Optimizing the Closed Suction Surgical Drainage System

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Background: Closed suction drains are indicated in a wide array of postoperative settings, with many distinct drainage systems available to the surgeon. The purpose of this study was to compare the suction gradients achieved using 2 different sizes of suction reservoirs and 2 different techniques for generating negative pressure.

Materials and Methods: Drainage reservoirs of 100 and 400 ml were chosen to evaluate their ability to achieve suction. Suction was established in both sizes of drains by pressing the sides of the reservoir together or by pushing the bottom of the reservoir toward the top. Negative pressures were recorded with the reservoir empty, and after every 10-ml addition of saline. Averages were graphed to illustrate the applied suction over a range of drain volumes.

Results: The 100-ml drainage system reached a peak suction of −117.6 mmHg, while the 400-ml drainage system reached only a peak suction of −71.4 mmHg. Both of the maximum suction readings were achieved using the full-squeeze technique. The bottom-pushed-in technique did not result in any sustained measurable levels of suction using either of the reservoir volumes.

Conclusions: Smaller drain reservoirs are more successful in generating a high initial suction than larger reservoirs, especially when the volume of fluid in the drain is relatively low. In all sizes of drains, compressing the sides of the reservoir is a far better technique for establishing negative pressure than pressing the bottom of the drain up toward the top.

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The authors report no conflicts of interest.

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Closed suction surgical drainage systems are routinely used when there is a postoperative risk of seroma development (Zawaneh & Putnam, 2008). Because of the frequent use of surgical drains, several different variations of drains have been developed, with a range of reservoir volumes and shapes. However, despite some physicians' preferences to use larger drainage reservoirs, many patients comment that they find these larger bulbs to be cumbersome and inconvenient during their postoperative recovery, and that they would have preferred smaller reservoirs if they could be confident that they provided comparable drainage. Furthermore, there are several methods of compressing these reservoirs to generate the negative pressure needed to pull collected fluid from the surgical wound (Figure 1). In the plastic surgical setting, drainage systems are especially important when performing certain operations, such as latissimus muscle flaps or breast reconstructions that require elevating abdominal

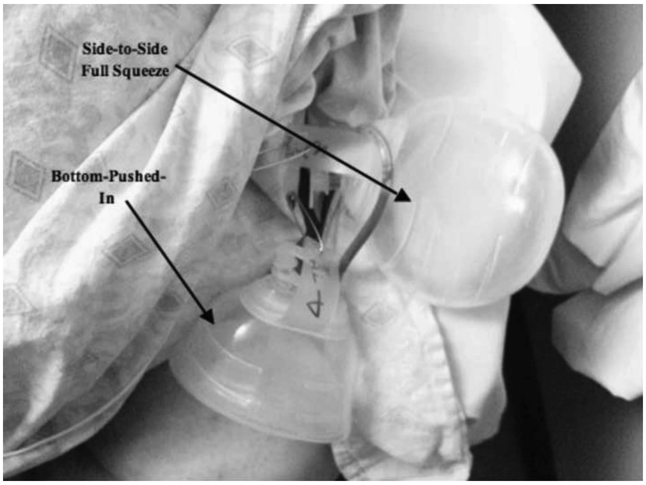

Figure 1. Actual photo of a patient with two 100-ml Jackson-Pratt drains placed in the abdomen. It can be observed that the drain with the side-to-side full-squeeze method for obtaining closed suction has begun to collect serous fluid, while the drain with the bottom-pushed-in method still appears to be empty.

tissue, as these procedures are known to have especially high rates of seroma formation (Scevola, Youssef, Kroll, & Langstein, 2002). Seromas that are not properly drained can cause delayed wound healing or even flap necrosis. Thus, it is vital to ensure that the surgeon's technique for applying suction and choice of drain reservoir volume maximize the ability of the drainage system to apply negative pressure to the potential space.

Because of the wide range of reservoir sizes and methods for establishing negative pressure, it must be wondered whether certain combinations are more successful than others at drawing fluid out of the surgical wound. The ability to effectively remove fluid more completely could potentially reduce complications traditionally associated with flap elevation and even facilitate patient recovery (Durai, Mownah, & Ng, 2009). The goal of this study was to objectively analyze the suction generated by drains with two common reservoir sizes and to compare the negative pressure attained by two frequently observed techniques for achieving closed suction.

MATERIALS AND METHODS

Air was removed from 100-ml Bard (Bard Medical Division, Covington, GA) and 400-ml Jackson-Pratt (Baxter Healthcare Corp., Deerfield, IL) surgical drain reservoirs by either squeezing the sides together (Figure 2a) or pushing the bottom toward the top (Figure 2b). Of the two ports on the top of each drain reservoir, one port was connected to 80 cm of 19 French reservoir tubing with a three-way stopcock (Bard Medical Division), allowing for saline to be injected into the drain reservoir in known volumes. The other port was connected with similar tubing to a sphygmomanometer (Figure 3). This device measures pressures ranging from −20 to −300 mmHg. Suction readings were repeated five times, and measurements were obtained to the nearest 1.0 mmHg with the drain empty and after each subsequent injection of 10 ml of saline until the reservoir reached capacity or until level of suction dropped below the measurable value of −20 mmHg.

Average negative pressures for each size of reservoir and for each method of removing air from the

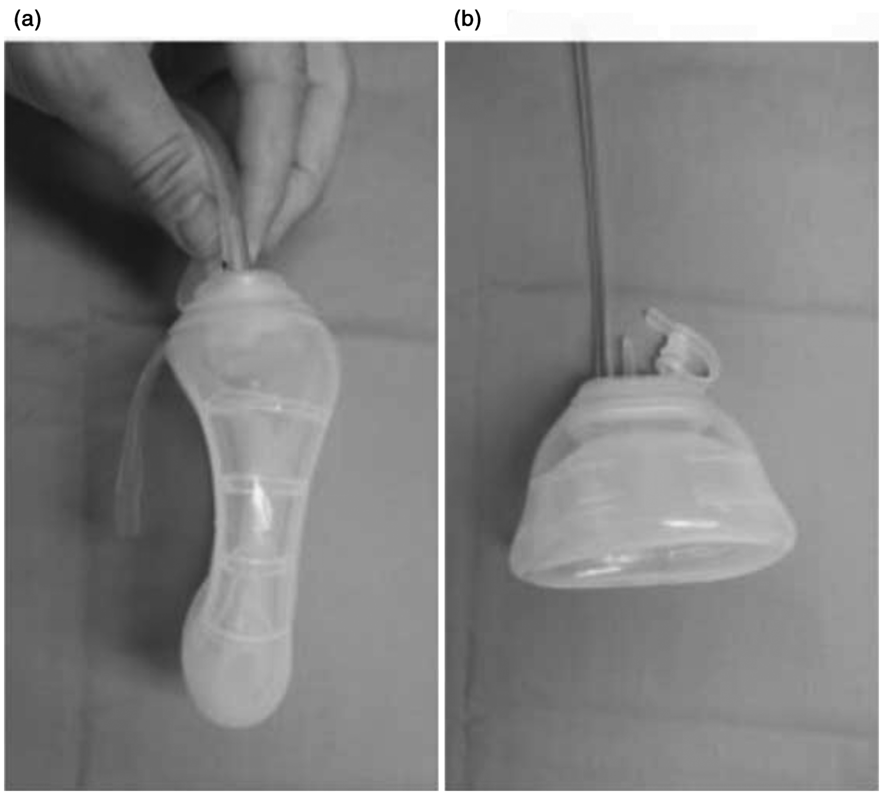

Figure 2. Air was removed from surgical drain reservoirs to generate negative pressure by either (a) squeezing the sides together or (b) pushing the bottom toward the top.

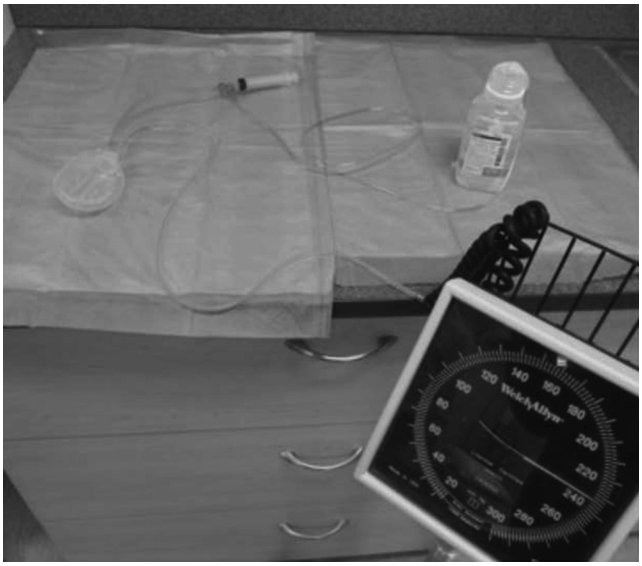

Figure 3. After removal of the air from the drain reservoir, one of the two ports on the top was connected to tubing with a three-way stopcock, allowing for saline to be injected into the drain reservoir in known volumes. The second port was connected with similar tubing to a sphygmomanometer to measure the suction of the drainage system.

reservoir were calculated with the drain empty and after each addition of saline. The resulting data were graphed to illustrate the applied suction achieved over a range of drain collection volumes (Figures 4 and 5).

RESULTS

Using the side-to-side full-squeeze technique, drains with 100-ml reservoirs reached an average maximum negative pressure of −117.6 mmHg (Table 1a). This value was achieved with the reservoir empty and the suction slowly dropped as the volume of retained saline increased. By the time the reservoir was filled to 60 ml of saline, the suction had dropped below a recordable level. Similar results were obtained using the side-to-side full-squeeze technique and the 400-ml reservoir. Using the 400-ml reservoir, the average maximum negative pressure was −71.4 mmHg, again achieved when the drain was empty (Table 2a). A *p* value of less than .05 was calculated when comparing the maximum suction obtained when using the 100-ml and 400-ml reservoirs and the side-to-side full-squeeze technique. As with the 100-ml drain, suction slowly decreased as the reservoir was filled; however, the 400-ml reservoir maintained measurable suction until it contained an average of 130 ml of saline.

Using the bottom-pushed-in technique on the 100-ml drainage system, no measurable negative pressures were recorded until the suction jumped to an average of −24.0 mmHg when the reservoir contained 70 ml of saline (Table 1b). From this point, suction maintained a relatively stable level until the drain reached capacity. In contrast, the 400-ml drainage system never reached true measurable levels of negative pressure using the bottom-pushed-in technique at any point while the reservoir was filled (Table 2b).

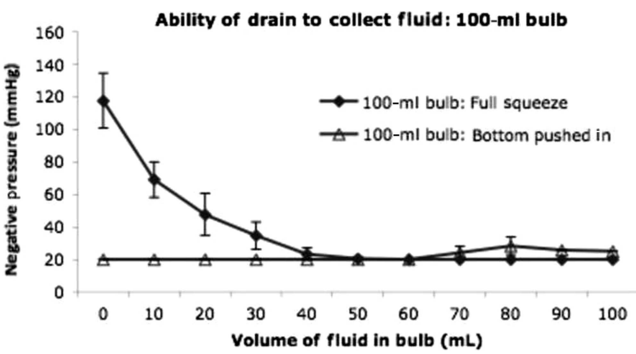

Figure 4. Using a 100-ml Bard drainage system, average suction was measured using either the full side-to-side squeeze or the bottom-pushed-in technique of generating negative pressure. Measurements were repeated five times and means were reported ± the standard deviation.

DISCUSSION

Because of the wide variety of surgical drainage systems currently available on the market, there is little consensus among surgeons as to which drains and which techniques for generating negative pressure are most effective (Swartz et al., 2012). However, on the basis of our findings, we concluded that smaller drain reservoirs were able to generate more suction than larger reservoirs and that compressing the sides of the drain bulb was the most effective technique for evacuating the air to generate negative pressure.

In 2002, Grobmyer and colleagues published a study that attempted to determine the suction gradients of three commonly employed surgical drains (Grobmyer, Graham, Brennan, & Coit, 2002). Among the three types of drains analyzed was the 400-ml Jackson-Pratt closed suction system that was also analyzed in our current study. In accordance with our data, Coit determined that the maximum suction was achieved when the reservoir was empty and that negative pressure

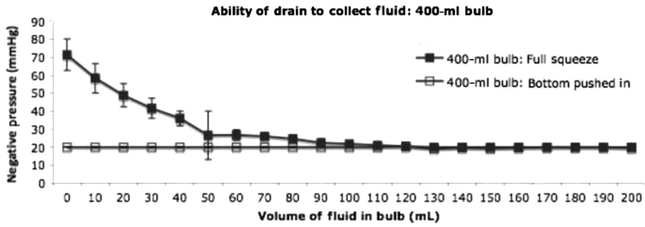

Figure 5. Using a 400-ml Jackson-Pratt drainage system, average suction was measured using either the full side-to-side squeeze or the bottom-pushed-in technique of generating negative pressure. Measurements were repeated five times and means were reported ± the standard deviation.

decreased as the reservoir filled. While it was not clear what technique was used to eliminate the air from inside the reservoir to generate the reported suction gradient, the authors were able to conclude that different types of closed suction surgical drainage systems do achieve different levels of negative pressure.

Whitson and colleagues (2009) further explored the topic of comparing different types of closed suction drains. In this study, the investigators compared not only drains from different manufacturers but also drains with different reservoir volumes (Whitson, Richardson, Iaizzo, & Hess, 2009). They determined that, when empty, 100-ml reservoirs were able to achieve a higher level of suction than 400 ml drain reservoirs. As before, our data verified this conclusion when using the side-to-side full-squeeze technique for generating suction. Although both of these studies did address the questions surrounding the commercially available drain options, neither discussed the variation in negative pressure that could be caused by the technique used when applying suction to the drainage system.

In 2009, Halfacree, Wilson, and Baines (2009) published the first study to address how user technique could affect the efficiency of a surgical drainage system. In this report, the investigators compared one-hand and two-hand compression methods for removing the air from the drain reservoir to generate suction. Regardless of the size of the drain reservoir, it was determined that the two-hand compression method caused significantly greater negative pressure than the one-hand method. However, the one-hand method did still generate a measurable level of suction. While our study analyzed two different techniques for generating suction, it was concluded that the bottom-pushed-in technique did not generate any measurable level of suction while the side-to-side full-squeeze method demonstrated a much more clinically useful range of negative pressures as the reservoir filled.

TABLE 1. Negative Pressures of 100-ml Drainage System

Volume of Saline Added (ml)	0	10	20	30	40	50	60	70	80	90	100
A Full squeeze											
Average negative pressure (mmHg)	−117.6	−69.0	−47.6	−34.6	−23.2	−20.5	≤−20.0	≤−20.0	≤−20.0	≤−20.0	≤−20.0
Standard deviation	16.8	10.9	13.0	8.4	3.9	1.0	0.0	0.0	0.0	0.0	0.0
B Bottom pushed in											
Average negative pressure (mmHg)	≤−20	≤−20	≤−20	≤−20	≤−20	≤−20	≤−20	−24.0	−28.3	−25.7	−26.0
Standard deviation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	5.4	0.6	0.0

TABLE 2. Negative Pressures of 400-ml Drainage System

Volume of Saline Added (ml)	0	10	20	30	40	50	60	70	80	90	100	110	120	130
A Full squeeze														
Average negative pressure (mmHg)	−71.4	−58.4	−48.8	−41.6	−36.0	−26.6	−26.8	−26.0	−24.6	−22.4	−21.8	−21.0	−20.5	≤−20.0
Standard deviation	8.8	8.2	6.5	5.6	4.2	13.5	2.9	1.6	2.1	2.3	1.7	1.4	1.3	0.0
B Bottom pushed in														
Average negative pressure (mmHg)	≤−20	≤−20	≤−20	≤−20	≤−20	≤−20	≤−20	≤−20	≤−20	≤−20	≤−20	≤−20	−20.5	≤−20
Standard deviation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0

Our study, in conjunction with these previous reports, clearly illustrates the massive variation in suction levels that can occur depending on the size and type of the drainage system, as well as the method used to generate the negative pressure. When the highest levels of suction are needed to prevent seroma development, a surgical drainage system with a small reservoir should be chosen and the surgeon should compress the reservoir in a side-to-side, two-handed manner to evacuate the air. In addition, since it was observed that drain suction decreased as the volume of fluid in the reservoir increased, drains should be emptied as frequently as possible to maintain the highest possible level of suction. At a minimum, since the drains used in this study lost any measurable amount of suction when the reservoir was approximately half full, care providers must empty the drain reservoirs before they reach this point, so that they can continue to pull fluid from the wound bed. If high outputs preclude timely emptying of fluid from the drain reservoirs, larger collection devices, such as the 400-ml container used in this study, should be considered at the small expense of slightly lower suction pressures. Although research is slowly filling in the gaps in our knowledge about the dynamics of surgical drain suction, further studies are still needed. It would be beneficial to address how, or to what degree, the length of the reservoir tubing effects the level of suction in the wound bed and how placement of multiple drains effects the total negative pressure generated in the potential space.

In summary, smaller drain reservoirs are more successful in generating a high initial suction than larger reservoirs, especially when the volume of fluid in the drain is relatively low. However, larger bulbs do tolerate higher volumes of fluid collection and allow for longer times to elapse before emptying. In all sizes of drains, compressing the sides of the reservoir is a far better technique for establishing negative pressure than pressing the bottom of the drain up toward the top.

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