Original Article

Hydrosurgery is Effective for Debridement of Diabetic Foot Wounds

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Abstract

Introduction: Diabetic foot wounds are serious complications of diabetes mellitus. Surgical debridement is a very important part of the management of diabetic wounds. Sharp debridement using the scalpel is normally performed. Versajet II hydrosurgery system is an alternative technique for debridement. To our knowledge, this is the first study conducted to evaluate the use of hydrosurgery debridement for diabetic foot wounds. Materials and Methods: This pilot study included 15 consecutive patients with diabetic foot wounds who were admitted to the National University Hospital (NUH) and were managed by the Diabetic Foot Team from June 2012 to December 2012. All wounds underwent hydrosurgery debridement. Patients' demographic details, clinical details on wound assessments, and outcome were recorded and analysed. Results: The Versajet II hydrosurgery system was found to show some advantages over standard surgical scalpel debridement. It allowed adequate debridement whilst preserving more viable tissue to promote rapid healing. It could be manoeuvred over complex wound terrain. The time required for debridement was short — an average of 9.5 minutes. Good wound healing was achieved in all 15 cases. Only 1 Versajet debridement was required in 13 cases and 2 required an extra debridement. Twelve wounds were healed by split thickness skin grafting (STSG) and 3 wounds by secondary healing. Two of the STSG were infected but they were subsequently healed by dressings via secondary healing. Conclusion: Although good wound healing was achieved in all 15 cases, further study that uses a larger cohort and a randomised controlled trial is required to fully evaluate the effectiveness, or otherwise, of the Versajet II hydrosurgery system for the debridement of diabetic foot wounds.

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Key words: Infective wounds, Versajet, Wound healing

Introduction

The prevalence of diabetes mellitus in Singapore is increasing. It was at its highest of 11.3% in the latest National Health Survey 2010 compared to 8.2% in 2004.[1] Diabetic foot wounds are serious complications of diabetes mellitus and can lead to limb loss if left untreated. Diabetics have a 10% to 25% lifetime risks of developing foot ulcers.[2] Neuropathy, poor circulation and injury contribute to the formation of diabetic foot ulcers and 85% of lower extremity amputations are preceded by diabetic foot ulcers.[3] Nather et al found the incidence of major amputations (above and below knee) to be 27.2% for diabetics with foot complications.[4]

The commonest procedure performed for diabetic foot surgery is surgical debridement. Debridement is the excision of necrotic, devitalised or infected tissue from a wound, leaving healthy and vascularised tissue behind. It is an essential part of wound care prior to wound healing. Sharp surgical debridement makes use of the scalpel to cut necrotic, devitalised or infected tissue from a wound.

Surgical debridement should cause only minimal damage to surrounding tissues. The preservation of viable tissue while removing necrotic tissue and slough allows wound healing to occur rapidly. Hydrosurgery debridement is a different modality described in many wound care literatures. It is used for wound bed preparation.[5-12] It enables the surgeon

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to simultaneously hold, cut and remove nonviable tissue precisely without collateral damage to healthy surrounding tissue, allowing the healing process to progress quickly.[13] In our literature review, there are many studies that utilise hydrosurgery debridement in their wound debridement and wound bed preparation but majority of these studies reported on burn wounds, traumatic wounds like open fractures and degloving wounds, plastic surgery reconstructive wounds and chronic vascular leg ulcers.[5-9,11,12] There are very few studies that report the usage of hydrosurgery debridement in diabetic foot wounds.[9,11,12] Vanwijck et al in 2010 studied 167 subacute and chronic wounds using hydrosurgery debridement and only 12 of them were diabetic foot wounds.[11] Caputo et al in 2008 performed a prospective randomised trial comparing hydrosurgery debridement versus standard scalpel debridement in lower extremity ulcers but only had 22 diabetic foot ulcers out of 41 ulcers.[12]

To our knowledge, this is the first study that aims to report our pilot experience in using the Versajet II hydrosurgery system[13] in the debridement of diabetic foot wounds.

Materials and Methods

This is a prospective pilot study of 15 consecutive patients treated for diabetic foot from June 2012 to December 2012. The indications for the Versajet included ray amputation wounds, wounds postdrainage for abscess, shin ulcers, and wounds postexcision of metatarsal bones. These wounds were graded according to Wagner's classification.[14]

Pertinent data on patients' demographics, diabetic history and control, American Society of Anaesthesiologist (ASA) grading,[15] clinical assessments, operative details and complications were recorded. Peripheral neuropathy was assessed using Semmes-Weinstein 5.07/10 g monofilament test (touch/pressure) and the ability to detect 7 or less sites out of 10 sites indicated presence of peripheral neuropathy.[16] Vibration perception was evaluated using the biothesiometer (Bio-Medical Instrument Company, Ohio, USA). Vascular assessment using ankle-brachial index (ABI) and toe-brachial index (TBI) were performed for each patient. Ulcer description and location were recorded. All wounds had a swab culture and sensitivity performed prior to treatment. Other parameters captured include inflammatory markers such as leukocyte count and C-reactive protein (CRP).

The Versajet was used in all 15 patients. It consisted of a disposable handpiece, power console with foot pedal activation and a waste bin. It projected a high velocity stream of sterile saline across the operating window and into the evacuation collector. This created a localised vacuum to hold and cut targeted tissue while aspirating debris from the operation site. The handpiece was held such that the waterjet was parallel to the wound so that tangential excision can be achieved. This allowed rapid removal of damaged devitalised tissues while preserving the surrounding viable tissues. There are 2 types of handpiece available for the operator to use depending on wound type and treatment strategy. The operator can regulate the waterjet velocity using the 10 power settings that are available and visualised on the power console.

All surgeries were performed by the senior author. General or regional anaesthesia was employed. After debridement, tulle gras and Kaltostat dressings were applied. Subsequently, wound inspections were performed on postoperative day 2 and wound dressings were done using Mepilex Ag. Regular wound dressings were performed for those wounds left for secondary granulation until healing had occurred. Patients who underwent split thickness skin grafting (STSG) had a negative pressure dressing applied and the wound was inspected only on postoperative day 5 to review the state of the STSG. Following that, non-adherent dressings using Mepilex Ag were used to dress the recipient site while the donor site was dressed with tulle gras and gauze dressings.

Results

In our study, the average age of our study population was 54.5 years (range, 41 to 71 years). There were 7 males and 8 females. Our patients were followed up for an average of 10 months (range, 6 to 12 months). Majority of them were ASA grade 3 (10/15; 67%). The average glycated haemoglobin (HbA1c) reading was 9.7% (range, 6.4% to 16%). Five of the patients had severe peripheral neuropathy with zero score in the Semmes-Weinstein 5.07/10 g monofilament test and severely diminished vibration perception as indicated by the biothesiometer (Bio-Medical Instrument Company, Ohio, USA). Six patients had spinal anaesthesia, 5 patients had general anaesthesia and 4 patients underwent ankle block during the surgery. Patient demographics, operative details, diabetes control and infective markers are shown in Table 1.

There were 4 patients with shin ulcers, 5 cases for ray amputation wound, 2 cases for excision of metatarsal wound and 2 cases with wound on dorsum of foot. One patient had a wound over the plantar aspect of 5th metatarsal head from drainage of abscess while another had a wound over the base of the 5th metatarsal. These wounds were categorised according to Wagner's classification (Table 2). All the wounds were infected and the organisms cultured from the wounds were tabulated (Table 2).

An average time of 9.5 minutes (range, 5 to 20 minutes) were used for a single Versajet debridement (Table 2). Thirteen patients had a single Versajet debridement prior to wound healing while 2 patients had an additional debridement. STSG was performed in 12 patients. The graft healed successfully in 10 cases. However, in 2 patients the grafts became infected and was subsequently left to granulate with regular local dressings. The remaining 3 patients had

Table 1. Patient Demographics, Wound Site, Diabetes Control and Infective Markers

No.	Age	Gender	Wound Site	Wagner Grading	Hba1c	ABI	TBI	Infective Markers		Semmes-Weinstein 5.07/10 g Monofilament	Bio-thesiometer (Volts)
								WBC	CRP		
1	66	Female	Ulcer dorsum of foot	2	7.2%	1.08	0.72	12.8	342	10/10	25
2	45	Female	Wound post 5th ray amputation	3	11.3%	1.31	0.93	10.1	18	0/9	50
3	49	Female	Ulcer shin	2	11.9%	1.23	0.62	12.1	236	5/10	22
4	48	Male	Wound post excision of 4th and 5th metatarsal bones	3	7.0%	1.07	0.46	8.8	22	0/10	>50
5	51	Female	Ulcer shin	2	6.4%	0.67	0.22	11.7	49	0/10	>50
6	47	Female	Wound post excision of 5th metatarsal bone	3	7.4%	0.76	0.72	8.5	18	0/10	>50
7	49	Male	Ulcer shin	2	9.9%	1.13	0.71	6.9	17	2/10	25
8	60	Male	Wound over plantar aspect of 5th metatarsal head	3	7.0%	1.03	0.78	7.2	34	0/10	45
9	71	Female	Wound post 1st ray amputation	3	9.9%	0.82	0.68	22.6	206	3/9	>50
10	41	Male	Abscess dorsum of foot	2	11.1%	1.05	0.91	8.8	206	7/10	20
11	66	Female	Wound over 5th metatarsal base	3	7.8%	0.9	1.0	7.0	16	0/10	>50
12	54	Male	Wound post 2nd and 3rd ray amputation	4	14.6%	1.18	0.75	25.4	133	5/7	49
13	51	Male	Wound post 5th ray amputation	4	9.1%	2.04	0.59	8.0	88	1/10	50
14	55	Male	Wound post 5th ray amputation	3	9.6%	1.15	0.48	7.3	73	5/10	40
15	65	Female	Ulcer shin	2	>16%	0.9	0.82	11.4	48	10/10	40

ABI: Ankle-brachial index; CRP: C-reactive protein; Hba1c: Glycated haemoglobin; TBI: Toe-brachial index; WBC: White blood cell

Table 2. Wound Culture, Versajet Debridement Details and Final Outcome

No.	ASA	Mode of Anaesthesia	Wound Swab Culture	Number of Procedures Performed Before Versajet	Number of Versajet Debridements	Duration (Minutes)	Final Outcome
1	2	Spinal	*Pseudomonas Aeruginosa, Arcanobacterium sp*	1	1	16	STSG
2	3	Spinal	*Streptococcus Agalactiae*	1	1	5	STSG
3	3	Spinal	*Streptococcus Pyogenes*	2	1	5	STSG
4	3	Ankle block	MRSA, *Pseudomonas Aeruginosa, Acinetobacter Baumanii*	3	2	11, 8	Secondary healing
5	3	Spinal	*Klebsiella Pneumoniae, Citrobacter Koseri, Morganella Morganii*	2	2	6, 5	STSG infected – left to granulate
6	3	Ankle block	*Escherichia Coli*, MRSA	3	1	12	STSG infected – left to granulate
7	2	GA	*Pseudomonas Aeruginosa, Stenotrophomonas Maltophilia*	2	1	8	STSG
8	2	GA	*Serratia Marcescens*	1	1	7	Secondary healing
9	3	Ankle block	*Streptococcus Agalactiae, Staphylococcus Aureus*	1	1	5	STSG
10	2	GA	*Streptococcus Agalactiae*	1	1	9	STSG
11	3	Spinal	*Streptococcus Agalactiae*	1	1	20	STSG
12	3	Ankle block	*Pseudomonas Aeruginosa, Klebsiella pneumoniae, Escherichia coli*	1	1	12	STSG
13	3	GA	*Pseudomonas Aeruginosa, Escherichiacoli, Enterococcus faecalis, Prevotella spp*	2	1	11	STSG
14	3	GA	*Morganella morganii*	1	1	8	Secondary healing
15	2	Spinal	*Klebsiella pneumonia*	0	1	7	STSG

ASA: American Society of Anaesthesiologist; GA: General anaesthesia; MRSA: Methicillin resistant *Staphylococcus Aureus*; STSG: Split thickness skin graft regular wound dressings done to allow secondary wound granulation and healing (Table 2). Both the 2 cases that failed STSG were found to have poor vascular supply based on their respective ABI (0.67; 0.76) and TBI (0.22; 0.72) findings. These 2 cases also had severe peripheral neuropathy as shown by the monofilament test and biothesiometer.

Discussion

Treatment of diabetic foot ulcer continues to be a challenge to healthcare professionals. There are many factors affecting wound healing in a diabetic patient and it is of great importance that the wound heals quickly to minimise risk of secondary infection and subsequent amputation. One vital aspect in the management of diabetic foot ulcer is the surgical debridement. The Versajet II hydrosurgery system is a useful tool for the management of diabetic wounds. It has been described in several articles for wound management.[5-12] However, there is lack of data on its use in the treatment of diabetic foot ulcers.[9,11,12] To our knowledge, this is the first study conducted to evaluate its effectiveness in the treatment of diabetic foot wounds.

Mosti et al in 2005 reported that 46 out of 68 (67.6%) patients who underwent the Versajet debridement required only 1 operative procedure to achieve an adequately debrided wound bed for split-skin grafting.[9] Granick et al in 2006 showed that the Versajet helped to reduce the number of debridements required to adequately prepare the wound bed for closure.[10] Similarly, we found that in our study population, 13 out of 15 patients required only one hydrosurgery debridement with Versajet while 2 patients required additional debridements prior to wound healing. A limitation of our study was to compare the results of Versajet debridement with surgical debridement using the scalpel as a control. Nevertheless, the majority of our patients only required one debridement using the Versajet to adequately prepare wound bed for eventual healing be it for secondary healing or STSG. Ten of our patients achieved complete wound healing after one debridement. The wounds were then ready for STSG similar to findings by Vanwijck et al.[11] In 2 patients, the split skin grafts were infected but proceeded to secondary healing with regular local dressings.

Caputo et al reported in a prospective randomised trial that hydrosurgery using the Versajet resulted in shorter debridement time without compromising wound healing.[12] In our study, the average time per procedure performed was also short; an average of 9.5 minutes (ranging from 5 to 20 minutes). The reduction in surgical time was significant as most of our patients were of ASA grade 3. A shorter anaesthetic time would be better for them. Versajet debridement could also be performed under regional anaesthesia. Four of our patients underwent Versajet debridement under ankle block and 6 of them had spinal anaesthesia. In our experience, this waterjet debridement could also be performed under local anaesthesia. In the latter, a power setting of 5 and below was preferred.

The Versajet II hydrosurgery system was found to give good control of excisional depth in debridement. This is particularly useful in wounds with exposed neurovascular bundles and tendons. Case study 1 demonstrated the usefulness of Versajet debridement for large wound over the dorsum of foot extending from medial to lateral border of the foot and ankle. The handpiece (tip angle of 45° or 15°; working end of 8 or 14 mm in length) allowed easy navigation over the wound without having to turn the patient in multiple positions. The patient was positioned supine (Fig. 1). Case study 4 demonstrated a deep, complex, contoured wound over the lateral foot resulting from an excision of the fourth and fifth metatarsal bone. There was a deep cavity with irregular edge and surface despite performing repeated sharp debridement with a knife. The Versajet was found to be good for wound bed preparation in this complex contoured wound without further alteration of its contour and preserved more viable tissue to encourage healing (Fig. 2).

Fig. 1. 1A and 1B show a left foot dorsum ulcer while 1C and 1D show the clean and smooth surfaced wound post Versajet debridement. 1E to 1F demonstrate the successful reconstructive surgery with split thickness skin graft.

Fig. 2. 2A and 2B show the wound post excision of 4th and 5th metatarsal bones with a resultant deep cavity and irregular wound surface and edges. 2C shows the smooth surface and wound edges after Versajet debridement. 2D to 2F show the wound contraction and secondary healing via regular local dressings.

Conclusion

In this pilot study, we found that the Versajet II hydrosurgery system showed some advantages over standard surgical scalpel debridement. It allowed adequate debridement of the diabetic foot wounds without much collateral damage which can occur with standard scalpel debridement. It preserved more viable tissue to promote rapid healing. We were able to manoeuvre the hand piece over deep and complex wound terrain without much difficulty to achieve a smoother and less irregular wound surface suitable to receive STSG. The time required for surgical debridement was shorter.

However, further studies that use a larger cohort and a randomised controlled trial are required in order to fully evaluate the effectiveness, or otherwise, of the Versajet for debridement of diabetic foot wounds.

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