

Negative-pressure wound therapy (NPWT) is used to treat many different types of wounds, but there is still a lack of large studies describing its effectiveness in breast surgery. Enhanced recovery, reduction of complications, and good scar quality might be improved by the application of NPWT. Existing data show that vacuum-assisted closure (VAC) application after expander-based breast reconstruction may be beneficial because of decreasing overall complications in comparison with standard wound treatment. There are few cases in which the use of negative pressure resulted in healing of complicated breast wounds after implant insertion – most breasts achieved healing, wherein duration of NPWT ranged from seven to 21 days. The use of NPWT leads to a decrease of seroma formation (from 70% to 15%), the mean percutaneous aspirated volume (from 193 ml to 26 ml) and the numbers of percutaneous aspirations (from three to one) in latissimus dorsi flap reconstruction. Furthermore, a prospective, within-patient, randomised study with 200 participants showed that treating closed incisional wounds after reduction mammoplasty with a VAC system resulted in a decrease of overall complications and protected against wound dehiscence. In the literature, there are cases showing that NPWT may be useful for the successful treatment of chronic and non-healing wounds, included non-puerperal mastitis and surgical sites affected by radiation therapy due to breast cancer. There is still a need for evidence confirming the effectiveness of NPWT in breast surgery because of the deficiency of large prospective studies that compare NPWT with standard treatment.

Key words: breast, breast reconstruction, negative-pressure wound therapy, wounds.

Contemp Oncol (Pozn) 2019; 23 (2): 69–73
DOI: <https://doi.org/10.5114/wo.2019.85199>

Is negative-pressure wound therapy beneficial in modern-day breast surgery?

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Introduction

Over the last three decades, negative-pressure wound therapy (NPWT) has been widely used to treat many different types of wounds, especially non-healing and chronic wounds [1, 2]. Generating negative pressure leads to excess fluid removal, reduction of oedema, increased dermal perfusion, stimulation of granulation tissue formation, and reduced bacterial colonisation [1–3]. It has been proven that application of vacuum-assisted closure (VAC) normalises the stress distributions around the closed incision in skin by up to 50%, which is connected with a reduction of the probability of dehiscence, poor cosmesis, and scarring [4, 5]. The NPWT device consists of a foam dressing, adhesive drape, and a trackpad that is applied on top of the drape and connected via a tube to the therapy unit, which generates sub-atmospheric pressure [3]. Despite the many gains described below, the use of this technique in breast surgery is not as frequent as in other surgical branches [6, 7].

Nowadays there are an increased number of tissue-expander techniques. The most common complications accompanying implant-based breast surgery are skin flap necrosis (10.9%), seroma (6.9%), infection (5.7%), cellulitis (2%), and haematoma (1.3%) [8]. Enhanced recovery, reduction of complications, and good scar quality can be improved by the application of NPWT [2, 6, 9–13]. Furthermore, the aesthetic results of breast surgery should be taken into consideration because of its psychological effect [10, 13–15]. Although the daily costs of VAC application are higher, the shorter duration of therapy with improved patient comfort seem to be a beneficial solution [16]. In this review, data are presented according to the usefulness and effectiveness of VAC systems in breast surgery.

Analysis

In this article we used the PubMed, Science Direct, and Wiley Online Library databases to search the literature; 40 publications were found by searching the phrases “NPWT breast surgery” and “VAC breast surgery”. Original papers and case reports have been included; papers repeated in different databases and articles that do not refer to the use of NPWT in breast surgery were excluded. After selection, 13 original papers and case reports were finally included in this literature review.

The use of NPWT in breast reconstruction with the use of implants

At the present, implant-based reconstruction after mastectomy is more common because of the shorter operation time and reduced donor-site morbidity [15]. Prevention of surgical site complications in oncological patients is crucial to avoid delay of chemotherapy and radiation treatments [15, 16].

Kim *et al.* demonstrated that the use of incisional NPWT after expander-based breast reconstruction may be beneficial because it decreases the overall number of complications in comparison with standard wound treatment (11.1% vs. 27.9%, $p = 0.019$), and skin necrosis is statistically significantly less frequent in patients treated with NPWT (8.9% vs. 23.5% in standard wound care, $p = 0.038$), which means that many patients have the chance to avoid reoperation [15]. Based on Gabriel *et al.* (2016), there is strong probability that regardless of mastectomy type (nipple sparing, skin sparing, and reduction pattern mastectomy) most postoperative wounds will probably achieve healing three months after surgical treatment in connection with incisional NPWT [17].

In 2015 Holt *et al.* conducted a study in which 24 patients were subjected to either therapeutic mammoplasty or skin-sparing mastectomy, immediate reconstruction on the side affected by breast cancer, and contralateral reduction. Surgical incision on the therapeutic side is treated with negative pressure (−80 mmHg, removed at the first appointment on day 6 in all cases), and reduction side was dressed with conventional dressings. The overall rate of wound breakdown in the 24 patients was 4.2% on the therapeutic side compared with 16.7% on the reduction side, and the mean time to healing was 10.7 days in the therapeutic side treated with the NPWT compared with 16.1 days on the reduction side, although due to the small sample size these results did not allow meaningful testing for statistical significance [18].

Gabriel *et al.* in 2018 performed a retrospective review of records for adult female patients who underwent breast reconstruction postmastectomy. All patients underwent nipple-sparing, skin-sparing, or skin-reducing mastectomy

with immediate or delayed expander-implant reconstruction (prepectoral tissue expander placement or partial submuscular/partial acellular dermal matrix expander placement). Analysis of 356 female patients (NPWT group = 177, standard care group = 179), accounting for 665 reconstructed breasts (NPWT = 331, standard care = 334), were analysed; patients who received radiation during treatment were excluded. Patients in the NPWT group were older and had higher incidences of diabetes, hypertension, and chemotherapy treatment. Negative-pressure therapy was applied at −125 mmHg; all patients were discharged home after one night and instructed to return for follow-up on postoperative days 3 and 7. In comparison with standard wound care, using the VAC system resulted in a decrease in overall complications (15.9% vs. 8.5%, $p = 0.0092$), surgical-site infections (4.5% vs. 2.1%, $p = 0.0225$), wound dehiscence (5.4% vs. 2.4%, $p = 0.0178$), necrosis (9.3% vs. 5.1%, $p = 0.007$), seroma formation (5.7% vs. 1.8%, $p = 0.0106$), and returns to the operating room (5.4% vs. 2.4%, $p = 0.0496$). Two drains were received by 329/331 breasts (99.4%) in the NPWT group and by 180/334 (53.9%) breasts in the standard care group; however, the mean number of days from drain placement to removal of the final drain per breast was 9.9 days in the NPWT group and 13.1 days for the standard care group ($p < 0.0001$) [19]. In Table 1 data summarised from studies related to the effectiveness of VAC systems used in implant-based breast surgery.

Treatment of infected wounds after breast surgery using NPWT

In the literature there are few cases describing the use of NPWT to heal complicated breast wounds after implant

Table 1. The use of NPWT in implant-based breast reconstruction surgery – summary

Study	N, range of age (years)	No. of patients with NPWT, no. of breasts ^a	No. of patients with standard treatment, no. of breasts ^a	Comparison of overall complications	NPWT duration time (days)	Outcome of NPWT
Gabriel <i>et al.</i> 2016, retrospective cohort study	13, 27–62	13, 26	0, 0	5/26 breasts (19%) ^b vs. no data	4.3	By 3-month follow-up 24 of 25 (96%) breasts achieved healing ^c
Dae Young Kim <i>et al.</i> 2016, prospective cohort study	206, 34.8–49.6	44, 45	162, 183	5/45 breasts (11.1%) ^d vs. 51/183 breasts (27.9%) ^e	3	–
Holt <i>et al.</i> 2015, case series	24, 42–70	24, 24	24, 24	1/24 breasts (4.2%) ^f vs. 4/24 breasts (16.7%) ^g	6	At days 6 and 12 nursing staff found an improvement in wound appearance on the treated side compared with the contralateral side in the majority of patients
Gabriel <i>et al.</i> 2018, retrospective cohort study	356, 40–64.2	177, 331	179, 334	28 breasts (8.5%) ^h vs. 53 breasts (15.9%) ^h	7	–

^aOperation types: nipple-sparing, skin-sparing, and reduction pattern mastectomy. ^bSuperficial dehiscence (3/5), skin flap necrosis (1/5) and delayed haematoma (1/5). ^cOnly flap necrosis in the breast of an obese, diabetic (with HGBA1c 9.7) patient required surgical revision. ^dMajor and minor necrosis (4/5), infection (1/5), and seroma (1/5); overall complication includes all patients affected by at least one of the above-mentioned. ^eMajor and minor necrosis (43/51), seroma (8/51), haematoma (5/51), infection (5/51), expander explanation (5/51); overall complication includes all patients affected by at least one of the above-mentioned. ^fBoth outcomes was statistically significant ($p = 0.019$). ^gFat necrosis following a complex two-pedicle therapeutic mammoplasty and axillary node clearance, ^hcomplications described as “wound breakdown”. ^hSurgical-site infections, wound dehiscence, necrosis, seroma, haematoma, expander exposed, expander removed, return to operation room

Table 2. The use of NPWT in complicated wounds after implant-based breast reconstruction surgery

Study	N, breasts, range of age (years)	Types of lesion	NPWT duration, frequency of dressing change (days)	Additional treatment	NPWT outcome
Accurso <i>et al.</i> 2017, case report	1 ^a , 1, 54	Seroma/hematoma and skin necrosis ^c	21 ^d , 3	Draining and daptomycin 350 mg daily IV, implant removal, rinsing of the cavity, inserting new implant	Healing achieved ^f
Cheong <i>et al.</i> 2016, case series	5, 8 ^b , 36–57	Wound dehiscence (4), abscess (3), skin necrosis (1), surgical site infection (1)	7 ^e , 2	Removing of breast implants and washout, packing operation cavity with sterile foam	Healing achieved (8/8 breasts) ^g

^aBRCA1-mutated women undergoing NAC-sparing risk-reducing mastectomy and direct-to-implant reconstruction with the use of an acellular dermal matrix (ADM). ^bBilateral nipple-sparing mastectomy; nipple sacrificing, skin-sparing mastectomy with the insertion of an expander; bilateral nipple-sparing mastectomy and the insertion of expanders (2 patients); skin sparing mastectomy and insertion of a tissue expander. ^cSeven days after surgical procedure. ^dNegative pressure –125 mmHg. ^eNegative pressure –75 mmHg. ^fAfter negative result for bacterial growth in the residual cavity and wound margins patient underwent insertion of the new implant without the ADM. ^gOne week after removing infected implants all patients had successful reinsertion

insertion. Patients with surgical sites affected by infection, skin necrosis, dehiscence, and seroma/haematoma were taken to the operating room for the removal of implant, rinsing of the cavity, and wound washout. Subsequently, the VAC system was applied and the dressing was changed for 2–3 days. Ten treated breasts (six patients) achieved healing, wherein duration of NPWT ranged from seven to 21 days (Table 2) [20, 21].

The use of NPWT in breast reconstruction using the patients' own tissues

As well as implant-based surgery there is also a possibility to reconstruct the breast using a latissimus dorsi flap, although it is connected with high rate of complications (back skin necrosis, breast skin necrosis, haematoma), especially donor site seroma, which occurs in approximately 60% to 80% of cases [22, 23]. There is a study suggesting that the use of NPWT leads to a decrease of seroma formation (from 70% to 15%), the mean percutaneous aspirated volume (from 193 ml to 26 ml), and the number of percutaneous aspirations (from three to one). There were no significant differences in the duration of drainage, the total drainage volume, and hospitalisation time. The study has limitations because of the small sample sizes (20 patients in the control group and 20 in the NPWT group), so there is a need for further investigations to confirm the results [24].

Application of NPWT in breast plastic surgery

Reduction mammoplasty is one of the most common procedures in plastic surgery, and it is beneficial for patients with symptomatic macromastia because of increased self-esteem and back, neck, and shoulder pain relief in about 76% cases [25, 26]. Despite its positive effects breast reduction is connected with complications such as seroma, minor dehiscence, infection, and delayed healing [27]. A prospective, within-patient, randomised study was carried out with 200 participants. Women aged over 18 years without any factors affecting healing (no pregnancy or lactation, no use of steroids, no tattoos in the area of the incision, no scar problems or allergies to product components) were included in this study; post-surgical incisions > 30 cm and active bleeding were exclusion criteria. The NPWT duration time was 14 days, and the system generated –80 mmHg negative pressure to the wound surface. Treating closed incisional wounds after bilateral

reduction mammoplasty with the VAC system resulted in a decrease of overall complications (NPWT 56.8% vs. standard care 61.8%; $p = 0.004$) and protected from wound dehiscence (NPWT 16.2% vs. standard care 26.4%; $p < 0.001$). Application of negative pressure resulted in significant reduction of superficial (from 17.8% to 11.2%) and partial (from 9.6% to 3.6%) dehiscence; there was no significant reduction in deep dehiscence because of the small number of patients with this type of complication. Ninety-day follow-up revealed an advantage of the NPWT – at 7, 21, and 42 days after surgery there were significantly fewer cases of wound dehiscence (16.2% in the NPWT group and 26.4% in the standard care group at day 21, $p < 0.001$ and 19.3% vs. 29.4% at day 42, $p < 0.001$). At 90 days there were a comparable number in the standard care and NPWT groups (14). Galiano *et al.* proved that there is greater benefit from using NPWT in patients with high BMI. What is more, the effects of vacuum-assisted closure increase with the weight of tissue resection [14].

Tanaydin *et al.* in 2018 conducted a prospective, randomised, controlled study on 32 patients with a mean age of 40.9 years (ranging from 18 to 61 years) treated with bilateral reduction mammoplasty; patients with factors delaying healing and skin conditions such as cutis laxa, hypertrophic scarring or keloids, postsurgical incisions still actively bleeding, and exposure of blood vessels, organs, bone, or tendon at the base of the reference wound were excluded from research [13]. Each patient received NPWT (–80 mmHg) on one breast and fixation strips on the another; follow-up visits were performed at day 0 (baseline, post-surgery), 7, 21, 42, 90, 180, and 365. Wound healing complications were defined as delayed healing (surgical incision not 100% closed at day 7 post-surgery), or occurrence of dehiscence or infection within 21 days post-surgery. The study showed that the total number of wound complications was significantly lower for the NPWT-treated breasts ($p < 0.004$) and there was significantly less dehiscence for the breasts treated with NPWT compared to the sites treated with fixation strips ($p < 0.001$). Aesthetic appearance and quality of scarring was significantly ($p < 0.05$) better in breasts treated with the NPWT using the VAS (visual analogue scale) and PSOAS (Patient and Observer Scar Assessment Scale) scores; however, skin viscoelasticity, transepidermal water loss, and hydration measurements showed no consistent significant improvement at one year follow-up [10, 13].

Ferrando *et al.* in 2018 compared negative-pressure therapy (17 patients, 25 surgeries) with standard dressing (20 patients, 22 surgeries) in patients undergoing complex oncological breast surgeries and reconstructions. The VAC provided -125 mmHg pressure for seven days; the standard dressings involved Steri-Strip skin adhesive closure for 14 days (changed after seven days). There was a significant reduction in overall complications between groups: 4% (1/25) in the NPWT group and 45% (10/22) in the standard wound treatment group ($p = 0.001$); skin necrosis incidence was significantly lower in the NPWT group than in the standard dressing group (4% vs. 32%; $p = 0.02$). The aesthetic result was also better in the NPWT group: in PSAS (median score 11 vs. 20; max. 50; $p = 0.002$), OSAS (median score 7 vs. 24; max. 50; $p = 0.01$), and MSS (median score 7 vs. 12; $p = 0.001$); however, there was no significant reduction in BIS score [28].

Treatment of breast inflammatory diseases using NPWT

Non-puerperal mastitis encompasses all the causes of inflammatory changes in the female breast and mamilla not related to lactation, for which the aetiology is still unknown. In general, non-puerperal mastitis does not require surgery to be treated, but in the literature there are cases describing patients unsuccessfully healed with non-surgical methods and healing with surgery connected with NPWT [29]. In total, seven cases of application of a VAC system for two weeks resulted in resolution of inflammatory symptoms. Although there were single differences between each treatment, healing was achieved in all cases [30, 31]. We identified two studies according to non-healing wounds, in which damaged tissues regenerated faster after NPWT, but these observations are based

on the authors' experience and cannot be taken as objective evidence [16, 32]. The use of NPWT in chronic breast wounds is summarised in Table 3.

Conclusions

Current data suggest that the use of NPWT in implant-based breast reconstruction surgery decreases overall complications in comparison with standard wound treatment, especially skin flap necrosis. What is more, there is a supposition that as much as 96% of breast wounds may achieve healing at three months after surgery, but this has to be confirmed in larger prospective studies [15, 17, 19]. It may be useful for the treatment of complicated wounds after implant-based breast reconstruction surgery, but it has been demonstrated only by cases series, so there is a need for stronger evidence [20, 21]. Despite the fact that vacuum-assisted closure does not significantly reduce the duration of drainage, the total drainage volume and hospitalisation time in patients who underwent breast reconstruction using latissimus dorsi flap is beneficial because the use of NPWT leads to a decrease of seroma formation, the mean percutaneous aspirated volume, and the number of percutaneous aspirations [24]. Generating -80 mmHg negative pressure to the wound surface after bilateral reduction mammoplasty resulted in a decrease of overall complications and significant reduction of superficial and partial dehiscence; visual scale scores showed that quality of scarring was better in breasts treated with NPWT [10, 13, 19]. However, at one-year follow-up there was no improvement in skin viscoelasticity, transepidermal water loss, and hydration measurements [10, 13]. Furthermore, in several cases the application of a VAC system for two weeks due to non-puerperal mastitis allowed resolution of inflammatory symp-

Table 3. Chronic and non-healing breast wounds successfully treated by negative-pressure wound therapy

Study	N, breasts, range of age (years)	Types of lesion	NPWT duration, frequency of dressing change (days)	Previous treatment	NPWT outcome
Luedders <i>et al.</i> 2011, case series	5, 5, 42–64	Non-puerperal mastitis, breast abscess ^a	4–13 days, 3–4 days	Incision and drainages; secondary reduction of tissue; hydrocolloid closure and wound lavage; antibiotic therapy ^e	Healing achieved (5/5)
Namdaroglu <i>et al.</i> 2016, case series	2, 2, 25–31	Non-puerperal mastitis, breast abscess	14 days, 3 days	Incision and drainages, antibiotic therapy ^f , oral prednisolone 0.5 mg/kg/day, surgery and wide excisions of the diseased ducts	Healing achieved (2/2)
Stoekel <i>et al.</i> 2006, case series	15, no data, no data	Complex breast wounds ^b	3–54 days ^c , no data	No data	7/15 healed by secondary intention, 6/15 treated with subsequent skin grafting, 2/15 delayed primary closure
Dian <i>et al.</i> 2010, case series	4, 4, 61–66	Surgical site affected by radiation therapy due to breast cancer	Approximately 4 weeks ^d , no data	No data	4/4 wound reduction, 1/4 patients died before wound closure

NPWT – negative pressure wound therapy. ^aFour patients had a positive wound culture of *Staphylococcus epidermidis*, one was positive for *B-haemolytic streptococci*. ^bFour of the patients had complicated transverse rectus abdominis myocutaneous flap wounds and one had a latissimus dorsi flap wound. ^cMean 15 days. ^dData shown only in one of cases. ^eUsed antibiotics: amoxicillin, amoxicillin+clavulanic acid, ciprofloxacin, flucloraxillin, trimethoprim + sulfametoxazole, cefuroxime, clindamycin, ciprofloxacin. ^fIn one patient with positive bacterial growth: amoxicillin + clavulanic acid

toms [30, 31]. Currently NPWT is successfully used in other surgical branches such as chronic wound, abdominal, cardiothoracic and orthopaedic trauma [33–36]. Further studies, providing evidence of high quality, are needed to make vacuum-assisted closure more common in breast surgery.

The authors declare no conflict of interest.

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Submitted: 4.02.2019

Accepted: 2.04.2019