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Clinical Experiences with the Hydrosurgical Debridement Tool at a Level I Trauma Hospital

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Abstract: The purpose of this current article is to report our increasing experience with the hydrosurgery device in debridement of a variety of wounds. 34 wounds in 14 patients with significant co-morbidities were debrided mainly by the hydrosurgery system in addition to cold knife that was used for minor eschar excision. The advantages of the hydrodebridement, technical tips during its application, limitations and disadvantages in wound bed preparation were reviewed and discussed based on our experience and current literature.

BACKGROUND

Wound debridement has been shown to accelerate wound healing compared to conservative treatment by the reduction of bacterial load and bioburden that is considered crucial for reconstruction [1]. There is a multitude of methods described for wound bed preparation. These include autolytic and enzymatic techniques, ultrasound debridement, and use of rotating burr, surgical brush, curette, maggot therapy, hydrodebridement and cold knife. The gold standard for wound bed preparation is sharp debridement utilizing cold knife in conjunction with pulsed lavage and/or irrigation. For this purpose, conventional blades, Goulian-Weck, Humby, Watson knives, and Padgett dermatome can be employed. Cold knife debridement has the advantage of being fast, but can be imprecise. There is a tendency to remove excessive healthy tissue along with the targeted necrotic tissue as differences occur between the shape of the knife, the dimensions of the wound and certain parts of the body. Furthermore jot every wound is suitably debrided using cold knife. Sharp knife debridement may result in sacrificing viable tissue while not always achieving complete excision of the nonviable tissue.

We have included hydrodebridement tool (Versajet™ Hydrosurgery System, Smith & Nephew Wound Management, Hull UK) in our armamentarium as an adjunct to cold knife or as the sole method for wound debridement for the past three years. This system utilizes high fluid technology for wound debridement. We published our experience on the use of the hydrosurgery system on 15 wounds in 15 patients previously [2]. In this article we report an additional 14 patients with 34 wounds. The purpose of this current article is to report our increasing experience with this instrument in debridement of a variety of wounds prior to final reconstructive surgery. The advantages of the technique, technical tips during its application, limitations and disadvantages were further reviewed and discussed based on our experience and current literature.

PATIENTS AND METHODS

We have used the hydrosurgery system as the sole method of wound debridement or in conjunction with sharp knife on 14 patients with 34 wounds. Patients with large eschar tissues that would benefit mainly from sharp knife debridement were excluded. Demographics of the patients including co-morbidities, wound characteristics, method of wound debridement, and type of reconstruction are displayed in the Table **1**. Ages of the patients ranged from 14 months to 70 years. Notable co-morbidities among eleven patients with a decreasing order were cigarette smoking, hypertension, homelessness, hepatitis C, diabetes mellitus, peripheral artery disease. One patient had multiple myeloma with pancytopenia, one patient had end-stage renal disease and sickle cell trait, and another one recently recovered from chemotherapy for anal carcinoma. Types of wounds included 6 burns, 3 necrotizing fasciitis, 3 venous stasis ulcers, 2 non-healing surgical wounds, 18 traumatic wounds, 1 Fournier gangrene and 1 pressure sore. A disposable Versajet™ handpiece with a 45 degree angle and a 14mm operating window was used in all cases.

RESULTS

All debridements were performed in the operating room under general anesthesia. A disposable Versajet™ handpiece with a 45 degree angle and a 14mm operating window was used in all cases. Five wounds in three patients underwent debridement and wound bed preparation by using the hydrosurgery system whereas remaining wounds in eleven patients needed a combination of the hydrosurgery system and cold knife for debridement. Cold knife was used as adjunct in these cases for removal of desiccated eschar tissue. In thirty-two wounds, a single debridement was

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Table 1. Patient and Wound Characteristics, Utilization of Hydrosurgery Device, Cold Knife and Wound VAC, and Reconstruction Type in the Management of Presented Wounds

Patient # - Age Sex	Comorbidity	Wound Site	Wound Size (cm)	Etiology	Reconstruction	# of Versajet Debridements	# of Sharp Debridements	Wound VAC	Complications
1 - 48y, M	Homeless, smoker, HTN, withdrawal from ETOH	Right abdomen	6 x 6	Burn	STSG	1	0	No	No
		Right thigh	5 x 9	Burn	STSG	1	0	No	No
2 - 49y, F	Smoker	LLE anterior	7 x 4.5	Scalding Injury	STSG	1	1	No	No
		RLE anterior	13 x 20	Scalding Injury	STSG	1	1	No	MWB
		RLE lateral	4 x 7	Scalding Injury	STSG	1	1	No	No
		RLE popliteal fossa	9.9 x 1.5	Scalding Injury	STSG	1	1	No	No
3 - 42y, M	Smoker	Suprapubic	24 X 8	Trauma	STSG	1	1	No	No
		Abdominal	24 X10	Trauma	STSG	1	1	No	No
		Chest	15 X 8	Trauma	STSG	1	1	No	No
		Dorsal penile	4 X 4	Trauma	STSG	1	1	No	No
		Left thigh	30 x 6	Trauma	STSG	1	1	No	No
		Right thigh	8 x 5	Trauma	STSG	1	1	No	No
		Right thigh	9 x 2	Trauma	STSG	1	1	No	No
4 - 47y, M	Homeless, Hep C, smoker, CT	Perineorectal	10 x15	s/p anal CA resection	B Gracilis flaps	2	2	Yes	POWI
5 - 38y, M	MM, pancytopenia , smoker	Pelvic	23 x 13	Necrotizing Fasciitis	STSG, local skin flaps	1	1	Yes	No
6 - 33y, M	None	Penoscrotal	8 x 10	Fournier gangrene	RFFF	1	0	No	No
7 - 14 months, F	None	Left forearm	3 x 3	s/p Laceration	STSG	1	1	No	No
8 - 48y, M	None	Right neck	8 x 8	Trauma	STSG	1	1	No	No
		Right forearm	30 x 7	Trauma	STSG	1	1	No	No
		Left medial thigh	10 x 14	Trauma	STSG	1	1	No	No
		Left medial knee	6 x 3.5	Trauma	STSG	1	1	No	No
		Left upper thigh	12 x 2	Trauma	STSG	1	1	No	No
		Left lower thigh	8 x 2	Trauma	STSG	1	1	No	No
		Right proximal thigh	8 x 1.5	Trauma	STSG	1	1	No	No
		Right middle thigh	6 x 4	Trauma	STSG	1	1	No	No
		Right distal thigh	2 x 3	Trauma	STSG	1	1	No	No
9 - 46y, M	Hep C, smoker	Right medial thigh	9 x 4	Necrotizing Fasciitis	Direct closure	1	1	No	No
		Right anterior thigh	30 x 10	Necrotizing Fasciitis	STSG	1	1	No	No

(Table 1) contd…..

Patient # - Age Sex	Comorbidity	Wound Site	Wound Size (cm)	Etiology	Reconstruction	# of Versajet Debridements	# of Sharp Debridements	Wound VAC	Complications
10 - 42y, M	Homeless, violence, poor nutrition	Neck/Anterior chest	25 x 25	s/p Assault	STSG	2	2	No	No
11 - 70y, M	DM, HTN, MI	Right lower extremity	7 x 15	Vascular insufficiency	STSG	1	1	No	No
12 - 60y, F	ESRD, VASCULITIS, HTN, CVA, SICKLE CELL TRAIT, ANEMIA	Left Lower extremity	5 x 5	Vascular insufficiency	STSG	1	1	Yes	MWB
13 - 49y, F	DM, HTN, PAD	Abdominal Wound	10 x 12	s/p Abd Hysterectomy	STSG	1	1	No	No
14 - 29y, F	Paraplegia, PAD	RLE	8 x 9	Vascular insufficiency	STSG	1	0	No	No
		Left Buttock	15 x 20	Pressure sore	STSG	1	0	No	No

LLE: Left lower extremity
RLE: Right lower extremity
s/p : Status post
STSG: Split-thickness skin graft
B: Bilateral
RFFF: Radial forearm free-flap

DM: Diabetes mellitus
CT: Chemotherapy
MWB: Minor wound breakdown
POWI: Postoperative wound infection
ETOH: Ethanol
MI: Myocardial infarction

HTN: Hypertension
ESRD: End-stage renal disease
CVA: Cerebrovascular accident
PAD: Peripheral artery disease
MM: Multiple myeloma

performed having proper wound bed preparation - two of which had long term V.A.C. (Vacuum Assisted Closure, KCI, San Antonio, TX) placed. While direct closure was performed in one wound, the remaining wounds were covered with either skin grafts or flaps. In two patients (patients 4 and 10), two debridements were required prior to definitive reconstruction. There was one post-operative wound infection (patient 4) that required incision and drainage and V.A.C placement in the operating room. In two patients (patients 2 and 12) minor wound breakdown occurred with complete healing subsequently without any surgical intervention. One patient with a large diabetic leg ulcer (patient 11) had a skin graft breakdown and was treated conservatively. Only in one patient (patient 4) there was a postoperative wound infection which was treated with an appropriate antibiotic treatment.

Overall, immediate skin graft take rate was higher when compared to the conventional methods of debridement based on our experience with similar wounds. The mean time to complete wound healing was 3 weeks and 2 days. The patient follow-up ranged from 3 months to 12 months with a mean follow-up of 5.6 months.

DISCUSSION

The hydrosurgery device has the ability to focus a high-powered stream of saline into a high-energy cutting implement that works by the Venturi effect. A jet of saline, propelled by a power console, travels across the operating window of a hand-held piece and then into a suction collector. This system of pressurized saline functions like a knife. The saline beam is aimed parallel to the wound so that the cutting mechanism is a highly controlled form of tangential excision [3].

There is a learning curve for the hydrosurgery system. Technical tips during its application are discussed in the next two paragraphs. Power settings range from 1 (lowest) to 10 (highest) with waterjet speed with pressures ranging between 265 and 670 mph or between 103 and 827 bar [3]. The power setting has an inverse relationship to the cutting duration. Increasing the power setting decreases the duration of debridement, whereas decreasing the power setting increases the duration of debridement. Alternating pressure of the handpiece can further modulate its use and effect on the wound surface. It would be safer if one starts with a lower setting and makes appropriate adjustments based on the individual wound being debrided.

At higher power levels, more tissue can be excised and at lower levels more delicate or thin tissue can be debrided. When the operating window is orientated parallel to the tissue, excision and aspiration are performed. The closer the operating window is to parallel, the more aggressive the tissue excision. When the operating window is orientated obliquely to the tissue, the primary action becomes irrigation and vacuuming of the contaminated tissue.

We were able to quickly master the technical aspects of the hydrosurgery system in each of the types of wounds encountered and the operating room staff felt comfortable using the hydrosurgery system in a short period of time.

We experienced many advantages utilizing the hydrosurgery system in wound debridement. This single device technique combines lavage and sharp debridement instrumentation with single-handed operation due to holding and treating with one device. The device provided the control to hold targeted tissue during irrigation and excision, and importantly, the handpiece provided the ability to perform simultaneous debridement as well as removal of debris by aspiration. This helped keep the operative field cleaner and drier compared to conventional lavage techniques.

The hydrosurgery system affords the surgeon a highly selective form of tangential excision that can precisely target damaged and necrotic tissue and debris and spare the viable adjacent tissues, as is well illustrated in patient 14 (Figs. **1-3**). In addition, when comparing the hydrosurgery system to cold knife debridement there appears to be less bleeding. Some authors have added epinephrine to the saline as a means to minimize bleeding, but, have found no benefit [4].

Fig. (1). Use of the hydrosurgery device for debridement and wound bed preparation in a right leg ulcer (patient 14).

Fig. (2). Completion of the wound bed preparation with homogenous bleeding at the wound bed.

We found that the lower power settings of 2 or 3 allowed us to debride devitalized, necrotic tissues of the hand while preserving important structures such as nerves, vessels and tendons. Meticulous debridement of thin tissue of the eyelids and fragile tissues of the penis, as in patient 6, (Figs. **4**, **5**) was also safely possible using lower power settings of the hydrosurgery system.

Another significant advantage of this device demonstrated was its ability to efficiently debride irregular and complex contour wounds such as deep pressure sores (patient 14) and deep perineal wounds (patient 4) (Figs. **6**, **7**). These wounds usually have irregular, complex architecture and three dimensional surfaces that are well suited for debridement with hydrosurgery system prior to definitive reconstruction.

Fig. (3). Reconstruction of the wound with split-thickness skin grafting.

Fig. (4). Wound bed preparation by means of the hydrosurgery in a penile wound status post Fournier gangrene (patient 6).

Fig. (5). Healed reconstruction of the penile wound with radial forearm free flap (3 months after reconstruction).

Similarly, in traumatic degloving type injuries where avulsion skin flaps developed, it was often very difficult to debride necrotic tissues under those flaps using conventional technique. By means of the handpiece, the hydrosurgery provided more effective debridement that also allowed the flaps to easily attach to the recipient wound bed. Furthermore, sharp knife sometimes caused unexpectedly deep debridements jeopardizing the viability of the avulsed flaps. A clinical comparison with similar patients revealed a better postoperative outcome in cases where hydrosurgery system was used.

Fig. (6). Perineo-rectal wound debrided with hydrosurgery device following anal cancer resection and radiation treatment (patient 4).

Fig. (7). Healed reconstruction of the defect with left gracilis muscle and right gracilis muscle-skin flap at 4 months (a new minor superficial wound in the posterior aspect of the skin island was due to abrasion and not associated with reconstruction).

Hydrosurgery system has had many drawbacks and limitations since it became available for clinical use. In our experience, in deep second degree as well as third degree burn injuries involving large flat surfaces, tangential excision using sharp knife has always been a superior option. In addition, using the hydrodebridement in such cases increased the time required for debridement, in addition to its cost. If the choice is made to utilize the system in large burn wounds, it is important to use warm saline to avoid cooling the patient [4]. However, in small three dimensional areas such as in hand, feet, and face requiring debridement hydrosurgery device proved to be a better alternative.

In our experience, there was no difference between the hydrosurgery system and conventional techniques in terms of operating time required for debridement, number of the debridements and outcome when treating superficial second degree burn wounds and superficial traumatic or postsurgical wounds, regardless of wound size. However, hydrodebridement proved to be costly when used in such cases.

The hydrosurgery device was not an option for removing eschar and debriding bone [1, 5, 6]. Furthermore it was not effectively applicable in wounds where the bulk and amount of necrotic tissue load was very high. In such cases, conventional sharp techniques provided faster and efficient debridement and better outcome. Nevertheless one can remove the bulky necrotic tissue with sharp techniques and use the hydrosurgery device for further and precise debridement in such cases. However, cost of the treatment would be an issue in such cases.

As outlined in the table, despite the fact that most patients included in this study had significant co-morbidities, wound complication rate overall was low with a few postoperative wound infections, higher graft take rate and better reconstructive outcome suggesting adequate wound debridement. In most cases, we used the cold knife to excise a minor dry necrotic tissue in addition to hydrodebridement and included this in the study. Therefore, it is difficult to attribute the results directly to hydrosurgery.

Nevertheless, our findings were comparable to those reported by Vanwijck *et al*. [7] with regards to skin graft take. A high percentage of successful engraftment after immediate skin grafting of chronic and subacute wounds following debridement with hydrosurgery was reported by these authors.

In the series of presented patients, we performed fewer debridements per wound than with conventional techniques. This finding was in agreement with Granick *et al*. [6] who demonstrated a statistically significant reduction in the number of debridements required to properly prepare the wound bed for closure in the Versajet™ group compared to traditional techniques. This is likely a product of sufficient removal of necrotic tissue and debris, as well as, a reduction in the bacterial count in the wound. Mosti *et al* [3] found that the use of Versajet™ decreased bacterial burden in lower extremity ulcers from 10^6 to 10^3 in approximately 43 % of the patients in the Versajet™ group when compared to traditional moist dressings. Our clinical evidence seems to support this data. On the other hand, Bowling *et al*. [8] demonstrated no statistically significant reduction in bacterial contamination of the porcine samples post hydrodebridement in a porcine model. Further research is necessary to evaluate the effects of the Versajet™ on bacterial load.

Mosti *et al*. [3] reported that the Versajet™ system allowed for an overall shorter hospital stay, thereby more than offsetting the cost of the handpiece and resulting in a total cost savings. Granick *et al*. [6] described an increase in cost saving with the Versajet™ system by virtue of decreased number of operative procedures and improved patient outcomes. Our experience with the Versajet™ system also demonstrates that fewer debridements were performed leading to cost savings. However, we believe that a study with a properly designed control group should be conducted to evaluate the cost effectiveness of the hydrosurgery system. Recently, Sainsbury [9] highlighted that the evidence available regarding hydrosurgery is largely based on expert opinion. He pointed out that clinical studies published regarding hydrosurgery have methodological flaws that include lack of control groups, selection bias and lack of blinding.

SUMMARY

Efficient debridement of traumatic wounds, pressure sores, burn wounds, and chronic non-healing wounds due to diabetes mellitus, venous insufficiency, peripheral vascular disease is an essential and crucial step in wound management. In this article, usage of a hydrosurgery system that utilizes high fluid technology is presented for debridement of various wounds in fifteen patients. Technical tips, advantages and pitfalls of the hydrosurgery device in wound debridement are provided. Inability to remove hard eschar and to debride the bone are two known drawbacks of the hydrosurgery system. Even though the hydrosurgery system cannot replace sharp techniques for desiccated eschar removal and other techniques for bone debridement, it can be an efficient alternative for soft tissue debridement in selected cases. However, its cost effectiveness needs to be studied in detail with well-controlled studies.

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