Low-Pressure Wound Irrigation

Establishing a Method to Compare Available Techniques and Products

Dr. Stefan Hellbardt

Aptar Radolfzell GmbH, Oeschlestrasse 54-56, 78315 Radolfzell, Germany

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Abstract

Cleaning of acute wounds by low-pressure irrigation is common clinical practice[1]. According to literature, syringes with 19-gauge angiocath are widely used for this purpose. With this simple technique, achievable flow rates are found to be sufficient for the removal of biofilm and bacteria, while avoiding additional wound damage[1]. Based on this procedure, we established a method to compare the performance of wound wash products and techniques.

We generated basic data by using a 50 ml syringe filled with isotonic saline connected to a 19-gauge injection needle. Three people were asked to generate different flow rates by manual syringe actuation. Impact force of the resulting saline stream onto a hypothetical wound surface was recorded by means of a plastic disk (diameter 7 cm) connected to a force sensor. Distance between needle or dispensing orifice, respectively, and plastic disk was fixed at 10 centimeters, a distance providing sufficient precision, while avoiding wound contact. Six different wound wash products were assessed in triplicate using the same set up. For each product type, average flow rates were calculated from delivered volume divided by actuation time.

Low-pressure needle irrigation by different operators resulted in flow rates ranging from 0.53 to 3.57 milliliter per second (ml/s). Corresponding impact force at the disk surface ranged from 2.9 to 59.7 milli-Newton (mN). Tested wound wash products provided flow rates between 1.6 and 10.0 ml/s, translating into impact forces of 19 to 121 mN. Only two out of the six commercially available products provided flow rates and impact forces comparable to manual needle irrigation.

The described method enables a fast comparison of wound wash products to standard low-pressure wound irrigation. Our study revealed considerable heterogeneity amongst tested products. This simple method may be used for irrigation technique characterization and better understanding of clinical outcomes.

Introduction

Wound cleansing is considered an important step in the treatment of acute and chronic wounds. The goals of wound cleansing range from removal of biofilm and dead tissue to mere reduction of debris and bacterial load. Consequently there is a range of techniques including high-pressure irrigation, swabbing, low-pressure irrigation, showering, bathing, washing the affected area under a running solution, or total immersion in a whirlpool bath (also known as hydrotherapy)[2].

Low-pressure wound irrigation is common clinical practice to prepare wound beds for further intervention and care[1]. In acute settings it often is the only available intervention before covering an open wound. Low-pressure wound irrigation aims to reduce debris and bacterial load, while avoiding further tissue damage or bacterial transfer into lower wound areas[1].

According to literature, syringes of at least 35 ml connected to a 19-gauge angiocath are widely used for low-pressure wound irrigation. At manual actuation, syringe pressure levels are achieved matching the desired range of 4 – 15 PSI[1]. Clean tab water or sterile saline solution is recommended for wound cleansing[3].

Numerous products are available to support low-pressure irrigation, including shields to prevent splashing, bottle-based systems, and products that are ready-to-use, even outside a hospital or clinic setting (saline wound sprays, saline ampoule). Saline wound sprays make use of the bag-on-valve (BOV) technology. In BOV cans, saline is separated by an inner bag from the surrounding pressurized air. Upon actuation, the BOV is supposed to deliver a constant stream of saline through a continuous valve and actuator[5].

The performance of the above systems is either user-dependent (syringe, bottle, ampoule) or differing from product to product (BOV-based saline wound sprays).

While these are subjective findings, a reproducible method to asses wound wash products and techniques could help by comparing their performance to common practice of low-pressure irrigation.

Materials and Methods

For assessment of syringe and needle procedure performance, a 50 ml syringe (Omnifix, B.Braun Melsungen AG, Germany) was connected to a 19-gauge needle (Sterican 19Gx1½", B.Braun Melsungen AG, Germany), and a manometer (Kistler Germany, Type 701A) by using commercially available plastic tubes and a three-way connector.

BOV-based saline wound wash products (Walgreens Saline Wound Wash, Arm&Hammer Simply Saline Wound Wash, Nurse Assist Sterile Saline Wound Flush, Amerigel Saline Wound Wash, NeilMed neilCleanse Wound Wash) were purchased from the U.S. market and shipped to Aptar Radolfzell for further analysis. Individual cans with obvious damage from shipping (e.g., broken actuators, empty cans) were excluded. All products were characterized regarding initial weight and valve pressure. For each product, three individual cans were assessed and results were averaged.

The Aptar Anastasia JET actuator was mounted to a commercially available can, assembled with an Aptar bag-on-valve system and filled with 0.9% saline.

Impact forces resulting from irrigation streams were assessed through a plastic disk (diameter 7 cm) coupled to a force sensor (Type KAP-TC, Zwick Roell, Germany) at a distance of 10 cm (3.94 inch) from the syringe or BOV dispensing orifice.

Impact force over time was automatically recorded at a frequency of 100 values per second, and transferred electronically to commercially available software for further analysis. Maximum pressure in the system (i.e., system pressure) was manually recorded from the manometer. Actuation time and total delivered volume was recorded and the average flow rate calculated.

Results

Needle and Syringe Instillation

The measurement equipment was set up by modifying a procedure published earlier[4], connecting needle, syringe and manometer as shown in Figure 1.

Figure 1: Set-up of measurement equipment for impact force and system pressure

Three different operators were asked to empty the syringe, filled with 50ml 0.9% saline, each at high, medium and low personal effort. The pressure measured in the syringe (i.e., system pressure, 2.0 – 37.9 PSI) correlated with the impact force measured on the plastic disc (2.9 – 59.7 mN) as shown in Figure 2. Observed levels of system pressure spread well over the desired range of 4 – 15 PSI that is reported in the literature.

We determined an optimal impact force range between 6.4 and 24.0 mN at a distance of 10 cm corresponding to the lower and upper limit of system pressure using needle and syringe instillation.

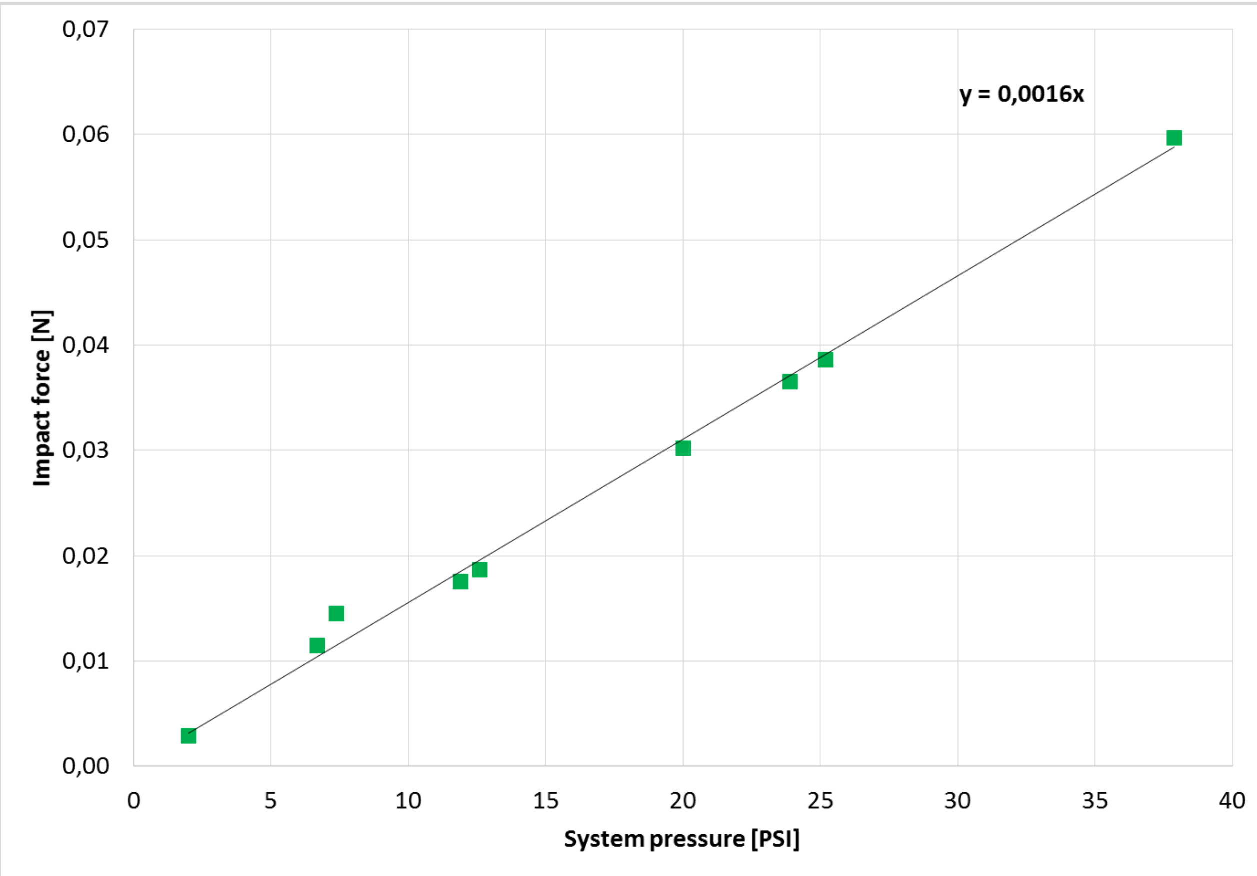

Figure 2: Correlation of maximum impact force and system pressure during manual actuation at different effort

Saline Wound Wash Products

Commercially available wound wash products were characterized regarding initial levels of valve pressure, and assessed in triplicates for maximum impact force, impact force over time, time to empty and total delivered volume [Table 1].

	Walgreens Saline Wound Wash	Arm & Hammer Simply Saline Wound Wash	NurseAssist Sterile Saline Wound Flush	Amerigel Saline Wound Wash	NeilMed neilCleanse Wound Wash	Aptar Anastasia JET
Initial valve pressure [PSI]	57.3	37.3	47.4	26.7	125.9	131.5
Max. Impact force [mN]	**52**	**121**	**101**	**107**	**47**	**19**
Actuation time [s]	28	25	23	29	51	95
Total volume [ml]	215	214	218	114	181	147
Flow rate [ml/s]	7.9	9.1	10.0	4.0	3.5	1.6

Table 1: Characterization and assessment of selected wound wash products

Figure 3 compares the maximum impact forces obtained from available wound wash products (bars) with the upper and lower force limits (lines) from needle and syringe instillation, corresponding to literature reported system pressure values.

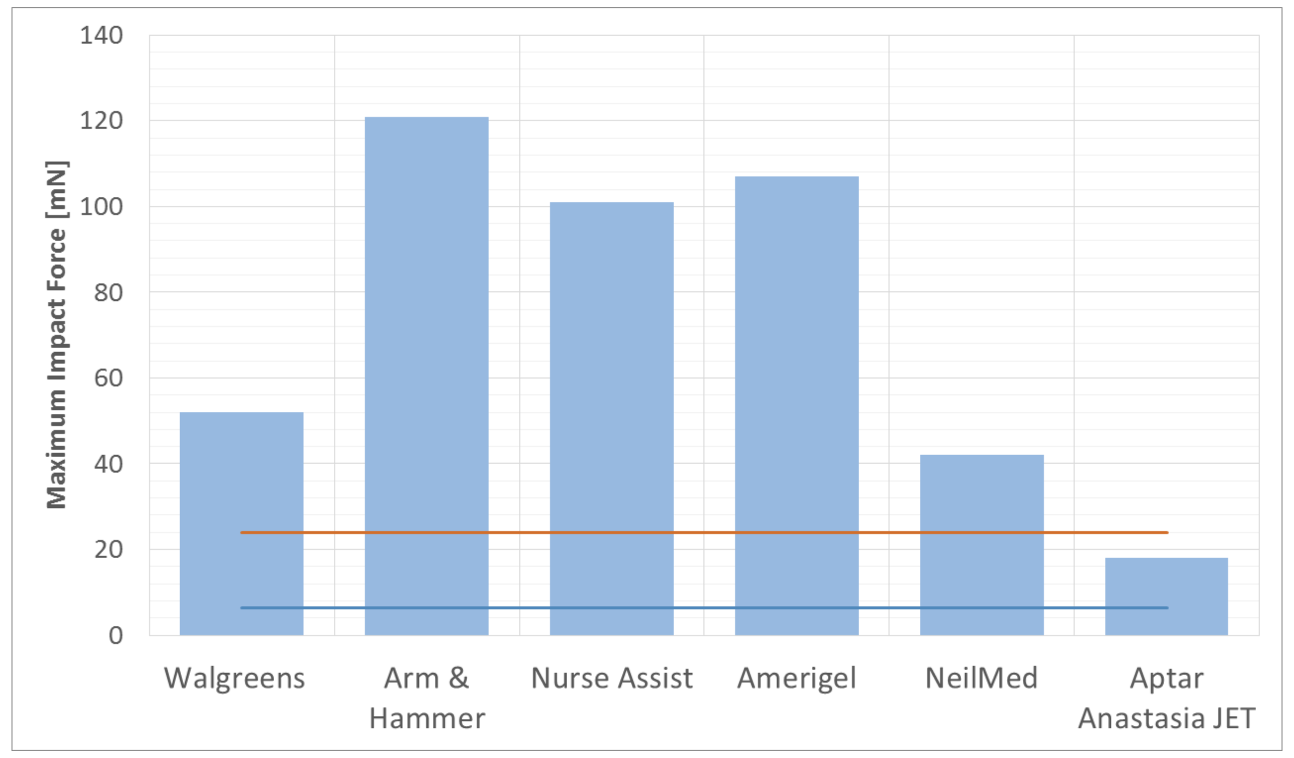

Figure 3: Maximum impact force of selected wound wash products

During wound instillation, the saline stream from the wound wash product should be constant and of a duration that enables to finalize a washing cycle without the need for changing. Figure 4 presents the impact force over time during complete emptying of the available wound wash products.

Three products' (Arm&Hammer, Amerigel, Nurse Assist) impact force levels are starting above 100 mN, then dropping quickly until the product empties in less than 30 seconds. Products from NeilMed and Walgreens empty at a more constant level and closer to the desired impact force range, indicated by the horizontal lines. The Aptar Anastasia JET delivered a long lasting stream of instillation saline at impact forces dropping below desired levels after approximately 30, up to 95 seconds.

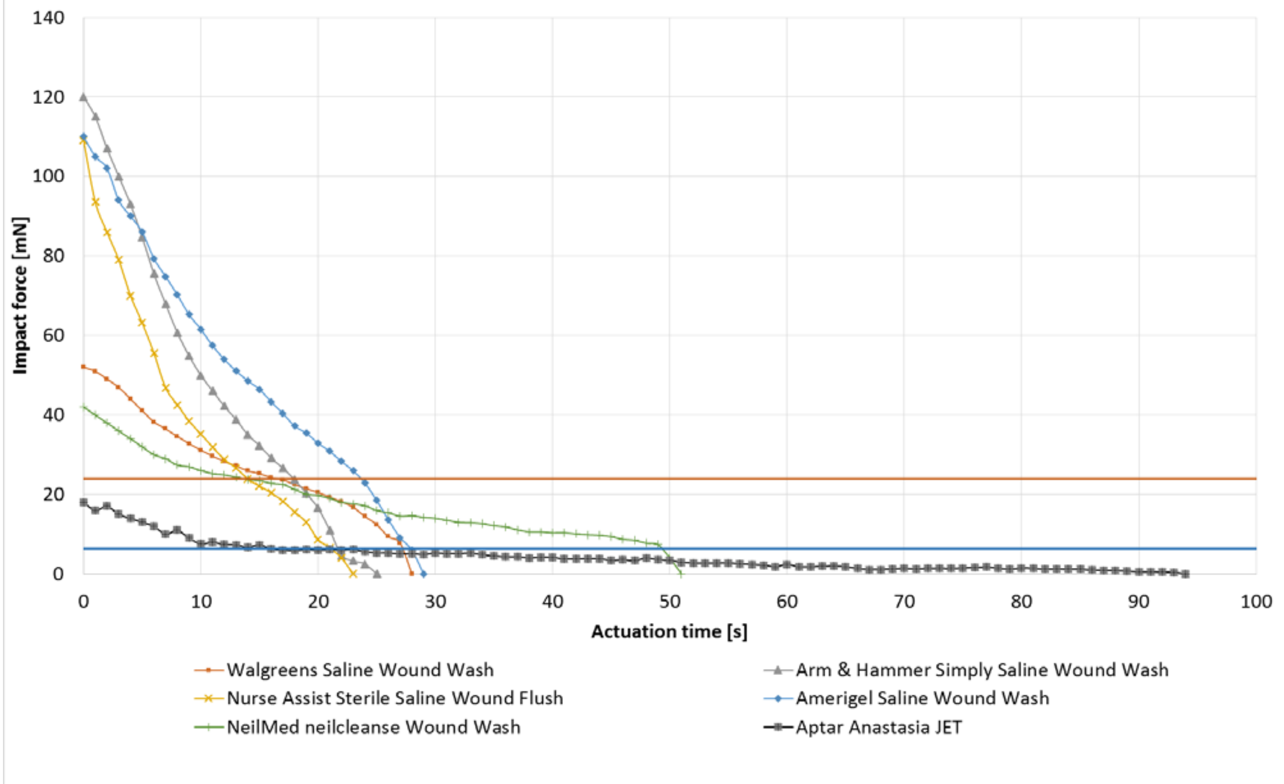

Figure 4: Impact force changes during emptying of available wound wash products

Discussion

Achieving the right performance in low-pressure instillation is critical to effectively remove bacteria and debris, while preserving wound integrity and avoiding damage.

Following available guidance, we established a simple method to compare marketed wound wash products, with literature-recommended syringe and needle instillation.

We found an impact force of 6.4 to 24.0 mN onto a simulated wound surface at 10 cm distance that is corresponding to literature recommended system pressure levels (4-15 PSI).

Testing of wound wash products available with bag-on-valve (BOV) technology revealed large differences between individual products with maximum impact force, change of impact force over time, as well as total use time until product emptied. Notably, maximum impact forces did not correlate with the initial outlet valve pressure of the individual products, indicating a strong influence of the actuator design on system performance.

Our method can be used to target an appropriate performance while developing new wound wash products, respecting available expert recommendation. This data could assist wound care specialists in understanding the variability of existing products, while using their experience in judging on available products.

Further work is needed to understand pressure levels at the wound surface and the correlation to clinical outcomes of low-pressure wound instillation.

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