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Prevention and therapy of acute and chronic wounds using NPWT devices during the COVID-19 pandemic, recommendation from The NPWT Working Group

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ORIGINAL ARTICLES

Abstract— **Recent SARS-CoV-2 pandemic leading to a rapidly increasing number of hospitalizations enforced reevaluation of wound management strategies.**

The optimal treatment strategy for patients with chronic wounds and those recovering from emergency and urgent oncological surgery should aim to minimize the number of hospital admissions, as well as the number of surgical procedures and decrease the length of stay to disburden the hospital staff and to minimize viral infection risk.

One of the potential solutions that could help to achieve these goals may be the extensive and early use of NPWT devices in the prevention of wound healing complications.

Single-use NPWT devices are helpful in outpatient wound treatment and SSI prevention (ciNPWT) allowing to minimize in-person visits to the health care center while still providing the best possible wound-care. Stationary NPWT should be used in deep SSI and perioperative wound healing disorders as soon as possible. Patient's education and telemedical support with visual wound healing monitoring and video conversations have the potential to minimize the number of unnecessary in-person visits in patients with wounds and therefore substantially increase the level of care.

***Keywords*—NPWT, Covid-19, SARS-CoV-2, chronic wounds**

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Introduction

THE epidemiological situation in the world caused by the SARS-CoV-2 virus leads to a rapidly increasing number of hospitalizations. Hospital wards are being converted into dedicated COVID-19 wards what brings many sudden changes in the system and treatment strategy. There are many recommended procedures for the prevention of surgical site infections (SSI), but only a few deals with the treatment of complications, and especially patients in home care. The current general strategy is to minimize the number of nonessential hospitalizations for three main reasons:

1) providing intensive care units the capacity for COVID-19 patients requiring intensive care;
2) preserving medical staff due to the shortage of medical personnel
3) reducing the risk of infection for hospitalized patients and medical staff

SSI symptoms after abdominal and chest injury surgery may camouflage asymptomatic SARS-CoV-2 infection especially in the era of COVID-19 pandemic.[1] Therefore minimizing hospitalization time may decrease the risk of viral transmission in post-surgical patients.

General strategy

The optimal treatment strategy for patients with chronic wounds and those recovering from emergency and urgent oncological surgery should aim to minimize the number of hospital admissions because of the surgical reasons described in detail in the ERAS protocol,[2] as well as the number of surgical procedures. On the other hand, the hospitalization time should be optimized to be as short as possible to

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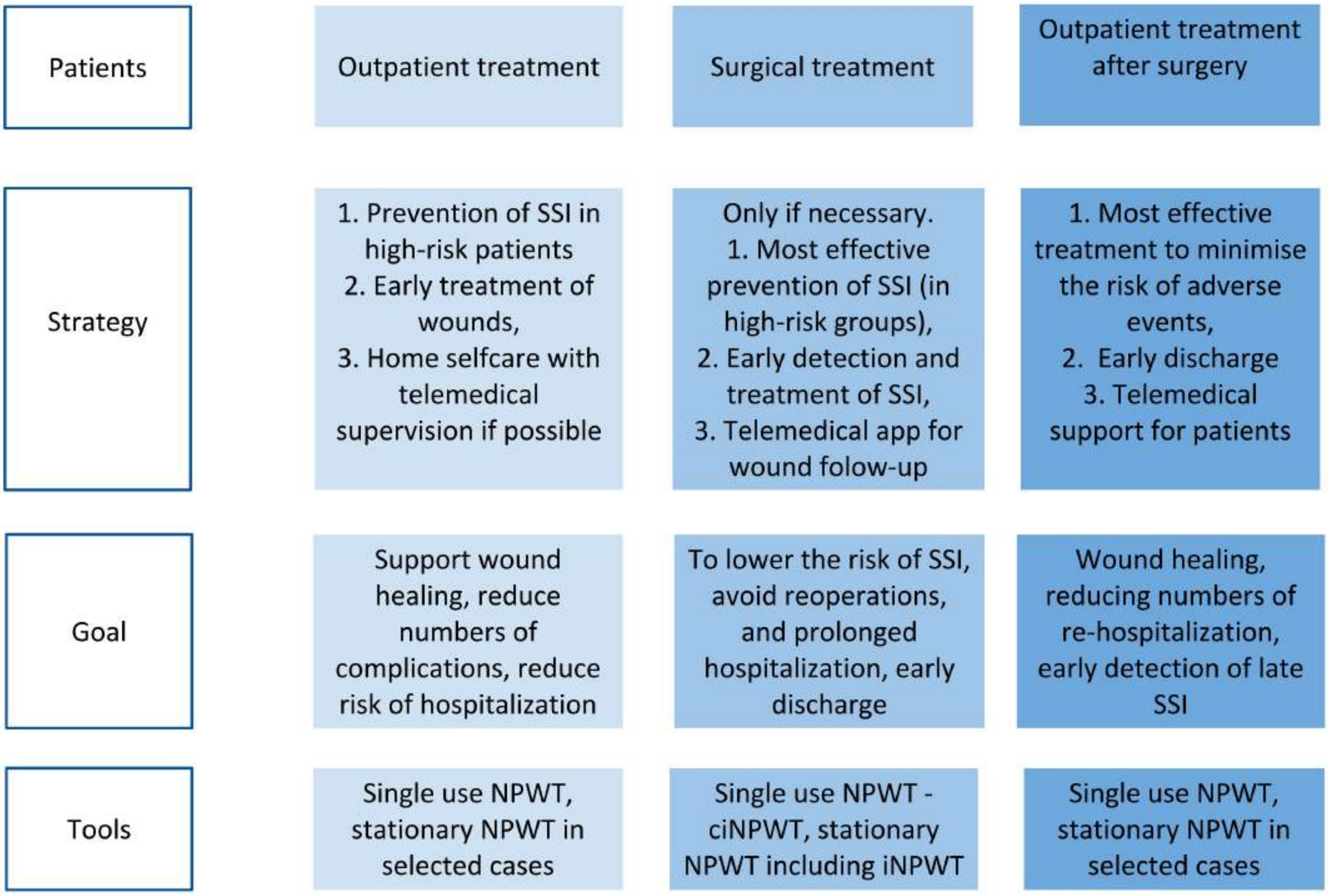

Figure 1. The treatment strategy in three most common settings (columns) during the SARS-CoV-2 pandemic.

disburden the hospital staff and to minimize viral infection risk. One of the potential solutions that could help to achieve these goals may be the extensive and early use of Negative Pressure Wound Therapy (NPWT) devices in the prevention of wound healing complications[3] (mainly surgical site infections — SSI[4] or wound dehiscence), particularly among higher-risk patients,[5] those with complex incisions with ort without prosthetic devices underlying the closed incision.[6–8] Li et al. proved that patients undergoing NPWT after open abdominal surgery had SSI less frequently[9] and the formation of enteroatmospheric fistulae were also less frequent in patients receiving.[10]

The relative liberal use of ciNPWT, may well be advantageous for patients who are discharged as an inpatient earlier than normal to free up capacity for acute COVID beds may continue to receive good quality healthcare at home.[11]

This strategy may be highly important in a group of patients undergoing urgent surgery or those with wounds classified as contaminated. Based on recent studies, ciNPWT significantly reduced the incidence rate of SSI in colorectal, inflammatory bowel disease patients or groin vascular surgery, as well as other disciplines such as Orthopaedic and Plastic Surgery.[12–14] NPWT could also be used more extensively in tearly wound healing complications and wound infections allowing a rapid, safe and effective inpatient discharge. Prevention of SSI using ciNPWT (closed incision NPWT) can lead to reduce the incidence of SSI, and also the number of wound dressing changes[15] (disburdening medical staff, and minimizing contact with the patients). In septic and complicated wounds, iNPWT (instillation NPWT) should be more commonly applied. It was stated that the utility of NPWT with instillation in complicated and non-healed wounds was associated with a significant decrease in bacterial overload reduction, time to wound closure and hospital discharge.[16] The principles of the treatment strategy are shown on (Fig. 1).

NPWT can be used as soon as possible in wound healing disturbances, especially those caused by infections. The stationary device initially applied in hospitalized patients can be continued in an ambulatory setting using a single-use portable NPWT device. Single-use ciNPWT devices are widely available on the market, intuitive, and easy to use. The education of patients on how to remove a vacuum wound dressing, in selected well-collaborating patients, can be very

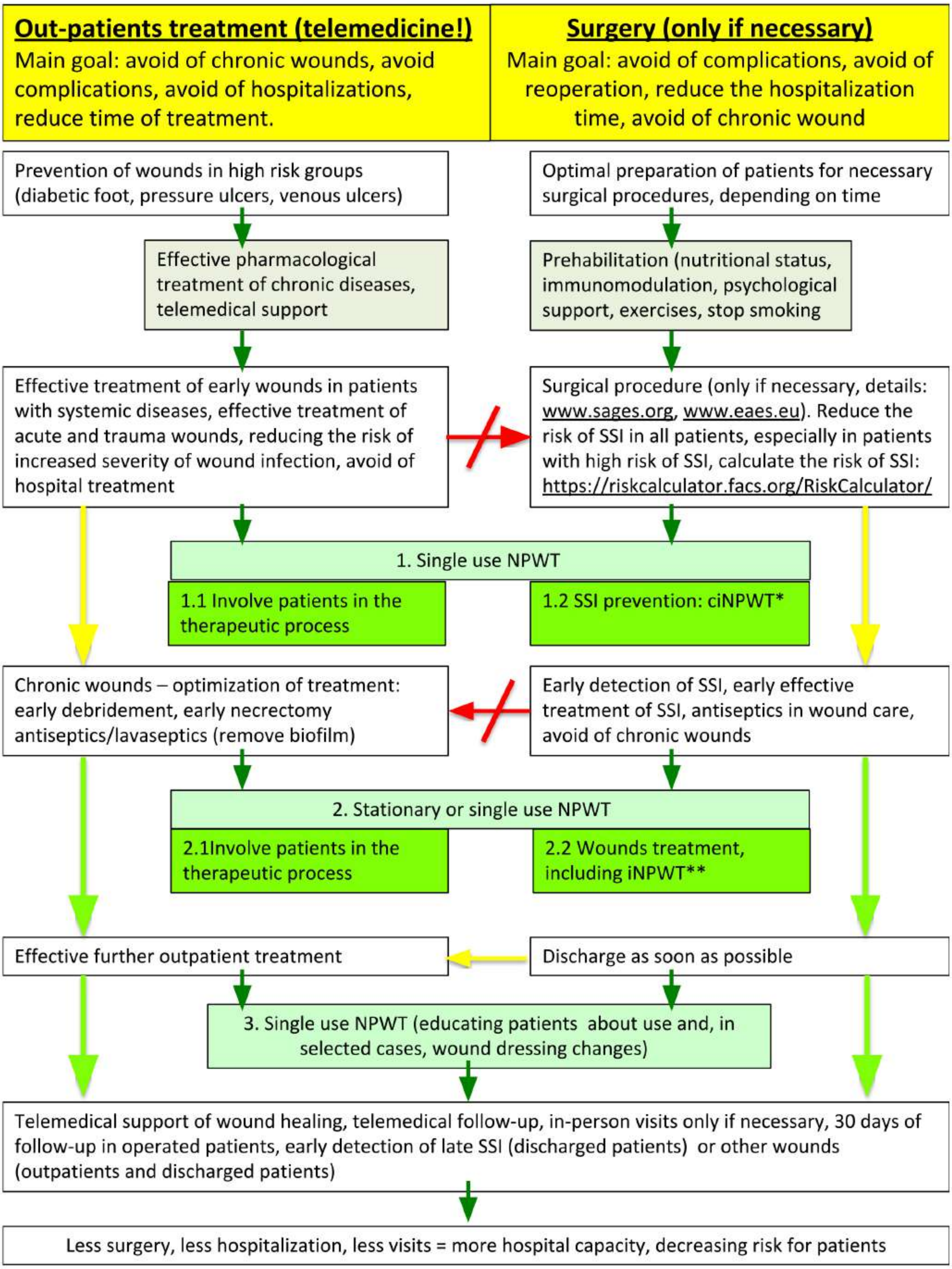

Figure 2. Proposed patient flow in a surgery hospital department.

helpful and is essential when dealing with the dressing's seal leak during NPWT at home. Current evidence support the home use of single-use NPWT (sNPWT) due to high patient-satisfaction.[17]

Dowset et al. provided data on the clinical and economic benefit of sNPWT in patients with chronic wounds allowing to free up medical staff.[18] Similar benefits have been shown in the closed incision groups also.[7, 19] The same principles will apply to acute and surgical wounds during the COVID-19 pandemic. This is especially important as there is evidence that the effectiveness of sNPWT is similar in inpatient and outpatient setting.[20]

The telemedical support for patients should lead to a good postoperative wound control and can be used in an outpatient treatment manner. Options with the possibility of digital photography transfer are preferable. The optimal flow of patients (out- and inpatients) is shown on (Fig. 2). The main problems associated with the wound healing process are listed below.

1. Problem: Management of outpatients with wounds

Goal: In patients with acute or chronic wounds the ambulatory treatment should be as effective as inpatient therapy while reducing the number of in-person visits. Solution (using NPWT):

1) The prophylactic[21] use of single-use NPWT devices if possible (reducing the number of wound dressings changes, making treatment more effective) is advised.
2) In chronic venous leg ulcers NPWT should be combined with compression therapy (using either bandaging or compression stockings.[22]
3) Patients should be educated on minimizing the risk of SARS-CoV-2 infection.
4) Telemedical support[23] for patients during wound dressing self-removal, dressing leaks, and, in selected cases, in wound dressing changes is essential, with secure video conversations as the gold standard.

2. Problem: Management of surgical patients (emergency and urgent oncologic procedures) and SSI

Goals:

1) reduction of the SSI severity and frequency;
2) effective treatment of SSI;
3) avoidance of reoperations;
4) early discharge

Solution (using NPWT):

1) NPWT in all patients with complicated wounds, (e.g. open abdomen,[24] open fractures[25]), and ciNPWT in high-risk patients for SSI, complex wounds and those associated with a prosthesis are recommended (if available and possible also in other patients); In order to minimize the costs of the ciNPWT — alternative low-cost methods can be advised.[26]

2), 3) NPWT therapy should be introduced as soon as possible in SSI (according to CDC classification:[27] superficial incisional SSI — single-use NPWT, stationary NPWT; deep incisional SSI — stationary NPWT (consider instillation — iNPWT); organ or space SSI — stationary NPWT (consider instillation — iNPWT)

4) optimal wound healing should be provided to patients with a higher risk of developing SSI (obesity or cachexia, ASA 3 and 4, immunosupression, steroids, cigarette smoking, comorbidities) by using an effective wound dressing suitable for discharge — single-use NPWT combined with patient education on wound dressing self-removal and, in selected cases, in wound dressing changes. Telemedical support for theses patients is essential to minimize in-person visits.[23] Patient should be educated that in case of skin infection presenting with pain, heat, redness, swelling or purulent discharge at the incision site, they should seek immediate consultation via telemedical support.

Even if lower risk for SSI is calculated, ciNPWT should be considered as first line treatment option for wound management. Such management may reduce the risk for developing SSI to the minimum and prevent readmission or complications during outpatient care.

In cases where patients would not be able to follow telemedical guidance on wound dressing changes or in more complicated dressing requiring in-person visits, it is highly advisable to prolong the intervals between dressing changes in order to minimize the number of in-person visits. NPWT is highly suitable to prolong dressing change intervals17 and can be recommended to achieve this.

3. Problem: Follow-up surveillance of outpatients after surgery

Goal: To facilitate wound follow-up with detection of SSI after discharge, reduce the number of in-person visits, and provide the most effective wound healing support. Solution (using NPWT):

1) The use of single pocket NPWT devices if possible (reducing the number of wound dressings changes, making(e) treatment more effective) is advised.
2) Patients should be educated on minimizing the risk of SARS-CoV-2 infection education.,
3) Telemedical support for patients during wound dressing self-removal and, in selected cases, in wound dressing changes with secure video conversations is essential.

Conclusion

In order to reduce the risk of viral transmission, early treatment of wound healing complications, and reducing the risk of SSI using NPWT is advisable, especially during the SARS-CoV-2 pandemic. NPWT should be considered in wound healing disorders and their prevention as the therapy can effectively decrease the number of complications, reduce the number of surgical interventions, decrease the length of stay, reduce the number of wound dressings changes, reduce the number of contacts between patients and medical staff and disburden the already decompressed healthcare system.

Single-use NPWT devices are helpful in outpatient wound treatment and SSI prevention (ciNPWT) allowing to minimize in-person visits to the health care center while still providing the best possible wound-care. Stationary NPWT should be used in deep SSI and perioperative wound healing disorders as soon as possible. Patient's education and telemedical support with visual wound healing monitoring and video conversations have the potential to minimize the number of unnecessary in-person visits in patients with wounds and therefore substantially increase the level of care.

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Severe deep neck infections successfully treated with negative pressure wound therapy with instillation — a case report

Krzysztof Szmyt, Adam Bobkiewicz, Łukasz Krokowicz, Tomasz Banasiewicz

CASE REPORT

***Abstract*— Background: Deep neck infection (DNI) is a life-threatening complication associated with significant mortality and morbidity rates. The most common causes of DNI are the tonsilitis, dentitis, salivary glands inflammation, malignancies, and foreign bodies. As a result of neck infection, patients are at high risk of potential secondary complications which include: descending mediastinitis, pleural empyema, septicemia, jugular vein thrombosis, pericarditis. We presented a case of successful management of DNI with the utility of negative pressure wound therapy with instillation (iNPWT).**

Method: A 37-year-old male with deep neck infection due to dentitis was qualified for iNPWT. Due to previous incisions and drainage of the neck abscesses, some undermined wounds drained towards each other's were revealed with an excessive amount of purulent content. Standard NPWT dressing was placed and polyurethane foam was covered with contact layer dressing. Additionally, an inflow drain was placed within one of the wounds in regard to instill an antimicrobial solution. The wound was instilled four times daily.

Results: The patient underwent a total of eight iNWPT sessions. Locally, a reduction in purulent content was achieved with a decrease of wounds' dimensions and improvement of wound bed granulation. Moreover, improvement of the patient's general condition and decrease of inflammatory markers was achieved.

Conclusions: iNPWT may play an important role in the management of combined, complicated wounds due to DNI. The instilled antimicrobial solution facilitates dissolving and removing of the purulent content that impairs the wound healing.

***Keywords*—deep neck infection, negative pressure wound therapy, instillation**

Introduction

DEEP neck infection (DNI) is defined as an infection within potential spaces located in the neck as a result of neck abscess or cellulitis. The most common causes of DNI are tonsilitis, dentitis, salivary glands inflammation, malignancies, and foreign bodies.[1] DNI is a life-threatening complication associated with an estimated mortality rate 0.3-1.6%.[2] As a result of neck infections, patients are at high risk of potential secondary complications which include: descending mediastinitis, pleural empyema, septicemia, jugular vein thrombosis, pericarditis.[3] Based on a recent literature review it occurs at a rate of 10-20%.[4, 5]

The problem of complicated septic wound exists as a result of previous surgical interventions as well as infections, and poses a real challenge in intensive care unit patients. The main goals of wound management are:

1) improving in the patient's general condition,
2) reducing local and systemic septic conditions, and
3) facilitating wound healing.

Holistic management should include extensive debridement, removal of the exudate and purulent discharge, and promotion of tissue granulation.

Current standard wound management in septic wounds is still based on placing drains within the subcutaneous tissue. However, such management is associated with limited effectiveness and does not reduce the severity of local infection.

Introduction of negative pressure wound therapy (NPWT) into the general practice revolutionized the strategy of wound care.[6] Moreover, the implementation of the instilled antimicrobial solution resulted in significantly better outcomes regarding time to wound healing, reduction in bacterial overload, and advancing hospital discharge.[7] The mechanism of action is based on controlled periodic instillation of a topical solution to the wound bed facilitating removal of cellular debris and cytokines, enhancing excaudate removal and decreasing the bacterial bio-burden.[8]

Application of standard NPWT in wounds complicated with dense purulent discharge, especially those associated with concomitant subcutaneous cavities and pockets may not be sufficient. Moreover, wound exudate has a tendency to agglomerate within natural spaces and impair wound healing. NPWT with instilled antimicrobial solution dissolves and flushes the cellular debris, non-viable tissue, and cytokines. By dissolving the purulent discharge, iNPWT facilitates its removal and penetrates into the wound, disrupting the biofilm.[9]

We present a case of successful management of deep neck infection with the use of negative pressure wound therapy with instillation (iNPWT).

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Figure 1. Patient after first surgical intervention – incisions of the neck abscesses.

Figure 2. Drains application within the subcutaneous tissue.

Figure 3. Wounds condition after few days of initial management. No improvement in wound healing.

Case study

A 37-year-old male was admitted to the intensive care unit due to extensive deep neck infection secondary to odontogenic causes. 3 weeks prior to his admission he had root canal treatment on tooth #44 and #47. On the first physical examination, the patient presented with extreme pain, large swelling with severe dyspnea, dysphonia, and dysphagia. Computed tomography (CT) performed in the emergency room showed pus collection on the right side of the neck and right submandibular area.

First, abscesses within the neck had been incised and drained and drains were placed within subcutaneous tissue with the intention of flushing and draining the purulent discharge (Fig. 1) (Fig. 2). Despite the wound's lavage with antimicrobial solution and administration of wide-spectrum antibiotics regimen (piperacillin with tazobactam 4.5 g 3 times per day i.v. and clindamycin 900 mg 3 times per day i.v.), there was no improvement in wound healing (Fig. 3). Moreover, a descending inflammation towards the anterior wall of the thoracic cavity was observed. During the next session of dressing change, an additional incision of neck abscess was made and NPWT dressing with instillation was applied. All wounds communicated with each other within the subcutaneous tissue.

Briefly, a standard V.A.C. Dressing System (KCI Medical, San Antonio, USA) was applied. Then, polyurethane (PU) foam was trimmed to an appropriate size. To prevent from ingrowing of granulated tissue within PU foam, a contact layer (Acticoat, Smith & Nephew Ltd, UK) was used and sutured to the PU foam. After flushing, the undermined cavities and wounds with antimicrobial solution, a superficial debridement of fibrin, and non-viable tissue was made. Then, PU foams covered with the contact layer were precisely applied within the wound bed and secured with stoma paste (Stomahesive paste® , ConvaTec, USA). Octeniline® (Schulke, Warsaw, Poland) was used as an antimicrobial solution.

Additionally, a flexible silicone drain was placed within one of the PU placed on the left side, whereas the port of the iNPWT system was applied within the wound localized in the lowest wound (Fig. 4). Finally, an adhesive drape was placed to keep the system sealed. Such management, applying inflow drain and outflow drain in the lowest wound allowed for distribution and drainage of antimicrobial solution within every undermined part of the wound (Fig. 5). The antimicrobial solution was delivered within NPWT dressing using a 50 ml syringe. Routinely, four times per day an appropriate volume of Octeniline® was instilled through the drain placed within the wound of the left jugular region. To achieve dwell time, we paused NPWT for 10 minutes. Next, negative pressure was applied again to actively drain the instilled antimicrobial solution. NPWT was set up in the continuous mode with the -100 mmHg level of negative pressure. The NPWT dressings were changed every three days or on-demand in case of an unsealed system.

After two sessions of iNPWT, we noted an improvement in wound healing: reduction in purulent drainage contents and decreased local signs of the inflammatory response (Fig. 6).

Figure 4. The first application of iNPWT with Octeniline® . Flexible silicone drain (10F) was placed inside the incision on the left side (red arrow). NPWT port was localized in the lowest incision (blue arrow).

Figure 5. Modified iNPWT allowed for distribution and drainage of antimicrobial solution within entire undermined wound (subcutaneous communication between wounds is marked in black).

Simultaneously, the reduction in inflammatory markers: C-reactive protein (CRP), procalcitonin (PCT), and white blood cells (WBC) levels were observed.

Every next NPWT dressing change was associated with trimming PU foam to be smaller in the size than the previous PU foam application. Thus, we observed macro-deformation causing a gradual reduction of the wound's size. Because of the proximity of both wounds and some problems with keeping the system sealed, we modified the NPWT strategy. Since PU foam covered with contact layer was placed within the wound bed (as previously described), the skin between wounds was also protected with contact layer and finally, both wounds of neck sites were covered with single PU foam (Fig. 7). For the next four iNPWT sessions, we increased the level of negative pressure to -125 mmHg. After two weeks of iNPWT, an extensive granulation of the wound bed without any purulent content was observed (Fig. 8). We achieved partial secondary closure. Constant improvement in clinical status was obtained and confirmed with imaging studies.

The patient was transferred to the otorhinolaryngology department. A total of eight sessions were performed. We did not observe any complications during the therapy.

Discussion

DNI is a serious bacterial infection in the presence of neck abscesses, cellulitis or/and phlegmons (from the skull base to the mediastinum).[10] The most common etiology is odontogenic (approximately of 40%) — as it was in the presented study. Other common causes include salivary gland infections, head and neck trauma, iatrogenic infections after surgical or dental procedures, neoplasm (benign and malignant).[5]

The surgical method of choice are incision and drainage of the abscess. Moreover, patients diagnosed with DNIs require advanced dental and respiratory tract procedures and the introduction of a wide spectrum antimicrobial regimen. The

Figure 6. Application of the third iNPWT dressing. Improvement in wound healing, reduction in purulent drainage contents and decreased inflammatory response were observed.

Figure 7. The sixth session of iNPWT. Wounds on both sites of the neck were covered with single piece of PU foam.

Figure 8. Third week of iNPWT. An extensive granulation of the wound bed with no purulent content was observed

crucial issue is to identify and treat the most underlying pathology responsible for the infection (for example: removal of the infected teeth or tonsil). On the other hand, DNIs may lead to some additional complications and appropriate management of these are crucial.[5, 11] This 'gold' standard treatment, in this case, was ineffective. We introduced iNPWT as a method of choice. Based on our experience, application iNWPT in complicated wounds may serve as an important alternative to standard management. Moreover, iNPWT is an accepted method improving the effectiveness of the standard NPWT therapy and can be helpful in complicated clinical situations, such as the open abdomen (OA) management[12] or in the treatment of infected implants.[13] iNPWT can be successfully used in the oral and mixillofacial surgery.[14]

In this case study, few clinical challenges were presented. Firstly, it was a serious and severe infection. Secondly, there was a large amount of purulent discharge and no improvement was achieved due to standard management. Thirdly, the localization of the infection within the neck, very close to the fragile, large blood vessels (carotid arteries — especially in the left side, and subclavicular vessels - especially on the right side, as well as lungs and trachea). To overcome the mentioned problems, a modified iNPWT was used.

The decision about the type of instilled fluid seems to be crucial. According to recent recommendations, there was no firm conclusion to indicate one standard antimicrobial solution used for iNPWT with a wide range of antiseptic agents.[8] In a presented clinical scenario, Octenilin® (octenidine-based wound irrigation solution) was used. Octenilin® was created for cleansing and moisturizing chronic wounds and burns.[15] This system can also be used to loosen encrusted dressings.[16] Octenidine-based solutions remove necrotic tissue, slough, and debris from the wound bed, and is particularly suitable for difficult-to-access locations, such as fissures and wound pockets.[17] The important benefit of iNPWT with Octenilin® was the effective evacuation of thick purulent discharge. This method prevents biofilm formation and helps in biofilm defragmentation. Cutting et al. demonstrated that the Octeniline® was effective against *Staphylococcus aureus* biofilms. In that paper, authors showed almost complete removal of a biofilm 24-hour after starting the therapy with Octenilin®.[18]

Another clinical problem was the localization of the wounds with the occurrence of fragile structures located close to them. Direct contact of PU sponge with exposed blood vessels is contraindicated because of the potential risk of vessel laceration and bleeding during the therapy and during dressing changes.

To avoid these complications, the authors recommended a contact layer — special non-adhesive fenestrated wound dressing added between the PU sponge and wound bed. That method was safe and widely accepted as a modification of the standard NPWT treatment.[19] Application of PU foam in the undermined wounds facilitates: 1) to keep the system sealed and 2) the adequate soaked of Octeniline® through the wound.

On the other hand, different dressings may be used in such a clinical situation.[20] Another option, dedicated for this type of wound is polyvinyl alcohol foam (PVA). Unfortunately, in the presented case the purulent exudation was too dense to be effectively suctioned by PVA foam.

To avoid any potential complication with bleeding, -100 mmHg as a level of negative pressure was used during iNPWT sessions. In the authors' opinion, that range of pressure is safe for fragile structures such as blood vessels or nerves. After the decrease of the local inflammation and improvement of granulated tissue, an increased level of negative pressure (-125 mmHg) was used.

Conclusions

In our opinion, iNPWT may play an important role in the management of combined, complicated wounds due to DNI. The subcutaneous application of NPWT was a promising and important technical trick and tip. The utility of iNPWT improves drainage, decreases inflammation, and protect the surrounding skin from irritation. Installed antimicrobial solution (especially Octenilin®) facilitates dissolving and removing of the purulent content that impairs wound healing.

Modification of iNPWT as presented in the study, seems to be a crucial element for good outcomes.

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