Negative pressure wound therapy in gynecologic oncology – current knowledge and clinical applications

Podtlaková terapie hojení ran v onkogynekologii – současné poznatky a klinické využití

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Summary: Negative pressure wound therapy is a modern and effective method for the prevention and treatment of postoperative wound healing complications, with growing applications in gynecology, especially in gynecologic oncology. Its mechanism of action includes enhanced drainage, reduction of edema, promotion of angiogenesis, and stimulation of granulation tissue formation, ultimately contributing to faster healing and a lower risk of infection, seroma, and wound dehiscence. Negative pressure wound therapy has been shown to be effective in the therapeutic management of complex, infected, or dehiscent wounds following gynecologic-oncologic surgery. Recent studies also suggest that its prophylactic application to primarily closed incisions after laparotomy or vulvectomy may significantly reduce surgical complications, shorten hospitalization, and accelerate recovery, which is particularly important in patients scheduled for adjuvant therapy. However, because most available evidence is based on retrospective studies, further prospective randomized trials are needed to confirm the role of this method in both therapeutic and prophylactic use and to guide its integration into standard perioperative care in gynecologic oncology.

Key words: negative pressure wound therapy – wound healing – surgical wound dehiscence – gynecologic surgery – gynecologic malignancies

Souhrn: Podtlaková terapie ran představuje moderní a účinnou metodu prevence a léčby komplikací hojení operačních ran, jejíž využití v posledních letech narůstá také v gynekologii, zejména v oblasti gynekologické onkologie. Mechanizmus účinku této metody zahrnuje zajištění efektivní drenáže, redukci edému, podporu angiogeneze a stimulaci tvorby granulační tkáně, což ve svém důsledku přispívá k rychlejšímu hojení a nižšímu riziku infekce, vzniku seromu či dehiscence rány. Účinnost podtlakové terapie byla prokázána při léčbě komplikovaných, infikovaných nebo dehiscentních ran po onkogynekologických operacích. Novější studie rovněž naznačují, že profylaktická aplikace podtlakové terapie na primárně uzavřené incize po laparotomii či vulvektomii může významně snížit výskyt chirurgických komplikací, zkrátit dobu hospitalizace a urychlit rekonvalescenci, což je obzvláště významné u pacientek, které mají podstoupit adjuvantní léčbu. Vzhledem k tomu, že většina dostupných důkazů vychází z retrospektivních studií, je třeba dalších prospektivních randomizovaných studií, které by potvrdily účinnost této metody jak v léčbě, tak v prevenci a umožnily její zařazení do standardní perioperační péče v onkogynekologii.

Klíčová slova: podtlaková terapie – hojení ran – dehiscence operační rány – gynekologické operace – gynekologické malignity

Introduction

Negative-pressure wound therapy (NPWT), also known as vacuum-assisted closure (VAC), is an effective treatment approach for both acute and chronic wounds. It is commonly used for managing surgical wounds, particularly those that are infected or dehiscent, where other treatment methods have failed to achieve proper healing [1,2]. NPWT has undergone significant development since its early historical origins in the 19th century. The modern concept, as we know it today, was fundamentally advanced by Argenta and Morykwas, who in 1997 published a breakthrough study demonstrating its clinical efficacy. Their research included not only clinical application but also *in vivo* experiments under laboratory conditions to optimize the level of negative pressure for the most efficient healing outcomes [2].

Given the prevalence of comorbidities in the current population, it is likely that the incidence of impaired surgical wound healing and surgical site infections (SSI) will remain high in the foreseeable future. Common risk factors such as obesity, diabetes mellitus, cardiovascular disease, anemia, smoking, immunosuppression, and malnutrition are all associated with delayed wound healing and increased susceptibility to infection. These conditions can impair local tissue perfusion, oxygenation, immune response, and collagen synthesis, thereby compromising the integrity of wound repair [3]. SSI contributes to prolonged hospitalization, increases the risk of further complications and nursing workload, and has a significant impact on healthcare system costs [4].

Therefore, it is important to seek effective preventive and therapeutic strategies to reduce the risk of wound healing complications, particularly in high-risk patient groups. NPWT shows great potential in the context of primarily closed surgical wounds (ciNPWT – closed-incision negative pressure wound therapy), which may reduce the incidence of SSIs, dehiscence, seromas, and hematomas. This, in turn, can shorten hospital stays, accelerate recovery, and potentially improve oncologic outcomes in patients scheduled for adjuvant therapy [4].

The aim of this review is to summarize current evidence from the published literature on NPWT in gynecologic oncology, focusing on both therapeutic and prophylactic applications. The article also describes the principles and mechanisms of NPWT, discusses clinical indications and implementation, and provides a detailed overview of both alternative and adjunctive wound management strategies.

Principle of negative pressure wound therapy

Modern NPWT systems use porous polyurethane foam applied to the wound bed, which is connected to a vacuum source via an electronic device operating in either continuous or intermittent mode. This creates sub-atmospheric pressure that positively influences the healing process. The mechanism of action involves mechanical stabilization and approximation of wound edges, removal of extracellular fluid, and stabilization of the wound environment. These effects reduce edema and bacterial colonization, improve perfusion, promote angiogenesis and granulation tissue formation, and accelerate wound healing [5]. Constant negative pressure also significantly increases local microcirculation and dilates the diameter of capillaries, arterioles, and venules. This technique is used to promote granulation tissue formation in open wounds, clean surgical incisions, and for the fixation of skin grafts. The benefits of NPWT include shortened healing time and a reduced risk of surgical complications, including surgical site infection, seroma, hematoma, and wound dehiscence [6,7].

The optimal pressure setting for NPWT should be adapted to the wound type, the condition of surrounding tissue, and the patient's risk of complications. While the traditionally used pressure of −125 mm Hg is effective for drainage and wound contraction, newer studies suggest that maximal biological effects, including granulation tissue formation and regional perfusion, can often be achieved at −80 mm Hg [8]. Experimental studies using NPWT on open surgical wounds have shown that pressures ranging from −50 to −170 mm Hg significantly reduce blood flow in bowel loops located directly beneath the dressing. This effect was localized and increased with suction intensity, while deeper loops were unaffected. Prolonged hypoperfusion may lead to ischemia and necrosis of the intestinal wall, increasing the risk of enterocutaneous and enteroatmospheric fistulas. Placing a nonadherent protective barrier between the intestines and the suction source has been associated with reduced petechial bleeding and therefore a lower risk of ischemic injury [9].

Experimental findings indicate that, while NPWT removes fluid through negative pressure, it also transmits compressive forces to surrounding soft tissues. This can increase local tissue pressure and paradoxically reduce perfusion. Both the level of negative pressure and the size and placement of the foam dressing play a crucial role. Larger foam surfaces transmit greater total force to adjacent tissues, especially at the edges where the pressure is highest (up to 187 mm Hg in experimental models). In contrast, smaller dressings using the same suction settings exert lower compressive force and may be preferable in cases where tissue ischemia is a concern, such as in patients with impaired peripheral circulation. Furthermore, if the foam is applied outside the wound itself or only partially covers the wound edges, the pressure distribution may differ significantly and can meaningfully influence both the therapeutic effect and the safety of treatment. This underscores the need not only to select an appropriate level of negative pressure but also to carefully adapt the size and placement of the foam dressing to the specific anatomical site and condition of the soft tissues [10].

NPWT is currently undergoing dynamic development, accompanied by numerous technological innovations. New modifications of this method are also being used in clean surgical settings, where NPWT is applied prophylactically to primarily closed surgical incisions [11]. Devices have also been developed to enable instillation, the targeted delivery of irrigation solutions, including antibiotics, directly into the wound [2,12].

Fig. 1. Evaluation of the extent of dehiscence, defect depth, and the presence of necrotic tissue and exudate.
Obr. 1. Zhodnocení rozsahu dehiscence, hloubky defektu, přítomnosti nekrotické tkáně a exsudátu.

Fig. 2. Removal of necrotic tissue and coagula to achieve a clean and well-perfused wound bed.
Obr. 2. Odstranění nekrotických tkání a koagul k dosažení čisté a dobře prokrvené spodiny rány.

Portable, single-use NPWT systems (suNPWT), particularly those with a canister (CB – canister-based), have recently become an attractive option in postoperative care. They allow patients to remain mobile and thereby help improve quality of life by enabling return to everyday activities [13]. Compared to conventional NPWT systems, they also offer economic advantages, as they require less specialist intervention, resulting in better clinical outcomes, shorter healing time, and reduced length of hospital stay [5,14].

Innovations have also focused on materials at the interface between the NPWT system and the wound surface, enabling the biological response to be tailored to the characteristics of the defect. For example, pore size in the filler material plays a crucial role in the rate of granulation tissue formation. Modern NPWT systems can also be combined with other surgical technologies, such as dermal scaffolds or processed allogeneic or xenogeneic materials, expanding therapeutic possibilities in regenerative surgery [15].

Use of negative pressure wound therapy in gynecologic oncology

Minimally invasive approaches, particularly laparoscopy and robotic surgery, are currently the preferred methods for many gynecologic procedures, including oncologic surgeries. They allow shorter hospitalization, lower rates of postoperative complications, and faster return to normal activity [16]. However, there remains a group of patients for whom laparotomy continues to be the most appropriate or necessary surgical approach [17].

Laparotomy is typically indicated in cases of extensive advanced oncologic disease, where the goal is radical cytoreduction and where minimally invasive techniques do not allow sufficient visualization or safe performance of resections and reconstructions [18,19]. Laparotomy is also preferred in patients with multiple adhesions from previous surgeries, in emergency situations (e.g., massive bleeding, perforation), or in cases where laparoscopic access to the abdominal cavity is contraindicated or unfeasible [20].

In oncogynecologic practice, NPWT has become established primarily in the treatment of complicated surgical wounds, for example, after abdominal surgeries (Fig. 1–5) or vulvectomy [16]. Wound healing complications such as infection, dehiscence, hematoma, or seroma represent significant clinical problems [21]. Their occurrence is influenced by patient-related factors such as obesity, diabetes mellitus, older age, anemia, or malnutrition, as well as intraoperative factors including the length of the procedure, bowel surgery, blood loss, or the technique of primary closure [22]. Hematomas and seromas, which develop due to insufficient hemostasis or lack of drainage, increase the risk of infection and impair healing. In this context, NPWT functions as a method that promotes drainage, reduces edema and bacterial contamination, and thereby improves the healing process even in high-risk patients [4,23].

Fig. 3. Application of the Mepitel silicone contact layer to exposed structures.
Obr. 3. Aplikace ochranné silikonové kontaktní vrstvy Mepitel na exponované struktury.

Fig. 4. Insertion of polyurethane foam trimmed to the wound shape to fill the defect.
Obr. 4. Vložení polyuretanové pěny upravené podle tvaru rány a vyplnění defektu.

Fig. 5. Hermetic sealing of the foam with an occlusive drape, connection of the suction port, and initiation of negative pressure with system leak check.
Obr. 5. Hermetické překrytí pěny okluzivní fólií, napojení sacího portu a spuštění podtlaku s kontrolou těsnosti systému.

In recent years, NPWT has thus emerged as a promising method for both the prevention and treatment of wound healing complications in oncogynecology. Although most available evidence comes from general surgery, the number of studies specifically focused on gynecologic and oncologic procedures remains limited, and these cases are often included within heterogeneous surgical cohorts.

The study by Argenta et al. represents one of the first case series describing the use of NPWT in gynecologic oncology patients. The authors reported three cases of patients with complicated wound healing following oncogynecologic procedures in whom NPWT led to significant clinical improvement. In all patients, exudate decreased within 48–72 hours, and robust granulation tissue formed within 5–7 days. The average time required to reach a condition suitable for secondary wound closure or continued epithelialization was 10 days. In one patient, NPWT was successfully used despite the presence of an enterocutaneous fistula, and in another, it was applied over exposed polypropylene mesh (MESH) without any serious complications. The authors concluded that NPWT is a safe and effective method for treating deep and infected wounds in patients undergoing gynecologic oncologic surgery, particularly in cases where conventional therapy has failed [24].

In a retrospective study, Schimp et al. analyzed 27 patients with gynecologic malignancies and complicated wound healing who were treated with NPWT. The results showed a 96% median reduction in wound volume from 330 cm^3 to 14 cm^3 after a median therapy duration of 32 days. Complete wound healing was achieved in 26 out of 27 patients (96%). Most patients (74%) were treated on an outpatient basis without complications. The only adverse event was minor wound bleeding. This study confirms the safety and efficacy of NPWT in patients with oncogynecologic disease and supports its use in the management of complex wounds after extensive surgical procedures [25].

In recent years, there has been increasing interest in the use of NPWT in patients undergoing surgical treatment for vulvar cancer. Recent studies have focused particularly on its effectiveness in preventing and treating wound healing complications after radical vulvectomy, often combined with inguinofemoral lymphadenectomy and reconstructive procedures. Given the anatomical location, high tension in surgical wounds, and frequent occurrence of infection, seromas, or dehiscence, these procedures present a significant risk of healing disorders that may delay adjuvant therapy and worsen prognosis [26]. In this context, NPWT has shown promise as a method for ensuring exudate drainage, reducing bacterial contamination, and promoting granulation tissue formation.

In a retrospective cohort study, Quercia et al. evaluated 18 patients after radical vulvectomy with inguinofemoral lymphadenectomy, of whom seven were treated with NPWT and 11 formed the control group. The NPWT group had significantly shorter hospital stays (14.2 ± 4.7 vs. 17.1 ± 6.1 days; $P < 0.05$) and faster complete wound healing (reduced by 31.9 days; 95% CI −43.5 to −20.3). Rates of infection, necrosis, or dehiscence did not differ significantly between groups [27].

Another retrospective study included 17 patients after vulvar cancer surgery, 16 of whom completed NPWT. All patients achieved complete wound healing, with a mean healing time of 43.5 ± 17.9 days. The therapy supported flap healing, reduced exudate, decreased edema, and reduced dressing change frequency. The authors also described specific technical strategies for overcoming anatomical challenges of the perineum during NPWT application [28].

Both studies support the use of NPWT as an effective means to improve healing outcomes and potentially shorten recovery following surgical treatment of vulvar cancer.

Prophylactic use of NPWT in gynecologic oncology

Prophylactic use of ciNPWT in gynecologic oncology represents a promising strategy for preventing postoperative wound healing complications in high-risk patients. Recent studies suggest that applying NPWT to primarily closed incisions following major abdominal procedures, such as cytoreductive surgery or radical hysterectomy, may significantly reduce the incidence of surgical site infections (SSI), seromas, and dehiscence.

A recent systematic review and meta-analysis including 57 randomized controlled trials with a total of 13,744 patients demonstrated that NPWT significantly reduces the incidence of surgical site infections (RR 0.66; 95% CI 0.59–0.74), wound dehiscence (RR 0.72; 95% CI 0.60–0.87), seroma (RR 0.67; 95% CI 0.54–0.83), and hematoma (RR 0.68; 95% CI 0.53–0.88) in primarily closed wounds compared to conventional dressings. The greatest benefit was observed in patients at elevated risk of complications, such as those with obesity, diabetes, or cardiovascular disease. The results were consistent across surgical disciplines, including gynecologic procedures, and confirm the value of prophylactic NPWT as an effective tool in the prevention of early postoperative complications [5].

In a retrospective cohort study, Martí et al. compared wound healing complications in 143 patients undergoing laparotomy for gynecologic malignancies. The group receiving conventional dressings (N = 85) was compared with a group treated with ciNPWT after wound closure (N = 58). The results showed a significantly lower complication rate in the ciNPWT group (6.9 vs. 31.8%; $P < 0.001$). Specifically, there was a reduction in the incidence of superficial infections (1.7 vs. 18.8%), seromas (3.4 vs. 18.8%), and wound dehiscence (1.7 vs. 18.8%). The average hospital stay in the ciNPWT group was reduced by nearly three days (6.2 vs. 8.9 days; $P < 0.05$). The effect was also confirmed in obese patients (BMI ≥ 30 kg/m^2), in whom complications were significantly less common when ciNPWT was used [29].

Another study examining the use of ciNPWT in women undergoing surgery for gynecologic malignancies evaluated its effect on wound healing complications. A retrospective analysis included 103 patients, of whom 48 were treated with ciNPWT and 55 served as the control group. Results showed a significantly lower rate of surgical site infection (2 vs. 15%; $P = 0.03$), seroma (2 vs. 15%; $P = 0.03$), and dehiscence (4 vs. 18%; $P = 0.04$) in the NPWT group. These data support the prophylactic use of NPWT as an effective means of reducing postoperative complications in gynecologic oncology [23].

These studies suggest that prophylactic application of ciNPWT after laparotomy may substantially reduce postoperative morbidity and offer potential cost savings through fewer complications and shorter hospitalization. Prophylactic NPWT may thus represent an effective intervention for improving perioperative outcomes and reducing the need for reintervention in this specific patient population.

Alternatives to negative pressure wound therapy

Although NPWT is considered one of the most effective methods for promoting healing in complicated wounds, it is not always suitable or accessible [16]. In many clinical situations, alternative methods may be indicated that are simpler, less costly, and less invasive. These alternatives include modern forms of moist wound healing, antimicrobial dressings, or biological materials. The choice of method should always be based on an individual assessment of the wound type, the patient's overall clinical condition, and the availability of medical resources [30].

Traditional dressings such as gauze, sterile absorbent cotton, or textile bandages are among the most commonly used materials in clinical practice. Their main advantages are low cost and wide availability. On the other hand, these materials have several limitations, including low absorbency, limited ability to maintain a moist environment, and insufficient protection against microbial contamination [31]. They also tend to adhere to the wound bed, which can lead to secondary tissue damage and pain during dressing changes [30,32].

The most commonly used types of moist dressings in modern wound care include hydrocolloids, alginates, and hydrogels, each with distinct properties and indications [33]. Hydrocolloid dressings consist of an adhesive matrix containing carboxymethylcellulose, pectin, and gelatin that forms a gel upon contact with exudate, supporting autolytic debridement. They are suitable for mildly exudative wounds, adhere well to the skin, and allow patients to engage in normal daily activities, including bathing. Their effectiveness has been confirmed in several meta-analyses showing improved healing outcomes compared to sterile gauze [30,34]. Alginates, derived from seaweed, have high absorbency and mild hemostatic properties, making them suitable for heavily exudating wounds, though they are not appropriate for dry wounds [35]. Hydrogels, composed primarily of water in a hydrophilic polymer network, are particularly indicated for dry and necrotic wounds, where they promote tissue hydration and provide a cooling, analgesic effect [35,36]. Proper selection of dressing type allows for the optimization of the wound environment and acceleration of healing based on the wound's current condition [30–32].

Another alternative to NPWT is the use of dressings with antimicrobial agents, such as silver, iodine, polyhexanide, or honey (e.g., Manuka honey) [33]. These dressings reduce microbial burden, minimize the inflammatory response, and may be indicated for colonized or infected wounds. Their use should be targeted and time-limited to avoid cytotoxicity and the development of bacterial resistance [32,37].

Newer and increasingly studied alternatives include growth factors, blood-derived therapies, and tissue engineering techniques (e.g., bioactive matrices, collagen-based dressings, xenogeneic grafts) [37–39]. These strategies aim to stimulate cell proliferation, angiogenesis, and accelerate re-epithelialization. Although their routine clinical use remains limited, they represent a promising direction in the personalized treatment of chronic wounds [40,41].

The combination of NPWT with dressings containing antimicrobial components has been the subject of several recent studies [15,42,43]. In a randomized controlled trial, Ali et al. demonstrated that combining NPWT with silver alginate dressing significantly accelerated granulation tissue formation, reduced pain intensity, and was more effective against infection compared to non-silver dressings [44]. Likewise, combining modern moist dressings with antimicrobial or biologically active substances shows potential to improve healing in clinically challenging wound types [32].

Conclusion

NPWT is an effective and safe method for preventing and managing wound healing complications in patients undergoing gynecologic-oncologic surgery. Current data, including studies focused on vulvectomy, cytoreductive procedures, and other extensive oncologic operations, consistently show reduced rates of surgical site infection, seroma formation, and wound dehiscence when NPWT is applied, both therapeutically and prophylactically.

Despite these promising results, most available evidence stems from retrospective or observational studies with limited sample sizes. There remains a need for high-quality prospective and randomized trials to determine the true efficacy of NPWT in gynecologic oncology and to establish standardized protocols regarding timing, duration, pressure settings, and optimal patient selection. Data on long-term outcomes, such as delays in adjuvant therapy, oncologic prognosis, and patient-reported quality of life, are also lacking. In addition, the cost-effectiveness of NPWT across healthcare systems, and its comparative value against other modern wound management strategies, require further investigation. Expanding the evidence base in these areas is essential to support the informed and evidence-based use of NPWT in gynecologic oncology and guide its integration into routine perioperative care.

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