Treatment for 332 cases of lower leg fracture in “5.12” Wenchuan earthquake

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【Abstract】Objective: To retrospectively analyze the medical treatment of 332 patients with lower leg fracture in Wenchuan earthquake admitted in West China Hospital.

Methods: From May 12, 2008 to June 15, 2008, 332 patients with lower leg fracture injured in Wenchuan earthquake were treated in our hospital. The data on trauma condition and clinical treatment were collected and analyzed.

Results: Among the 332 cases of lower leg fracture, there were 179 cases of open fracture, accounting for 53.9%, in which 91% belonged to Gustilo II or III injury with serious pollution. Many patients had posttraumatic complications, vascular and nerve injury, wound infection or osteofascial compartment syndrome. After medical treatment, blood vessels were reconnected, wound surface was repaired and wound infection was under control.

Conclusion: For the patients with lower leg fracture in earthquake, we followed the principle of “complete debridement - restoring the continuity of bone bracket - timely recovering blood supply of limbs and repairing nerve damage - repair the wound surface at stage I or II” so as to reduce the incidence of amputation and infection.

Key words: Earthquakes; Leg; Fractures, bone; Wounds and injuries

The “5.12” Wenchuan earthquake in China is one of the most devastating earthquakes for centuries, which caused more than 90,000 people injured and hospitalized. Totally 1,410 patients were admitted into orthopedics department of our hospital, including 332 cases of lower leg fracture (23.5%). Leg fractures in earthquake are often caused by high energy injury and most cases are severe. External forces not only destroy the skin on middle and lower tibia, but also damage muscles, blood vessels and nerves in deep tissue. Because of the delayed diagnosis and treatment, patients are in high risk of complications, limb necrosis and infection.

METHODS

General data

During the “5.12” Wenchuan earthquake, 332 patients with lower leg fracture were admitted into our department, including 194 males and 128 females, aged from 8 years to 99 years (mean 38.5 years). There were 140 cases of blunt injury (42.2%), 113 crush/buried injury (34.0%), 79 falling injury (23.8%). The compression time was from 30 minutes to 48 hours, 5.2 hours on average. The time period from injury to treatment was 1-64 hours, 23.3 hours on average. There were 153 patients (46.1%) with closed fracture and 179 patients with open fracture (53.9%). In open fracture, according to Gustilo classification, there were 16 cases (8.9%) of Gustilo I, 78 (43.6%) Gustilo II and 85 (47.5%) Gustilo III.

Examinations

Patients underwent the laboratory tests immediately after the arrival. The main indexes were as follows: hemoglobin, hematocrit, alkaline phosphatase, albumin, creatinine, blood urea nitrogen, electrolytes, etc. Meanwhile, radiological examinations were conducted, including abdominal B-type ultrasound, X-ray in chest and injured limbs, CT or MRI.

After re-examination and injury classification, patients with severe injury were given systematic supportive treatment according to the “ABC” principle. First, the airway was usually checked to observe whether the airway was unobstructed or wheezy phlegm, glossocoma, “three depression sign” existed. Second,
the ventilation function was assessed, including the strength of cough, breathing mobility and so on. Third, the effective capacity of circulation was assessed and the main indexes included blood pressure, pulse, urine output, etc. If pulse pressure difference was decreased (<30 mm Hg), pulse was accelerated and urine output decreased, it indicated low blood volume and the doctors should pay attention to fluid replacement. Urine output <30 ml/h suggested renal infusion deficiency. The renal function can be monitored by detecting the urine volume, serum creatinine and urea nitrogen. Doctors can monitor the condition of digestive system through abdominal signs (abdominal pain, distention and bowel tones), and characteristics of vomit and stool.

Smear and bacterial culture of secretion were done routinely for open wound. The patients with open fractures were classified according to Gustilo classification. After the trauma condition was stabilized, the patients with injury grade < Gustilo II and injury time < 12 hours were given debridement, suture and internal fixation, while the others were given wound debridement and drainage stent external fixation. The patients with closed fracture were given manipulative reduction, plaster or splint external fixation, selective open reduction and internal fixation later. If possible, anastomosis or bridge grafting of injured blood vessels and nerve should be timely conducted. The patients with infection or necrosis should be given repeated debridement. The amputation should be decisively done for the patients with smash injury as soon as possible. Open decompression should be performed for the suspected osteofascial compartment syndrome.

**RESULTS**

**Injury of blood vessels**

Among all 332 cases, 24 patients had vascular injury (7.5%). In 153 cases of closed fracture, there were 9 patients associated with vascular injury, including 5 with popliteal artery or vein injury, 2 anterior tibial artery or vein injury and 2 posterior tibial artery or vein injury. There were 4 patients with complete vascular rupture, 3 with partial vascular rupture and 2 with extensive contusion thrombosis. Six patients were directly sutured, while the other 3 were bridge-grafted with ipsolateral great saphenous vein. In 179 cases of open fracture, there were 16 patients associated with vascular injury (8.9%), including 7 with popliteal artery or vein injury, 5 anterior tibial artery or vein injury and 4 posterior tibial artery or vein injury. There were 8 patients with complete vascular rupture, 2 with partial vascular rupture and 6 with extensive contusion thrombosis. Nine patients were directly sutured, while the other 7 were bridge-grafted with ipsolateral great saphenous vein. The revascularization was good in all patients after operation.

**Nerve injury**

Totally, there were 36 cases of nerve injury (9.6%). In 153 cases of closed fracture, there were 11 patients associated with nerve injury (7.2%), including 5 tibial nerve injury and 6 common peroneal nerve injury. There were 4 patients with complete vascular rupture, 2 with partial vascular rupture and 6 with extensive contusion and regional crush injury. For the patients with complete and partial vascular rupture, the adjacent joint could be directly repaired after lysis. Four patients with contusion and regional crush injury just underwent epineurium lysis.

In 179 cases of closed fracture, there were 21 patients associated with nerve injury (11.7%), including 9 tibial nerve injury and 12 common peroneal nerve injury. There were 11 patients with complete vascular rupture, 4 with partial vascular rupture and 6 with extensive contusion and regional crush injury. For the 11 patients with complete vascular rupture, the vessels were directly repaired in 7 cases, bridge grafted with free saphenous nerve in 4 cases. Six patients with contusion and regional crush injury just underwent epineurium lysis.

**Wound infection**

All 153 patients with closed fracture were admitted to hospital and underwent plaster or splint external fixation and selective operation. No wound infection was observed. Among 179 patients with open fracture, 7 had gas gangrene and 32 had non-specific infection. A total of 31 patients had amputation, including 24 with severe crush injury and 7 with gas gangrene. Twenty-three patients had below-knee amputation and eight had above-knee amputation. No serious infections were observed after amputation.

**Osteofascial compartment syndrome**

At admission, 28 patients (8.4%) were diagnosed as having osteofascial compartment syndrome of lower leg, including 20 patients with closed fracture and 8 with open fracture. All patients underwent open decomp-
pression and delayed suture. Three patients had acute renal failure. After giving fluid expansion, diuresis, alka-
lization of urine and hemodialysis, their renal function
turned to normal

Fracture
After admission, 153 patients with closed fracture firstly received plaster or splint external fixation. At stage
II, 70 patients underwent selective open reduction, plate
and screw internal fixation, and the other 83 patients
underwent closed reduction and internal fixation of in-
tramedullary nail with lock. The 179 patients with open
fractures of lower leg firstly had debridement after
admission. Eighteen cases of Gustilo I fracture were
treated with open reduction, plate and screw internal
fixation; 15 cases of Gustilo II fracture were treated
with open reduction and internal fixation of intramedul-
larly nail with lock. Eighty-six patients were given stent
external fixation, 28 transcalcaneal traction and 32 plas-
ter external fixation.

Wound repair
Totally 32 cases of non-specific infection underwent
debridement and vacuum sealing drainage (VSD). Then
according to bacterial culture results of wound secretion,
the dosage of antibiotics was adjusted. All wounds
healed smoothly afterwards. Sixteen patients had skin
and soft tissue defects, in which 3 patients received
delayed suture, 6 delayed dermatoplasty and 7 flap
transfer (local ipsilateral leg rotation flap in 2 cases,
sural nerve nutrient flap in 3 cases and saphenous neu-
rotrophic retrograde flap in 2 cases)

DISCUSSION

Treatment of vascular injury
In "5.12" Wenchuan earthquake, lower leg fractures
are mostly high energy injury, combined with vascular
and nerve injury. In 332 cases of lower leg fractures,
there were 25 cases of vascular injury (7.5%). Leg in-
jury combined with vascular injury can be easily diag-
nosed if fracture exists, and the clinicians usually think
of vascular injury. The vascular injury of lower leg with-
out fractures is easily miss-diagnosed and often con-
sidered as serious soft tissue injury.

If the patient had fast local bleeding, rapidly in-
creased pressure, apparent soft tissue swelling, low
skin temperature and pale skin color, he was diagnosed
as having artery injury. If the patient had such manifes-
tations as slow swelling, distal cyanosis and skin
cyanosis, he was diagnosed as having venous injury.
After partial rupture of blood vessels or major vascular
injury, blood flow went through the collateral circulation
or vascular pulsation conduction. Before vascular throm-
busis caused by vascular contusion, the local blood
circulation and vascular pulsation still existed, leading
to the miss-diagnosis of vascular injury. The earthquake
injury patients had been oppressed too long and the
leg became swelling, which increased the difficulty of
diagnosis. Therefore, for the suspected patients with
vascular injury, it is suggested to repeatedly perform
examinations, and observe the local swelling, arterial
change, skin temperature and color. Moreover, vascu-
lar ultrasound or angiography should be conducted to
confirm the diagnosis.

For repairing vascular injury, actively treat life-threat-
ening complications and rebuild a remote blood circu-
lation within 8 hours. The principle of repairing vascular
injury is to ensure that the vessels are anastomosed
under low tension. After debridement, for vascular de-
fect<2 cm, perform end-to-end anastomosis; for defects
within 2-3 cm, according to the pressure on ananomoses
during operation, liberate the broken end of vessels and
adjust the degree of joint flexion to reduce vascular
tension; for defects >3 cm, carry out the great saphen-
ous vein autografting. Sharp injury of vessel breakage
<1/2 of circumference should be repaired, while vascu-
lar grafting should be done for the defects>1/2 of cir-
cumference or over 3 cm. In this group, 18 cases
(75%) of vascular injuries could be sutured directly,
which was related to their injury mechanism. In open
fractures, the displacement of fractured bone mostly exacer-
bates vascular injury, increasing the technical
difficulty of direct suture. In that condition, free bridge
grafting of ipsilateral great saphenous vein need to be
performed.

The postoperative treatments focus on keeping the
body temperature, anti-infective, anti-coagulant and anti-
convulsive therapy. At the same time, doctors should
pay attention to the systemic observation and treat-
ment to prevent renal damage caused by the release of
myoglobin and K+; and prevent generating oxygen free
radicals in reperfusion of ischemic tissue, which can
aggravate the progressive injury of skeletal muscle and
vascular endothelium.
Treatment of nerve injury

For tibial and fibular fractures associated with vascular and nerve injury, early survival of limbs depends on the timely diagnosis and treatment of major artery injury, but final functional recovery depends on the results of fracture and nerve repairs. Therefore, we should firstly make an accurate diagnosis, carefully check whether clinical manifestations of nerve injury exist or not, and investigate the degree of injuries. The tibial and fibular open fracture of earthquake injury was severe, and the patient was not able to complain or cooperate in physical examination due to pain or consciousness disturbance, which made it difficult to diagnose nerve injury. Therefore, the patients with suspected nerve injury should be carefully examined before operation. For the patients with poor systemic condition and consciousness disturbance, re-examine when the systemic conditions were improved and regained consciousness. Vascular injury and nerve injury are often associated, and the patients with vascular injury are often accompanied by varying degrees of nerve damage. For the patients with suspected nerve damage, it is necessary to detect both blood vessel and accompanied nerve. Use microsurgical techniques to suture nerve under no pressure.

After debridement, small nerve defect can be directly sutured. The big defect, according to intraoperative condition, liberate the free fractured ends, flex neighboring joints to reduce tension, directly repair defects and perform plaster fixation after operation. If tension is too large to be directly repaired, free nerve graft is needed. In the study, nerve rupture caused by closed fracture can be directly repaired, while in nerve injury caused by open fracture, 4 patients received free bridge-grafting of saphenous nerve. It may be due to the injury mechanism, i.e. open fractures often result in long-segmental nerve damage because of high energy when injury occurs. There were 18 cases of common peroneal nerve injury, accounting for 56% of all nerve injury, because the common peroneal nerves are superficial, with less soft tissue around.

Fracture treatment

External fixator for bone fracture is more and more widely used in clinic. It has potential advantages in the treatment of extensive soft tissue injury and defects, such as open fracture, comminuted fracture, multiple fracture, fracture associated with wound infection, etc. In earthquake injury, the serious pollution of fracture wound surface inevitably causes infection. Besides, incomplete debridement can cause infection, too. On the fractured leg, soft tissue is thin and blood supply at inferior segment of lower leg is poor. As external fixators, screws have no anti-infection ability, once infection happens, wound and nail sites can be easily infected. Therefore, it is necessary to debride wound thoroughly and maintain the nursing care for screw trajectory so as to prevent infection.

The fracture reduction and stable fixation after debridement is necessary for the treatment of open fracture. During the fixation, avoid damaging blood supply. External fixation combined with some internal fixation is conducted for lower leg open fracture: after thorough debridement, reduce large bone blocks or slices, unstable spiral or oblique fracture completely, avoid stripping periosteum, utmostly reduce the direct operating on bone segments. According to the sizes of bone blocks or slices and the stability of fractured ends, 1-3 bone screws should be used to connect the separated bone blocks with fractured ends.

For the fractures with closed wound, doctors should pay attention to the maintenance of an effective fixation or traction. For the patients requiring internal fixation, if no signs of wound infection are observed one week after injury, they can undergo open reduction and internal fixation.

Wound repair

The patients with earthquake crush syndrome usually have poor general condition. The patients are given decompressive fasciotomy or amputation, which have wound surface left. Renal replacement therapy is given at the same time, which may induce wound leakage, errhysis and arterial bleeding might occur. These wounds should be sutured as soon as possible to reduce the risk of wound leakage and infection. If the wound is infected, change dressing and timely debride to remove necrotic tissues. The silver ion antiseptic dressing can be used to treat wound infection and promote wound closure as early as possible. Besides partial pressurization, suture and bandaging, vascular embolization can be used for hemorrhaghe of blood vessels on wound surface.

The wound of Gustilo III a fracture can be directly
closed after complete debridement. Before suture, tension must be reduced by skin relaxation and free skin graft implantation. Since Gustilo III b fracture is associated with soft tissue defect due to severe crush injury, based on the degree and size of soft tissue crush injury on lower leg and the characteristics of tissue flaps, select the adjacent tissue to translocate and cover the wound. If the soft tissue defect is small and the surrounding skin is normal, the local skin flap or fascial flap transplantation is recommended. If skin defect is large and deep tissues such as bone, nerves, tendons, blood vessels are exposed, distal skin flap is recommended. For skin defects in the upper leg, muscle avulsion and osteomyelitis, muscle flap should be used for repair. Vascular anterograde or retrograde island flap, for its rich blood supply, strong anti-infection ability, safety and feasibility, is used for soft tissue defects in extremities, especially for lower leg wound repair. If the patient has a large area of soft tissue defects in extremities and no pedicle flap or island flap around can be used, the latissimus dorsi musculocutaneous flap grafting for wound coverage is a good choice.

It is found that the nutrient vessels around cutaneous nerve play an important role in blood supply of skin. The small saphenous vein-sural nerve and great saphenous vein-saphenous neural flap have rich vascular net, and nerve-accompanying artery and major veins are thick, so survival rate of transferred flap is high. In this group, 7 cases underwent skin flap transfer, including 3 with sural nerve nutrient flap, 2 with saphenous nerve nutrient retrograde flap, and all survived.

In conclusion, for patients with lower leg fractures caused by earthquake injury, based on the principles of "complete debridement- restoring the continuity of bone bracket - timely recovering blood supply of limbs and repairing nerve damage-repairing wound surface at stage I or II", doctors should fix the fracture with external fixation stent and apply micrological technique to repair vascular and nerve damage, so as to reduce the incidence of amputation and wound infection and promote fracture healing.

REFERENCES


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