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Negative pressure wound therapy with instillation, a cost-effective treatment for abdominal mesh exposure

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Abstract

Purpose

Negative pressure wound therapy with instillation (NPWTi) has been proved to be a safe and effective treatment option for abdominal wall wound dehiscence with mesh exposure. Our aim in this study is to examine whether it is also cost-effective.

Methods

We performed a retrospective cohort study with 45 patients treated for postoperative abdominal wall wound dehiscence and exposed mesh: 34 were treated with conventional wound therapy (CWT) and 11 with NPWTi. We carried out a cost analysis for each treatment group using the Diagnosis-

related group (DRG) system and a second evaluation using the calculated costs “per hospital stay”. The differences between NPWTi and CWT were calculated with both evaluation systems. Comparative analysis was performed using the Mann–Whitney U test.

Results

Mean costs using the DRG estimation were 29,613.71€ for the CWT group and 15,093.37€ for the NPWTi group, and according to the calculated expenses “per hospital stay”, 17,322.88€ for the CWT group and 15,284.22€ for the NPWTi group. NPWTi showed a reduction in the total expense of treatment, related to a reduction in episodes of hospitalization and number of surgeries required to achieve wound closure. However, differences were not statistically significant in our sample.

Conclusions

NPWTi proves to be an efficient treatment option for abdominal wall wound dehiscence with mesh exposure, compared to CWT. More trials aimed to optimize treatment protocols will lead to an additional increase in NPWTi efficiency. In addition, to generalize our results, further studies with larger samples would be necessary.

Keywords

Abdominal wall
Diagnosis-related groups
Efficiency
Surgical mesh
Vacuum-assisted closure

Introduction

Restoration of the abdominal wall with synthetic materials is often inevitable in abdominal surgery [1, 2]. This situation creates a group of patients potentially at risk of chronic, severe complications. Abdominal wall wound dehiscence with mesh exposure is a dangerous adverse event with important morbidity [3], a high incidence of chronicity, progressive debilitation of the abdominal wall and deterioration of quality of life [4]. This complication is

also relevant in terms of costs, often requiring multidisciplinary involvement, long hospital stay or prolonged homecare, use of costly materials and repeated surgeries with or without replacement of the exposed mesh.

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Negative pressure wound therapy (NPWT) is a method of wound treatment with proven efficacy in many settings, including abdominal wall dehiscence [5, 6, 7]. The design of NPWT-instillation (NPWTi) devices increased the potential benefits of traditional NPWT, especially in infected sites with involved prosthetic material [8, 9, 10] such as abdominal meshes.

Recently, NPWTi has been proved to be an effective therapy option in this particular setting. Compared to treatment with conventional dressings, total recovery was reached in a shorter period of time, with less hospital stay and less need for additional surgeries [11]. From this data, a reduction in costs is suggested and the lower mesh replacement requirements imply an added economic advantage. We have considered this a crucial aspect to be determined and have, therefore, conducted a study of costs and global efficiency, comparing the use of NPWTi with conventional wound treatment (CWT) options.

Materials and methods

We conducted an observational retrospective cohort study at Hospital Gregorio Marañón (Madrid, Spain) between January 2010 and December 2013. We included all patients that were hospitalized at the Department of General Surgery with the diagnosis of abdominal wall wound dehiscence with mesh exposure during our studied period. The Center's Ethical Committee approved the study. All patients recruited were informed and signed a consent form.

Abdominal wall wound dehiscence is defined as a rupture of skin integrity after closure of a surgical wound and mesh exposure as the contact of the prosthetic material with the outer environment, whether visible or not. All the implants were placed suprafascially.

Out of an initial population of 202 patients with the diagnosis of abdominal wall wound dehiscence, 45 presented also with abdominal mesh exposure and were included in our study. Patients were divided into two groups: 34 patients were treated with conventional dressings and 11 with NPWTi. Conventional

dressings refer to saline-soaked gauze dressings, antiseptic solutions and open lavage. NPWTi therapy was applied with the V.A.C. ULTA device with instillation (VAC Veraflo®, KCI Clinic, Spain SL), using hypertonic saline as irrigation solution [11] with dressing changes every 3 days. The strategy to reach definite wound closure, in both treatment groups, was planned carefully in collaboration with the Department of General Surgery and the need for additional procedures was determined by the judgement, experience and training of the surgeon who applied the therapy.

Three variables were studied to determine the effectiveness of NPWTi. First, "Number of hospitalization episodes", which refers to the number of hospital admittances for the considered process, excluding any hospitalization time due to other causes. The second variable used was "Number of additional surgeries", indicating the secondary surgeries performed to reach wound closure, when required. Wound closure was defined as the restoration of the integrity of the skin at the wound site, and additional surgeries required to achieve this objective included procedures of: simple closure; debridement; mesh removal; or substitution. Lastly, "Total time of hospitalization", the total number of days of hospital stay, adding the days of hospitalization for each episode. All three parameters were then used for the cost analysis evaluation.

Specific costs of NPWTi are essentially those of the consumables used, some of them serving throughout the duration of the therapy (cons1) and others changed with each dressing, every 3 days (cons2). A register of the consumables and their costs can be found in Table 1. The total cost of the consumables for NPWTi was determined according to the number of days of therapy.

$$\text{Cost VAC Veraflo}^{\circledR} = \text{cons1} + (\text{cons2} \times \text{Days of treatment})/3.$$

Table 1

Consumables used for NPWTi (VAC Veraflo®)

Material	Cost (€)	Requirement
Cons1 represent those materials that last throughout the length of the therapy; only o is used per patient. Cons2 represent materials that are changed with each dressing, an therefore, consumed every 3 days		
[a]Consumables 1		
[b]Consumables 2		

Material	Cost (€)	Requirement
V.A.C. VeraLink™ Cassette (instillation bag unit)	88	Once (cons1[a])
V.A.C. Veraflo™ dressing	152.2	Each dressing
Canister and tubing	76	Each dressing
$\text{Cost of VAC Veraflo}^{®}\ \text{consumables} = \text{cons1} + \frac{\text{cons2} \times \text{Days of treatment}}{3} = 88 + \frac{228.2 \times \text{D}}{}$		
Cons1 represent those materials that last throughout the length of the therapy; only o is used per patient. Cons2 represent materials that are changed with each dressing, an therefore, consumed every 3 days		
[a]Consumables 1		
[b]Consumables 2		

The compared analysis of costs was performed with two different measures. First, we used Diagnosis-related groups (DRG). DRG is a system that classifies patients in groups with a common diagnosis, and relates each group to an expected consumption of hospital resources per single hospitalization episode. All the patients in our sample, in both treatment groups, share a common diagnosis. DRG-estimation of expenses for this diagnosis is set at 8253€ according to the National Health Service Catalog of November 27th 2008 [12]. As DRG-estimated prices do not include those of specific practices not used conventionally, the specific NPWTi costs were added to the DRG estimation in the corresponding patient group. The calculation for each patient of our sample was performed as follows:

$$\text{CWT group} : [8253 \in] \times [\text{number of episodes of hospitalization}]$$

$$\text{NPWTi group} : [8253 \in] \times [\text{number of episodes of hospitalization}] + [\text{specific}$$

We conducted a second evaluation of costs, the calculation of consumed resources “per hospital stay”, using the exact cost for each patient per hospital bed-day (198€) and per major surgery (477.35€), with data offered by the Department of Economics and Management at Gregorio Marañón Hospital. The specific NPWTi costs were also added to the corresponding group.

$$\text{CWT group} : [198 \in] \times [\text{days of hospitalization}] + [477.35 \in] \times [\text{number of ad}$$

$$\text{NPWTi} : [198 \in] \times [\text{days of hospitalization}] + [477.35 \in] \times [\text{number of additic}$$

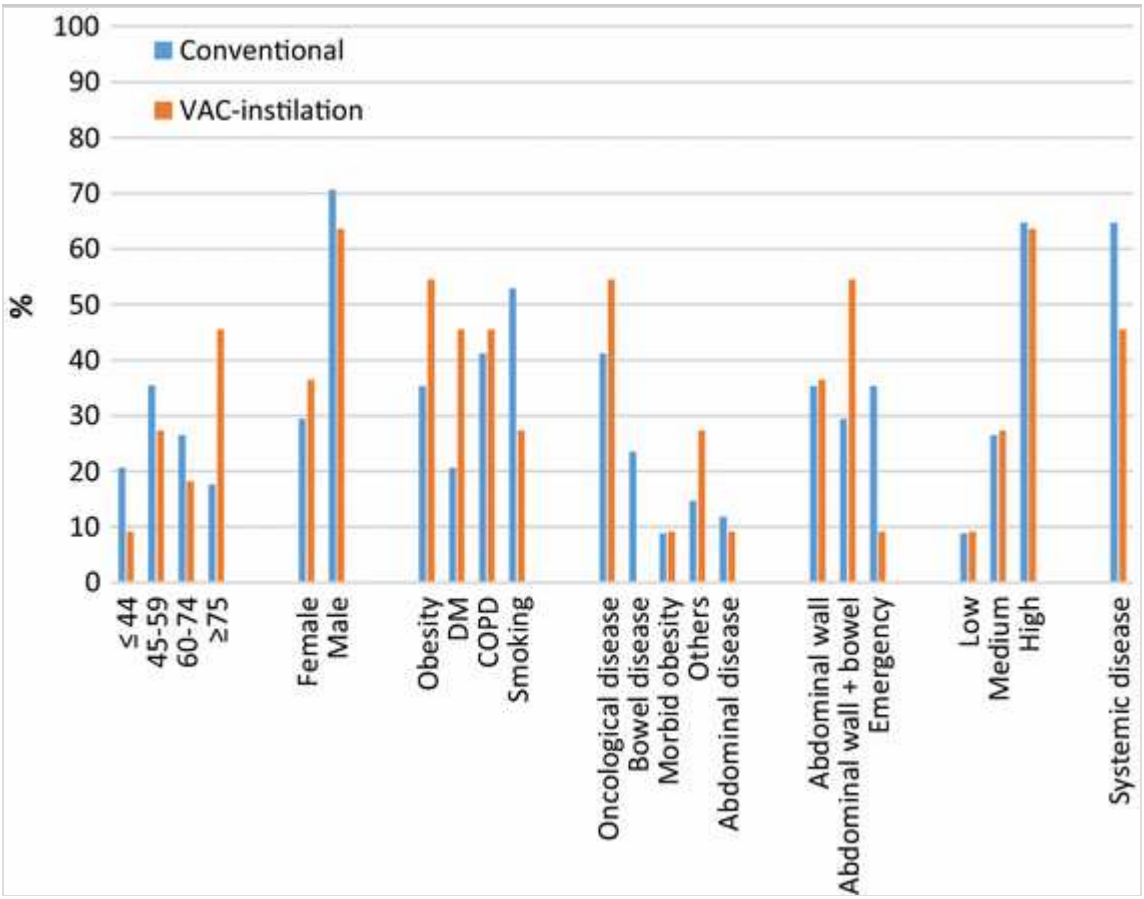
The Mann–Whitney U test was used for hypothesis testing ($p = 0.05$).

Results

Both groups were comparable regarding demographic and clinical characteristics, as is shown in Graphic 1.

Graphic 1

Detail of the demographic features of each group. Demographic and clinical features of our sample of patients in the two groups of study were comparable with no statistical differences in terms of age ($p = 0.124$), gender ($p = 0.187$), presence of comorbidities ($p > 0.05$), underlying cause for surgery ($p > 0.05$), immediate cause for surgery ($p > 0.05$), surgical risk ($p > 0.05$) and presence of systemic disease ($p > 0.05$)



The results of the variables studied for each group are shown in Table 2. The analysis of the sample showed that the number of hospitalization episodes was higher in the CWT group (0–19, median 3) than in the NPWTi group (1–3, median 2). In addition, total hospitalization stay was measured in 88.21 days (SD 77.05) for the CWT group and 69.09 (SD 33.56) for the NPWTi group. Finally, 94.1% of patients in the CWT group required one or more additional surgeries to obtain a definite wound closure (5 simple closures, 2 debridements, 14 mesh removals, 11 mesh substitutions), as opposed to only 54.5% in the NPWTi group (5 simple closures, 1 debridement, 0 mesh removals or substitutions). Based on this data, the cost analysis was performed as explained above.

Table 2

Study of compared outcomes between CWT and NPWTi (SD)

	CWT mean (SD)	**NPWTi mean (SD)**	*p*
Hospitalization episodes	3.59 (3.19)	1.64 (0.67)	0.003
Additional surgeries	2.29 (2.11)	0.82 (0.75)	0.009
Hospital stay (days)	88.21 (77.05)	69.09 (33.56)	0.745

	CWT mean (SD)	NPWTi mean (SD)	*p*
Time to recovery (months)	31.29 (37.19)	2.40 (1.57)	0.000
Results of compared analysis (using the Mann–Whitney U test) between both treatment groups in the number of hospitalization episodes and of additional surgeries required, the length of hospital stay (days) and the total time to recovery (months). The differences observed in the variable "length of hospital stay" were not statistically significant in our sample			
CWT conventional wound therapy, *NPWTi* Negative pressure wound therapy with instillation			

In the NPWTi group, therapy was applied for a period ranging from 7 to 36 days (mean 19.73 ± 9.5 days). Taking also into account the prices of the consumables, mean cost of VAC Veraflo® therapy (NPWTi) was in our sample 76.07€ per patient day. According to the previously described equation, mean cost of the therapy was 1588.45€ (DT 723.25; IC_{95}: 1102.17–2074.74). Detail is shown in Table 3.

Table 3

Costs of NPWTi per patient

Patient no.	NPWTi days	NPWTi costs (€)
1	21	1685.26
2	30	2369.80
3	36	2826.16
4	28	2217.68
5	20	1609.20
6	25	1989.50
7	19	1533.14
8	11	924.66
9	12	1000.72
10	7	620.42
11	8	696.48
Detail of the specific costs of NPWTi based on the calculations described in Table 1. Mean costs are 76.07€ per patient day		

Diagnosis-related groups

Tables 4 and 5 detail the expenses for each patient according to DRG for CWT (Table 4) and NPWTi (Table 5).

Table 4

DRG-estimated costs per patient in the CWT group

Patient no.	Number of hospitalization episodes	Total costs (€)
1	3	24,759
2	1	8253
3	2	16,506
4	2	16,506
5	1	8253
6	2	16,506
7	3	24,759
8	4	33,012
9	4	33,012
10	3	24,759
11	7	57,771
12	4	33,012
13	7	57,771
14	4	33,012
15	2	16,506
16	2	16,506
17	3	24,759
18	19	15,6,807
19	2	16,506
20	1	8253
21	4	33,012
22	7	57,771
23	4	33,012
24	1	8253

Patient no.	Number of hospitalization episodes	Total costs (€)
25	3	24,759
26	2	16,506
27	1	8253
28	2	16,506
29	2	16,506
30	3	24,759
31	5	41,265
32	4	33,012
33	5	41,265
34	3	24,759
	Mean cost	29,613.71 € (DT: 26,343.68; IC_{95}: 20,421.95–38,805.45)

Table 5

DRG-estimated costs per patient in the NPWTi group (specific NPWTi costs are added)

Patient no.	Number of hospitalization episodes	Hospital costs (€)	Total costs (€) (NPWTi costs + hospital costs)
1	1	8253	9938.26
2	1	8253	10,622.80
3	2	16,506	19,332.16
4	2	16,506	18,723.68
5	3	24,759	26,368.20
6	2	16,506	18,495.50
7	2	16,506	18,039.14
8	2	16,506	17,430.66
9	1	8253	9253.72
10	1	8253	8873.42
11	1	8253	8949.48

Patient no.	Number of hospitalization episodes	Hospital costs (€)	Total costs (€) (NPWTi costs + hospital costs)
	Mean costs	13,504.91 €	15,093.37 € (DT:6990,35; IC_{95}: 11,169.85–19,016.87)

Total cost of treatment for CWT was 29,613.71€ (DT: 26,343.68; IC_{95}: 20,421.95–38,805.45) and for NPWTi, 15,093.37€ (DT: 6990.35; IC_{95}: 11,169.85–19,016.87) with a mean difference of 14,520.34€ (IC_{95}: 4459.49–24,581.18).

Per hospital stay Same size and kind of letter than previous section entitled "Diagnosis-related groups"

The data for each patient are shown in Tables 6 and 7.

Table 6

Costs “per hospital stay” for each patient in the CWT group (costs per hospital bed-day, costs per surgery)

Patient no.	Length of hospital stay (days)	Cost of hospital bed-day (€)	Additional surgeries	Surgery cost (€)	Total cost (€)
1	43	8514	3	1432.05	9946.05
2	33	6534	0	0	6534
3	7	1386	2	954.70	2340.70
4	12	2376	1	477.35	2853.35
5	5	990	1	477.35	1467.35
6	8	1584	1	477.35	2061.35
7	233	46,134	4	1909.40	48,043.40
8	166	32,868	2	954.70	33,822.70
9	47	9306	6	2864.10	12,170.10
10	117	23,166	8	3818.80	26,984.80
11	107	21,186	6	2864.10	24,050.10
12	49	9702	2	954.70	10,656.70

Patient no.	Length of hospital stay (days)	Cost of hospital bed-day (€)	Additional surgeries	Surgery cost (€)	Total cost (€)
13	76	15,048	4	1909.40	16,957.40
14	59	11,682	2	954.70	12,636.70
15	9	1782	1	477.35	2259.35
16	36	7128	1	477.35	7605.35
17	109	21,582	3	1432.05	23,014.05
18	153	30,294	9	4296.15	34,590.15
19	4	792	0	0	792
20	45	8910	1	477.35	9387.35
21	25	4950	2	954.70	5904.70
22	67	13,266	3	1432.05	14,698.05
23	62	12,276	2	954.70	13,230.70
24	231	45,738	2	954.70	46,692.70
25	53	10,494	1	477.35	10,971.35
26	67	13,266	1	477.35	13,743.35
27	172	34,056	1	477.35	34,533.35
28	40	7920	1	477.35	8397.35
29	166	32,868	0	0	32,868
30	61	12,078	1	477.35	12,555,35
31	64	12,672	1	477.35	13,149.35
32	313	61,974	2	954.70	62,928.70
33	124	24,552	2	954.70	25,506.70
34	26	5148	1	477.35	5625.35
	Mean costs	16,241.82 €		1081.06 €	17,322.88 € (DT: 15,111.59; IC_{95}: 12,050.19–22,595.56)

Table 7

Costs "per hospital stay" for each patient in the NPWTi group (costs per hospital bed costs per surgery, NPWTi costs)

Patient no.	Length of hospital stay (days)	Cost of hospital bed-day (€)	Additional surgeries	Surgery cost (€)	Hospital stay cost (€)	Total cost (€) (hospital cost + NPWTi c
1	51	10,098	2	954.70	11,052.70	12,737.96
2	97	19,206	0	0	19,206	21,575.80
3	73	14,454	1	477.35	14,931.35	17,757.51
4	144	28,512	1	477.35	28,989.35	31,207.03
5	70	13,860	1	477.35	14,337.35	15,946.55
6	66	13,068	0	0	13,068	15,057.50
7	66	13,068	0	0	13,068	14,601.14
8	20	3960	0	0	3960	4884.66
9	64	12,672	1	477.35	13,149.35	14,150.07
10	61	12,078	1	477.35	12,555.35	13,175.77
11	32	6336	0	0	6336	7032.48
	Mean cost	13,392 €		303.77 €	13,695.77 €	15,284.22 € (DT: 6990.35, IC_{95}: 10,588.03–19,98(

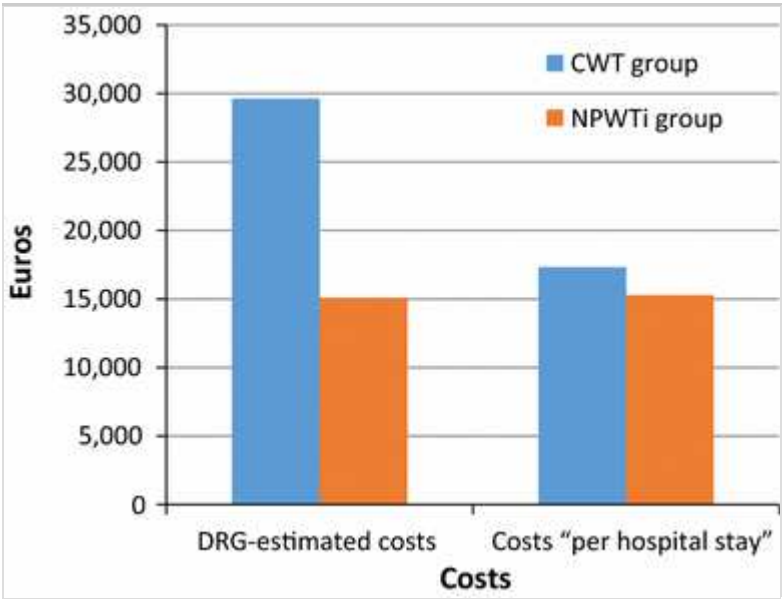
Total cost of treatment was higher in the CWT group, with a mean difference of 2038.66€ (IC_{95}: 4729.77–8807.09), being mean total cost in the CWT group 17,322.88€ (DT: 15,111.59; IC_{95}: 12,050.19–22,595.56), and mean total cost in the NPWTi group 15,284.22€ (DT: 6990.35; IC_{95}: 10,588.03–19,980.41).

Graphic 2 shows a higher cost of CWT than NPWTi according both to analysis based on DRG estimations and costs "per hospital stay". Differences, though considerable in economic value, resulted statistically non-significant ($p = 0.062$; $p = 0.54$).

Graphic 2

Expenses for each treatment group according to DRG and according to costs

"per hospital stay". Overall costs of treatment (mean costs) for each group of study according to both evaluation systems used



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Discussion

Following restoration of the abdominal wall with synthetic materials, wound dehiscence is an infrequent but severe complication with important morbidity and mortality, as high as 38% is some reports [13]. The ideal treatment for this particular adverse event has not yet been found. Moreover, it is related to a high consumption of health-care resources [14, 15], especially in high-risk patients.

In a previous report, the NPWTi therapy proved to be a conservative treatment option with fewer complications and less time to recovery for abdominal wall wound dehiscence with mesh exposure [11]. The reduction observed in the mentioned study regarding recovery time and number of surgeries as well as the lower mesh replacement requirements suggested an added economic advantage.

Before any new treatment method is implemented for a particular indication, it is necessary to carry out cost analysis and efficiency investigations. This is even more crucial when the proposed new therapy in itself adds costs to the standard practice. NPWT requires a specific device that is used with its own specific dressings, which are more expensive than standard dressing materials.

The benefits regarding efficiency of NPWT have been defined previously [16,

17, 18]. NPWT is able to reduce overall expenses, compensating the higher cost of the device and dressings with lower expenses in other aspects of patient therapy, such as total time to recovery, number of surgeries required or days of hospital care. Many studies have described how NPWT has similar or even lower costs of care for the complete pathological process than conventional methods, but with better results [19, 20], associated to an increase in efficacy and security [21, 22, 23]. The cost-effectiveness of NPWT in the treatment of abdominal dehiscence has also been mentioned in some previous reports [4, 24].

More recent studies analyze the specific and overall costs of NPWT with instillation (NPWTi) [25, 26]. Gabriel et al . We have added "27". Please link it with the reference list. [27] initially presented a reduction in costs per patient treated with NPWTi with respect to CWT, and in a more recent evaluation, they quantified the economic benefit of NPWTi with respect to NPWT, finding a reduction in overall therapy costs, related to a further reduction in time to recovery with NPWTi. To date, there are no studies in the literature that analyze cost-effectiveness of NPWTi in treatment of abdominal wound dehiscence.

Hospital managements and health-care providers in our national health system use the DRG system for the design and development of budget distribution and resource allocation plans. In our sample, the cost for a single episode of hospitalization for one patient with the diagnosis of complicated postoperative wound of the abdominal wall is 8253€ [14]. The difference of 14,520.34€ between the mean cost of NPWTi and CWT groups is secondary solely to a lower number of hospitalization episodes in the NPWTi group. In a more accurate analysis of costs “per hospital stay”, we considered the exact expenses related to “hospital bed-day” as well as the expenses related to each major surgery. According to this system, mean expenses for CWT rose to 17,322.88 € and for NPWTi, to 15,284.22 €, with a difference of 2038.66 €.

In both methods, we can assert that the higher expenses associated to NPWTi are compensated with the reduction related to a more effective therapy. In the analysis “per hospital stay” the difference is more discrete because the differences in regard to the number of days of hospital day were also non-significant. To date, NPWTi has only been applied in a hospital setting, with discharge delayed till the vacuum therapy has been completed. This leads to a hospital stay period of 20 days (mean value) in this treatment group.

There are no standard protocols that define the optimal length of vacuum therapy with instillation, and less so for each specific clinical setting in which this therapy can been used effectively. Therefore, the end of treatment is decided based on clinical data. Our data is consistent with other reports with abdominal wall dehiscence with exposed mesh, treated with conventional NPWT for a mean of 24–26 days. Additionally, some comparative studies [27] have proven the beneficial effects of adding instillation to the negative pressure therapy, reporting a mean of 20.9 days of conventional vacuum therapy versus a mean of 4.9 days of instillation therapy. The authors report a further decrease in length of NPWTi with respect to initial studies due to their advances in management of the instillation device. Furthermore, experimental studies have presented even lower durations of therapy, suggesting that 6–7 days of instillation with normal saline could be enough to obtain a good-quality granulation tissue on porcine models [28, 29], time that could be sufficient to eradicate local infection.

The above data suggest that NPWT is probably being applied for longer periods than would be necessary for optimal results, which would be consequently related to an avoidable use of resources related to longer hospital stay, as explained above. It can also be proposed that NPWTi be used on an outpatient basis, which could further reduce expenses [24, 30]. We consider that these aspects of the therapy should be studied further to attain maximal effectiveness and efficiency.

Because of the non-probabilistic sampling method used, generalization of our data would prove unprecise. Nevertheless, this study has confirmed our hypothesis in our group of patients, leading the way to further projects with larger randomized samples that could confirm the data in a larger population.

In the study, costs are an estimation. An activity-based economic analysis with collection of actual costs for each patient through the entire process would be more accurate.

Conclusions

NPWTi proves to be an efficient treatment option for abdominal wall wound dehiscence with mesh exposure, compared to CWT. Lower costs of NPWTi are related to less time to recovery, fewer complications and less number and complexity of additional surgeries required. This reduction of expenses compensates the higher costs related to the device and dressings of NPWTi.

However, to generalize our results, further studies with larger samples are necessary. More trials aimed to optimize treatment protocols (total time of NPWTi treatment, use of this therapy on an outpatient basis) will lead to an additional increase in NPWTi efficiency.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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