DISCUSSION

Healing is a complicated, interdependent process that involves complex interactions between cells, the cellular microenvironment, biochemical mediators, and extracellular matrix molecules that usually result in a functional restoration of the injured tissue.[77, 78]

The goals of wound healing are to minimize blood loss, replace any defect with new tissue (granulation tissue), and restore an intact epithelial barrier as rapidly as possible. The rate of wound healing is limited by the available vascular supply and the rate of formation of new capillaries and matrix molecules.[79]

These events are heavily influenced by locally acting growth factors that affect various processes including proliferation, angiogenesis, chemotaxis and migration, gene expression, proteinases, and protein production. [80-82]

Disruption of any of these factors may adversely affect the healing process, resulting in a chronic or non-healing wound. Blood flow increases and bacterial colonization of wound tissues decreases following the application of sub-atmospheric pressure to wounds.[41]

Any increase in circulation and oxygenation to compromised or damaged tissue enhances the resistance to infection.[79] Successful, spontaneous healing and healing following surgical intervention are correlated with tissue bacterial counts of less than 10^5 organisms per gram of tissue. Higher levels uniformly interfere in wound healing.[83]

Increase in local tissue oxygen levels reduces or eliminates the growth of anaerobic organisms, which have been correlated to decreased healing rates. Additionally, the increased flow should make greater amounts of oxygen available to neutrophils for the oxidative bursts that kill bacteria. [29]

Clinical applications of VAC therapy include; diabetic foot infections, pressure ulcers, open abdominal wounds, sternal wounds, soft tissue defects after trauma, necrotising fasciitis, hydradenitis suppurative and extravasation injury, skin graft fixation and burns.

Our study was conducted for thirty patients with complicated wounds admitted to the Casualty Department, Plastic Surgery Unit and Burn Unit at Alexandria Main University hospital.

The study included 17 males (56.7%) and 13 females (43.3%).Their ages ranged from 3 years old to70 years old with 19 patients (63.3%) above 30 years and 11 patients (36.7%) below 30 years. The mean age was 38 years.

The results of the current study revealed that among the 30 patients, the commonest cause was trauma, with 13 patients were due to road traffic accident, multiple associated medical conditions were encountered in the patients; with the most common disease was diabetes mellitus. The most common anatomical site of the wounds was the lower limb, with 8 patients with wounds in the leg, 8 patients in the foot. The longest diameter of the wounds ranged from 3 cm to 44 cm with mean diameter of 20.3 cm. The mean reduction in size of wound was (43.6%). The number of VAC dressings ranged from 4 to 16 times, with

mean number of 7 dressings. Among the 30 patients with VAC dressings, 21 cases(70%) proceeded to split thickness graft, 6 cases (20%) showed spontaneous healing , while two cases(6.7%) underwent local flaps and one case was closed directly.

Five Randomized clinical trials (RCTs) [84-88] reported a positive effect of VAC therapy on wound healing in diabetic ulcers. Four of the five RCT studies reported a significant wound volume reduction. Healing times were found to be shorter. None of the studies disclaimed differences in treatment-related complications compared with the control therapy.

It was stated in the consensus document released by the World Union of Wound Healing Societies [89] that VAC therapy can be used in post surgery diabetic foot wounds. It is not recommended for infected or ischemic wounds.

In our study we applied VAC therapy on non healing diabetic foot ulcers in which other several modalities were used and failed before; but we get total healing of the wound.

Three RCTs [58, 90,91] and 2 large retrospective studies (n _ 2,348 and n _ 278) [92, 93] reported favorable results using VAC therapy in grade 3 and 4 pressure ulcers. Significant wound volume reductions were noted in 3 of the 5 studies. [58, 90, 92] It was observed in all the studies that wound treatment using VAC therapy was more comfortable for the patients and could very well be used in outpatient care.

Vuerstaek et al. [94] conducted a study on venous leg ulcers that reported faster wound bed preparation times, faster median time to complete healing, and better skin graft take rate in VAC-treated wounds. Furthermore, cost efficiency was in favor of VAC treated wounds in both pressure ulcers and venous leg ulcers.

Argenta et al [95] reported the use of VAC technique in 300 patients with non-healing ulcers, 99% of which healed. They concluded that the VAC negative pressure technique significantly increases the rate of granulation tissue formation and local blood supply, and therefore a useful adjunct to wound care.

Clare et al [96] confirmed the effectiveness of this technique for the treatment of chronic non-healing wounds or ulcers. Clare et al[96] reported severe PVD (Peripheral Vascular Disease) as the most common reason for failure of VAC, and suggest that patients with severe PVD should be treated by other modalities.

In our study, we did not encounter any case of PVD and therefore failure of VAC.

Ford et al[90] reported improved results in patients with chronic osteomyelitis after VAC treatment. They postulated that the negative pressure created by the VAC device facilitates antibiotic penetration from surrounding capillaries into the bone, thus controlling infection.

Morykwas et al[41] showed in a pig model that peak blood flow levels were 4 times higher than baseline values with continuous pressure of -125mmHg. They also found a significantly higher rate of granulation tissue formation and a significant decrease in bacterial flora after 4 to 5 days of treatment.

Clinical and experimental studies have shown that removal of third space fluid results in a decrease in tissue turgor and a decrease in capillary after-load, which promoted capillary circulation and inflow. In addition, the removal of excess exudates from the wound is believed to remove inhibitory factors, which inhibit vascularity. These fluids contain high levels of matrix metelloproteinases and their degradation products, which have been shown to suppress the proliferation of keratinocytes, fibroblasts and vascular endothelial cells in vitro. [97]

Bacterial counts in human wound tissues treated with VAC have demonstrated significant decrease after 3 to 4 days, paralleling the results of animal studies. [41]

Because the negative pressure applies controlled tension to every point on the inner surface of the wound, the sum of the applied forces becomes large and tends to draw the edges of the wound inward. Prospective, randomized trials have showed a decrease in the ulcer volume and in the mean number of polymorphous neutrophils and lymphocytes in wound treated with VAC. [98-100]

Mullner et al. [101] conducted a prospective clinical trial from 1994 to 1996 in 45 patients and evaluated the efficacy of a vacuum sealing technique in dealing with sacral pressure ulcers, acute traumatic soft tissue defects and infected soft tissue defects following rigid stabilization of lower extremity fractures. They described decrease in the dimension of initial wounds after VAC therapy in 84% of the patients, thus facilitating healing time and eradication of any pre-existing infection.

In our study the reduction in the size of the wounds occurred in all the patients but with variations with mean reduction of 43.6 %.

In another study De Franzo et al [102] used VAC therapy on 75 patients with open wounds of lower extremity but without osteomyelitis. They reported a rapid granulation tissue formation, reduction in bacterial count and successful wound closure in 95% of cases.

Early wound debridement and coverage of exposed bone with well-vascularised tissue, within 72 hours, remains the 'gold standard' management of open fractures [103]. However VAC may permit temporization of open fractures beyond 72 hours pending definitive soft tissue cover, with potential down staging of the wound. This facilitates medical optimization of the patient and often less complex surgery [104].

Tissue loss from the foot, exposed tendons, tissue loss in gunshot wounds and degloving injuries has proven appropriate indications. [102-108].

The results of present study were comparable with that of Ghani et al,[109] in which trauma was the commonest cause (43.3%) comparable to that of Ghani et al,[109] (60%). In contrast to current series they excluded wounds with concomitant osteomyelitis, gross infection, and wounds having slough and devitalized tissues. We included all such cases and performed surgical debridement prior to application of VAC. The culture and sensitivity report in our series was positive in 60% of cases and yet we proceed with VAC. Probably the inclusion of such cases explain greater mean VAC application in our series when compared to Ghani et al (mean no. of VAC application 5.3 in study by Ghani et al vs 6.9 in our study).

Barker et al. [110] conducted the first large series (112 patients) on the use of VAC in the management of abdominal wounds and he found that VAC prevents the abdominal compartment syndrome. VAC satisfies the fundamental aims of managing the open abdomen [111]. In particular, it prevents the abdominal compartment syndrome, while using the concept of reverse tissue expansion to optimise both skin and fascial approximation.[112]

In this study we had a case of burst abdomen who tried conventional dressings for three months with no improvement but after 3 weeks of VAC therapy total closure of the wound was done. Also we had 3 cases of abdominal flap necrosis following abdominoplasty operation in which conventional dressings were used and failed before getting very good results with VAC therapy.

Skin grafting relies on adequately securing the undersurface of graft to the recipient bed during the critical period of inosculation and capillary ingrowths' between days two and five. While a tie-over dressing is usually adequate, problems may arise when attempting to graft irregular surfaces (such as the perineum and inguinal fold regions), areas prone to movement or exudative recipient beds. Shear forces between graft and bed or fluid collections resulting in separation of the two surfaces result in interruption of the re-vascularisation process and hence a reduction in graft 'takes'. Optimal take occurs in clean, granulating defects. VAC may be used for wound bed preparation to help reduce size and to assist tissue granulation in the wound. [113]

In one patient, we used VAC after skin grafting in order to decrease the exudate from the recipient area. The same technique was also used by Senchenkov et al. [114]

Application of VAC is very versatile and can be used on various anatomical sites with good results. It has also been used after resection of musculoskeletal tumors and for closure of partial foot amputations.[115, 116]

Post-sternotomy mediastinitis occurs in 1%–5% of patients following midline sternotomy. VAC has been used extensively in the treatment of sternal wound infections and is indicated before primary closure, as preparation for secondary closure with vascularised tissue, and as an adjunct to flap healing. The literature favors VAC applied in a continuous fashion (to optimise the sternal splinting effect) at levels around -125 mmHg.[117]

In common with the abdominal dressing, full-thickness perforations, whether intrinsic or added by the surgeon, are required to allow transmission of negative pressure through the dressing. Such a dressing may also negate potential haemodynamic consequences of VAC applied close to the heart; although no detrimental effect has been observed clinically, one animal study suggests that VAC applied directly to the heart decreases cardiac output and interposition of a rectus flap rectified this hemodynamic influence. [118]

A double layer foam dressing enables optimal thoracic stabilization (sternal layer) combined with even distribution of negative pressure over the entire wound surface (subcutaneous layer). Care should be taken not to overlap the foam on intact skin. [119]

In one case of this series, we used VAC on post-sternotomy wound. The wound responded well and the remaining defect was closed by a split-thickness skin graft. We used intrmittent sub-atmospheric pressure of -125 mmHg, which is similar to the pressure used in most of the other studies. [83,95,116]

Philbeck *et al* [120] reported that intermittent or cycled treatment appears more effective than continuous therapy, because intermittent cycling results in rhythmic perfusion of the tissue which is maintained because the process of capillary autoregulation is not activated. They also suggested that as cells which are undergoing mitosis must go through a cycle of rest, cellular component production and division, constant stimulation may cause the cells to ignore the stimulus and thus become ineffective. Intermittent stimulation allows the cells time to rest and prepare for the next cycle. For this reason it is suggested that cyclical negative pressure should be used clinically.

Other studies [121,122] suggest that this may follow a 48-hour period of continuous vacuum, which can be applied to exert a rapid initial cleansing effect.

In another study by Timmers et al. [51] the continuous negative pressure was used in the range of -25to -300 mmHg and using two types of foams, i.e. black polyurethane foam (PU) and white polyvinyl alcohol (PVA) foam. Significant cutaneous blood flow was found in both types of foams up to pressure of -300 mmHg. They proposed that type of foams may affect the end result, whereas we used locally available foam commonly used for filling of cushions etc. and achieved comparable results.

Clare et al. [96] described some practical problems in the use of VAC for treatment of wounds located over a small area, but we did not encounter any such problem.

A randomized controlled trial comparing VAC with modern wound dressings for leg ulcer has been carried out by Vuerstaek et al. [94] The VAC proved superior with respect to the time to complete healing and wound-bed preparation time compared with conventional wound care.

In this study 18 cases (60%) tried conventional wound care before trying VAC dressing with mean time 1.97 months but no progress occurred by the conventional wound care although after application of VAC in the same patients good results was obtained with mean time 0.85 month.

The various complications of VAC technique mentioned in the literature include localized infection, bleeding, increased pain, bad odour, toxic shock syndrome and anasarca. [95, 100, 123, 124] None of these complications occurred in our patients except bad odour at the time of change of dressings in a few cases and slight pain in others.

In 2 cases, there was mild oozing/bleeding from the hypervascular bed of wound. However, it was never threatening. To manage this oozing/bleeding we used gauzes soaked with a diluted solution of adrenaline and packed for 2-3 minutes, which resulted in fairly bloodless field. In two cases we injected the diluted adrenaline solution through the VAC tube, waited for 15-20 minutes, and then changed the dressing. Similarly Price et al. [124] made a modification by injecting the 0.25% bupivacaine into the system 15-20 minutes before removing the dressing to avoid the pain during VAC changes. It has also been

postulated by Blackburn et al. [125] that tulle gauzes may be applied on the wound bed before application of VAC, Also we used it in four cases.

It is difficult to seal the area with Opsite®, especially if there is marked exudate or if perineum is involved. Because once there is fluid underneath the Opsite®, it will never be airtight again. We employed two ways to encounter this problem (i) by using the dry dressing gauzes around the margins and then sealed with Opsite ®, (ii) by applying the hydrocolloid dressing (Duoderm®) and applied the Opsite® on top of it to obtain the air tight seal in two cases, however some cases where the wound margins are very closed to the anus we failed to make air tight seal so we did not apply VAC.

Application of VAC becomes difficult in the presence of external fixators used in orthopaedic surgery. Sometimes we included the whole fixators in the dressing using a sterile plastic bag. Also its application becomes difficult in wounds involving the hand or the foot so we include the whole hand or the whole foot like a socket.

SUMMARY

Chronic wounds are more common in elderly patients and in those with multiple health problems. With an aging population one may expect increase in both the incidence and cost of chronic wounds.

Non-healing wounds affect about 3 to 6 million people in the United States, with persons 65 years and older accounting for 85% of these events. Non-healing wounds result in enormous health care expenditures, with the total cost estimated at more than $3 billion per year.

There are many factors that can affect wound healing which interfere with one or more phases in this process, thus causing improper or impaired tissue repair. Wounds that exhibit impaired healing, including delayed acute wounds and chronic wounds, generally have failed to progress through the normal stages of healing. Such wounds frequently enter a state of pathologic inflammation due to a postponed, incomplete, or uncoordinated healing process.

Vacuum-assisted closure (V.A.C.) therapy involves the controlled uniform application of continuous or intermittent negative pressure to the wound bed transferred via open-pore foam.

The following mechanisms have been attributed to VAC therapy: creates a moist environment, reduces edema, increases local blood flow, stimulates angiogenesis and formation of healthy granulation tissue, stimulates cell proliferation, reduces size and complexity of the wound, removes soluble healing inhibitors from the wound, and reduces bacterial load.

The aim of our study to assess the role of the vacuum assisted closure (VAC) therapy in the management of complicated wounds.

The study was conducted for thirty patients with complicated wounds admitted to the Casualty Department, Plastic Surgery Unit and Burn Unit at Alexandria Main University hospital.

The study included 17 males (56.7%) and 13 females (43.3%).Their ages ranged from 3 years old to70 years old with 19 patients (63.3%) above 30 years and 11 patients (36.7%) below 30 years. The mean age was 38 years.

All patients were subjected to full history taking, clinical examination, routine laboratory investigations and informed written consent before application of VAC.

The results of the current study revealed that among the 30 patients, the commonest cause was trauma, with 13 patients were due to road traffic accident, multiple associated medical conditions were encountered in the patients; with the most common disease was diabetes mellitus. The most common anatomical site of the wounds was the lower limb, with 8 patients with wounds in the leg, 8 patients in the foot. The longest diameter of the wounds ranged from 3 cm to 44 cm with mean diameter of 20.3 cm. The reduction in the wound size ranged from 10% to complete healing with mean reduction of 43.6 %. The number of VAC dressings ranged from 4 to 16 times, with mean number of 7 dressings.

The duration of these dressings took from 2 to 8 weeks with mean duration of 3.5 weeks. Among the 30 patients with VAC dressings, 21 cases(70%) proceeded to split thickness graft, 6 cases (20%) showed spontaneous healing , while two cases(6.7%) underwent local flaps and one case was closed directly.