Effectiveness of Negative Pressure Wound Therapy on Closed Incision of Flap Coverage for Pressure Ulcer

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Objective: *Flap coverage for pressure ulcers has high risk of wound complications. Negative pressure wound therapy (NPWT) has recently been used over closed incisions to decrease surgical site complications including seroma, dehiscence and also infection. This study aimed to investigate the role of NPWT in close incision after flap coverage for pressure ulcers.*
Material and Method: *Comparative study was designed to compare effectiveness of NPWT on closed incision of flap coverage for pressure ulcers. In a control group, we performed a retrospective chart review of 20 patients between 2013 and 2014 who underwent flap coverage for pressure ulcers and had conventional gauze-based postoperative wound dressing. In an experiment group, NPWT was placed on close incisions after flap coverage for pressure ulcers and the data were collected prospectively from 10 patients between 2014 and 2015. Drain content, which represented seroma in this study, was monitored daily for 7 days. The result of wound dehiscence and infection was monitored until postoperative day (POD) 30.*
Results: *In the first group (control), median drain content on POD 1, 2, 3, 4, 5, 6, 7 were 87.5, 100, 70, 45, 35, 25, 30 mL while in second group (NPWT), median drain content were 100, 42.5, 22.5, 15, 10, 5, 2.5 mL, respectively. The result showed statistical significant difference on POD 2 to 7 (p-value = 0.03, 0.02, 0.04, 0.05, 0.02, respectively). Wound dehiscence occurred 60% in control group and 20% in experiment group (p = 0.06). Wound infection occurred 20% in control group while 0% in experiment group (p = 0.27).*
Conclusion: *NPWT can reduce drain content in patients who had flap coverage for pressure ulcer. NPWT showed a trend to reduce wound dehiscence and wound infection.*

Keywords: *Flap, Negative pressure therapy, Wound, Pressure ulcer*

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Pressure ulcers remain one of the challenging problems with incidence of 9% in hospitalized patients especially in the spine injury group and could rise to 33 to 60%[1]. The most promising surgical treatment for pressure ulcer is flap coverage due to harvesting good quality tissue from other areas to cover pressurized bone and also could be used to obliterate cavity[2].

Despite multiple articles describing advancements in surgical technique, complication rates were stilled high, such as wound dehiscence, hematoma, and seroma formation[3,4]. These complication results in suboptimal treatment outcome caused by additional operations, prolonged hospital stay and increased total cost of treatment.

Since they were introduced two decades ago, negative-pressure wound therapy (NPWT) dressings have been frequently used for open surgical and traumatic wounds[5,6]. Traditional open negative-pressure wound therapy is thought to improve wound healing by increasing blood flow and angiogenesis, draining exudate and decreasing edema, increasing tissue granulation, and contracting wound edges[7-9]. The application of negative-pressure wound therapy has been spreading steadily to different surgical fields and different wound types. Recently, negative-pressure therapy has been used on closed, clean surgical incisions with successful outcomes. A growing body of literature has been published, supporting the theory that closed incision negative-pressure therapy decreases the incidence of wound dehiscence and other surgical-site occurrences, including surgical-site infections[10,11]. These results proved to be true especially in high risk wounds, such as sternal wound, complex trauma wound, or complex open fracture wound. However, there still no published studies for NPWT over closed incision local flap coverage for pressure ulcers. Effectiveness of this treatment needs to be proven and the results may directly improve

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guidelines for management of pressure ulcers in the future.

Material and Method

We conducted a prospective, experimental study in a group of Thai surgical patients who were admitted to Siriraj Hospital to compare the outcomes of flap coverage for pressure between standard postoperative care and the experimental group that performed NPWT over close incision postoperatively. The primary outcome we would like to compare, was wound dehiscence. The secondary outcomes were drain content, surgical site infection, hematoma.

The research study has been reviewed and approved by Siriraj Hospital Institutional Review Board, protocol number 736/2557 (EC1).

Between December 2014 and November 2015, NPWT was performed in 10 patients who underwent flap coverage for pressure ulcers, using petroleum mesh gauze, polyurethane foam, and iodine-impregnated incision drape (Fig. 1) 120 mmHg negative pressure was applied for 7 days. Demographic data were recorded and outcomes of treatment (drain content, surgical site infection, wound dehiscence, hematoma) were measured. We collected data on age, gender, body mass index (BMI), comorbidities, location of pressure ulcers, number of previous flap coverage operations, and time from latest operation to admission for demographic data. We measured drain content daily from postoperative day 1 to day 7. We detected wound dehiscence on 2 separate occasions, first on postoperative day 7, then if the patient didn't had wound dehiscence, we followed the patient to postoperative day 30 to confirm that no perioperative wound dehiscence occurred.

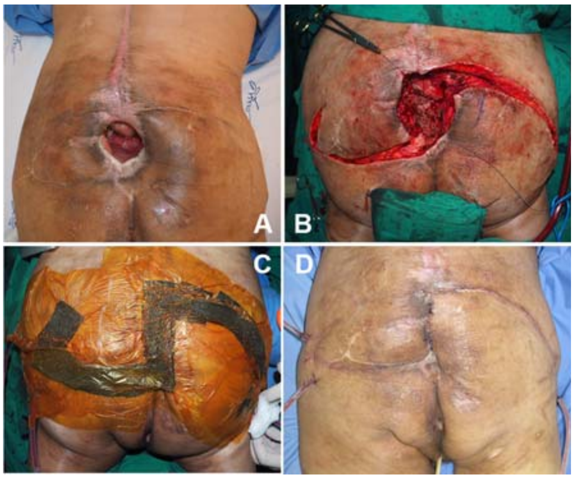

Fig. 1 Pressure ulcer treated with bursectomy and NPWT. A) Preoperative, B) After bursectomy, C) NPWT on closed incision, D) Postoperative day 7.

Retrospective chart review was performed to collect data for the control group that included patients who underwent flap coverage for pressure ulcers from January 2013 to November 2014. We recruited 20 patients for this group. All demographic data and treatment outcomes were recorded same as in the experimental group.

We defined the term "surgical site infection" according to CDC definition. We defined "wound dehiscence" as any breaking open of the surgical incision along the suture. "Hematoma" was defined as any blood collection within tissue, under close-incision.

The data we collected from all subjects were analyzed with PASW Statistics (SPSS) version 18. All the continuous variables were checked for their mean, median, maximum, minimum, and standard deviation. All the categorical variables were evaluated for their proportion. All the categorical outcomes were compared between groups with Fisher's exact test. Drain content in both group was compared using Mann-Whitney U test. Statistical significant was determined by p-value <0.05.

Results

We obtained data from 30 patients. The demographic data of the patients included in our study were shown in Table 1.

From the data we obtained, we found no statistical significance between experimental and the control group in terms of age, body mass index (BMI), gender, comorbidities, smoking, associate spine injury, locations of pressure ulcer, and history of previous surgery for pressure ulcers.

The categorical type outcomes are reported in Table 2.

We found that wound dehiscence tends to decrease in the experimental group especially within postoperative day 30^{th} (20% vs. 60%, $p = 0.058$), although not statistical significant. The result also showed the same trend to reduce surgical site infection in the experimental group (0% vs. 20%, $p = 0.272$), but with no strong impact on wound dehiscence ($p = 0.058$ vs. $p = 0.272$). This study found no postoperative hematoma in both group, so comparative result was not done. For additional surgery needed, we found quite low incidence, so it is difficult to compare results also.

Table 1. Demographic data

Characteristic data	Experimental (n = 10)	Control (n = 20)	*p*-value
Age (years), mean ± SD	35.1±19.7	49.3±19.8	0.074
Body mass index (BMI), mean ± SD	25.2±3.6	21.9±3.4	0.060
Gender, n (%)			0.675
Male	8 (80.0%)	13 (65.0%)	
Female	2 (20.0%)	7 (35.0%)	
Diabetes mellitus	-	1 (5.0%)	1.000
Hypertension	1 (10.0%)	1 (5.0%)	1.000
Smoking	1 (10.0%)	3 (15.0%)	1.000
Spine injury	5 (50.0%)	9 (45.0%)	1.000
Grading of pressure ulcer			1.000
Grade 3	-	1 (5.0%)	
Grade 4	10 (100%)	19 (95.0%)	
Location of pressure ulcer			0.886
Right ischial	5 (50.0%)	8 (40.0%)	
Left ischial	3 (30.0%)	6 (30.0%)	
Left trochanteric	0 (0.0%)	1 (5.0%)	
Sacral	2 (20.0%)	4 (20.0%)	
Coccyx	0 (0.0%)	1 (5.0%)	
Previous operation	3 (30.0%)	9 (45.0%)	0.694

Table 2. Wound complications outcome

Outcome	Experimental (n = 10)	Control (n = 20)	*p*-value*
Wound dehiscence			
Within postoperative day 7th	2 (20.0%)	9 (45.0%)	0.246
Within postoperative day 30th	2 (20.0%)	12 (60.0%)	0.058
Infection	0 (0.00%)	4 (20.0%)	0.272
Hematoma	0 (0.00%)	0 (0.00%)	1.000
Additional operations	0 (0.00%)	3 (15.0%)	0.532

* Fisher's exact test

From Table 3, negative pressure wound therapy on closed incision reduced amount of drain content and showed statistical difference from postoperative day 3rd and continue on to postoperative day 7. In addition to reducing the amount of drain content, it showed a trend to reduce postoperative drain content more rapidly (Fig. 2).

Discussion

Negative-pressure wound therapy (NPWT) has been used over open, chronic wounds across a range of surgical disciplines for over 20 years. A meta-analysis in 2011 reported that, when compared with standard wound care, NPWT significantly decreased both wound size and time to healing[12]. Articles reporting the use of this same negative-pressure technology over closed, clean surgical incisions were published as early as 2006 and quickly spread to a variety of surgical disciplines, including orthopedic, cardiothoracic, plastic, and vascular surgery[13]. The majority of patients included in these studies were at higher risk of surgical-site occurrences because of factors including severe trauma, location of wound, obesity, tobacco use, age, and others. Despite the plethora of literature that has been published documenting the use of closed incision NPWT, there is still no consensus on its effectiveness in reducing surgical-site occurrences.

Table 3. Postoperative drain content

Drain: median (range)	Experimental (n = 10)	Control (n = 20)	*p*-value*
Day 1	100.0 (10, 190)	87.5 (10, 310)	0.373
Day 2	42.5 (10, 120)	100.0 (20, 300)	0.055
Day 3	22.5 (0, 70)	70.0 (0, 330)	0.005**
Day 4	15.0 (0, 55)	45.0 (0, 200)	0.017
Day 5	10.0 (0, 40)	35.0 (0, 120)	0.039
Day 6	5.0 (0, 90)	25.0 (0, 110)	0.024
Day 7	2.5 (0, 30)	30.0 (0, 100)	0.035

* Mann-Whitney U test; ** Statistical significance

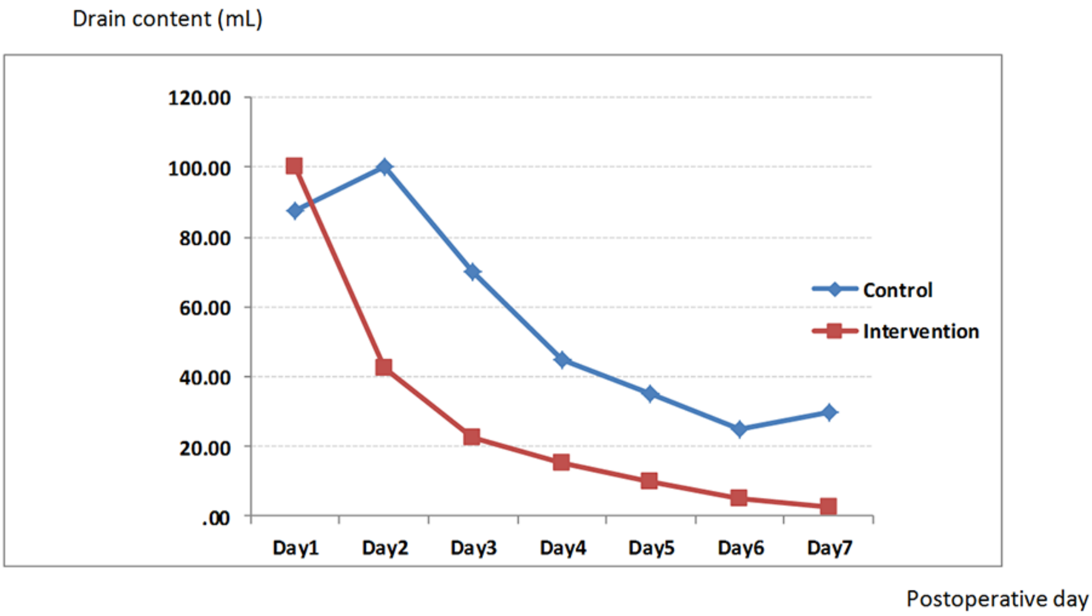

Fig. 2 Volume of drain content on each postoperative day.

The mechanism of action of NPWT has been studied since its initial application over open wounds. An increase in blood flow as a result of negative-pressure wound therapy was detected using laser Doppler probes in 1997[5]. Subsequent studies confirmed hyper-perfusion around the wound, and also reported a region of hypo-perfusion closer to the wound edges[14-16]. It was later confirmed that the areas of hypoxia were associated with a rise in vascular endothelial growth factor, suggesting angiogenesis as a method for increased blood flow[17]. A similar increase in perfusion was noted in closed incision negative pressure therapy[18]. Closed incision negative-pressure therapy is also associated with increased lymphatic clearance. Increased lymphatic involvement as a result of closed incision negative-pressure therapy was suggested in a study which demonstrated that nano-spheres passed to lymph nodes and highly vascular organs more quickly under closed incision NPWT dressing compared with standard care[19].

NPWT is also believed to aid healing by contracting wound edges and thereby reducing lateral tension, a process referred to as macro-deformational strain[20,21]. Wilkes et al demonstrated through finite element analysis that closed incision NPWT reduced lateral stress around the incision by 50 percent[20]. This reduction in lateral tension is thought to decrease the incidence of dehiscence and improve scar appearance[20]. In addition to increased perfusion, angiogenesis, and splinting, closed incision NPWT is also thought to wick fluid through the incision and protect the incision for longer (5 to 7 days).

To our knowledge, this is the first clinical study for NPWT on closed incision after flap coverage for pressure ulcer. Our data showed that NPWT could reduce the amount of postoperative drain that may imply reducing the amount of seroma formation. Although not statistical significant, our data revealed a trend that NPWT on closed incision after flap coverage for pressure ulcers could reduce occurrences of wound dehiscence (from 60% to 20%) and surgical site infection (from 20% to 0%). These may be due to limitations of this study that sample size was too small to represent statistical significance in different between groups. Other limitation may be due to many confounding factors such as age and BMI that showed difference in mean, although not statistical significant (may also from small sample size). This problem could be solved by sample randomization, so we suggest prospective randomized controlled trial studies be conducted in the future (multicenter research trial should be suggested to increase sample size if not enough by single center).

Conclusion

Closed incision negative-pressure therapy is undeniably more expensive than standard wound management. The cost of this device may be justified because of its potential ability to reduce the incidence of postoperative complications, which cost us far more than money, but also burden to the patients, social support, and health care provider that is invaluable. For these reasons, we recommend considering the use of closed incision negative-pressure therapy over surgical incisions after flap coverage for pressure ulcers.

What is already known on this topic?

Pressure ulcer remains one of the challenging problem. The most promising surgical treatment for pressure ulcer is flap coverage due to harvesting good quality tissue from other areas to cover pressurized bone and also could be use to obliterate cavity. Despite multiple articles describing advancements in surgical technique, complications rate were stilled high; such as wound dehiscence, hematoma, and seroma formation. These complications result in suboptimal treatment outcomes caused by additional operations, prolonged hospital stay, increased total cost of treatment. A growing body of literature has been published, supporting the theory that closed incision negative-pressure therapy decreases the incidence of wound dehiscence and other surgical-site occurrences, including surgical-site infections in high risk wound, such as sternal wound, complex trauma wound, or complex open fracture wound.

What this study adds?

To our knowledge, this is the first clinical study for NPWT on closed incision after flap coverage for pressure ulcers. Our data showed that NPWT could reduce the amount of postoperative drain that may imply reducing the amount of seroma formation and also revealed a trend that NPWT on closed incision after flap coverage for pressure ulcers could reduce occurrences of wound dehiscence and surgical site infection. So from now on, we recommend considering the use of closed incision negative-pressure therapy over surgical incisions in all patients after flap coverage for pressure ulcers.

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Potential conflicts of interest

None.

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ประสิทธิภาพของการปิดแผลด้วยแรงดูดสูญญากาศต่อบาดแผลจากการรักษาแผลกดทับด้วยการย้ายผิวหนัง

ชิตพงศ์ ศิริทองถาวร, อภิรักษ์ ช่วงสุวนิช

วัตถุประสงค์: *การรักษาบาดแผลกดทับด้วยการย้ายผิวหนัง มีโอกาสเกิดภาวะแทรกซ้อนได้สูง มีความพยายามลดผลแทรกซ้อนจากบาดแผลที่เย็บด้วยการปิดแผลด้วยแรงดูดสูญญากาศและพบว่าสามารถจะลดผลแทรกซ้อน เช่น น้ำเหลืองคั่ง แผลแยก และการติดเชื้อได้ การทดลองนี้จะศึกษาผลของการปิดแผลด้วยแรงดูดสูญญากาศ (NPWT) บนบาดแผลที่เกิดจากการย้ายผิวหนังเพื่อปิดแผลกดทับ*

วัสดุและวิธีการ: *การศึกษานี้เป็นการศึกษาเปรียบเทียบ 2 กลุ่มระหว่าง NPWT บนบาดแผลจากการย้ายผิวหนัง เพื่อปิดแผลกดทับจำนวน 10 ราย และกลุ่มควบคุม ซึ่งมาจากการศึกษาย้อนหลังของผู้ป่วยแผลกดทับ ที่ได้รับการย้ายผิวหนังเพื่อรักษา และปิดแปลด้วยผ้าซับโลหิตระหว่างปี พ.ศ. 2556 ถึง พ.ศ. 2557 การบันทึกจำนวนของน้ำเหลืองที่ไหลออกมาในขวดในช่วง 7 วันหลังผ่าตัด การเกิดการแยกของแผล, การติดเชื้อหลังผ่าตัดจนถึง 30 วันหลังผ่าตัด และนำมาเปรียบเทียบระหว่างกลุ่มโดยวิธีทางสถิติ*

ผลการศึกษา: *จำนวนเฉลี่ยคัดหลั่งของน้ำเหลืองในกลุ่มควบคุมตามลำดับวันหลังผ่าตัด 1, 2, 3, 4, 5, 6, 7 คือ 87.5, 100, 70, 45, 35, 25, 30 ซีซี และในกลุ่ม NPWT คือ 100, 42.5, 22.5, 15, 10, 5, 2.5 ซีซี ตามลำดับ มีความแตกต่างของจำนวนเฉลี่ยของสารคัดหลั่งชัดเจนและมีนัยสำคัญทางสถิติ ตั้งแต่วันที่ 2 ถึง 7 หลังผ่าตัด (ค่า p = 0.03, 0.02, 0.04, 0.05 และ 0.02 ตามลำดับ) อัตราการเกิดบาดแผลแยก คือ 60% ในกลุ่มควบคุม และ 20% (ค่า p = 0.06) ในกลุ่มทดลองการติดเชื้อเกิด 20% ในกลุ่มควบคุมแต่ไม่พบเลยในกลุ่มทดลอง (ค่า p = 0.27)*

สรุป: *NPWT สามารถจะลดจำนวนของสารคัดหลั่งในการทำการย้ายผิวหนังเพื่อปิดแผลกดทับซึ่งอาจจะนำมาถึง การลดภาวะแทรกซ้อน เช่น บาดแผลแยกหรือการติดเชื้อได้*