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RESEARCH ARTICLE

EFFECT OF VACUUM ASSISTED CLOSURE ON WOUND HEALING.

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Abstract

Vacuum assisted closure (VAC) is a relatively new technology with applications in a variety of difficult to manage acute and chronic wounds. It is known by many pseudonyms—TNP (topical negative pressure) SPD (sub-atmospheric pressure) VST (vacuum sealing technique) and SSS (sealed surface wound suction).¹

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Introduction:-

Dressings to treat complex wounds have traditionally been made of cotton gauze which could be soaked with a variety of chemicals including normal saline and sodium hypochlorite solutions. In the 1960s, the importance of keeping the wound moist was discovered and a wide array of hydrogels, alginates, and other polymeric and biologically based dressings were developed. More recently, these dressing materials have been combined with antimicrobial compounds such as silver. Most of these products are used based on clinicians' experience of ten coupled with invitro and in vivo experimental work and limited noncontrolled clinical trials. For the average clinicians, finding the best dressing for a specific wound can be a daunting task.

The VAC was first investigated by Morykwas and Argenta et al. in 1997.² Their work followed on from studies of negative pressure years previously that had suggested it might improve wound healing. Early work suggested that negative pressure increased blood flows as evidenced by hyperaemia.³ Morykwas and Argenta² used a swine model to investigate the effect of negative pressure applied via the VAC on wound healing.

The aim of this work was to get the maximum benefit of VAC in the management of acute and chronic wounds without abuse or misuse.

The VAC Technique:-

VAC uses medical grade open cell polyurethane ether foam (which is FDA approved for open wounds) as a dressing.² The pore size is generally 400–600 μ m (thought optimal for tissue growth).² This foam is cut to fit and closely applied to the selected wounds. An evacuation tube with side ports, which communicate with the reticulated foam, is embedded in it. The aim of the reticulation being that the negative pressure will be applied equally to the entire wound bed. An adhesive drape is then applied over the area with an additional 3–5 cm border of intact skin to provide an intact seal. The evacuation tube is connected to an adjustable vacuum pump and a canister for collection of effluent. The pump can be adjusted in terms of both the timing (intermittent vs. continuous) and magnitude of the vacuum effect. In general an intermittent cycle (5 min on, 2 min off) is employed as this has been shown to be most

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beneficial.² Effectively the technique converts an open wound into a controlled and temporarily closed environment.

Mechanisms of action:-

Wounds generally heal by primary, where edges are brought into close apposition for example by suturing, or secondary intention, where the wound edges are not opposed and a matrix of small blood vessels and connective tissue must be formed in between in order for keratinocytes to migrate across the surface and re-epithelialise the defect. It is a complex, intricate process. The aims of the process can be considered as minimization of blood loss, replacing any deficits with new tissue (granulation) and restoring an intact epithelial barrier as quickly as possible. In order to achieve healing debris must also be removed; any infection controlled and inflammation eventually cleared. The wound then heals with granulation, remodeling of the connective tissue matrix and finally maturation. The rate of healing may be limited by vascular supply and the capacity of the wound to form new capillaries/matrix. Any disruption in the various processes involved—proliferation, angiogenesis, chemotaxis, migration, gene expression, protein production can lead to a chronic wound. When we consider the postulated mechanisms of action of the VAC and how they tie in with our generally accepted ideas surrounding the way wounds heal it is easy to suppose a likely benefit in quicker resolution of wounds.

Removal of oedema/exudate management:-

Localised oedema can compress the vascular and lymphatic systems in a wound. The VAC removes excess fluid and, therefore, is thought to restore the vascular and lymphatic flow.¹ Practically, the next best wound dressing (wet to moist saline dressings) involves labour intensive and potentially hazardous dressing changes. The VAC ensures a closed environment for wounds and, therefore, adheres to universal precautions. They also need to be accessed far less frequently.¹ The VAC system allows collection of the removed fluid for analysis. Some centres^{4,5} have shown high levels of proteolytic enzymes in chronic wounds and burns. These enzymes if left in situ could result in matrix degradation and a non-healing wound environment. They have also been demonstrated in the effluent from VAC treated wounds along with cytokines and various acute phase proteins.^{6,7}

Reduction in levels of bacteria:-

Infection is known to impede wound healing. Reduced levels of bacteria have been demonstrated in VAC treated wounds.² It has also been demonstrated that VAC treated wounds require fewer courses of antibiotics relative to conventionally treated wounds.^{6,7} This is thought to be due to multiple factors: the positive effect of removing excess wound fluid on local blood and lymphatic flows, greater amounts of oxygen made available for the bacteria killing oxidative bursts and the closed nature of the system. Gouttefangeas et al.⁸ measured the cellular content of the foam from the VAC and found high levels of granulocytes, cd4, cd5 and T cells. They supposed the foam to be an attractive habitat for immune cells, partially recruited by a foreign body reaction. However, one recent study of 25 patients undergoing VAC treatment suggests there may be a negative effect on bacterial clearance.⁹ In this study, serial cultures showed that bacterial colonization increased significantly during treatment. Though of note, the treatment was beneficial in most cases with rapid wound healing and there were no controls to provide meaningful comparison.

Mechanical stress causing granulation tissue formation and angiogenesis:-

Ilizarov et al. showed that applied mechanical stress to tissues stimulated mitosis and found that new vessels were formed as a result.^{10,11} This and the reduction in oedema could explain changes in blood flow and new vessel formation. However, further theories suggest that the vacuum may directly affect vasomotor tone and vaso-active mediators or simply have a mechanical effect forcing the blood through the area more quickly.¹ It is thought that in vivo the external forces applied to cells through the extra cellular matrix are balanced by intracellular cytoskeletal forces with integrins acting as trans-membrane bridges. This balance is thought to be disturbed by application of the VAC leading to release of various intra cellular second messengers which together cause changes in expression of immediate early genes which results in matrix molecule synthesis and, therefore, proliferation.¹⁰ The presumption is that this also occurs when the vacuum on the foam is released, causing progressive up-regulation when the vacuum is applied intermittently. This is born out by the finding of more granulation tissue in wounds where the vacuum is applied intermittently.² Recent work in China¹² also found that levels of the matrix metalloproteinases 1, 2 and 13 were reduced over time in five chronic wounds treated by the VAC technique. Lower levels of these MMP's would presumably lead to reduced collagen and gelatin breakdown and aid wound healing.¹² A further Chinese group recently examined the protein BcL-2¹³ They found that expression of this protein was increased in an animal model

on treatment with VAC therapy. This protein helps modulate apoptosis, and the results of the study suggest that the VAC may promote the healing process partly through modulation of apoptosis.

Reverse tissue expansion/skin stretching:-

The vacuum is thought to encourage migration of keratinocytes across wound defects. A pure in-drawing produced by the vacuum, the so-called 'mechanomechanical creep' effect. This is well seen in abdominal wounds treated by the VAC where a centripetal effect is observed.¹⁴ It can also be compared to the stretching of tissue produced by tissue expanders used prior to skin grafting procedures

Complications:-

When used within recommendations, complications resulting from the use of the VAC are infrequent—but do occur.

Pain:-

Most wounds treated by the VAC are painful by their very nature—for example; burns, pressure sores and infected wounds. However, as with all 'dressings' this pain can be exacerbated by dressings changes. Although VAC treatment carries the advantage of fewer dressings changes, strategies to minimize pain should be employed.¹⁵

Infection:-

One case report has been published highlighting the occurrence of Toxic Shock Syndrome following VAC treatment¹⁶. Frank pus within the wound to be treated is a contra-indication to treatment with the VAC. The manufacturers and body of opinion in the literature suggest that the wound bed should be debrided and prepared prior to treatment and any necessary antibiotic treatment commenced. However, the original studies reported enhanced clearance of bacteria in VAC treated subjects² and the clinical experience reported by many groups suggests a positive effect on avoidance of infection. No direct comparison has been made in a clinical trial of infection rates specifically in VAC vs. non-VAC treated patients.

Fluid depletion:-

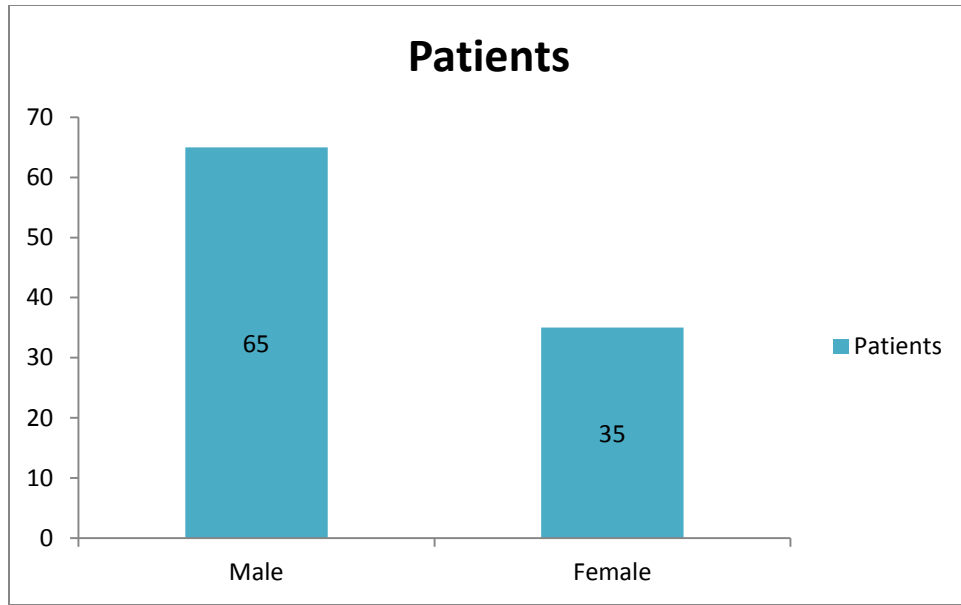
One recently published case report mentioned two cases of patients at extremes of age (10 months and 82 years).¹⁷ Both patients suffered fluid depletion following VAC treatment for skin loss following meningococcal septicaemia and chronic leg ulcers, respectively. In both cases, large amounts of fluid had been lost from the wounds over the course of their treatment. This problem should be considered and managed appropriately where large amounts of effluent are collected by the VAC.

Material and Methods:-

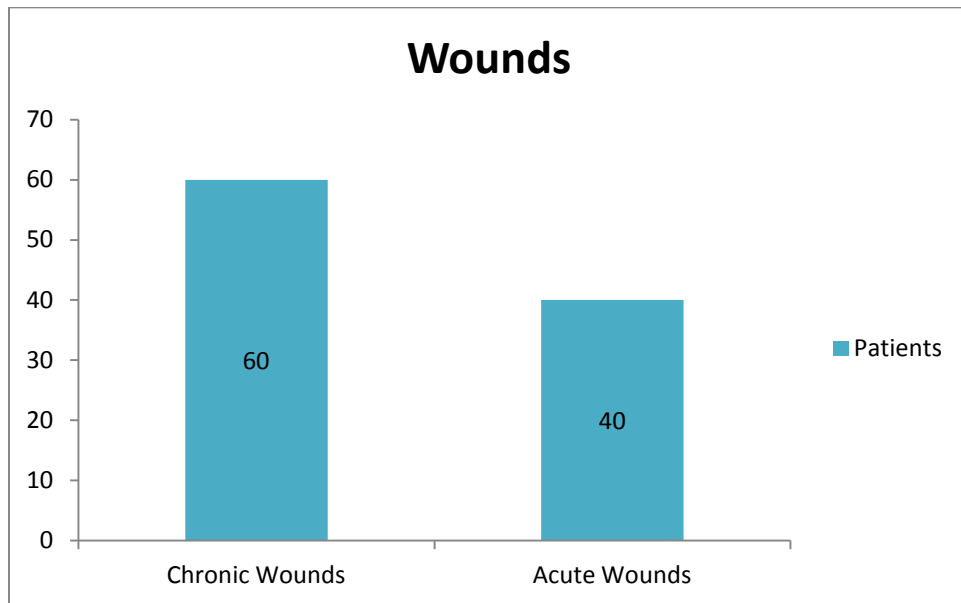
The study was conducted in the Department of General Surgery, Bhatia General Hospital from 16th March 2015 to 15TH March 2016 on 100 patients with acute and chronic wounds admitted in Bhatia General Hospital Hospital. The patients consent was taken for the procedure they underwent. There was no inclusion or exclusion criteria specified in the study.

Observation and Results:-

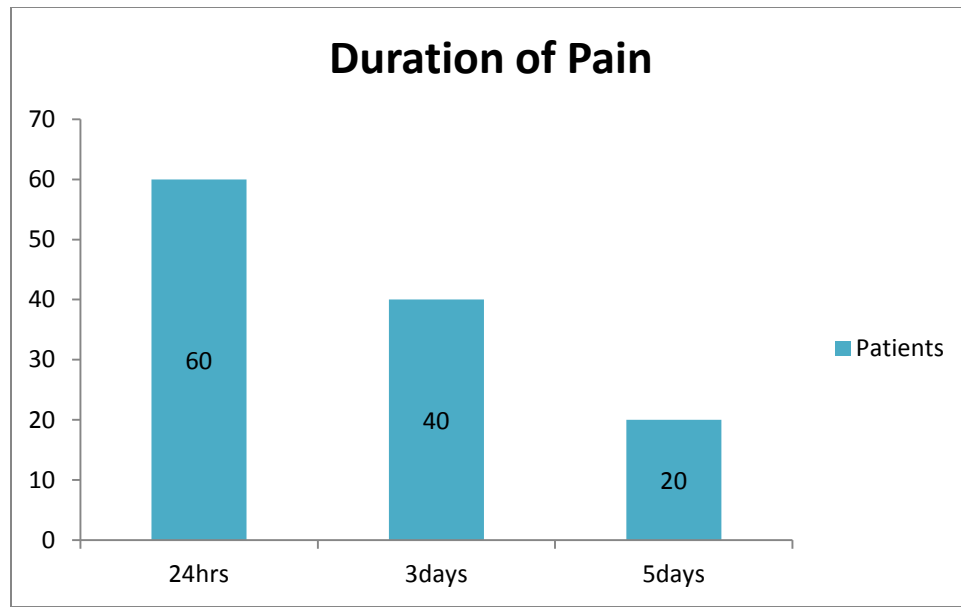
- 1) Sex of patient



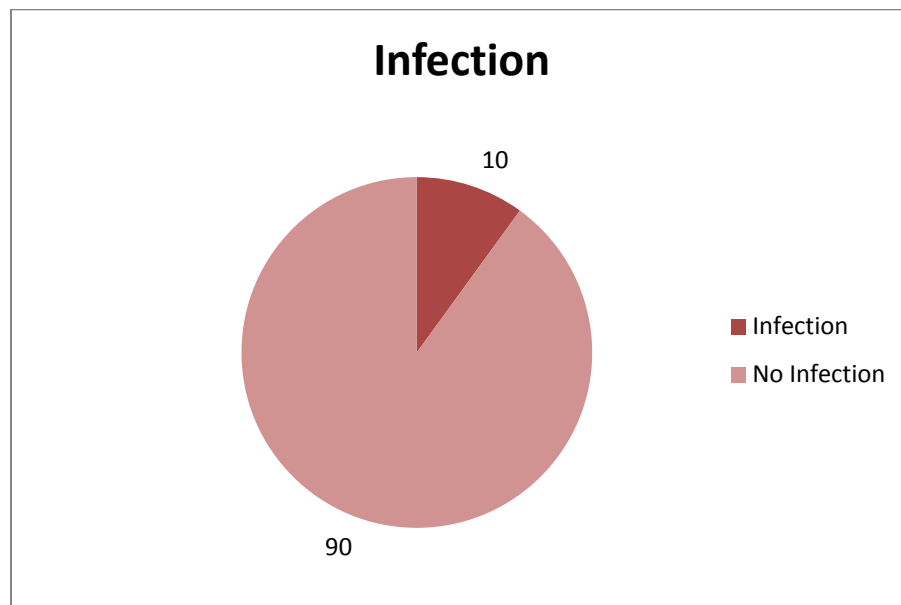
2) Type of wound.



3) Complications- a)Duration of pain



b) Infection.



c) Fluid Depletion –nil

The hospitalization period varied from 1 to 6 weeks. The follow up period was upto 6 months. No mortality was recorded during this study.

Bacterial growth:

Day 4: 40% no growth,

Day 8: 60% no growth

Decrease in Wound size 10% on 4th day, 20% on 8th day, 40% on 12 day, 60% on 16 day

Discussion:-

Healing is an intricate, interdependent process that involves complex interactions between cells, the cellular microenvironment, biochemical mediators, and extracellular matrix molecules that usually results in a functional restoration of the injured tissue^{18,19}. The goals of wound healing are to minimize blood loss, replace any defect with new tissue (granulation tissue followed by scar 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 molecules²⁰. 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 production¹⁸. Disruption of any of these factors may adversely affect the healing process, resulting in a chronic or nonhealing wound.

Blood flow increases and bacterial colonization of wound tissues decreases following the application of subatmospheric pressure to wounds. Any increase in circulation and oxygenation to compromised or damaged tissue enhances the resistance to infection²⁵. Successful, spontaneous healing and healing following surgical intervention are correlated with tissue bacterial counts of less than 105 organisms per gram of tissue²⁶. Higher levels uniformly interfere in wound healing. Increase in local tissue oxygen levels reduce or eliminate the growth of anaerobic organisms, which have been correlated to decreased healing rates^{27,28}. Additionally, the increased flow should make greater amounts of oxygen available to neutrophils for the oxidative bursts that kill bacteria²⁹.

Our study showed that in VAC group after day 4, there were 40% of patients who had no bacterial growth, and on day 8 there were 60% of patients who had no bacterial growth.

From our own experience, the VAC is a promising new technology in the field of wound healing. With multiple applications in a variety of wounds including those that can prove difficult to heal: pressure sores, amputation sites, skin grafts, lower limb ulceration, sternotomy wounds, burns and abdominal wounds. Broadly speaking, the applications are for both acute and chronic wounds, salvage procedures or as an adjuvant therapy to improve results of various surgical procedures.

The indications for the VAC as chronic open wounds (diabetic ulcers and stage 3–4 pressure sores) acute and traumatic wounds, flaps and grafts, sub-acute and dehiscent wounds as well as partial thickness wounds. They advise that non-enteric and unexplored fistulas and wounds containing necrotic tissue and eschar should not be treated with the VAC. Its use is also contraindicated on wounds containing untreated osteomyelitis or malignancy (due to the effect on cellular proliferation). The scientific basis for the VAC has been tested rigorously and the theories surrounding its' mechanisms of actions explored. Centres around the world continue to explore various applications of the VAC and to attempt to improve the way it is used.

However, the VAC is costly and there is a need for larger randomised controlled trials to prove the effectiveness of the technique in the various patient groups suggested by the current anecdotal evidence.

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