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Clinical Application of Bilateral Proximal Lower Limb Tourniquet in the Emergency Treatment of Limb Fractures with Hemorrhagic Shock

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Abstract

Objective: To analyze the clinical application of bilateral proximal lower limb tourniquet in the emergency treatment of limb fractures with hemorrhagic shock. **Methods:** A total of 80 patients with limb fractures and hemorrhagic shock who were admitted to our hospital between February 2016 and April 2020 were selected for the study. Patients were divided into two groups according to their order of admission. The control group (40 patients) had a conventional tourniquet applied to the injured limb, while the experimental group (40 patients) had a bilateral proximal lower limb tourniquet applied in addition to the conventional tourniquet on the injured limb. We observed and recorded the 24-hour mortality rate, the incidence of tourniquet shock, the occurrence of postoperative thrombosis, skin, muscle, and nerve damage, and the time required for blood pressure to recover to the lower limit of the normal range. **Results:** The 24-hour mortality rate in the experimental group was 0.0%, significantly lower than the 12.5% in the control group, with a statistically significant difference ($P<0.05$). There was no statistically significant difference between the two groups in terms of the incidence of tourniquet shock, postoperative skin, muscle, and nerve damage, or postoperative limb thrombosis ($P>0.05$). Compared with the control group, the experimental group had a significantly shorter time for blood pressure to recover to the lower limit of the normal range ($P<0.05$). **Conclusion:** In the clinical emergency treatment of patients with limb fractures and hemorrhagic shock, using a bilateral proximal lower limb tourniquet significantly reduces the 24-hour mortality rate, promotes faster recovery of blood pressure to the lower limit of the normal range, and does not increase the risk of tourniquet shock or postoperative skin, muscle, nerve damage, or limb thrombosis, making it valuable for clinical application.

Keywords

Bilateral proximal lower limb; Tourniquet; Limb fracture; Hemorrhagic shock; Emergency treatment

Introduction

As the construction industry and transportation infrastructure in China rapidly develop, the number of patients with limb fractures is steadily increasing. Limb fractures are often accompanied by a high risk of hemorrhagic shock. If hemorrhagic shock is not corrected in a timely and effective manner, it can lead to death [1]. The clinical symptoms of hemorrhagic shock primarily include impaired consciousness, inadequate blood perfusion, and decreased blood pressure, with the condition progressing rapidly and potentially leading to death [2]. In the current clinical setting, it is crucial to develop scientific emergency measures for patients with limb fractures and hemorrhagic shock to shorten emergency response times, restore patient consciousness as soon as possible, and stabilize the patient's condition, ultimately improving prognosis [3]. In our hospital, the use of bilateral proximal lower limb tourniquets for the emergency treatment of patients with limb fractures and hemorrhagic shock has yielded favorable results, which are analyzed as follows.

1. General Data and Methods

1.1 General Data

This study selected 80 patients with limb fractures and hemorrhagic shock who were admitted to our hospital between February 2016 and April 2020. Informed consent was obtained from the patients or their families, and the study was approved by the hospital's ethics committee. Based on the order of admission, patients were divided into two groups: a control group (40 patients) and an experimental group (40 patients). In the control group, there were 23 males and 17 females, aged 20-61 years, with an average age of 36.2 ± 3.4 years. The types of injuries were as follows: 22 patients had unilateral lower limb injuries, and 18 patients had unilateral upper limb injuries. The causes of injury were: 17 cases of road traffic accidents, 13 cases of falls from height, and 10 cases of machine-crushing injuries. In the experimental group, there were 25 males and 15 females, aged 23-62 years, with an average age of 35.7 ± 4.1 years. The types of injuries were as follows: 24 patients had unilateral lower limb injuries, and 16 patients had unilateral upper limb injuries. The causes of injury were: 19 cases of road traffic accidents, 12 cases of falls from height, and 9 cases of machine-crushing injuries. There was no statistically significant difference in baseline data between the two groups ($P>0.05$).

1.2 Methods

Before hospital admission, patients had lost significant blood, resulting in insufficient circulatory volume and a high risk of peripheral circulatory failure. Patients exhibited signs of severe shock, such as acidosis, coagulopathy, hypothermia, and low hemoglobin, with insufficient myocardial oxygen supply, which could lead to cardiac arrest. After receiving the patients, the 120 emergency medical services initially performed bandaging and established venous access based on the patient's condition for fluid resuscitation. For patients in the control group, routine preoperative preparations were made, and emergency surgery was performed to explore, debride, and stop the bleeding. A conventional tourniquet was applied to the proximal end of the injured limb to significantly reduce bleeding, maintain a clear surgical field, and facilitate surgical procedures while preventing further tissue damage. In addition to these measures, patients in the experimental group were also treated with a bilateral proximal lower limb tourniquet. For lower limb injury patients, there was no need to apply a tourniquet to the injured side. After blood evacuation from both lower limbs using a blood-evacuating band, the tourniquet was inflated to block blood flow to the lower limbs. After continuous use of the tourniquet, the patient's blood pressure significantly increased. Once effective hemostasis was achieved during surgery, rapid blood and fluid resuscitation was initiated. As the heart rate decreased and blood pressure stabilized, the tourniquet pressure on one lower limb was gradually reduced to restore blood supply to that limb. After the patient's vital signs stabilized, the tourniquet on the other lower limb was gradually released. Once effective hemostasis was achieved, and the patient's systolic blood pressure remained above 90 mmHg for over 10 minutes, the tourniquet on one lower limb was released, with cuff pressure reduced by 15 kPa every 5 minutes. After completely releasing one side, if the systolic blood pressure remained above 90 mmHg for 10 minutes, the same gradual release process was applied to the other side. This slow release of tourniquet pressure allowed for gradual restoration of blood flow to the lower limbs, effectively preventing tourniquet shock. The same team of medical personnel performed resuscitation procedures for both groups, with equal rates of blood and fluid resuscitation.

1.3 Observation Indicators

The 24-hour mortality rate, the incidence of tourniquet shock, the occurrence of postoperative thrombosis, skin, muscle, and nerve damage, and the time taken for blood pressure to recover to the lower limit of the normal range were recorded.

1.4 Statistical Analysis

The experimental data were statistically processed using SPSS 21.0 software. Count data were expressed as percentages (%), and intergroup comparisons were conducted using the chi-square test. Measurement data were expressed as mean ± standard deviation ($\bar{x} \pm s$), and intergroup comparisons were conducted using the t-test. A P-value of less than 0.05 was considered statistically significant.

2. Results

2.1 Observation of 24-Hour Mortality, Tourniquet Shock, and Postoperative Complications

The 24-hour mortality rate in the experimental group was 0.0%, significantly lower than the 12.5% in the control group, with a statistically significant difference (P<0.05). There was no statistically significant difference between the two groups regarding the incidence of tourniquet shock, postoperative skin, muscle, and nerve damage, or postoperative limb thrombosis (P>0.05), as shown in Table 1.

Table 1. Observation of 24-Hour Mortality, Tourniquet Shock, and Postoperative Complications (n, %)

Group	Number of Cases	24-Hour Mortality	Tourniquet Shock	Postoperative Skin, Muscle, and Nerve Damage	Postoperative Limb Thrombosis
Control Group	40	5 (12.5)	0 (0.0)	1 (2.5)	0 (0.0)
Experimental Group	40	0 (0.0)	2 (5.0)	3 (7.5)	2 (5.0)
χ^2		11.2853	3.2821	1.6842	3.2821
P		0.0008	0.0700	0.1944	0.0700

2.2 Observation of the Time Required for Blood Pressure to Return to the Lower Limit of the Normal Range

Compared with the control group, the time required for blood pressure to return to the lower limit of the normal range in the experimental group was significantly shorter (P<0.05), as shown in Table 2.

Table 2. Observation of the Time Required for Blood Pressure to Return to the Lower Limit of the Normal Range ($\bar{x} \pm s$)

Group	Number of Cases	Time for Blood Pressure to Return to the Lower Limit of the Normal Range (hours)
Control Group	40	49.17±7.64
Experimental Group	40	18.57±3.03
t		37.2312
P		0.0001

3. Discussion

Although modern medicine has made significant advances in the treatment of severe hemorrhagic trauma, severe trauma accompanied by massive hemorrhage continues to have a high clinical mortality rate [4]. For patients with open fractures or major limb amputations involving large vascular injuries, the risk of hemorrhagic shock is high due to severe bleeding from open arterial and venous injuries [5]. During surgical exploration, achieving effective hemostasis may be challenging, leading to prolonged surgery and large amounts of intraoperative blood loss, with circulatory recovery taking a long time [6]. Excessive fluid resuscitation may further accelerate blood loss, resulting in hypothermia, metabolic acidosis, and coagulopathy [7]. High surgical risks, impaired oxygen delivery to the heart and brain, low hemoglobin, and blood dilution may lead to intraoperative cardiac arrest. In clinical practice, when treating patients with open arterial and venous injuries, proportional blood component transfusion, permissive hypotension resuscitation, and restrictive fluid resuscitation are critical to correcting and preventing coagulopathy and traumatic shock [8]. However, in cases of severe blood loss, patients may experience hypotension (systolic pressure

<50mmHg), persistent oliguria or anuria, low glomerular filtration pressure, and inadequate coronary and cerebral perfusion. Clinical studies have shown that moderate-volume balanced fluid resuscitation, allowing blood pressure to remain within a permissive hypotension range until effective surgical hemostasis is achieved, is beneficial [9]. The goal is to restore tissue perfusion without significantly disrupting the body's compensatory mechanisms and internal environment. Temporary application of bilateral proximal lower limb tourniquets can rapidly increase venous return to the heart, stabilize heart rate and blood pressure, and prevent excessive fluid resuscitation before achieving effective hemostasis, thereby maintaining stable vital signs [10]. This method significantly reduces the mortality rate due to hemorrhagic shock, laying a solid foundation for performing emergency surgical debridement and exploration and improving limb salvage rates.

In cases of severe shock or peripheral circulatory failure, blood perfusion to critical organs such as the kidneys, brain, and heart may become severely compromised, potentially leading to irreversible damage to brain cells and myocardial cells [11]. Additionally, it increases the risk of serious complications such as infection, coagulopathy, acute respiratory distress syndrome (ARDS), and acute renal failure, with complex injury mechanisms. Not only do clinicians face a series of acute-phase complications, but they also must contend with the long-term economic burden caused by chronic disability. The process from drawing blood for testing to intravenous infusion of plasma or red blood cells typically takes 30 to 60 minutes. During this time, patients with severe blood loss and extremely low blood pressure are at great risk. Using a blood-evacuating band on the uninjured lower limb to displace blood into the proximal body region, similar to performing an auto-transfusion before actual transfusion, increases blood volume in the torso and improves effective circulatory blood flow [12].

In this study, the experimental group had a significantly shorter time for blood pressure to return to the lower limit of the normal range compared to the control group ($P<0.05$). The results indicate that the experimental group achieved faster recovery of systolic blood pressure to the lower limit of the normal range, thereby enhancing the anti-shock effect and providing a better foundation for transfusion, fluid resuscitation, anesthesia, and surgery.

In this study, the 24-hour mortality rate in the experimental group was 0.0%, significantly lower than the 12.5% in the control group, with a statistically significant difference ($P<0.05$). The results show that the use of a bilateral proximal lower limb tourniquet can significantly reduce the 24-hour mortality rate. This method effectively blocks blood flow to the lower limbs, optimally redistributing the body's limited blood supply without requiring excessive fluid resuscitation before achieving effective hemostasis. This allows for the rapid recovery of blood pressure to the lower limit of the normal range, ensuring adequate blood supply to vital organs. With the same rate and type of fluid resuscitation, patients in the experimental group recovered blood pressure faster. The control group required more fluid resuscitation, leading to greater blood dilution, reduced hemoglobin, and impaired oxygen transport. The larger volume of fluid required before achieving adequate hemostasis in the control group diluted the blood and resulted in significant loss of coagulation factors, making it difficult to form effective clots, or causing existing clots to dislodge, worsening the bleeding.

In this study, there was no statistically significant difference between the two groups in terms of the incidence of tourniquet shock, postoperative skin, muscle, and nerve damage, or postoperative limb thrombosis ($P>0.05$). The results indicate that the use of a bilateral proximal lower limb tourniquet for emergency treatment of patients with limb fractures and hemorrhagic shock does not increase the incidence of tourniquet shock or postoperative skin, muscle, nerve damage, or limb thrombosis. In actual clinical practice, to effectively prevent tourniquet shock, the tourniquet should be slowly and gradually deflated, and the duration of tourniquet use should be minimized while ensuring effective anti-shock treatment.

4. Conclusion

In conclusion, the use of a bilateral proximal lower limb tourniquet for emergency treatment of patients with limb fractures and hemorrhagic shock can significantly reduce the 24-hour mortality rate, promote faster recovery of blood pressure to the lower limit of the normal range, and does not increase the risk of tourniquet shock, postoperative skin, muscle, nerve damage, or postoperative limb thrombosis, making it valuable for clinical application.

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