In-hospital low-cost custom made VAC: Effective method for reducing infection in late presenting Open lower limb fractures in overburdened Indian hospitals

Towseef Ahmad Bhat^{a,*}, Rouf Ibrahim^b, Tariq Ahmad Bhat^c, Aejaz Ahmad Bhat^d

^a Pt. JLN Govt. Medical College, Chamba, HP, India¹

^b SKIMS MC Bemina, Srinagar, India

^c Govt Sub district Hospital, Chadoora, Budgam, J and K, India¹

^d Registrar, Physical Medicine and Rehabilitation, GMC, Srinagar, India¹

ARTICLE INFO

Article history:

Received 5 October 2017

Received in revised form 7 November 2017

Accepted 23 November 2017

Available online 24 November 2017

Keywords:

VAC

Low cost

Tibia

Femur

Fracture

ABSTRACT

Background: Open fractures are still associated with troublesome rates of infection. Thorough debridement irrigation and antibiotic cover are of paramount importance irrespective of the fixation method. VAC therapy is a well known method of accelerating the wound healing and decreasing the infection in non healing ulcers. The main drawback of VAC therapy is requirement of a special equipment and high cost. We in our hospital are using low cost custom made VAC therapy for non healing ulcers in lower socio-economic people and have seen extremely good results in wound healing and infection control.

Objective: To evaluate the role of pre operative low cost custom made VAC therapy as an adjunctive method of decreasing the rates of infection in late presenting lower limb open fractures.

Methods: A retrospective study of 26 open femur and tibia fractures for which low cost VAC therapy was used between January 2014 to January 2017.

Results: 2 out of 26 cases (7.4%) ended up with deep infection.

Conclusion: Pre operative in-hospital low cost custom made VAC therapy is a useful adjunctive method of reducing infection rates in late presenting open fractures.

© 2017

1. Background

The treatment of open fractures has come a long way from early amputation in 1850's to present day complex multidisciplinary surgeries.¹ Despite tremendous advances in orthopaedic surgeries open fractures are still associated with significant morbidity and disability.² The standard principles which are to be followed to achieve a satisfactory outcome in open fractures are proper wound irrigation, thorough wound debridement, proper antibiotic cover and early bone stabilization. Other factors which certainly play important role are timing of initial surgical intervention, early wound closure, fixation method, and negative pressure wound therapy or vacuum assisted closure (VAC).^{3–8}

The problem about open fractures gets further complicated in countries like India where 70% population live in rural areas with limited health care facilities. The problem of inadequate washing, incomplete debridement and improper wound closure at peripheral hospitals before reaching the tertiary care hospitals often make the problem worse. Further unavailability of operating room in overburdened tertiary care hospitals at right time further complicates the problem.

Negative pressure wound therapy can be used as an adjunctive therapy to control the infection and aid in fracture union. New Vacuum-assisted closure (VAC) was pioneered by Argenta LC and Morykwas M in 1993 for treatment of non-healing leg ulcers.^{9,10} However cost of the commercially available portable VAC Kit is not affordable for most of the patients in our setup.

We routinely a hospital based low cost custom made VAC for non healing ulcers in our hospital with excellent results. We occasionally use the same for late presenting open fractures with unhealthy wounds before going for definitive bony fixation.

* Corresponding author.

E-mail addresses: towseefortho@gmail.com (T.A. Bhat), ibrahimrouf@gmail.com (R. Ibrahim), bhatariq@gmail.com (T.A. Bhat), aejzabhat92@gmail.com (A.A. Bhat).

¹ Former SR Ortho SKIMS MC Bemina Srinagar, India.

2. Materials and methods

The study is a retrospective study conducted between January 2014 to January 2017. We collected data about the open fractures of tibia and femur for which hospital based pre operative VAC was done. Among 32 cases with open femur and tibia fractures we could get complete information about 26 cases which were included in the study. VAC therapy is a routine in our hospital for non healing ulcers. We occasionally use it for late presenting open fractures. We decided to collect their data realizing they are proving to be very effective in infection control and are very economical.

26 patients who were included for the study had presented to our hospital more than 48 h after the trauma or had inadequately debrided or sutured wounds at the peripheral hospitals. The cause of delay was patients being referred from far flung hilly areas with poor road connectivity or patients with other serious injuries which were managed first before being referred to orthopaedic management. In all the cases the wounds were not very healthy. Out of 26 patients 16 were tibia and 10 were femur fractures. All the open fractures were of Gustilo and Anderson type II, IIIA or

IIIB.¹¹ Patients with underlying malignancy, HIV, chronic liver or kidney disease or patients on immunosuppressant drugs were excluded from the study.

2.1. VAC apparatus

Central negative suction of the hospital with an in-ward suction unit was used to create negative pressure around the wound. The suction unit in the ward has a meter to monitor the pressure and a key to control the pressure at the desired level (Fig. 1a). Sterile foam, suction tube with side pores and loban are the three things required for the VAC (Fig. 2a). The negative pressure can be used continuously or intermittently. In our study we used intermittent negative pressure as continuous negative pressure usage often cause pain around the wound.

2.2. Technique of VAC application

1. All the wounds were thoroughly debrided and washed before applying the hospital based low cost VAC.

Fig. 1. a: In-hospital Suction unit for VAC with pressure gauge, b: Tube connected to suction unit and patient's limb, c: VAC dressing applied over a thigh wound (femur fracture), d: VAC dressing applied over a leg wound (Tibia fracture).

Fig. 2. a: Case of both bone leg fracture. b: Same case with unhealthy wound and external fixator insitu. c: Post VAC healthy wound. d: Local flap and Ilizarov Ring fixation done for the same patient. e: New bone formation and well uniting fracture. f: Well taken flap with well aligned limb.

- Wound was well covered with sterile foam dressing of proper size. It helps in uniform distribution of negative pressure over entire wound. Foams used in VAC dressing are black foam and pink foam. We used pink foam made of polyurethane ether in our study. The advantages with pink foam are larger pore size, lighter, more hydrophobic and easily collapsible. Suction tube is embedded into the foam which is then connected to a vacuum pump with a metre for pressure control (Fig. 1a, b).
- The foam is then covered with adhesive dressing (Ioban) covering at least 5 cm of normal skin for adequate coverage of wound (1c, 1d). A separate adhesive draping for embedded tube covering a minimum of 5 cm of tubing was done.
- Controlled negative pressure was applied on the inner surface of wound. With negative pressure foam compresses and wrinkles appear in the Ioban which is a proof that negative pressure is created in the wound (1c, 1d). Negative pressure of more than 120 mmHg is recommended for traumatic wounds as these are

associated with lot of wound oedema. For chronic painful non healing ulcers lesser negative pressure can be used as high negative pressure often causes pain around the wound.

VAC Dressing was changed every 48 to 72 h. Controlled negative pressure caused macro and micro molecular changes in the wound which helped in decreasing infection and reducing wound size. For femoral fractures skin/skeletal traction was used during the application of VAC dressing. For tibia fractures either external fixator or Bohlar Brown splint was used for limb immobilization (Fig. 2a, b).

Pre operative VAC was used for 4 to 12 days depending upon the type of the wound. Wound irrigation, thorough debridement and antibiotic cover were used in all the patients. A healthy wound with adequate granulation tissue with no drainage for 48 h was taken as end point of the VAC before definitive procedure was done for fracture fixation (Fig. 2c). Antibiotic protocol was kept uniform

with inj. Cefazolin, inj Amikacin and inj Metrogyl. First dressing was done on the 2nd post-op day in all the patients. Most of the patients were discharged on the 2nd post-op day after changing the dressing; however, admission was prolonged for the patients ($n = 4$) if more than normal wound discharge was seen on the first dressing. Among these patients one was with femur fracture and 3 with tibia fractures. Wound swab was taken from these patients and sent for culture and sensitivity which came out to be *E. coli*, *Staph. Aureus*, *Pseudomonas Aeruginosa* in 3 and sterile in one patient. Antibiotics were changed in these 3 patients as per culture report.

Patients were followed weekly in the OPD for first three weeks; wounds were closely observed for any signs of infection. Afterwards patients were called monthly for first 3 months, then at 6 months and 1 year.

Post operatively Knee ROM was started on 2nd post operative day and partial weight bearing was started from 4th to 6th week. Full weight was allowed as per the radiological assessment of union.

The final point was taken as the united fracture with completely healed wound with no signs of infection and no functional deficit.

All the patients with history of smoking were made to stop the smoking during the treatment. The haemoglobin level of all the patients was kept at ≥ 9 gm%, serum albumin level ≥ 3.5 gm% during perioperative period.

3. Results

Total 26 patients were included in the study with 16 tibial and 10 femur fractures. Out of which 18 were men and 8 women. The mean age of the study group was 36 years (Range: 20–60 years) as shown in Table 1. The most common causes of trauma were road traffic accidents, fall from height and fire arm injuries. Soft tissue and bony injuries were more severe in patients with fire arm injuries because of high energy impact. Such patients besides soft tissue coverage also needed bone transport because of bone loss.

The average day of presentation to the orthopaedic department of our hospital was 4.6 days (range = 3–9 days) after the trauma. The average delay for the surgery from day of admission was 6.5 days (range = 4–12 days). The cause of delay was need of multiple VAC dressings and sometimes unavailability of operating room. The average number of VAC dressings done per patient was 2.9 (range = 1–4) as shown in Table 2.

In patients with femur fracture closed reamed interlocking nailing was done in 8 and mipo plating was done in 2 distal femoral fractures. Wound was primarily closed at the time of intra-medullary nailing in 8 patients and in 2 patients partial thickness skin grafting was done. In 16 patients with tibia fractures closed interlocking nailing was done in 11. Ilizarov ring fixation was done in 5 patients for which external fixator were used as temporary method of bony stabilization. Primary wound closure at the time of fracture fixation was done in 10 patients, in 2 patients wound was covered by local flap (Fig. 2d), in 1 patient free flap was used and in 3 patients partial thickness skin grafting was done (Table 3). The flap converge was done with the help of the dept. Of plastic surgery and such patients were also followed up in both Ortho and Plastic

surgery their OPD. One patient among 10 femur fracture cases ended up with infected non union which was managed with debridement and exchange nailing with antibiotic impregnated nailing. At the end of 1 year of follow up 1 patient among 10 femur fracture cases ended up with infected non union which was managed with debridement and exchange nailing with antibiotic impregnated nailing and 14 out of 16 tibia fractures united without any second surgical intervention (Fig. 2e, f). 2 among 16 tibia fractures had unfavourable results, 1 with non union and 1 with chronic osteomyelitis as shown in Table 3. Total patients that ended up with deep infection in our study were 2 (7.4%) as shown in Table 3.

4. Discussion

Despite tremendous improvement in surgical techniques management of compound fractures still remains a challenge. Steps of paramount importance for management of open fractures include antibiotic cover, wound irrigation, wound debridement and early fixation.^{12–14} In developing countries like India with 70% of population living in rural areas where tertiary care hospitals with required facilities are not available the situation is further complicated by factors like late presentation to the hospital when wound is already infected, or wound is already stitched at periphery after inadequate washing and debridement of the wound. This tremendously increases the chances of infection. Majority of people in our country belong to lower socio-economic class who cannot afford costly modern equipments.

A large number of studies have shown VAC therapy extremely effective in helping wound healing and infection control of non healing ulcers and soft tissue defects.^{15–18} The dressing used in VAC therapy acts as a physical barrier from environmental contamination of the wound. The negative pressure created around the wound in VAC therapy decreases wound oedema, increases capillary growth (angiogenesis) and increases rate of cell mitosis producing granulation tissue at a much faster rate.¹⁹ The high vascular environment created by VAC therapy increases oxygen delivery and immune cells in the wound which prevents bacterial proliferation.^{20–22} Wounds treated with VAC therapy have shown a decreased bacterial load per gram of tissue on quantitative cultures.^{23,24} The faster granulation tissue formation decreases the overall size of wound thus making the need of subsequent surgical procedures less taxing.^{25–28}

The wound size reduced after application VAC decreased though we didn't calculate the decrease in wound size. In 19 (73%) patients primary wound closure was done 7 (26%) patients needed some form of grafting for wound coverage. Many studies have shown significant decrease in wound size with VAC therapy as compared to other dressing methods however most of the studies reported in the literature are on non healing ulcers,^{29,30} Although some studies have shown it to be very effective in orthopaedic trauma.³¹

The infection rate in our study was only 7.4% despite the fact that all the cases presented late (after 48 h) and were operated on an average 7th day of admission because of unavailability of operating room. The infection rate in open fractures has reported from 8% to 12% in compound fractures.³² J Halvorson et al. in their study on VAC assisted closure in open paediatric fractures have shown only 2 cases of deep infection and no case of osteomyelitis in and recommended it as an effective method of reducing infection.³³

VAC has been proved to be very effective in wound care management in trauma wounds and open fractures for decreasing wound size and controlling infection.^{34–37} Bhattacharyya T et al. in their study have recommended not delaying wound coverage beyond 7 days even while using VAC as chances of infection

Table 1
Age and sex distribution of the patient.

Total no. of patients	26
Men	18
Women	08
Tibia fractures	16
Femur fractures	10
Mean age in years (range = 20–60)	37

Table 2

Days of presentation, surgery and no. Of VAC dressings done.

Day of presentation after the trauma Mean/ range (	Day of surgery(from the day of admission) Mean/ range	Average no of VAC dressings used per patients before surgery Mean/ range
4.6/3–9	6.5/4–12	2.9/1–4

Table 3

Method of bony fixation, wound closure and final out come.

Bone involved	Fracture fixation method	Wound closure method	Final out come
Femur (n = 10)	Closed nailing(n=8) Mipo plating (n = 2)	Primary wound closure(n=8) Split skin grafting(n=2)	Union (n=9) Infected non union(n= 1)
Tibia(n = 16)	Closed nailing(n=11) Ilizarov ring fixator(n=5)	Primary wound closure(n=10) Local flap (n=2) Free flap (n=1) Split skin grafting (n=3)	Union(n=14) Non union without infection = 1 Chronic osteomyelitis: 1

increase significantly after 7 days.³⁸ The average day of wound closure in our surgery was 6.9 although it got delayed up to 12 days in some making the wound more susceptible to infection.

In all the studies conventional VAC therapy has been used, the cast of which is beyond the paying capacity of most of Indian population. We in our study used low cast customised VAC which is almost free to the patients with equally effective results. M Singh et al. have shown excellent results in wound healing with manually operated vacuum devices using ROMOVAC drain as negative pressure creating apparatus.³⁹

In our study we observed that low cost custom made VAC therapy can be a useful adjunctive modality of reducing infection rates in compound fractures in developing countries where most of the patients cannot afford commercially available costly equipment.

5. Conclusion

VAC therapy is an extremely effective modality for controlling infection in non healing ulcers and open fractures. The main drawback of the VAC therapy is costly equipment which can be well managed by using low cost custom made VAC in developing countries.

There are only very few observational studies available on role of VAC therapy in compound fractures. More randomized controlled studies are needed to assess the role of VAC therapy in compound fractures.

Financial assistance

None.

Conflict of interest

None.

Acknowledgements

I am extremely thankful to all the staff members of our department without their support it would have been possible to conduct this study.

I would like to thank all the post graduate students of our department, theatre staff and radiology section of SKIMS MC for providing technical help during this study.

References

- Buckwalter JA. Advancing the science and art of orthopaedics: lessons from history. *J Bone Joint Surg Am.* 2000;82(12):1782–1803.
- Halawi MD Mohamad JMD, Morwood MD Michael PMD. Acute management of open fractures: an evidence-based review. *Orthopedics.* 2015;38(November (11)):e1025–e1033.
- Bhabulkar Sudhir, Raza HKT. Open fractures. *Indian J Orthop.* 2008;42(October–December (4)):365–367.
- Azam Quamar, Sherwani MKA, Abbas Mazhar, Gupta Rahul, Asif Naiyer, Sabir AB. Internal fixation in compound type III fractures presenting after golden period. *Indian J Orthop.* 2007;41(July–September (3)):204–208.
- Giannoudis PV, Papakostidis C, Roberts C. A review of the management of open fractures of the tibia and femur. *J Bone Joint Surg.* 2006;88:281–289.
- Kaltenecker G, Wruhs O, Quaiocoe S. Lower infection rate after interlocking nailing in open fractures of the femur and tibia. *J Trauma.* 1990;30:474–490.
- Gregory P, Sanders R. The management of severe fractures of the lower extremities. *Clin Orthop.* 1995;318:95–105.
- Nahm NJ, Como JJ, Wilber JH, Vallier HA. Early appropriate care: definitive stabilization of femoral fractures within 24 hours of injury is safe in most patients with multiple injuries. *J Trauma.* 2011;71:175–185.
- Argenta LC, Morykwas MJ. Vacuum-assisted closure: a new method for wound control and treatment: clinical experience. *Ann Plast Surg.* 1997;38:563–576.
- Morykwas MJ, Argenta LC, Shelton-Brown EI, McGuirt W. Vacuum-assisted closure: a new method for wound control and treatment: animal studies and basic foundation. *Ann Plast Surg.* 1997;38:553–562.
- Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty five open fractures of long bones. *J Bone Joint Surg [Am].* 1976;58-A:453–458.
- Rogers FB, Shackford SR, Vane DW, Kaups KL, Harris F. Prompt fixation of isolated femur fractures in a rural trauma center: a study examining the timing of fixation and resource allocation. *J Trauma.* 1994;36:774–777.
- Fakhry SM, Rutledge R, Dahners LE, Kessler D. Incidence, management, and outcome of femoral shaft fracture: a statewide population-based analysis of 2805 adult patients in a rural state. *J Trauma.* 1994;37(2):255–261.
- Charash WE, Fabian TC, Croce MA. Delayed surgical fixation of femur fractures is a risk factor for pulmonary failure independent of thoracic trauma. *J Trauma.* 1994;37:667–672.
- Argenta LC, Morykwas MJ. Vacuum-assisted closure: a new method for wound control and treatment: clinical experience. *Ann Plast Surg.* 1997;38:563–576.
- Orgill DP, Bayer LR. Negative pressure wound therapy: past, present and future. *Int Wound J.* 2013;10(Suppl. 1):15–19.
- Armstrong DG, Lavery LA, Diabetic Foot Study Consortium. Negative pressure wound therapy after partial diabetic foot amputation: a multicentre randomized controlled trial. *Lancet.* 2005;366(9498):1704–1710.
- Bickels J, Kollender Y, Wittig JC, et al. Vacuum-assisted closure after resection of musculoskeletal tumours. *Clin Orthop Relat Res.* 2005;441:346–350.
- Fleischmann W, Strecker W, Bombelli M, Kinzl L. Vacuum sealing as treatment of soft tissue damage in open fractures. *Der Unfallchirurg.* 1993;96(9):488–492.
- Mous CM, Vos MC, van den Bemd GJ, Stijnen T, Houvius SE. Bacterial load in relation to vacuum assisted closure wound therapy: a prospective randomized trial. *Wound Repair Regen.* 2004;12(1):11.
- Ogill DP, Manders EK, Sumpio BE, et al. The mechanisms of action of vacuum assisted closure. More to learn. *Surgery.* 2009;146(1).
- Scherer SS, Pietramaggiore G, Mathew JC, Prsa MJ, Huang S, Orgill DP. The mechanisms of action of the vacuum assisted closure device. *Plast Reconstr Surg.* 2008;122(3):786–797.
- Gurtner GC, Werner S, Barrandon Y, Longaker MT. Wound repair and regeneration. *Nature.* 2008;453:314–321.
- Webb LX, Dedmond B, Schlatterer D, et al. The contaminated high-energy open fracture: a protocol to prevent and treat inflammatory mediator storm-induced soft-tissue compartment syndrome (IMSICS). *J Am Acad Orthop Surg.* 2006;14(Suppl):S82–6.
- Saxena V, Hwang CW, Huang S, et al. Vacuum-assisted closure: microdeformations of wounds and cell proliferation. *Plast Reconstr Surg.* 2004;114:1086–1096.

26. Norbury K, Kieswetter K. Vacuum-assisted closure therapy attenuates the inflammatory response in a porcine acute wound healing model. *Wounds*. 2007;10:97–106.
27. Li XY, Li WZ, Li YJ, et al. The influence of vacuum-assisted drainage on the growth of capillaries in the wound produced by explosion in pig. *Zhonghua Shao Shang Za Zhi*. 2007;23(4):292–295.
28. Ubbink DT, Westerbos SJ, Evans D, Land L, Vermeulen H. Topical negative pressure for treating chronic wounds. *Cochrane Database Syst Rev*. 2008;(3):CD001898.
29. Eginton MT, Brown KR, Seabrook GR, Towne JB, Cambria RA. A prospective randomized evaluation of negative-pressure wound dressings for diabetic feet. *Ann Vascular Surg*. 2003;17(6):645–649.
30. Singh S, Mackey S, Soldin M. VAC it – some techniques on the application of VAC dressings. *Ann R Coll Surg Engl*. 2008;90:161–162 40–51.
31. Putnis Sven, Khan Wasim S, Wong James M-L. Negative pressure wound therapy – a review of its uses in orthopaedic trauma. *Open Orthop J*. 2014;8:142–147 10.2174/1874325001408010142.
32. Griffin M, Malahias M, Hindocha S, Khan W. Update on the management of compound lower limb fractures. *Open Orthop J*. 2012;6:518–524.
33. Halvorson J, Jinnah R, Kulp B, Frino J. Use of vacuum-assisted closure in paediatric open fractures with a focus on the rate of infection. *Orthopedics*. 2011;34(7):e256–60.
34. Herscovici DJR, Sanders RW, Scaduto JM, Indante A, DiPasquale T. Vacuum-assisted closure (VAC therapy) for the management of patients with high-energy soft tissue injuries. *J Orthop Trauma*. 2003;17(10):683–688.
35. Leininger BE, Rasmussen TE, Smith DL, Jenkins DH, Coppola C. Experience with wound VAC and delayed primary closure of contaminated soft tissue injuries in Iraq. *J Trauma*. 2006;61:1207–1211.
36. Andrew N. Pollak use of negative pressure wound therapy with open cell foam for lower extremity trauma. *J Orthop Trauma*. 2008;22:10.
37. Dedmond BT, Kortesis B, Pungner K, et al. The use of negative-pressure wound therapy (NPWT) in the temporary treatment of soft-tissue injuries associated with high-energy open tibial shaft fractures. *J Orthop Trauma*. 2007;21(1):11–17.
38. Bhattacharyya T, Mehta P, Smith M, Pomahac B. Routine use of wound vacuum-assisted closure does not allow coverage delay for open tibia fractures. *Plastic Reconstr Surg*. 2008;121(4):1263–1266.
39. Singh M, Singh R, Singh S, Pandey V, Singh D. Vacuum assisted closure in wound management – poor man's VAC©. *Internet J Plastic Surg*. 2008;6(1):s1.