition, the temperature in high altitude area is low, the temperature difference between day and night is large, the shock caused by blood loss is easy to cause the patients' limbs to be wet and cold, and the rapid rehydration under low temperature environment will also aggravate the cold degree of patients, resulting in the increase of oxygen consumption of patients; therefore, heat preservation treatment is also an important measure to improve the microcirculation state of high altitude HTS patients.

In the study of Fengju Tian, it is believed that patients with mild hypothermia (35–36 ℃) only need to be covered with quilts; Hot water bags, electric baking lamps and other heating tools are not recommended to avoid the increase of peripheral circulation and tissue metabolism rate, thus increasing the consumption of oxygen and disturbing the collective compensatory function; for patients with moderate or severe hypothermia (central temperature < 35℃), measures such as rewarming blanket, adjusting room temperature, warming the venous fluid and body cavity flushing fluid to 37℃ can be taken to slowly raise the temperature to 35–36℃, too fast and too high temperature rise is not recommended to prevent shock aggravation (Fengju Tian, 2012).

Improving cardiopulmonary function

The hypoxic environment at high altitude has a great influence on the respiratory, circulatory, nervous and blood systems of human body; the hypoxic state can reduce the blood flow of coronary artery by 30% and increase the blood viscosity by 3–5 times compared with that of the low altitude. In the process of massive infusion and fluid replenishment during Anti shock, it is easy to cause cardiac failure of patients. It is important to protect and improve the cardiopulmonary function by giving patients a certain dose of myocardial nutrition medicine. Treatment measures shall be taken [30]. Digitalis preparations (such as Lanatoside C, cedilanid) can reduce the heart rate of HTS patients in high altitude area, enhance myocardial contractility, increase cardiac output and reduce central venous pressure [12]. According to Langjie Zaxi [14], when the patient's central venous pressure is high, arterial pressure is low, and enough vasodilators are replenished, the shock cannot be corrected, intravenous injection of 0.2–0.4 mg cediland can effectively prevent the occurrence of cardiopulmonary complications.

Improving acid-base balance

In the environment of hypoxia and partial pressure in HTS patients, due to severe hypoxia, the ability of lactating metabolism is weakened, which leads to the occurrence of acidosis [10]. Acidosis will not only accelerate the temperature drop and coagulation dysfunction of shock patients, but also aggravate the vasospasm of gastric mucosa and make it difficult to remove the reverse diffusion of H +, which can induce stress ulcer [10]. According to Langjie Zaxi, most patients in the early stage of shock do not need special treatment. With the correction of shock and the release of tissue hypoxia, acidosis can be corrected through the compensatory mediation of the body; however, when the shock lasts for a long time and there is no obvious improvement, it needs to be corrected with 5% sodium bicarbonate and blood gas analysis [14]. In the study of Zhao Jie and others [10, 15, 19], it is believed that early and low-dose administration of sodium bicarbonate can not only effectively control the occurrence of acidosis, but also better protect renal function and reduce the incidence of complications after shock.

Complications

ARDS, MOF and PTPI were reported more frequently in the complications of HTS patients' death in high altitude area.

Some studies have shown that the pulmonary arterioles contract, the vascular resistance increases, the pulmonary hypertension and the permeability of pulmonary capillaries increase, and the cerebral edema, pulmonary edema and ARDS are very likely to occur at the same time of hemorrhagic shock. This is also the main reason for implementing restrictive fluid replenishment and monitoring physiological indicators in the process of Soviet Union. Some studies believe that migration to or long stay in the high altitude will cause contracting of pulmonary arteries, increase of vascular resistance, pulmonary hypertension, and increase of the permeability of pulmonary capillaries. Hemorrhagic shock can easily cause cerebral edema, Pulmonary edema and ARDS, which is also the main reason for implementing restrictive fluid replacement and monitoring of physiological indicators during the resuscitation process [10, 13]. In addition, the high-altitude hypoxia environment leads to the compensatory increase of heart rate and cardiac output of HTS patients with altitude, which leads to fibrosis or scarring of necrotic areas of myocardium, thus aggravating the cardiopulmonary pathological factors in shock [11]. At the same time, trauma can change neuroendocrine function, cause sustained hypermetabolism and other adverse effects, and then cause renal failure; in the process of resuscitation, real-time use of furosemide is the main measure to prevent acute renal failure [12].

Limitations

The included studies in this systematic review are mainly based on clinical retrospective analysis, and the experience summary of HTS treatment in high altitude area was taken as evidence-based basis, with relatively low level of evidence. None of the included studies carried out blind evaluation of outcome indicators in the design process, nor did they carry out sample size estimation before the trial design. In

addition, there are few reports of measurement results in the study, which cannot form an effective quantitative analysis, resulting in the incomplete evaluation of evidence.

Conclusions

The level of oxygen supply, rehydration and other treatment strategies for HTS patients in high altitude area are different from those in low altitude areas. The dynamic changes of physiological indexes in the process of treatment is an important sign of adjusting the treatment plan. Effective prehospital first aid and rapid medical transport have a positive effect on patients' later rehabilitation.

Abbreviations

HTS: Traumatic hemorrhagic shock; CNKI: China national knowledge infrastructure; CBMdisc: China biology medicine disc; ARDS: Adult respiratory distress syndrome; MOF: Multiple organ failure; PTPI: Pulmonary infection; RCT: randomized controlled trial; MINORS: Methodological index for non-randomized studies; HSD: 7.5% hypertonic saline/6% dextran.

Declarations

Acknowledgment

Not applicable.

Authors’ contributions

LZ, SZ, CW and HQ were responsible for the survey, analyzed the data and was a major contributor in writing the manuscript. CD and YO were responsible for the collect the data. ML was responsible for the translate. All authors read and approved the final manuscript.

Funding

The study was supported by Military logistics research project from Army Medical University, China (No. 2019HQZX12).

Availability of data and materials

Not applicable.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1. Characteristics of Included Studies

Included studies	Study Design		Object of study					Average altitude of the treatment area (m)	Quality
	Type	Sample size	Sex (Men/Women)	Age	Injury factors▲	Damage situation△	Shock index		
Mingfang Guo, 1993	Retrospective	26	21/5	12-66	□□□	□	N/A	2,850	A
Litang Zhang. et al, 1994	Retrospective	126	102/24	2-52	□□□□□□	□□□	N/A	2,850	B
Wenkui Gao, 2000	Retrospective	69	55/14	6-65	□□□□	□□□	N/A	2,261	A
Zhongjiang Yu, 2004	Retrospective	270	246/24	2-74	□□□□	□□□□□	≥1	2,850	B
Wubin Han, 2005	Retrospective	28	21/7	21-42	N/A	□□□□	>1	3,700	A
Langjie Zhaxi, 2005	Retrospective	10	7/3	1.5-50	□□□	□□	>1	3,650	A
Hongming Lv, 2008	Retrospective	31	29/2	14-56	N/A	□□	N/A	2,850	B
Qing Zhao, 2009	Retrospective	52	52/18	11-60	□□□□	□□□□	/	3,100	A
Jizhi Ma, 2010	Retrospective	45	42/3	25-50	□□	N/A	>1.5	2,850	A
Xianjian He, 2011	Case report	1	1/0	24	□	□	1.37	4,200	B
Jie Zhao, 2011	Retrospective	316	248/68	35.9	□□□	□□□	>1	2,850	A
Fengju Tian, 2012	Retrospective	56	45/11	42.5±27.5	□□□	□□□	N/A	2,261	B
Yumei Ma, 2017	Retrospective	29	49/13	38.7±13.0	□□□	N/A	1.5±0.5	2,261	A

▲□ traffic accident, □ high falling□□ crush injury□□ fall and hurt, □ stab or cut, □ firearm injury, □ explosion injury; △□ abdominal viscera,□ thoracic viscera, □ limbs fracture, □ craniocerebral injury, □Other: Non organ injury; N/A, not available; A, high; B, middle.

Table 2. Evidence Based Intervention of HTS at High Altitude

Interventions	The amount of measures	Major measures	Included studies
Prehospital emergency care	9	Hemostasis	(1)(3)(6)(7)(10)
		Ventilation	(1)(3)(6)(7)
		Bandaging	(1)(3)(6)(7)
		Fracture fixation	(1)(3)(7)
		preoxygenation	(1)(3)(7)(10)
		Heat preservation	(3)(7)
		Transportation of patients	(1)(3)(6)(7)(10)
		Establish venous access	(1)(3)(6)(7)(10)
Improving oxygen supply	3	Long time and large flow oxygen supply (4-6 L/min)	(1)(2)(4)(7)(10)(13)
		Long time and large flow oxygen supply (6-8 L/min)	(9)(12)
Replenish circulating blood volume	8	Establish two or more vein channels	(1)(5)(11)(12)(13)
		the volume of fluid infusion is 1-2 times of the volume of blood loss	(2)(4)(7)(9)(11)(12)(13)
		Equilibrium liquid and electrolyte	(2)(3)(4)(10)(11)
		7.5% sodium chloride solution and 6% hydroxyethyl starch solution	(9)(10)(13)
		7.5% sodium chloride and 6% dextran solution	(7)(8)(12)
		the supplement of whole blood or self- return blood	(1)(2)(3)(4)(8)(9)(13)
		the regulation of fluid infusion speed by timely monitoring physiological data (blood pressure, pulse, urine volume and pulse pressure)	(1)(2)(4)(5)(6)(7)(8)(9)(11)(12)(13)
Improving microcirculation	8	Dopamine	(2)(3)(4)(6)(8)(10)
		Hydroxylamine	(4)(8)
		Phentolamine	(3)(8)
		Keep warm (patient, treatment room or infusion)	(5)(9)(12)(13)
Improving cardiopulmonary function	2	Lanatoside C	(4)(5)
		Cedilanid	(2)(6)
Correcting acid-base balance	1	5% sodium bicarbonate	(2)(6)(7)(11)

(1) Mingfang Guo, 1993, (2) Litang Zhang. et al, 1994, (3) Wenkui Gao, 2000, (4) Zhongjiang Yu, 2004, (5) Wubin Han, 2005, (6) Langjie Zhaxi, 2005, (7)Hongming Lv, 2008, (8) Qing Zhao, 2009, (9) Jizhi Ma, 2010, (10) Xianjian He, 2011, (11) Jie Zhao, 2011, (12 Fengju Tian, 2012, (13) Yumei Ma, 2017.

Table 3. Outcome of Treatment

Included studies	Cure	Transfer	Amputation	Death	Cause of death
Mingfang Guo 1993[9]	11	0	6	9	N/A
Litang Zhang 1994[10]	106	0	0	20	ARDS(6), PTPI(5), pulmonary edema(5), abdominal abscess(2), stress ulcer(1), knife edge crack(1)
Wengkui Gao 2000[11]	65	0	0	4	MOF(2), Not described (2)
Zhongjiang Yu 2004[12]	252	0	0	18	ARDS(5), MOF(5), stress ulcer(4), acute renal failure(2), PTPI(1), thoracic closed drainage tube accident(1)
Wubin Han 2005[13]	27	0	0	1	MOF(1)
Langjie Zhaxi 2005[14]	8	0	0	2	N/A
Hongming Lv 2008[15]	25	0	0	6	N/A
Qing Zhao 2009[16]	64	0	0	6	N/A
Jizhi Ma 2010[17]	43	1	0	1	TBI(1)
Xianjian He 2011[18]	0	1	0	0	N/A
Jie Zhao 2011[19]	285	0	0	31	N/A
Fengju Tian 2012[20]	54	0	0	2	MOF(1), septic shock(1)
Yumei Ma 2017[21]	29	0	0	0	N/A

MOF, Multiple Organ Failure; ARDS, Adult Respiratory Distress Syndrome; PTPI, Pulmonary Infection; TBI, Traumatic Brain Injury.

Figures

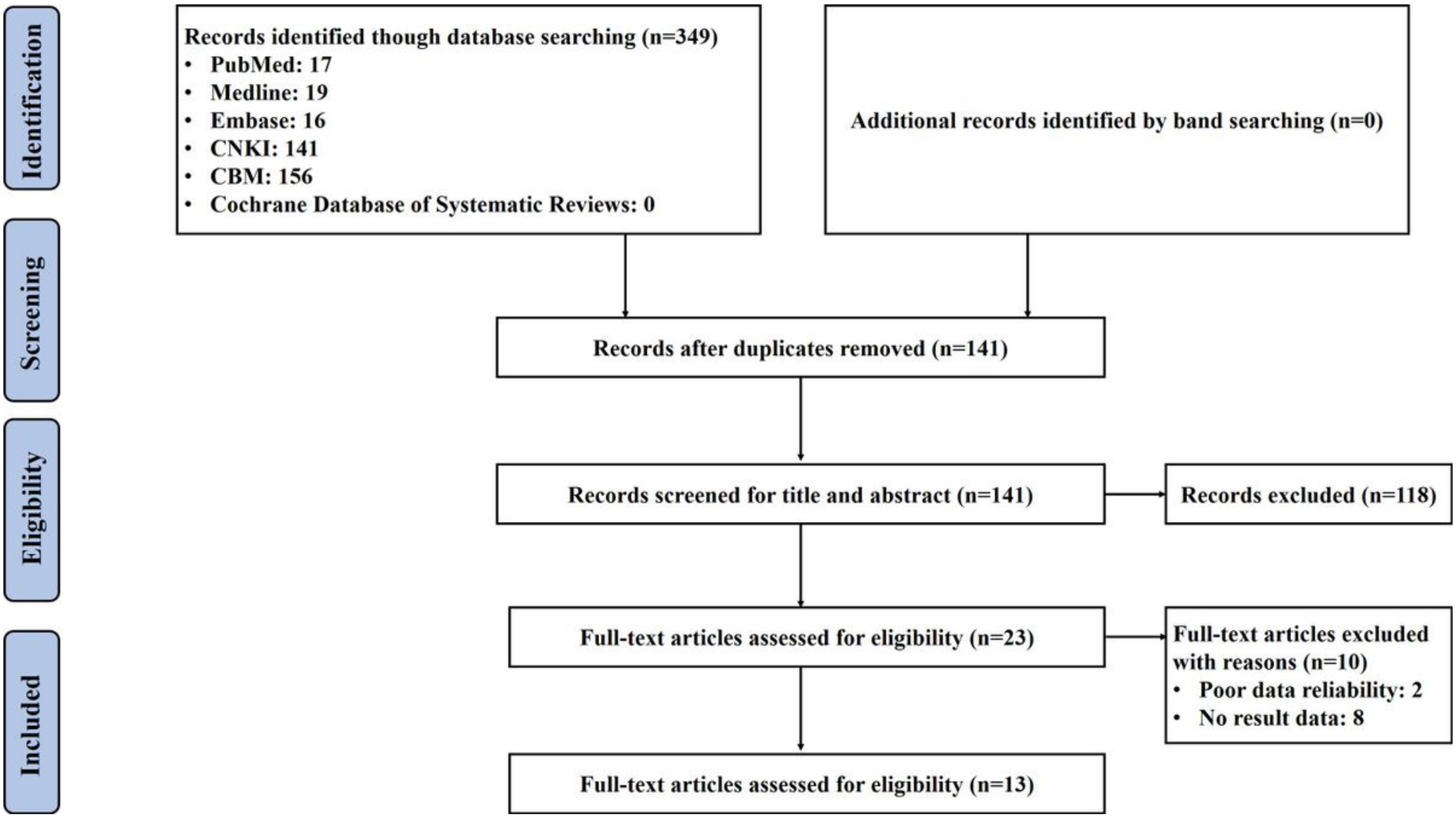

Figure 1

Flow chart of literature selection process.