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Experimental comparison of abdominal drainage systems

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ABSTRACT

Background: In an experimental study the performance of different closed abdominal drainage systems was tested.
Methods: A vacuum bottle designed for Redon Drainage, a flexible plastic bulb designed for Jackson-Pratt drains and a V.A.C.® Negative Pressure Wound Therapy System were used. In a porcine cadaveric study mimicking the abdominal cavity the intrinsic pressure (IP) at one and three minutes (T0, T3) and the amount of evacuated fluid were measured.
Results: The Redon and Jackson drainage displayed a rapid decline to IP values of almost zero comparing T0 and T3. Only the V.A.C.® system was able to preserve constant values of negative IP values measured at both time points. Only the V.A.C.® system was able to remove almost the whole amount of inserted fluid.
Conclusions: In an experimental setting the V.A.C.® system was superior to the other two tested systems in delivering constant negative IP and the amount of evacuated fluid.

1. Introduction

Closed suction drainage systems are frequently used in surgical practice[1] and a plethora of different drainage systems is commercially available. The main goal of abdominal drainage is to collect postoperative fluids and to prevent or minimize the risk of wound complications.[2]

Recently, the usefulness of postoperative drainage in children as well as adults has been challenged by a variety of reports demonstrating no significant advantage of intra-abdominal drain placement when compared to postoperative treatment without drains.[3,4] The findings of these studies may be related to retrograde bacterial contamination when the inserted drain serve as a portal for bacterial entry into surgical spaces, high negative pressures injuring the tissue or clogging of the drains by tissue or viscous fluids.[5] Moreover, the drainage systems may even be inefficient in collecting considerable amounts of postoperative fluid.

Surprisingly, there is only a small number of studies examining the efficacy of different closed suction drainage systems in an experimental setting.[6,7] Therefore, the aim of the present study was to assess the efficacy of three different closed abdominal drainage systems (mechanical high negative pressure, mechanical low negative pressure and electronic controlled constant negative pressure) in terms of applied negative pressures and the amount of collected fluids in an experimental setting mimicking an abdominal cavity.

2. Material and Methods

In the present study the following three different closed suction devices were evaluated: A vacuum bottle designed for Redon Drainage (Exulock Large 400®, Fresenius Kabi AG, Bad Homburg, Germany); a flexible plastic bulb designed for Jackson-Pratt drain (Pfm Medical Soft-Drain Flat Reservoir 100 mL®, Nonnweiler, Germany) and a V.A.C.® Negative Pressure Wound Therapy System programmed to -125 mmHg (ActiV.A.C. ®, KCI, Acelity, Wiesbaden, Germany).

In a first set of experiments the blank negative pressures of the three different systems were measured. Each system was connected to a 40 cm long 10F silicone tube (Web-Sil Flat drain, 10 mm, Websinger, Wolkersdorf, Austria) and a standard digital manometer system (Reed 8230 Digital 30 psi Manometer). The measurements were repeated three times on two different days resulting in a total of six measurements per system.

In a second set of experiments en bloc abdominal organs of a male pig cadaver were put into a plastic bag. A 10 F Jackson-Pratt silicone flat drain was positioned between the bowel loops. For

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assessment of the intrinsic pressure (IP) we placed a pressure transducer close to the tip of the drain (Fig. 1). The plastic bag was tightly sealed. Before each measurement, the air was evacuated from the plastic bag using a vacuum pump connected to the catheter until the pressure transducer showed neither negative nor positive pressure inside the bag. Then the catheter was blocked. In order to rule out any leakage of the plastic bag the pressure inside the bag was recorded for five minutes. No changes of pressure readings were seen within these five minutes. Thereafter, 100 mL of aqua were inserted into the bag through the catheter and the Jackson catheter was connected to the different suction devices. The negative IP was measured at 0 and 3 min (T0, T3) using an electronic manometer (Reed 8230 Digital 30 psi Manometer) and reported in mmHg. The evacuated volumes in ml were determined from the manufacturer's packaging at three minutes. The experiments were repeated three times for each drainage system on two different days resulting in a total of six measurements per system.

For statistical analysis SPSS 22 was used. The Kolmogorov-Smirnov test confirmed non-parametric distribution of all values measured. Therefore, the Kruskal-Wallis test was used for comparison of the blank negative values, the IPs and the amount of removed fluid of the three different systems tested. Additionally, the Mann-Whitney-U test was used for comparison of the negative IPs of each system at T0 and T3. A *P*-value of < 0.05 was considered to be statistically significant.

3. Results

In a first set of experiments the blank negative pressure values of the three suction systems were assessed. While the V.A.C.® Therapy-System displayed a mean negative blank pressure of -125.5 mmHg (range -123 to -130, SD 2.4), the Jackson plastic bulb with maximum compression resulted in a significantly higher (p=0.03) mean negative blank pressure of -151.6 mmHg (range -135 to -161, SD 8.9). With a mean negative blank pressure of -608.6 mmHg (range -598 to -622, SD 8.6) the Redon bottle showed significantly higher values compared to the other systems (p=0.03 vs Jackson plastic bulb, p=0.00 vs. V.A.C.®-System).

The negative IPs of the three different drainage systems assessed in a second set of experiments in pig cadaver experiments are depicted in Fig. 2. At T0 the Redon bottle caused significantly higher negative IPs compared to the Jackson and V.A.C.® systems. At T3, both the Redon and Jackson drainage displayed a rapid decline to IP values of almost zero. Only the V.A.C.® system was able to preserve constant values of negative intrinsic pressure values measured at both time points.

After three minutes the Jackson drainage was able to drain almost half of the inserted fluid. The amount of removed fluid was significantly higher when using the Redon system. However, only the V.A.C.® system was able to remove nearly the whole amount of inserted fluid (Fig. 3).

4. Discussion

While there is a considerable amount of studies examining the necessity and performance of abdominal drainage in clinical settings, the number of studies investigating the performance of different drainage systems in experimental settings is surprisingly low. Whitson and colleagues have tested four popular suction devices employing a developed calibrated digital collection system.[7] In concordance with our results the Jackson-Pratt 100 mL system was the least reliable and ceased to collect fluid well before reaching its prescribed 100 mL volume. Each of the four tested devices lost absolute negative pressure as volume collection increased, indicating that emptying the reservoirs at intervals is necessary to ensure constant negative pressure.[7] We were able to confirm these results by showing a rapid loss of negative intra-abdominal pressure of the Jackson-Pratt system and the vacuum bottle (Exulock Large 400). In an examination with different closed suction drainage systems connected to a pneumatic pressure

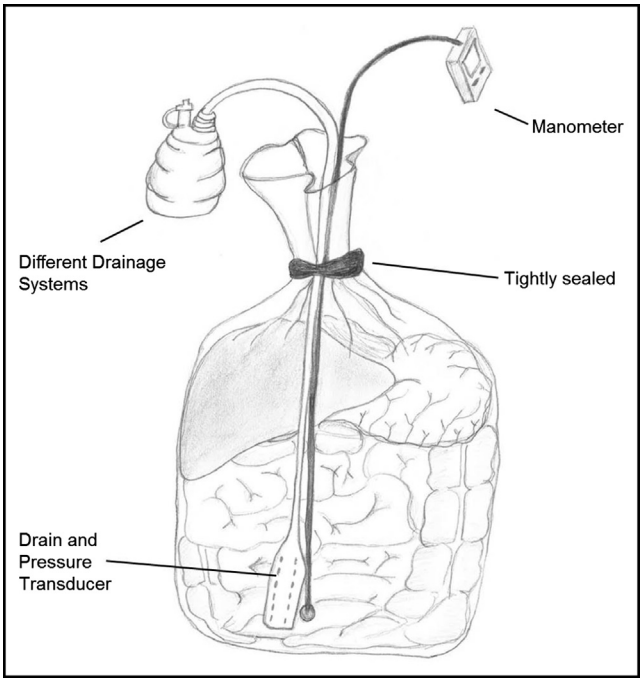

Fig. 1. Illustration of the experimental setup using en bloc abdominal organs of a male pig put in a sealed plastic bag.

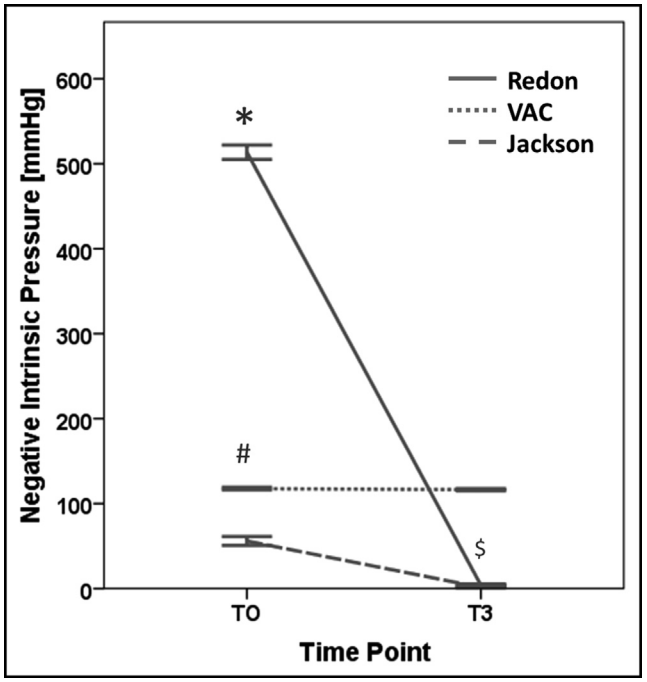

Fig. 2. Line graphs depicting the negative intrinsic pressures of the three different drainage systems measured at T0 and T3. The values are means ± standard deviation. * p<0.05 vs. VAC T0 and Jackson T0; # p<0.05 vs. Redon T0 and Jackson T0; $ p<0.05 vs. corresponding T0 and versus VAC T3.